Element Six Technologies Ltd *v* IIa Technologies Pte Ltd
[2020] SGHC 26

Case Number : Suit No 26 of 2016

Decision Date : 07 February 2020

Tribunal/Court : High Court

Coram : Valerie Thean J

Counsel Name(s) : Alvin Yeo SC, Daniel Chan, Vivian Siah, Daryl Kwok (WongPartnership LLC) (instructed counsel), Chan Kwok Chuan Jason, Pang Sze Ray Melvin, Nicholas Tong Wei Jie, Ong Eu Jin (Amica Law LLC) for the plaintiff; Davinder Singh SC, Srruthi Ilankathir, Hanspreet Singh (Davinder Singh Chambers LLC) (instructed counsel), Tony Yeo Soo Mong, Meryl Koh Junning, Yeo Javier and Chiew Jing Yi (Drew & Napier LLC) for the defendant.

Parties : Element Six Technologies Ltd — IIa Technologies Pte Ltd

Patents and Inventions – Validity

Patents and Inventions – Infringement

7 February 2020 Judgment reserved.

Valerie Thean J:

Introduction

1 The plaintiff, a company incorporated in the United Kingdom, is part of the Element Six Group, which designs, develops and produces synthetic diamonds. In particular, the plaintiff specialises in the production of synthetic diamond material using chemical vapour deposition ("CVD") techniques for technical applications in various industries, including optics, semiconductors and sensors. It is part of the De Beers Group, which is in turn a subsidiary of Anglo American PLC. The defendant, a company incorporated in Singapore, is a major manufacturer of CVD diamonds and has its diamond growing facility in Singapore. CVD refers to a process by which diamonds are grown from a substrate (*ie*, a diamond seed) by placing the substrate in a CVD reactor containing a mixture of gases and bombarding it with atoms. [note: 1]

2 In this suit, the plaintiff contends that the defendant has infringed two of its patents registered in Singapore, Singapore Patent No 115872 ("SG 872") and Singapore Patent No 110508 ("SG 508"). It relies on three samples of diamonds purchased, it contends, from the defendant or the defendant's related entities or distributors. The defendant seeks to revoke the two patents. It also contends that the diamonds in question are not its responsibility and, in any event, do not infringe the patents.

Facts

The patents

SG 872

3 SG 872 contains both product and process claims. The key product claim is Claim 1, which describes a CVD single crystal diamond material of a specified thickness of at least 0.5mm with certain characteristics. In particular, the diamond material has low optical birefringence, which is indicative of low strain, in the range of values stated in the claims (for convenience, I will refer to this range of values as the "SG 872 Range"). Birefringence refers to an optical property which is used to determine a diamond's suitability for high-end optical applications. [note: 2]

4 The key process claim in SG 872 is Claim 62. It describes a method of producing the CVD diamond material which comprises, among other things, substrate preparation and the deliberate adding of nitrogen to the synthesis process. The level of nitrogen concentration (300ppb to 5ppm) is selected to be sufficient to prevent or reduce the formation of local strain generating defects, while also being low enough to prevent or reduce deleterious absorptions and crystal quality degradations. [note: 3]

SG 508

5 SG 508 is a process claim in respect of the controlled conversion of a coloured single crystal CVD diamond to another colour under suitable and controlled heat treatment conditions, also referred to as annealing. The colours which may be produced include those in the pink-green range.

The samples

6 The plaintiff's case on infringement is premised on three samples which were purchased by the plaintiff and/or its agents between 2014 and 2015, prior to the commencement of the suit on 12 January 2016 ("Sample 2", "Sample 3", and "Sample 4", collectively the "Samples"). The Samples were purchased either from the defendant directly (in the case of Sample 4) or from entities that are allegedly related to the defendant (in the case of Samples 2 and 3).

(a) Sample 2 is an optical grade single crystal CVD diamond plate with product code "2PCVD303004N". Sample 2 was purchased by Dr Andrey Jarmola on behalf of the plaintiff from Microwave Enterprises Ltd ("MWE"), under instructions from Dr Daniel James Twitchen on or around 12 May 2014. [note: 4]

(b) Sample 3 is a single crystal CVD diamond gemstone with product code "LG10225420". Sample 3 was purchased by Dr Simon Lawson on behalf of the plaintiff from Pure Grown Diamonds Inc ("PGD") on or around 27 October 2015. [note: 5]

(c) Sample 4 is an optical grade single crystal CVD diamond plate with product code "2PCVD505005N". Sample 4 was purchased by Mr Pascal Pierra on behalf of the plaintiff directly from the defendant in Singapore in or around October 2015. [note: 6]

Summation of parties' positions and issues

7 The defendant by counterclaim disputes the validity of SG 872 and SG 508 and seeks their revocation. In its defence, the defendant denies responsibility for the Samples and contends that, in any event, the Samples fail to show any infringement of the patents.

8 The case, therefore, may be analysed by reference to these issues:

(a) Validity of SG 872 and SG 508;

(b) Whether the defendants are responsible for the Samples; and

(c) Whether the Samples infringe SG 872 and SG 508.

Decision

9 As I explain below, I hold that SG 872 is valid, while SG 508 is not. Samples 2, 3 and 4 originate from the defendant, and infringe SG 872 but not SG 508.

Part I: Validity of SG 872 And 508

10 As stated by the Court of Appeal in *Mühlbauer AG v Manufacturing Integration Technology Ltd* [2010] 2 SLR 724 ("*Mühlbauer*") at [15], in order for an invention to be patentable, it must satisfy the three conditions set out in s 13(1) of the Patents Act (Cap 221, 2005 Rev Ed) ("Patents Act"). These are that:

(a) the invention is new (*ie*, the novelty requirement);

(b) it involves an inventive step (*ie*, the inventiveness or non-obviousness requirement); and

(c) it is capable of industrial application.

11 Requirement (c) is not in dispute in the present case for either of the patents.

Claim construction

12 Claim construction is integral to understanding whether claims are novel and inventive, and I therefore deal with this issue first. The claims of a patent provide the patentee with the monopoly which it is entitled to: *First Currency Choice v Main-Line Corporate Holdings Ltd and another appeal* [2008] 1 SLR(R) 335 ("*First Currency Choice*") at [23]. In *Lee Tat Cheng v Maka GPS Technologies Pte Ltd* [2018] 1 SLR 856 ("*Lee Tat Cheng*"), the Court of Appeal reaffirmed the following key principles of claim construction at [41]:

(a) In ascertaining the true construction of a patent specification, the claims themselves are the principal determinant. What is not claimed is deemed to be disclaimed.

(b) The description and other parts of the patent specification form the context for, and may assist in, the construction of the claims.

(c) The claims are to be construed purposively, and not literally. This would give the patentee the full extent, but no more than the full extent, of the monopoly which a person skilled in the art, reading the claims in context, would think the patentee was intending to claim. In this regard, the starting point is to ask the threshold question: What would the notional skilled person have understood the patentee to mean by the use of the language of the claims? The *Improver* questions (see [30] above), which were derived from *Catnic* ([26] supra), have also been used as guidance in construing patent claims.

(d) As a general rule, the notional skilled person should be taken to be a workman or technician who is aware of everything encompassed in the state of the art and who has the skill to make routine workshop developments, but not to exercise inventive ingenuity or think laterally.

(e) Purposive construction does not entitle the court to disregard clear and unambiguous words in a patent claim, and the court is not entitled to rewrite or amend the claim under the guise of construction. In construing a claim purposively, the language that the patentee has adopted is more often than not of utmost importance. It is not permissible to put a gloss on or expand a claim by relying on a statement in the patent specification.

(f) If an allegedly infringing article falls within the words of one of the claims of a patent properly construed, the patent would have been infringed. To constitute infringement, the article concerned must usurp each and every one of the essential elements of the claim in question.

13 The "notional skilled person" referred to by the Court of Appeal in *Lee Tat Cheng* is referred to by parties in this case, as is common, as a person skilled in the art ("PSA").

14 In the present case the defendant's PSA is a composite person having a Master's degree in mechanical or chemical engineering and having a doctorate in applied physics, electrical engineering, optical engineering or a closely related field, aided by an engineer/technician with skills in mechanical polishing, laser cutting and correlated measurements. The plaintiff disputes this, and contends that the PSA is a team of people collectively having a Bachelor of Science in physics, chemistry or material sciences, and knowledge of diamond properties in all its forms at the material time (natural, high-pressure high-temperature ("HPHT") and CVD diamonds) as well as working knowledge of CVD diamond synthesis and commercial production. [note: 7] This disagreement has no practical significance, as no finding in the case turns upon this fine distinction. The present case would require consideration of a team of persons working in the field of growing CVD diamonds. In my judgment, the relevant PSA in such a field would include a team of individuals with expertise in diamonds and science generally, with access to individuals possessing doctorate qualifications. This is evidenced by the composition of the relevant teams on both sides in the present case. The plaintiff's team included scientists such as Dr Phillip Martineau (who has a doctorate in solid state physics) [note: 8] and Dr Geoffrey Scarsbrook (who has a doctorate in material physics). [note: 9] As for the defendant, while the composition of its team is less clear, the defendant's chief scientist, Dr Devi Misra, has a doctorate qualification as well. [note: 10]

Claims in dispute

15 For SG 872, arguments centred on Claim 1, a product claim, and Claim 62, a process claim. For SG 508, arguments focused on Claim 1. I deal with these in turn.

Validity of SG 872 Claim 1

The Claim 1 invention

16 Claim 1 and in particular 1(ii) and 1(iii) are the focus of the dispute between parties: [note: 11]

1. A CVD single crystal diamond material which shows at least one of the following characteristics, when measured at room temperature (nominally 20°C):

…

ii) a low optical birefringence, indicative of low strain, such that in a sample of a specified thickness of at least 0.5 mm and measured in a manner described herein over a specified area of at least 1.3 mm x 1.3 mm, the modulus of the sine of the phase shift, $|\sin \delta|$, for at

least 98% of the analysed area of the sample remains in first order (δ does not exceed π/2) and the |sin δ| does not exceed 0.9;

iii) a low optical birefringence, indicative of low strain, such that in a sample of a specified thickness of at least 0.5 mm and measured in a manner described herein over a specified area of at least 1.3 mm x 1.3 mm, for 100% of the area analysed, the sample remains in first order (δ does not exceed π/2), and the maximum value of $\Delta n_{[average]}$, the average value of the difference between the refractive index for light polarised parallel to the slow and fast axes averaged over the sample thickness, does not exceed 1.5 x 10^{-4};

17 The plaintiff frames the inventive concept behind Claim 1 in SG 872 as follows: [note: 12]

> The inventive concept behind SG 872 is the development of a new grade of single crystal CVD diamond material with exceptionally low strain such that it exhibits very good optical characteristics, specifically a low birefringence, making it suitable for high-end optical applications such as etalons. The low strain also enables the material to be grown to significant thicknesses, such that is also useful for applications requiring thicker diamond material of good optical transparency, such as gemstones.

18 The product in Claim 1 is for use primarily in optical applications. The utility of this invention is in its ability to create, on a commercial scale, diamonds for use in optical applications. These diamonds, having the properties those in the diamond trade term "Type IIa", may also function as high quality gemstones. While natural diamonds could also be similarly used if they possessed the requisite properties, Dr Martineau explained that such natural diamonds are "a very uncertain supply" as natural diamonds with "particular properties" are required. [note: 13]

Priority date for Claim 1

19 I deal first with the priority date of Claim 1. The plaintiff claims a priority date of 21 November 2002 for Claim 1 on the premise that, GB Patent Application No 0227261.5 ("GB 261"), its priority document, was filed on 21 November 2002. [note: 14] While the defendant accepts that the priority date of Claim 1(ii) of SG 872 is 21 November 2002, it contends that the priority date of Claim 1(iii) is 20 November 2003, [note: 15] because Claim 1(iii) is not supported by but extends beyond what is disclosed in GB 261.

20 The relevant provision is s 17(2) of the Patents Act:

> (2) Where in or in connection with an application for a patent (referred to in this section as the application in suit) a declaration is made, whether by the applicant or any predecessor in title of his, complying with the relevant requirements of the rules and specifying one or more earlier relevant applications for the purposes of this section made by the applicant or a predecessor in title of his, and the application in suit has a date of filing, within the period referred to in subsection (2A)(*a*) or (*b*), then —
>
> (*a*) if an invention to which the application in suit relates is *supported by matter disclosed in the earlier relevant application or applications*, the priority date of that invention shall, instead of being the date of filing the application in suit, be the date of filing the relevant application in which that matter was disclosed or, if it was disclosed in more than one relevant application, the earliest of them; and

(*b*) the priority date of any matter contained in the application in suit which was also disclosed in the earlier relevant application or applications shall be the date of filing the relevant application in which that matter was disclosed or, if it was disclosed in more than one relevant application, the earliest of them.

[emphasis added]

21 The relevant principles on s 17(2) of the Patents Act, which is *in pari materia* with s 5(2) of the Patents Act 1977 (c 37) (UK), were set out by the English Court of Appeal in *Unwired Planet International Ltd v Huawei Technologies Co Ltd and others* [2017] Bus LR 1971 ("*Unwired*") at [56]. The English Court of Appeal referred to the following "structured approach" in considering questions of entitlement to priority:

(a) First, to read and understand, through the eyes of the PSA, the disclosure of the priority document as a whole.

(b) Second, to determine the subject matter of the relevant claim.

(c) Third, to decide whether, *as a matter of substance and not form*, the subject matter of the claim can be *derived directly and unambiguously* from the disclosure of the priority document.

22 I summarise two further points made by the Court of Appeal at [71]–[72] relevant to this case:

(a) The assessment of priority is not done by asking whether everything which falls within the claim is clearly and unambiguously taught by the priority document. The exercise of determining priority involves asking whether the *invention* is directly and unambiguously derivable from the priority document, not whether every possible embodiment of the invention is so derivable.

(b) The priority document must be read with the benefit of the common general knowledge which forms the factual matrix against which the technical disclosure is assessed. Consequently, the disclosure may mean something different to a PSA who possesses the requisite knowledge than it does to someone reading the document without that knowledge. That observation is particularly relevant in a case where one is concerned not merely with what is made explicit by the document, but also with what is implicit in it, given that both explicit and implicit disclosure may be taken into account for priority.

23 The subject matter of Claim 1(ii) is a CVD diamond of low optical birefringence where mod sine delta does not exceed 0.9. The subject matter of Claim 1(iii) is a CVD diamond of low optical birefringence where the maximum value of delta n average does not exceed 1.5 x 10^{-4}. According to the defendant's expert, Dr Christoph Nebel, [note: 16] the scope of the subject matter that is disclosed in GB 261 is limited by way of mod sine delta not exceeding 0.9. The material would only have a maximum phase shift of delta of 1.11998. The defendant rests on the assertion that the scope of Claim 1(iii) includes materials with the phase shift up to 1.571. In other words, the scope of Claim 1(iii) could include materials having 0.9 < mod sine delta < 1.

24 The plaintiff's expert, Prof Mark Newton, explained in his AEIC that Dr Nebel had miscalculated the derivation of mod sine delta from delta n, as Dr Nebel had taken first order at π when first order ought to be π/2. On that premise, a delta n average value of 1.5 x 10^{-4} as specified in Claim 1(iii) converts at L (thickness) of 0.5mm and λ (wavelength) of 589.6nm to mod sine delta = 0.72. [note: 17] The defendant emphasises that in cross-examination, Prof Newton accepted that Claim 1(iii)

discloses a wider range of birefringence measurements compared to Claim 1(ii). However, whether or not Claim 1(iii) is broader than Claim 1(ii) is not relevant to the issue. Dr Newton explained that there is no 1:1 mapping between Claim 1(ii) and 1(iii) of SG 872. [note: 18] The true question is whether the priority document, GB 261, directly and unambiguously conveys to the PSA an invention of sufficient breadth to encompass Claim 1(iii) of SG 872. I hold that it does. In this regard, the defendant does not contend that there is *any* difference in the inventive concept or the method between GB 261 and SG 872. Claims 1(ii) and 1(iii) are simply different ways of *quantifying* or *measuring* the optical birefringence of the CVD diamond produced through the process disclosed in GB 261 and SG 872, through the respective parameters. The defendant does not suggest that there is *any* difference in the process taught in GB 261 and SG 872, which is capable of giving rise to the claimed product in Claim 1. A low birefringent CVD diamond within the range claimed in Claim 1(iii) can therefore be derived directly and unambiguously from the priority document GB 261. There is implicit disclosure, and no difference in substance.

25 Accordingly, in my judgment, Claim 1(iii) is entitled to claim priority from GB 261, the operative date being 21 November 2002. This would also mean that the following pieces of prior art are not citable against SG 872: [note: 19]

(a) HP Godfried *et al*, "Diamond Solid Etalons for High-Stability DWDM Wavelength-Lockers" ("Godfried"), a conference paper presented in 2003.

(b) The plaintiff's alleged prior sales of SG 872 diamonds on its website around September 2003.

(c) The material contained in Singapore Patent No 110506 ("SG 506") which is not entitled to a priority date of 20 September 2002.

(d) The material contained in SG 508 which is not entitled to a priority date of 6 September 2002.

Is the product novel?

26 The applicable provision for the novelty requirement is s 14 of the Patents Act, which states:

Novelty

14.—(1) An invention shall be taken to be new if it does not form part of the state of the art.

(2) The state of the art in the case of an invention shall be taken to comprise all matter (whether a product, a process, information about either, or anything else) which has at any time before the priority date of that invention been made available to the public (whether in Singapore or elsewhere) by written or oral description, by use or in any other way.

(3) The state of the art in the case of an invention to which an application for a patent or a patent relates shall be taken also to comprise matter contained in an application for another patent which was published on or after the priority date of that invention, if the following conditions are satisfied:

(*a*) that matter was contained in the application for that other patent both as filed and as published; and

(*b*) the priority date of that matter is earlier than that of the invention.

27 There are two steps to the novelty inquiry. The first is to identify the prior art which are relevant to the invention in question. The second is to consider if the particular piece of prior art identified *anticipates* the invention. This is a question of fact. To anticipate the claim, the prior art must contain clear and unmistakeable directions to do what the patent claims to have invented. In *Mühlbauer* at [17], the Court of Appeal adopted the test for anticipation set out in the English Court of Appeal decision of *The General Tire & Rubber Company v The Firestone Tyre and Rubber Company Limited* [1972] RPC 457, stating:

> A signpost, however clear, upon the road to the patentee's invention will not suffice. The prior inventor must be clearly shown to have planted his flag at the precise destination before the patentee.

28 The plaintiff contends that the prior art raised by the defendant do not plant the flag "at the precise destination" before the patentee. I briefly summarise the principles relevant in considering this issue.

29 First, the prior art must constitute an *enabling disclosure*. As the Court of Appeal explained in *Genelabs Diagnostics Pte Ltd v Institut Pasteur and another* [2000] 3 SLR(R) 530 at [24], "[t]he prior disclosure must not only identify the subject matter of the claim in the later patent, it must do so in a way that enables the [PSA] to *make or obtain it*, a kind of enabling disclosure" [emphasis added]. The concepts of disclosure and enablement must be kept distinct: *Mühlbauer* at [17]. Applying the principle of enabling disclosure to the present case, it is not sufficient for the defendant to *disclose* a low birefringent CVD diamond within the SG 872 Range in the prior art. That prior art must also *enable* the PSA to make or obtain the said CVD diamond.

30 Second, it is not necessary for the invention to be *expressly* disclosed in the prior art. Such disclosure can be *implicit* in that a PSA reading the prior art "must be taken to read documents in an intelligent way, seeking to find what is disclosed as a matter of substance": *Research in Motion v Inpro* [2006] RPC 20 at [128] (see generally *Terrell on the Law of Patents* (Colin Birss gen ed) (Sweet & Maxwell, 18th Ed, 2016) ("*Terrell*") at paras 11.68–11.71).

31 The disclosure can also be *inherent*. That is to say, if a PSA following the directions in the prior art will find that it *inevitably* results in the invention being made or done, the invention will not be novel. This is notwithstanding the fact that the prior art might not have described the invention in the same terms as the patent.

32 In the House of Lords decision of *Merrell Dow Pharmaceuticals Inc v HN Norton & Co Ltd* [1996] RPC 76 ("*Merrell Dow*") at [44], Lord Hoffmann described this principle in the following terms: "if the recipe which inevitably produces the substance is part of the state of the art, so is the substance as made by that recipe". Furthermore, "[w]hether or not a person is working a product invention is an objective fact independent of what he knows or thinks about what he is doing": *Merrell Dow* at [47]. In *Merrell Dow*, Lord Hoffmann explained the principle with the following example at [36]. The Amazonian Indians have for centuries used a powdered tree bark to treat malaria. They were using quinine. Later, scientists discovered that the active ingredient within the tree bark was quinine. Could the scientists patent quinine, on the basis that they discovered this active ingredient which the Amazonian Indians had no knowledge about? The manufactured quinine could not be patented, on the premise that the teachings of traditional medicine contained sufficient information to extract the same product.

33 Third, the requirement of *inevitability* must be assessed in a practical manner. Neuberger J (as he then was), citing *Fomento v Mentmore* [1956] RPC 87 at 101 in *Kirin-Amgen Inc v Roche Diagnostics GmbH* [2002] RPC 1 at [702], observed that if the required result was obtained "save in exceptional circumstances (as one might say, 99 cases out of 100)" it would not deprive the earlier disclosure of its anticipating quality.

34 Fourth, the prior art must be considered separately when applying the test of anticipation. The court is not to combine or "mosaic" the disparate pieces of prior art: *ASM Technology Singapore Pte Ltd v Towa Corp* [2018] 1 SLR 211 ("*ASM Technology*") at [59]. There is, however, a limited exception to the rule against "mosaicing". Where an earlier document is referred to in a later document, it is possible to refer to the earlier document, but, even then, only to the extent of the specific portions referred to by the later document: *Mühlbauer* at [68].

35 Fifth, the prior art must be construed as if the court had to construe it at the *date of publication*, to the exclusion of information subsequently discovered by the PSA. An *ex post facto* analysis is not permissible: *Mühlbauer* at [18(a)]. In this connection, I should mention that while the plaintiff objects to the defendant's use of publications post-dating the priority date for novelty, one ought to distinguish between the use of such publications *to subjectively interpret the prior art* and *as a means to objectively establish a scientific fact*. The former is impermissible given the rule against an *ex post facto* analysis. But there is nothing objectionable with using such publications as a means of proving a scientific fact. In *Smith & Nephew Plc and Convatec Technologies Inc* [2013] RPC 6, Birss J held that material post-dating the date of priority could be used to establish the solubility of a compound called AgCMC.

36 Sixth, as to the requirement that the prior art must have been "made available to the public", this is satisfied even if the prior art was disclosed only to a single member of the public, unless such disclosure was given in confidence: *Institut Pasteur and Another v Genelabs Diagnostics Pte Ltd and Another* [2000] SGHC 53 ("*Institut Pasteur*") at [188]. In addition, the requirement will still be satisfied even if no one has inspected the prior art: see *Dien Ghin Electronic (S) Pte Ltd v Khek Tai Ting (trading as Soon Heng Digitax)* [2011] 3 SLR 227 at [29]; *First Currency Choice* at [38], citing Aldous J (as he then was) in *Lux Traffic Controls Limited v Pike Signals Limited* [1993] RPC 107 at 133.

37 Finally, the burden of proving anticipation rests on the party resisting the patent claim: *ASM Technology* at [59].

General observations on defendant's approach to novelty

38 In view of the breadth of prior art alleged, I sum up the allegations and main findings here.

39 The defendant made two contentions of a general nature. First, a prior art which discloses a natural or HPHT diamond within the SG 872 Range will anticipate Claim 1 as CVD diamonds are not a distinct type of diamond. I disagree and hold that CVD diamonds are a distinct type of diamond: see [44]–[54] below.

40 Second, the defendant contends the parameters of Claim 1 are arbitrary and meaningless. I hold otherwise. Nevertheless, that the birefringent parameters are meaningful and of technical significance does not mean that a prior art may not have anticipated SG 872. Lord Hoffmann's reminder in *Merrell Dow* about quinine is apt here. The defendant seeks to otherwise show that the prior art is within the SG 872 Range of birefringence. On this issue, the mere fact that the prior art discloses and enables the production of a "low birefringent" CVD diamond does not, in and of itself,

mean that Claim 1 is anticipated. Insofar as the defendant relies on prior art which discloses diamonds of "low birefringence", qualitative terms such as "low birefringence" or its near cousin, "low strain", should be treated with circumspection, in so far as there is no *quantitative measurement* involved. Dr Nebel himself expressed scepticism towards the use of qualitative terms, including with respect to birefringence. His evidence was that terms such as "high quality" could mean different things in different contexts, and was not sufficiently scientifically precise to function as a definition. [note: 20] I therefore do not consider that a mere enabling disclosure of a CVD diamond with "low birefringence" in the prior art will in and of itself anticipate SG 872, unless the defendant also proves that such a diamond will have a birefringence value within the SG 872 Range.

41 It should be noted that while Dr Nebel had cited an extensive list of prior art in his expert report, the defendant, in its closing submissions, focused in the main on two pieces of prior art, WO 01/96633 and WO 01/96634 ("WO 633" and "WO 634") and SG 506. Given my observations at [39]–[40], the other pieces of prior art would in any event have been irrelevant. Thus, the defendant seeks to prove anticipation by these patents using the following three types of arguments for anticipation: [note: 21]

(a) The first argument relies on prior art that enables a PSA to make CVD diamond material with a certain dislocation density, Raman peak width and various electrical properties. The defendant asserts that there are certain *correlations* that can be observed between these properties and optical birefringence. For example, if the prior art would enable a PSA to make a CVD diamond of a certain dislocation density, and it is proven that the dislocation density results in a birefringence value that will fall within the SG 872 Range, the prior art will anticipate Claim 1 of SG 872. I organise these as Category (a) correlations below.

(b) The second argument relies on prior art which enables a PSA to make CVD diamond material suitable for applications such as etalons, anvils and diamond detectors. If the defendant can prove that such applications will have a birefringence value within the SG 872 Range, I accept that such prior art will anticipate Claim 1 of SG 872. I refer to these as Category (b) correlations below.

(c) Lastly, there is also a collection of prior art, referred to as Category (c) correlations below, where the defendant seeks to show that the Claim 1 product inevitably results from a similar method of teaching as SG 872.

42 Finally, I accept that it is not *necessary* for the defendant to conduct experiments to prove that the prior art anticipates SG 872. [note: 22] Neither is the position being taken by the plaintiff, as clarified during oral closing submissions. [note: 23] As stated in *SmithKline Beecham plc and others v Apotex Europe Ltd and others* [2005] FSR 23 at [74], "a party attacking the validity of a patent is free to choose his weapons of attack to suit his own convenience, taking into account relevant considerations of cost and effectiveness". Nevertheless, it still remains that the burden is on the defendant to prove anticipation. In the present case, the defendant could have proved anticipation by conducting experiments on the prior art to show that they would inevitably result in a CVD diamond of low birefringence within the SG 872 Range. There is no question that the defendant possesses the capabilities to carry out these experiments. As the defendant did not, it had to otherwise satisfy its burden of proof. I hold that it has not satisfied this burden of proof.

43 I turn then to the specific arguments summarised above.

Whether CVD diamond is a distinct type of diamond

44 A key plank of the defendant's contentions on novelty rests on the premise that "[t]here is no difference between a CVD diamond, a mined diamond and a HPHT diamond". [note: 24] According to the defendant, a CVD single crystal diamond material simply refers to a diamond that is grown by the process of CVD. CVD does not describe a *property* of the product. Therefore, for the purpose of novelty, any prior art which discloses a single crystal diamond of any origin (*ie*, mined, HPHT or CVD) with the same properties in SG 872 will invalidate SG 872. It is asserted that "a diamond is a diamond regardless of its origin". [note: 25]

45 In other words, the defendant construes Claim 1 of SG 872 as a product-by-process claim. *Terrell* at para 11–129 explains the key issue in such questions as follows:

> A claim to a product when made by a new process is not enough in itself to make the product new, for "it is still the same product even if made in a different way". However *this is a rule of the law of novelty, not a rule of mandatory claim interpretation.* Thus the process feature in question has to be ignored for the purposes of novelty but taken into account for the purposes of infringement and insufficiency. [emphasis added]

46 The essential issue is whether the product, when produced by the process is itself a new, or unique, product. To make good their claim, the defendant has to show that a CVD diamond is exactly like a natural diamond in its various characteristics and properties.

47 In this regard, the defendant relies on the evidence of Mr Alexander Dean, who construed the phrase "CVD single crystal diamond" as follows: [note: 26]

> 14. Chemical vapour deposition ("CVD") is a process used for manufacturing various materials, including the manufacture of artificial diamond. It is not a physical feature of a diamond. The claim is clearly directed towards a product and not a process (not least because the patent includes subsequent method claims for making "a CVD diamond", see claim 62).
>
> …
>
> 17. Therefore, following established EPO and UK case law, the term "CVD single crystal diamond" should be construed as *diamond possessing those physical properties which are a direct result of the diamond having been made via a CVD process, regardless of the actual method used to produce said diamond, and which is also a single crystal. Accordingly, any diamond having such properties, even if [it] was made naturally or by an alternative synthetic process to CVD, would satisfy this claim feature.* To be clear, said physical characteristic(s) would need to be common to all diamonds made via CVD.
>
> [original emphasis omitted; emphasis added in italics]

48 Mr Dean's description does not answer the question. To say that the CVD process is not a physical feature of a diamond does not mean that the CVD process cannot give a diamond unique physical features that distinguish it as a product.

49 On the other hand, the plaintiff was able to demonstrate that a CVD diamond is distinguishable from natural and HPHT diamonds. [note: 27] Prof Newton explained that the distribution of defects in the three forms of diamond are different as a result of their different growth conditions. [note: 28]

50 For instance, the distribution of nitrogen defects are different: [note: 29]

(a) HPHT diamonds typically contain primarily nitrogen in single isolated atoms on atomic sites (single substitutional nitrogen, N_S^0), often at levels of more than 100 ppm, thus resulting in a visibly yellow [appearance]. In addition, it often contains metal impurities from the 'solvent-catalyst' used in synthesis.

(b) In contrast, many natural diamonds can have much higher levels of nitrogen but remain transparent and visible because the nitrogen aggregates into clusters of two or more nitrogen atoms which have different optical properties. [Significant] nitrogen aggregation is typical of natural diamonds because the time and temperature associated with them being held in the earth's [mantle].

(c) In CVD diamond, whilst nitrogen may go into the structure as single isolated atoms or combined with a number of other defects such as vacancies, the nitrogen in the gas phase also affects the growth process, which in turn creates significant additional defects in the diamond. It is these additional defects that tend to dominate the impact that nitrogen has on the colour of as [*sic*] grown CVD diamond.

51 Another example of the differences between the three types of diamond is their distribution of dislocations. Dislocations are linear defects which typically extend to the external surfaces of a single crystal. [note: 30] Prof Newton explained: [note: 31]

In practice, the three materials have very different distributions of dislocations:

(a) In CVD diamond *the dislocations typically run approximately paralleled and in the growth direction, and clumping of dislocations associated with their origin at defects at the interface to the substrate is quite common*.

(b) In HPHT diamond the *majority of dislocations tend to fan out from the seed along the growth sector boundaries*. Those lying within growth sectors tend to follow either the growth direction for the sector or the preferred crystallographic direction which is the <110>.

(c) The dislocations in natural diamond tend to *lay on the various <110> directions, but in IIa diamond often form a superstructure of dislocation cells*. The arrangement of dislocations may also be driven by slip, or by dislocation climb and other diffusion driven events, so the structure is complex and 'messy'.

[emphasis added]

52 In cross-examination, Dr Nebel agreed, in the main, with Prof Newton's explanation of the difference in distribution of dislocations in CVD and HPHT diamonds (and offered no comment on natural diamonds). Although he introduced a qualification in respect of CVD diamonds, he did not dispute the substance of Prof Newton's explanation concerning the distribution of dislocations: [note: 32]

MR YEO: Thank you. Let's go to 249, which does talk about distribution of dislocations. …

Q: Okay. Maybe I will take these in turn. If I were -- I pass over the first line, which says there are very different distributions. Let me come back to that and, rather, put the subparagraphs to you. Paragraph 249(a), that statement made about the dislocations, the distribution of dislocations in CVD diamonds, do you agree with that?

A: *I agree with that, yes.*

Q: Thank you. At (b), this time it is talking about HPHT diamonds and I am going to ask you whether you agree with that.

A: I would like to make a comment to (a). If you prepare the surface, you can have 45 degree growth of dislocations. I indicated it already, if your surface roughness would be under certain angles, you basically split the growth direction of dislocations perpendicular to this direction. So, once again, if you say HPHT shows dislocations, they grow sidewise, would be perfect because they show it indeed, HPHT. But when you do the growth perfectly, you don't have dislocations at all. So we are just discussing a property which is manipulative. We can tune the growth depend on how we would like and we cannot say this defect is only available in HPHT, because for this, as I said, if you tilt the surface a bit, you have a dislocation growing in an angle which you don't -- or, at least, which is interesting and, actually, this technique is currently under investigation to grow better CVD diamond; to grow the defects out of the game so you have in the middle something which is okay. Now you say HPHT has this effect phenomena, I know about that. That's okay. I only want not to conclude you can say CVD diamond is distinguishable from HPHT by just looking on these defects again.

…

Q: Dr Nebel, let me come back, because I do want to move on with this. First of all, just on what is stated in (b) on HPHT diamonds, do you agree with that?

A: *I basically agree with it, yes*

…

Q: Again, coming back to 249(a), you would qualify -- I think earlier you had agreed to it -- you would qualify that by saying it depends on whether you grow it in that way. If you grow it in a different way, then you will not see this.

A: Yes.

Q: Would that be fair?

A: *It's okay, yes.*

Q: Thank you. Let me go to paragraph 249(c) … in relation to distribution of dislocations in natural diamonds, would you agree with (c)?

A: First of all, I want to say I have no idea about natural diamond.

Q: I see. You have no idea about natural diamonds -- as in, you have no idea on the distribution of dislocations in natural diamond?

A: As generated by a specific growth taking place 500 kilometres down the earth in a volcano.

Q: Your specialty is, really, grown diamonds, either HPHT or CVD; would that be fair?

A: No, because I am not a HPHT diamond grower. I know the like properties they generate and, therefore, this is an important part of the community, but I'm a CVD guy.

Q: Thank you.

[emphasis added]

53 In this connection, the defendant points out that Prof Newton agreed that the defects in CVD diamonds can also be found in natural and HPHT diamonds. [note: 33] Dr Newton "could not point to any defect that exists only in CVD diamond and no other diamond". [note: 34] Even if there is a difference in the distribution of defects in CVD diamonds, the plaintiff has not shown that this will cause CVD diamonds to possess a unique property that other types of diamonds do not possess. [note: 35] Further, if defects in a diamond are distributed homogeneously, the resulting material will have low birefringence regardless of its origin and could be used for optical applications. [note: 36] The diamond will not perform any differently depending on its origin. [note: 37]

54 These points again do not answer the question. It is clear that a CVD diamond is a distinct type of diamond as the *distribution, nature and combination of defects* differ among the three types of diamonds. Arising from these differences, a PSA will be able to identify the type of diamond through instruments such as DiamondView or a photoluminescence spectrometer. [note: 38] Indeed, the defendant's expert Dr Filip De Weerdt accepted in cross-examination that the DiamondView instrument was a "reliable test" for identifying CVD diamonds: [note: 39]

Q: Dr De Weerdt, you have, yourself, used DiamondView to identify CVD grown diamond; correct?

A: That is correct, yes.

Q: You would consider it a reliable test; correct?

A: It's a subjective test. You have to be trained in recognising images.

...

Q: Dr De Weerdt, you have to be trained to apply it, but do you agree if a trained person is applying DiamondView, it is a reliable test for identifying CVD grown diamond? "Yes" or "no"?

A: For a trained person, indeed counsel is correct, it's reliable, but the problem is you never know what growth conditions are and what results are going to be in the DiamondView instruments.

Parametritis

55 A parametritic claim is one where the claim is defined by "technically meaningless" and "arbitrary" parameters (see *Raychem Corp's Patents* [1998] RPC 31 ("*Raychem*") at 47). The defendant contends that SG 872 is one such claim.

56 As explained by Laddie J in *Raychem* at 37, parametritis does not constitute an independent ground for invalidating a patent. The task of the court remains the same, which is to ascertain whether there has been anticipation.

57 The defendant's contention that the parameters in Claim 1(ii) and Claim 1(iii) are technically meaningless and arbitrary is unmeritorious. In fact, the parameters in Claims 1(ii) and Claims 1(iii) are *essential* insofar as they provide a quantitative measurement of the birefringence in the diamond material. As Prof Newton explained, it was with such measurements that the suitability of the diamond for optical applications could be determined by the end user. [note: 40]

58 Accepting for present purposes the plaintiff's position that the CVD diamond material in SG 872 is of lower birefringence than that produced previously, it would have been logical and sensible to define that birefringence in the quantitative terms specified in Claims 1(ii) and 1(iii). [note: 41] As of 21 November 2002 (*ie*, the priority date of SG 872), those parameters *could* be measured using a system known as the Metripol (previously known as the Deltascan), which was developed by Dr Anthony Michael Glazer (the plaintiff's expert), Dr Werner Kaminsky (the defendant's expert) and Dr Morten Geday (the defendant's witness) in or around 1995.

59 In this regard, while the experts are in agreement that cross-polar imaging could be used to assess birefringence, the images would only have provided a "qualitative assessment" of birefringence, rather than a "quantitative measure". The cross-polarised images would thus not have been a substitute for the Metripol and the parameters in Claims 1(ii) and 1(iii) of SG 872. Dr Kaminsky said as follows: [note: 42]

> Q: But, Dr Kaminsky -- and I think Professor Glazer also agrees on this point -- the crossed-polars are what we call a qualitative assessment; they're not a quantitative measure of birefringence; correct?
>
> A: That's correct.
>
> Q: In fact, it was in order to arrive at a quantitative measure of birefringence that Professor Glazer, with obviously your invaluable participation and Dr Lewis, came to invent the Metripol precisely to be able to measure birefringence quantitatively; correct?
>
> A: That is correct, yes.

60 In other words, cross-polar images are able to provide an *estimate* of the birefringence in the CVD diamond. Essentially, a PSA can compare the colours in a cross-polar image with a chart known as the Michel-Levy chart to obtain an estimate of birefringence. However, the Metripol furnishes a quantitative measurement with precision. It is not dependent upon the perception of the user. It is useful, and therefore is not technically meaningless.

61 The other aspect of the defendant's contention that SG 872 is a parametritic claim is the alleged inaccessibility of the Metripol as of 21 November 2002, the priority date of SG 872. Dr Geday's

evidence was that before 2004, there were fewer than eight units of the Metripol sold. [note: 43] The defendant therefore contends that the Metripol was a "rare and inaccessible apparatus". [note: 44] This contention ignores the fact that the SG 872 patent itself referred to the Metripol (under its previous name Deltascan) and Oxford Cryosystems, the supplier of the Metripol. A PSA reading the patent would thus know where and how to obtain the Metripol and there is nothing to suggest that the Metripol was not for sale. Dr Glazer's evidence was that around 30 units of the Metripol were sold. [note: 45] Even if one were to take the defendant's case at its highest (*ie*, that there were fewer than eight units sold), the fact that these units were sold shows that the Metripol was certainly *available* for the PSA to obtain. Dr Geday and Dr Kaminsky confirmed this in cross-examination. [note: 46]

62 For completeness, I note that there were also similar instruments to the Metripol which could be used to measure birefringence as of the priority date, such as the Polscope, although both Dr Glazer and Dr Geday considered that instrument to be "inferior in terms of precision". [note: 47] SG 872 does not mandate the use of the Metripol to measure birefringence and there is no evidence to suggest that these alternative instruments were not accessible.

63 I turn then to consider whether WO 633/634 has birefringence within the SG 872 Range.

WO 633 and WO 634

64 WO 633 and WO 634 are patents owned by the plaintiff which claim an "electronic grade" CVD diamond. It is accepted by the experts from both parties that the processes in WO 633 and WO 634 are, for the purposes of this suit, the same. In both patents, the PSA is taught to *eliminate* nitrogen in the synthesis gas phase. [note: 48] There is no dispute that both patents are citable against SG 872 as prior art. As highlighted above, WO 633 and 634 does not provide a quantitative measurement of the birefringence of the CVD diamond material produced. Nevertheless, the defendant's position is that such diamond material will be of low birefringence within the SG 872 Range.

(1) Category (a) correlations

65 For Category (a) correlations, some care must be taken to identify whether the authors of that prior art were seeking to establish a certain correlation between, for example, dislocation density and birefringence, or whether those were just *empirical observations based on a limited set of data*. In this regard, continuing with the example of dislocation density, I accept that the defendant does not need to prove a precise mathematical correlation between dislocation density and birefringence. [note: 49] In other words, it is not necessary to show a *known formula* to convert dislocation density into a corresponding value of optical birefringence. It will suffice, for instance, if the defendant can show, as it contends, that CVD diamonds with a dislocation density of less than $100/mm^2$ will have a birefringence of less than 10^{-4}, which is within the SG 872 Range.

(A) Alleged correlation between dislocation density and birefringence

66 I deal with this correlation first as it is the premise for several of the other correlations discussed below.

67 Dr Nebel relies on various publications to prove the alleged correlation between dislocation density and birefringence. According to Dr Nebel, diamonds with a dislocation density of less than $100/mm^2$ will have a birefringence of less than 10^{-4}. Diamonds with a dislocation density of less than

$10/mm^2$ will also have a birefringence of less than 5×10^{-5}. [note: 50] Both of these birefringence values fall within the SG 872 Range.

(I) Ruoff 1987

68 In Arthur Ruoff *et al*, "Synthetic diamonds produce pressure of 125 GPa (1.25 Mbar)" (1987) 2(5) J Mater Res 614 ("Ruoff 1987") [note: 51] at p 617, the authors stated that:

> The diamonds that have reached pressures substantially above 1 Mbar with a sample in a gasket hole have all had exceptionally low birefringence (4×10^{-5}–10^{-4}) and hence low strain. *Their dislocation density is likely to be less than $10^4/cm^2$ [$100/mm^2$].*
>
> [emphasis added]

69 However, as the plaintiff points out, there are several difficulties with Dr Nebel's reliance on Ruoff 1987 to prove the alleged correlation between dislocation density and birefringence.

70 First, Ruoff 1987 concerned HPHT diamonds and not CVD diamonds. It does not establish that a *CVD diamond* with a dislocation density of less than $100/mm^2$ *will* have a birefringence of less than 10^{-4}. This is a material difference. This is because, as Prof Newton explained, and I have dealt with this at [51], the birefringence of a diamond material is affected not just by its dislocation density, but also by the *distribution and direction of propagation of those dislocations*, which may vary between the different types of diamond.

71 Prof Newton's evidence is also that one cannot derive the optical birefringence of a CVD diamond from its dislocation density: [note: 52]

> 263. Dr Nebel describes Method 1 at [264] of 1st CEN as follows:
>
> > *"By measuring the density of dislocations which causes strain. Dislocation densities are typically expressed in units of dislocations per square cm or mm of image area."*
>
> 264. Dislocation density is not an unambiguous measurement as it provides no information on the finer distribution of the dislocations (e.g. type of dislocation, clumping together of dislocations or relative regularity, directional alignment, alignment into dislocation walls and other macrostructures) all of which are features of CVD diamond under various circumstances.
>
> 265. Consequently, Method 1 fails to provide … unambiguous characterisation of the material in all aspects which may affect birefringence and in the data provided record all the potential variables relevant to achieving that.
>
> 266. As mentioned, Dr Nebel also failed to provide a fixed correspondence relationship between measurement of density of dislocations and measurement of optical birefringence based on optical retardation which, when applied, would generate a value for |sin □| or Δn in the ranges described in claims 1(ii) and 1(iii) of SG 872.
>
> 267. Furthermore, dislocation density does not sum/average through thickness in the same way as set out in SG 872 but can only be expressed as a surface measurement.
>
> 268. Accordingly, Method 1 is different from and not an exact substitute for the quantitative

assessment of optical birefringence based on optical retardation, which can be expressed in terms of |sin □| or Δn, as set out in SG 872.

72 In cross-examination, Dr Nebel disagreed that "the three materials [*ie*, natural, HPHT and CVD diamonds] have very different distributions of dislocations". [note: 53] However, Dr Nebel did not disagree that the birefringence of a diamond material is affected not just by its dislocation density, but also by the *distribution and direction of propagation of those dislocations, which he agreed (in the main) could vary among the different types of diamonds:* see [52] above.

73 In any event, the alleged correlation was also expressed in equivocal terms: the authors had only stated that the dislocation density of the HPHT diamonds in their experiment was "likely" to be less than 100/mm^2. It does not appear that the authors in Ruoff 1987 were seeking to establish the precise nature of the correlation between optical birefringence and dislocation density. They were merely seeking to report their empirical findings on the optical birefringence and dislocation density of the HPHT diamonds they had grown. Further, there is no mention of the *thickness* of the diamonds in Ruoff 1987, and in particular, whether they were at least 0.5mm (which Claim 1 of SG 872 requires). [note: 54] As stated in SG 872 itself, "dislocations can slowly multiply during growth" (increasing thickness), which will therefore also increase birefringence. [note: 55]

74 These objections to Ruoff 1987 apply equally to the other publications that Dr Nebel relied on, which I discuss briefly.

(II) Surovtsev 2015, Mokuno 2014

75 In N V Surovtsev and I N Kupriyanov, "Temperature dependence of the Raman line width in diamond: Revisited" (2015) 46 J Raman Spectrosc 171 ("Surovtsev 2015") [note: 56] the authors state that HPHT diamonds were used in the study and the average value of the birefringence was estimated to be less than 5 x 10^{-5} and the dislocation density found to be within 1-10/mm^2. The study was not conducted on CVD diamonds and there is nothing to suggest that the authors were seeking to establish a wider correlation between optical birefringence and dislocation density.

76 In Yoshiaki Mokuno *et al*, "A nitrogen doped low-dislocation density free-standing single crystal diamond plate fabricated by a lift-off process" (2014) 104 Appl Phys Lett 252109 ("Mokuno 2014"), [note: 57] a nitrogen-doped single crystal diamond plate was fabricated by CVD from a HPHT synthetic type IIa seed substrate. The resulting diamond plate had a dislocation density of 4/mm^2 and an average birefringence of less than 3 x 10^{-5}. The diamond in Mokuno 2014 was CVD diamond. However, the authors were merely reporting the dislocation density and birefringence of the *one* particular diamond plate which they had fabricated, rather than seeking to suggest any wider correlation.

(B) SG 506

77 Whilst the above deals with WO 633/634, the argument made by the defendant in the context of SG 506, which refers to a CVD diamond with dislocation density of less than 100/mm^2, fails for the same reasons.

(C) Alleged correlation between breakdown electric field and birefringence

78 Next, the defendant highlights that the correlation between *breakdown electric field* and optical

birefringence shows that WO 633 and WO 634 anticipate Claim 1 of SG 872. [note: 58]

79 Example 3 of WO 634 discloses a CVD diamond with a breakdown electric field of 100 V/µm. According to Dr Nebel, the "significantly good breakdown voltage … indicates that this diamond would have low dislocation density and therefore low birefringence [less than 10^{-4}]". [note: 59] In the same vein, WO 634 discloses CVD diamond material with breakdown electric fields larger than 45 V/µm. [note: 60]

80 To prove the correlation between breakdown electric field and optical birefringence, the defendant relies on Michal Pomorski, "Electronic Properties of Single Crystal CVD Diamond and its Suitability for Particle Detection in Hadron Physics Experiments" (2008) ("Pomorski 2008") which concerned a study on single crystal diamond material supplied by the plaintiff, "grown with the microwave assisted CVD technique on <1 0 0> oriented high-pressure high-temperature (HPHT) diamond substrates". [note: 61] More than 30 samples of various thicknesses (50 to 500µm), sizes (3 x 3 to 5 x 5mm^2) and surface preparations were tested with respect to their "detector properties" and their results compiled. The birefringence of the samples was assessed using cross-polar imaging. [note: 62] For a sample which had a breakdown electric field of 0.1 V/µm (BDS11), the cross-polar images appeared as bright areas, indicating high birefringence. For a sample which broke down at fields larger than 3 V/µm (SC13BP), the cross-polar images were dark, indicating that there was no strain and hence low birefringence. [note: 63]

81 Accordingly, the defendant's position is that *diamonds with a breakdown electric field of more than 3 V/µm will have a birefringence of less than* 10^{-4}, which is within the SG 872 Range. The diamond material in WO 633/634 would all have breakdown electric fields larger than 3 V/µm.

82 However, Prof Newton highlights certain difficulties with the alleged correlation between breakdown electric field and birefringence. First, in so far as that correlation is *premised* on identifying a correlation between breakdown electric field and *dislocation density*, followed by dislocation density and birefringence, the difficulties in identifying the correlation between dislocation density and birefringence have been discussed above.

83 Further, in Pomorski 2008, the author had used 30 samples which were 50 to 500µm thick. The only sample for which an explicit thickness was given was 400µm thick. However, SG 872 requires the diamond material to be at least 0.5mm thick (*ie*, at least 500µm). Furthermore, it also appears that the areas which were tested in Pomorski 2008 were less than 1.3 x 1.3 mm in area, which is required by SG 872. [note: 64]

(D) Alleged correlation between Raman FWHM and birefringence

84 I had earlier addressed the alleged correlation between dislocation density and birefringence. In his presentation to the court, Dr Nebel also explained that from the *dislocation density*, one could derive the *strain* (measured by what is known as Raman Full width at half maximum ("FWHM")) and in turn derive the *birefringence*. WO 633 and WO 634 disclose a CVD diamond of a low Raman FWHM of 1.52cm^{-1} and 1.54cm^{-1}. According to Dr Nebel, the typical Raman FWHM of a high quality diamond with near-perfect lattice is around 1.5cm^{-1}. Relying on various publications, Dr Nebel contends that *diamonds with Raman FWHM of less than 1.6*cm^{-1} *will have birefringence of less than 3 x* 10^{-5}, which is at least five times less than the maximum birefringence claimed in SG 872.

85 To prove the alleged correlation between Raman FWHM and birefringence, the defendant relies on the following publications.

(I) Surovtsev 2015S

86 In the supplementary materials for Surovtsev 2015 ("Surovtsev 2015S"), [note: 65] it is reported that a given sample in the study had a Raman FWHM of 1.53cm^{-1} and average birefringence of about 3±1 x 10^{-5}. However, as pointed out by Prof Newton, Surovtsev 2015S concerned work on HPHT diamonds as opposed to CVD diamonds. The same difficulties with using *HPHT diamonds* to prove the alleged correlation between dislocation densities and birefringence for *CVD diamonds* would apply here. Further, Surovtsev 2015S only concerned empirical observations of Raman FWHM and average birefringence, and did not seek to establish the proposition that a Raman FWHM of 1.53cm^{-1}would result in birefringence in the 10^{-5} range. [note: 66]

(II) Sumiya 1997

87 H Sumiya, N Toda & S Satoh, "Mechanical properties of synthetic type IIa diamond crystal" (1997) 6 Diamond and Related Materials 1841 ("Sumiya 1997") concerned work on HPHT and natural diamonds as opposed to CVD diamonds. Moreover, it is unclear how Dr Nebel manages to establish a correlation between optical birefringence and Raman FWHM when Sumiya 1997 does not contain any discussion of the concept of birefringence, let alone the birefringence values of the diamonds in the experiment conducted by the authors.

(III) Crisci 2011

88 Alexandre Crisci *et al*, "Residual strain around grown-in defects in CVD diamond single crystals: A 2D and 3D Raman imaging study" (2011) 208(9) Phys Status Solidi A 2038 ("Crisci 2011") [note: 67] was a study reporting the results of Raman imaging investigation of defects in single crystal CVD diamonds.

89 In cross-examination, Dr Nebel agreed with Prof Newton that the focus of Crisci 2011 was on the effect of *five particular defects* in the diamond (representing about 1.2% of the total surface area of the sample), rather than its *dislocation density*. [note: 68] The correlation which Dr Nebel sought to draw was that *from the dislocation density of the diamond*, one could derive strain (measured in Raman FWHM) which was in turn indicative of birefringence. Crisci 2011 therefore does not support the correlation which the defendant seeks to draw.

(IV) Howell 2012

90 Daniel Howell *et al*, "Inclusions under remnant pressure in diamond: a multi-technique approach" (2012) 24 Eur J Mineral 563 ("Howell 2012") is concerned with natural diamonds and not CVD diamonds. Further, in so far as Howell 2012 used the Metripol to measure the birefringence of the samples, that to some extent supports the plaintiff's position that one cannot rely on dislocation density and Raman FWHM (among others) to determine whether the birefringence of a CVD diamond falls within a given range.

(E) Alleged correlation between charge collection efficiency and birefringence

91 WO 633 and WO 634 disclose a diamond with a charge collection efficiency ("CCE") of more

than 96%. According to the defendant, diamonds with a CCE of more than 90% will have low dislocation density and therefore a birefringence of less than 1.5×10^{-4}. Dr Nebel relies on A Lohstroh *et al*, "Effect of dislocations on charge carrier mobility – lifetime product in synthetic single crystal diamond" (2007) 90 Appl Phys Lett 102111 ("Lohstroh 2007") for the proposition that the presence of dislocations reduces the CCE of a given sample. Lohstroh 2007 contains no discussion of the birefringence of the diamond, and Dr Nebel explained in cross-examination that the correlation between CCE and birefringence was premised on the relationship between dislocation density and birefringence. The difficulties associated with that latter correlation have already been explained above.

(2) Category (b) correlations

92 The defendant also contends that WO 633/634 anticipates Claim 1 of SG 872 as it is explicitly mentioned that the diamond material is suitable for use in anvils and diamond detectors. The defendant asserts that anvils and detectors are of low birefringence falling within the SG 872 Range. While there is no mention of etalons in WO 633/634, the defendant relies on Godfried and Whitehead 2003 to prove that the diamond material in WO 633/634 was suitable for use as etalons as well. These arguments are related to that concerning SG 506, where the defendant relies on the reference to etalons in SG 506 to prove that it anticipated Claim 1 of SG 872.

93 The plaintiff argues that the prior art was concerned with *electronic grade* CVD diamonds rather than *optical grade* CVD diamonds. [note: 69] The electronic grade single crystal diamond had minimal nitrogen content and thus possessed good charge carrier mobilities, making it suitable for electronic applications. The plaintiff contends that such electronic grade CVD diamonds gave rise to a relatively high level of birefringence. This was explained in the patent as follows (see in particular the sentence highlighted in emphasis): [note: 70]

> The CVD diamond material of the invention is produced by a CVD method in the presence of a controlled low level of nitrogen. The level of nitrogen utilised is critical in controlling the development of crystal defects and thus achieving a diamond material having the key characteristics of the invention. It has been found that material grown with high levels of nitrogen show deleterious absorptions. High levels of nitrogen may also degrade the crystal quality of the material. *Conversely, material grown under conditions with essentially no nitrogen, or less than 300 ppb of nitrogen has a comparatively higher level of local strain generating defects, which affect directly or indirectly many of the high performance optical properties of the diamond*. [emphasis added]

94 It was Dr Scarsbrook's evidence that the electronic grade material in WO 633 and WO 634 was of comparatively lower birefringence than the preceding material, but was still not suitable for the "optical market": [note: 71]

> … we had managed to grow reasonable thicknesses of electronic diamond by controlling the substrate surface and, yes, it was comparatively low birefringence compared to some of the thinner layers that had cracked during growth in the earlier stages. However -- and, to be honest -- *at that stage the reason why birefringence in the electronic material wasn't measured was because we didn't really consider it relevant. In fact, it was more than that, we hadn't even considered it. We were much more focused on the electronic properties and it was only later -- it was a bit of a surprise to us initially, but it wasn't sufficiently low birefringence for the applications we were trying to address in the optical market.*

[emphasis added]

95 As Prof Newton explained in cross examination: [note: 72]

A: Your Honour, as in no value was specified, but in applications where low birefringence was required, the material failed because the birefringence was too high.

Q: Are you saying that 634 and 633 failed?

A: No. What I'm saying is that material grown under the conditions of 634 had a comparatively higher level of local strain generating defects which adversely affected some of the optical properties so that there would be applications that were out of reach for this material.

…The electronic application, the material with excellent electronic properties, still turned out to be a material with high strain, your Honour, and relatively high birefringence. The excellent electronic properties were still achieved in a material that had substantial concentrations of dislocations.

96 Dr Philippe Bergonzo, who gave expert evidence on behalf of the plaintiff, provided a similar account: [note: 73]

A: It cracks easily, showing high strain, because it has bundles of dislocation, et cetera, and the comparative data in SG 872 patent show that the WO 633/634 type of material has a high optical scatter as a result of strain, and this is provided in example 9 of SG 872. Even though the high purity, therefore, it has higher strain and higher dislocation density despite the use of the best available substrates in 2002, of course. … The example of SG 872 in Table 2 says this data shows that material grown without nitrogen deliberately added a substantially higher scatter than material grown with some added nitrogen. … Basically, this is a new material completely different that has new optical properties and this is not the same material as the electronic property I was showing before.

97 Dr Scarsbrook, Prof Newton and Dr Bergonzo's evidence that the electronic grade material in WO 633 and WO 634 had a higher birefringence than the SG 872 Range is, to some extent, supported by sample 4 of Example 9 in SG 872 (although I note that there is no quantitative measurement of *birefringence*, as opposed to *scatter*, in Example 9). A set of five samples was measured for scatter, indicative of strain which is in turn indicative of birefringence. The first three samples were made using the method in SG 872, while the fourth sample was made using the method in WO 633/634 (*ie*, where nitrogen was below 300 ppb). The result, as stated in the patent, was as follows: [note: 74]

This data shows that material grown without N deliberately added has a substantially higher scatter than material grown with some nitrogen added. This is consistent with observations that the stress level (as revealed by birefringence) is higher. In comparison there appears to be relatively little difference between the three samples grown with different levels of nitrogen in the process and different process pressures although there are small variations. The high values of scatter for both the CVD grown without nitrogen and the natural type IIa stone shows the particular benefit of CVD diamond synthesised by the method revealed here, and as natural type IIa diamond is known to contain stress and dislocations the scatter is presumably by a similar mechanism. [emphasis added]

98 Indeed, in its written submissions, the defendant acknowledged that SG 872 itself discloses

that the controlled addition of low levels of nitrogen will reduce the birefringence of CVD diamonds. [note: 75] It suffices to note at this point that the defendant could have performed experiments to prove that the controlled addition of low levels of nitrogen will *not* reduce birefringence in CVD diamonds, but did not do so. The burden is on the *defendant* to prove that the patent is not novel or lacks inventiveness: *ASM Technology* at [59] and [78].

99 Instead of the controlled addition of low levels of nitrogen, WO 633 and WO 634 teach the *removal of nitrogen* in the synthesis gas phase. There is therefore no overlap in the range of nitrogen concentration between WO 633/634 and SG 872. At p 18 of WO 633, it is states as follows: [note: 76]

> It is also important in the method of the invention that the impurity content of the environment in which the CVD growth takes place is properly controlled. *More particularly, the diamond growth must take place in the presence of an atmosphere containing substantially no nitrogen, i.e. less than 300 parts per billion (ppb, as a molecular fraction of the total gas volume), and preferably less than 100 parts per billion*. [emphasis added]

100 This distinction is summed up by Prof Newton's explanation: [note: 77]

> A: So if I had two identical substrates and I grew on one of them with 633 and the other with 872, which would I expect to have the lower birefringence? That, I think, is your question and it's the 872 every time, as far as I'm concerned.

101 This explanation, nevertheless, does not go to the heart of the inquiry, which is the claim that is asserted by Claim 1. This is the birefringence within the SG 872 Range. While, depending on the quality of the substrate, the teaching in SG 872 may allow a PSA to attain lower levels of birefringence, the birefringence claimed in Claim 1 is for a specific range, intended for optical instruments. On this issue, the plaintiff's label for WO 633/634, "electronic grade", does not further the analysis, because there is no range specified for electronic grade diamond. Anvils and etalons are, in any event, optical instruments. Therefore it is important to examine the defendant's assertions that the teachings in WO 633/634 and SG 506 allowed and provided for the production of anvils, detectors and etalons in the SG 872 Range of birefringence.

(A) Detectors

102 In the "Summary of the Invention" for WO 633, it is stated that: [note: 78]

> … the diamond of the invention has electronic characteristics which are substantially greater than those present in natural high quality diamond. This is surprising and provides the diamond with *properties which are useful, for example*, for electronic applications *and for detectors*.
>
> The single crystal CVD diamond of the invention is of high chemical purity and is substantially free of crystal defects.
>
> [emphasis added]

103 The defendant, relying on Dr Nebel's evidence, contends that the diamond in WO 633 can be used for diamond detectors, which "must have a birefringence of less than 10^{-4}". [note: 79] In support of this contention, the defendant relies on the following publications: US 932; E A Burgemeister, "Dosimetry with a diamond operating as a resistor" (1981) 26(2) Phys Med Biol 269 ("Burgemeister 1981"); D R Kania *et al*, "Diamond radiation detectors" (1993) 2 Diamond and Related Materials 1012

("Kania 1993"); A M Zaitsev, *Optical Properties of Diamond: a Data Handbook* (Springer, 2001) ("Zaitsev"); Grzegorz Kowalski *et al*, "Synchrotron X-ray studies of strain in (100)-oriented high pressure-high temperature (HP-HT) synthetic diamonds" (1996) 5 Diamond and Related Materials 1254 ("Kowalski 1995");"); Pomorski 2008; and G P Freeman *et al*, "Differences between counting and non-counting diamonds – Part II: birefringency and luminescence" (1952) 18(1) Physica 9 ("Freeman").").

104 It ought to be emphasised that what the defendant must show is that for a CVD diamond to be used as a diamond detector (as opposed to a natural or HPHT diamond), it must have a birefringence *within the SG 872 Range*. On that basis, the only publications that are potentially relevant are US 932, Burgemeister 1981 and Freeman. The other publications, at their highest, only go towards showing that for a CVD diamond to be used as a diamond detector, it should ideally be of *low birefringence*, which Dr Scarsbrook accepted was a "good way of pre-selecting [diamonds suitable for use as detectors]". [note: 80] However, the precise range is not quantified:

(a) Kania 1993: "[T]ype IIa, low birefringence diamonds are best for radiation detectors. [note: 81]

(b) Zaitsev: "The birefringence effect can also be used for the selection of diamonds suitable for fabrication of radiation detectors." [note: 82]

(c) Kowalski 1995: "The presence of any source of strain would affect the performance of diamond in electronic applications (radiation detectors)."

(d) Pomorski 2008: "Cross-polarised light microscopy is a fast technique allowing a pre-selection of diamond samples of superior quality, which is helpful for detector development."

(I) US 932

105 I turn then to US 932, which relates to a method for the detection of ionising radiation by means of a diamond detector, and the construction of the said diamond detector using HPHT diamonds. [note: 83] The defendant contends that it supports its argument that diamond detectors must have a low birefringence of less than 10^{-4}. Since the diamond in WO 633 is suitable for use as detectors, it would thus appear that the diamond produced in WO 633 would also be of low birefringence.

106 The relevant extracts in US 932 read:

… In the accomplishment of said objects of the invention a diamond is used as the radiosensitive element of the detector, whose diamond has low (2 x 10^{-3}at.% or less) nitrogen concentration and *low (10^{-4} or less) birefringence*, and in which diamond the lifetime of the free carriers generated by the ionizing radiation is 10^{-6}s or longer.

Because the free carriers generated by the ionizing radiation are trapped at impurities in the diamond crystal, only the purest diamonds are suitable for use as detector elements. Diamonds can be preselected optically in terms of purity as regards to low nitrogen concentration by transparency in ultraviolet or infrared light of certain wave lengths, *and as regards to small strain in the crystal lattice by low birefringence*.

According to the invention it appears that a nitrogen concentration less than 2 x 10^{-3}at.% (3.5 x

$10^{18}cm^{-3}$), *a birefringence less than* 10^{-4} and a lifetime of free carriers of 10^{-6}s or longer *are essential conditions for good radiosensitivity of a diamond*.

…

However, not all natural diamonds, which are preselected optically in the above mentioned way, meet the conditions of the said lifetime of free carriers of 10^{-6}s or longer. Therefore, preselected natural diamonds have to be tested individually with a suitable radioactive source and those which can be used as s suitable radiosensitive element are extremely rare.

Thus, according to the invention, a synthetic diamond crystal having the said properties is used advantageously as the radiosensitive element. Synthetic diamond crystals are manufactured at high temperature and high pressure from carbon.

[emphasis added]

107 However, US 932 relates to HPHT diamonds. It claims that for HPHT diamonds, a certain concentration of nitrogen, together with a stated birefringence, allows *HPHT diamonds* to be used as detectors. There is nothing to suggest that the *CVD diamond* in WO 633, which has a different nitrogen concentration, would have the same low birefringence of less than 10^{-4}, notwithstanding that it was suitable to be used for diamond detectors. [note: 84] Prof Newton explained as follows:

In summary, in natural and HPHT diamond, rules on nitrogen concentration and birefringence were proposed by US 932 to be necessary conditions, for Ib HPHT synthetic diamonds with a charge lifetime exceeding 10^{-6} s, the same rules having been shown not sufficient in natural diamond. These rules were $<2 \times 10^{-3}$ atomic percent of N in the solid and birefringence $<10^{-4}$.

There are a number of issues illustrating the differences between US 932 and WO 634:

(a) In US 932, the level of nitrogen permitted in the diamond solid is orders of magnitude greater than that in the CVD diamond of WO 633. The nitrogen present during CVD diamond growth has a catalytic effect of forming SP2 or non-diamond carbon defects in CVD diamond which are not present in HPHT diamond. As a consequence, the impact of the different point defects in HPHT diamond can be expected to modify the behaviour to dislocations.

(b) The distribution of dislocations is very different in HPHT and CVD diamond, in particular dislocations in CVD align along the growth direction, which is also often used as the direction for charge carrier drift, and so the interaction with the dislocations is much lower.

(c) US 932 is concerned with detector behaviour at a bias voltage of 50 V/mm or 0.05 V/µm, whereas WO 633 provides measurements at 1 v/µm. At the lower applied voltage, the trapping of carriers by defects will have a much greater impact on drift distances, by an order of factor of 20.

Consequently, the teachings of US 932 provide little guidance on the behaviour to be expected in CVD diamond, and certainly does not give a measure of dislocation density or birefringence in the manner presumed by Dr Nebel.

108 Therefore, while birefringence is a measure that applies uniformly across all kinds of diamonds, a HPHT diamond's use as a detector is not solely dependent on its birefringent values, but also on

other factors such as the distribution of nitrogen in the diamond. This nitrogen structure is different in the CVD diamonds produced from WO 633/634: as Prof Newton stated, "[i]n US 932, the level of nitrogen permitted in the diamond solid is orders of magnitude greater than that in the CVD diamond of WO 633". The correlation between the birefringence values of the WO 633/634 diamond and the US 932 diamond has not been established, despite their both functioning as detectors. Dr Nebel had no response to this.

(II) Burgemeister 1981 and Freeman

109 Dr Nebel also referred to Burgemeister 1981 and Freeman, which go towards showing that in order for a *natural diamond* to be used for detectors, it ought to have birefringence of less than 10^{-4}. [note: 85]

(a) In Burgemeister 1981, it was stated that counting diamonds (*ie*, detectors) should be colourless, of type IIa and *show little birefringence*. Several thousand natural diamonds were preselected based on these criteria, and eventually, it was found that one of them was able to operate as a detector – a colourless type IIa diamond with little birefringence less than 10^{-4}. However, as observed by Prof Newton, Burgemeister 1981 merely reports that a *natural diamond* of birefringence less than $10^{-4}$was suitable for use as a detector. There was no reference to CVD diamonds at all.

(b) In Freeman, it was observed that the "order of birefringency" of counting diamonds is always corresponding to circa 1000 Å, for 1mm thickness of the crystal, corresponding with changes in the refractive index of the order of 10^{-4}. However, Freeman was concerned solely with natural diamonds and not CVD diamonds.

110 These articles, concerned with natural diamonds selected for use in detectors, are irrelevant to the discussion. All they show is that low birefringent material make good detectors, rather than illustrating, as required, that all detectors are low birefringent.

(B) Anvils

111 The diamond in WO 634 is said to be "suitable for use as diamond anvils in high pressure experiments and manufacture". [note: 86] Likewise, Dr Scarsbrook stated during the expert panel that the diamond in WO 633 was also able to be used for anvils. [note: 87] It is not disputed that anvils have low birefringence and both Dr Scarsbrook and Dr Bergonzo acknowledged this. [note: 88]

112 What is in contention is whether CVD diamond anvils must have a birefringence of less than 10^{-4}, as the defendant claims. If so, the birefringence of the CVD diamond in WO 633/634 must fall within the SG 872 Range.

113 The various publications are as follows.

(I) Seal 1984 and Seal 1987

114 In Michael Seal, "Diamond Anvils" (1984) 16 High Temperatures-High Pressures 573 ("Seal 1984"),"), it is stated that "[t]he most commonly specified material parameter for the diamond is 'low birefringence' … it is possible to select diamonds with values as low as 0.00005 [*ie*, less than 1.5 x 10^{-}

^{4}]." In similar vein, Michael Seal, "Diamond Anvil Technology" in M H Manghnoni, *High-Pressure Research in Mineral Physics* (M H Manghnoni & Y Syono eds) (1987) ("Seal 1987") states that:

> [I]t is common practice to set a stress birefringence specification for diamond anvil material … A specification of stress birefringence < 0.0001 is probably a good compromise between material of high internal stress which must be suspect as regards strength, and the rarity of very low birefringence material.

115 Both Seal 1984 and Seal 1987, however, deal with *natural diamonds* and in any event merely specify the "common practice". It is not stated that CVD diamonds outside the SG 872 Range cannot be used as anvils.

(II) Vohra 1992

116 In Yogesh K Vohra & Suresh S Vagarali, "Isotopically pure diamond anvil for ultrahigh pressure research" (1992) 61 Appl Phys Lett 61 ("Vohra 1992"),"), it is said that "[i]n few specialized applications, like high pressure research using diamond anvil cell devices, natural diamond crystals with low intrinsic strain and strain birefringence lower than 10^{-4} are usually employed." [note: 89] Vohra 1992, however, relates to natural diamonds and in any event, merely states that natural diamonds of birefringence lower than 10^{-4} are "usually employed".

(III) Ruoff 1987 and Ruoff 1989

117 In Ruoff 1987, the authors said that:

> In the present experiment … synthetic diamonds grown by the General Electric Company were used … They are excellent quality diamonds … Their birefringence is below 10^{-4}, indicating the presence of only very low strains, approaching the value for the very best natural stones.

Similarly, in Arthur L Ruoff & Yogesh K Vohra, "Multimegabar pressures using synthetic diamond anvils" (1989) 55 Appl Phys Lett 232 ("Ruoff 1989"), the authors stated that:

> It is usual to use low birefringence (2×10^{-5} in good stones) as a criterion for perfection and a careful selection process on the very best stone is used to find these for high-pressure studies.

118 Ruoff 1987 and Ruoff 1989 are concerned, however, with HPHT diamonds instead of CVD diamonds. In any event, they merely state that low birefringent diamonds were used for experiments/studies and do not go further to establish that diamond anvils must be within the SG 872 Range.

(IV) Plaintiff's website

119 The defendant also relies on a certain extract from the plaintiff's website dated 18 September 2003 to contend that diamond anvils *must* have a birefringence of less than 10^{-4}. However, the extract relied upon does not show that diamond anvils *must* have a birefringence of less than 10^{-4}. [note: 90] It merely states that " ***specially selected*** anvils … with low … birefringence" are available for sale, and matched to specifications (*normally* < 0.0001 or < 0.00005) [emphasis added in italics and bold italics].

(C) Etalons

120 It is claimed that the material in WO 633 and WO 634, apart from being suitable for use as detectors and anvils, was also suitable for use as *etalons*, which is said to fall within the SG 872 Range.

(I) Isberg and Godfried

121 In making this argument, the defendant relies on Godfried, a conference paper presented in September 2003. It post-dates the priority date of SG 872 and is not citable as prior art.

122 However, Godfried, in stating that the authors "have developed solid *etalons* made from synthetic single-crystal CVD diamond" [emphasis added], cites Jan Isberg *et al*, "High Carrier Mobility in Single-Crystal Plasma-Deposited Diamond" (2002) 297(5587) Science 1670 ("Isberg"), *which referred to the process in WO 633/634*. Isberg makes no reference to etalons. However, the defendant contends that the citation of Isberg in Godfried shows that the electronic grade diamonds produced using the method disclosed in Isberg (*ie*, WO 633/634) could be used as etalons and were of low birefringence within the SG 872 Range.

123 I reject the defendant's contention. Godfried was vetted by the plaintiff. I accept the plaintiff's explanation that the diamond material referred to in Isberg was *not the same* as that in Godfried. The reference to Isberg in Godfried was necessary so as to provide an example of single crystal CVD diamond material. In this regard, the plaintiff relies on the evidence of Dr Scarsbrook, who was part of the vetting circle in the plaintiff and was therefore privy to the changes that had to be made to Godfried prior to publication. Dr Scarsbrook explained in cross-examination as follows: [note: 91]

MR SINGH:	And footnote 1 refers to the Isberg Paper of 2002; correct?
A:	That is correct.
Q:	You would expect that distinguished authors like Godfried and his co-authors would have a footnote for a reason -- yes?
A:	Absolutely.
Q:	Would you agree with me that if a paper that talks about making diamond etalons refers to it being made from synthetic single crystal CVD diamond, with a footnote to the Isberg paper, then it follows, and it must be understood, that the etalons were made from single crystal diamond described in that paper?

A: Actually, no. So the problem that you're referring to here is that -- Element Six was about five years ahead of the field in its work at this point. When it published the electronic patent, that would be the WO633 and 634 patents, they were the first disclosure of any kind of high -- I apologise, in qualitative terms, high quality diamond in terms of the levels of quality we were talking about, and when Isberg -- sorry, when Godfried was publishing this paper, there was no other reference for him to give other than -- sorry, I'll start again. The only paper available -- the patents were available -- was the Isberg paper. The only way that Godfried in his paper could refer to CVD diamond was through the -- was to refer to the Isberg paper because there was nothing else, really, to refer to. The Godfried audience was an audience of people who were optics people. They knew nothing about CVD diamond and the difficulty was that the conference organisers -- well, I mean, any conference of quality will have its papers refereed and one of the referees had basically said we need some indication of what you mean by CVD diamond. So some indication of what was meant by CVD diamond was given, the only indication that could be given, was a reference to the Isberg Paper. It doesn't actually mean that the Isberg Paper is exactly the same material as was being referred to in the Godfried Paper.

Q: And you know this, how?

A: So like many large companies, Element Six had a vetting circle –

Q: I am only interested in your personal knowledge.

A: Yeah, that's –

Q: Did you speak to Godfried about this?

A: My contact was mainly Dan Twitchen who was –

Q: Sorry, if you didn't speak to him, then I don't want to know. Did you speak to the organisers of that conference yourself?

A: No.

124 In re-examination Dr Scarsbrook explained further:

Q: Dr Scarsbrook, you were asked about this footnote in the Godfried Paper and the Isberg paper?

A: Yes.

Q: And the reason was put to you or suggested to you, though you did not agree.

A. Yes.

Q: I think you gave your answer, I am not going to repeat that, and I think it also appears in part at paragraph 25 of your second affidavit. It was suggested to you that you didn't have personal knowledge of some of these matters and you were trying to say something about

your being part of a vetting circle.

A: Sure.

Q: Could I just find out what you were trying to explain?

A: Yes, sure, absolutely. So companies like Element Six obviously are very concerned about what they put out in publication. A number of reasons. One is obviously it could damage opportunities for filing patents. The other one quite honestly is it can damage reputation, so it's important regarding quality size. And being involved in the patent office it meant that I was at that time involved quite actively in the vetting circle and so the reason why this came to my attention was because the vetting circle had approved the paper. It had gone out for refereeing -- well, it had gone to the journal and it came back with the fact that we were going to have to make changes before it was actually going to be acceptable. So, to that extent, I was aware of what changes were made and why they were made, because they had to be explained to the vetting circle.

125 Further, *even if* etalons *could* be produced from WO 633/634, with birefringence within the SG 872 Range, it does not show that CVD diamonds suitable for use in etalons will be the *inevitable* result of following the directions in WO 633/634. The defendant could have conducted experiments on WO 633/634 to establish this, but did not do so. In the circumstances, Isberg is not evidence that a PSA, following the directions in WO 633/634 will *inevitably* produce a CVD diamond suitable for use in etalons.

(II) Whitehead 2003

126 Whitehead 2003 is an internal research report of the plaintiff dated 27 March 2003. [note: 92] Whitehead 2003 discloses the properties of diamonds disclosed by the plaintiff to the RD42 Collaboration ("RD42") before the priority date of SG 872, which were grown using the method in WO 633/634. According to the defendant, Whitehead 2003 discloses that these diamonds were suitable for use as etalons. Whitehead 2003 reproduced a cross-polarised image of the Type IIIa diamond and observed that "the only place where there is significant strain is at the boundary between the vertical and lateral growth". Dr Nebel concluded from the cross-polarised image that the diamond in WO 633/634 would have been of low birefringence within the SG 872 Range.

127 I repeat my finding at [125] above. It is not sufficient for the defendant to show that selected CVD diamond material produced according to the directions WO 633/634 *could* be used as etalons. The test for anticipation requires a PSA, following the directions in WO 633/634, to inevitably produce a low birefringent diamond of requisite thickness within the SG 872 Range.

Conclusions on WO 633/644

128 To conclude this section, the defendant has not proved the alleged correlations between on the one hand, breakdown electric field, Raman FWHM, charge collection efficiency and on the other, birefringence. Further, the defendant has also not proved that the CVD diamond in WO 633/634, while suitable to be used for detectors and anvils, necessarily had a birefringence value less than 10^{-4}. In the circumstances, the defendant has not discharged its burden of showing that WO 633 and/or WO 634 anticipates Claim 1 of SG 872.

129 Given my finding that WO 633 and WO 634 do not anticipate Claim 1 of SG 872, it follows that various pieces of prior art with the same material would also not be anticipatory:

(a) Mara Bruzzi, "Status of the R&Ds on Diamond Particle Detectors", presented at the 11th International Workshop on Vertex Detectors in November 2002.

(b) The disclosure of diamonds to the RD42 Collaboration, Bookham Technology and ABB Group Services Centre before 21 November 2002. These three disclosures were technical research collaborations in any event and obligations of confidentiality could be inferred from the circumstances and available documents: *Strix Ltd v Otter Controls Ltd* [1995] RPC 607.

SG 506

130 SG 506 was filed on 19 September 2003 and claims a priority date of 20 September 2002 based on its priority document GB Patent Application No. 0221949.1 ("GB 949"). Although published on 1 April 2004, it is citable as prior art against SG 872 because of s 14(3) of the Patents Act, which is analysed in detail at [136]–[139] below. The plaintiff contends that the defendant has not proven that the SG 506 process would *inevitably result* in CVD diamonds with birefringence values in the SG 872 Range. [note: 93]

131 The "Summary of the Invention" in SG 506 reads:

> According to the present invention, a method of producing *a* plate of single crystal diamond includes the steps of providing a diamond substrate having a surface substantially free of surface defects, growing diamond homoepitaxially on the surface by chemical vapour deposition (CVD) and severing the homoepitaxial CVD grown diamond and the substrate transverse, typically normal (that is, at or close to 90°), to the surface of the substrate on which diamond growth took place to produce a plate of single crystal CVD diamond.
>
> The homoepitaxial CVD diamond growth on the surface of the substrate preferably takes place by the method described in [WO 634]. Using this method, in particular, it is possible to grow thick, high purity single crystal diamond on a substrate. A growth thickness of the homoepitaxial grown CVD diamond of greater than 10 mm, preferably greater than 12 mm, and more preferably greater than 15 mm, can be achieved. Thus, it is possible, by the method of the invention, to produce single crystal CVD diamond plates having at least one linear dimension exceeding 10 mm, preferably exceeding 12 mm and more preferably exceeding 15 mm. ...

132 In essence, SG 506 relates to a method of improving the quality of substrates by growing a CVD diamond using the methods claimed in WO 633/634, and cutting a CVD plate from the grown diamond parallel to the growth direction. By *repeating* this process several times, it is claimed that the *dislocation density* of the resulting material will be greatly reduced: [note: 94]

> Combining the various features of this invention, it is possible to produce diamond with a lower dislocation density than the starting substrate material, with the lower limit on dislocation density set only by the number of times the method is to be repeated. In particular, the large area plate of the invention and any layers subsequently synthesised on it can have a dislocation density, typically intersecting a surface normal to the growth direction (this surface generally showing the highest dislocation density in CVD diamond), *which is less than 50/mm^2, and preferably less than 20/mm^2, and more preferably less than 10/mm^2 and even more preferably less than 5/mm^2.* … [emphasis added]

133 SG 506 discloses and enables the making of diamonds with dislocation densities of less than 50/mm^2, 20/mm^2, 10/mm^2 and 5/mm^2. According to Dr Nebel, diamonds with a dislocation density of

less than 100/mm^2 will have a birefringence of less than 10^{-4}. Diamonds with a dislocation density of less than 10/mm^2 will also have a birefringence of less than 5 x 10^{-5}. These values fall within the SG 872 Range. I should also add that in its closing submissions, the defendant appears to also have conflated the SG 506 process with the WO 633/634 process, as it argues that "[SG 506] showed that the method claimed in [WO 633] and [WO 634] grew low birefringent diamonds". [note: 95] It is evident, however, from the foregoing discussion that the general teaching in WO 633/634 and SG 506 are distinct, notwithstanding their areas of overlap.

(1) Example 1 of SG 506 and etalons

134 According to the defendant, the diamond material produced from SG 506 is suitable for use as etalons. The defendant cites Example 1 of SG 506:

> Example 1
>
> Two {001} synthetic diamond substrates were prepared for CVD diamond growth according to the method described in [WO 633]. A layer was then grown onto these diamond substrates to a thickness of 6.7 mm. The layers were characterised for their dislocation direction, and it was found that >90% of dislocations visible by X-ray topography were within 20° of the growth direction, and >80% of the dislocations were within 10° of the growth direction.
>
> One plate was cut out of each of these layers such that the major faces of each plate had dimensions > 6 x 5 mm and the direction of growth was in the plane of the major faces.
>
> One plate was then used for a second stage of CVD diamond growth, preparing it according to the method of [WO 633], thus producing a second layer which was in excess of 4 mm thick and suitable for the preparation of a 4 x 4 mm plate cut to include the growth direction in a major face. This layer was then characterised for [its] dislocation density in the direction of growth, by producing a small facet and using the method of a revealing plasma etch, *which found the dislocation density to be very low and in the region of 10/mm^2. This made the material particularly suited to the application of etalons*.
>
> [emphasis added]

135 Although SG 506 was an unpublished patent application at the time of SG 872's priority date, it is entitled to claim a priority date of 20 September 2002 from its priority document GB 949, and is therefore prior art.

136 As a preliminary objection, the plaintiff contends that Examples 1 and 2 of SG 506 are not citable for lack of novelty against SG 872, pursuant to s 14(3) of the Patents Act. [note: 96] Examples 1 and 2 of SG 506 are not relevant as they are not found in the priority document of SG 506 (*ie*, GB 949). Section 14(3) reads:

> (3) The state of the art in the case of an invention to which an application for a patent or a patent relates shall be taken also to comprise matter contained in an application for another patent which was published on or after the priority date of that invention, if the following conditions are satisfied:
>
> (*a*) that matter was contained in the application for that other patent both as filed and as published; and

(*b*) the priority date of that matter is earlier than that of the invention.

137 In order to determine the "priority date of that matter", s 17(2)(*b*) is relevant:

> 2) Where in or in connection with an application for a patent (referred to in this section as the application in suit) a declaration is made, whether by the applicant or any predecessor in title of his, complying with the relevant requirements of the rules and specifying one or more earlier relevant applications for the purposes of this section made by the applicant or a predecessor in title of his, and the application in suit has a date of filing, within the period referred to in subsection (2A)(*a*) or (*b*), then —
>
> (a) if an *invention* to which the application in suit relates is *supported by matter disclosed in the earlier relevant application or applications*, the priority date of that invention shall, instead of being the date of filing the application in suit, be the date of filing the relevant application in which that matter was disclosed or, if it was disclosed in more than one relevant application, the earliest of them; and
>
> (b) the priority date of any *matter* contained in the application in suit which was also *disclosed* in the earlier relevant application or applications shall be the date of filing the relevant application in which that matter was disclosed or, if it was disclosed in more than one relevant application, the earliest of them.
>
> [emphasis added]

138 Thus, an invention is entitled to claim priority from an earlier patent application if it is capable of being "supported by matter disclosed in the earlier relevant application". However, a "matter" is only allowed to claim priority from an earlier application if it was "disclosed".

139 In that regard, Examples 1 and 2 were not disclosed in the priority document of SG 506 (*ie*, GB 949). Accordingly, they are not relevant for the novelty inquiry.

140 I proceed to consider if Examples 1 and 2 of SG 506 anticipate Claim 1 of SG 872, on the assumption that they were disclosed in GB 949. In this connection, it should be noted that it is possible for specific examples in a prior patent to anticipate a later invention: see *eg Jushi Group Co Ltd v OCV Intellectual Capital LLC* [2019] RPC 1 ("*Jushi*") at [44]; *Liqwd Inc & Anor v L'Oreal (UK) Ltd & Anor* [2018] EWHC 1394 at [193].

141 A PSA following the directions in Example 1 of SG 506 would produce diamond material "particularly suited to the application of etalons". The question then is whether etalons *must* have a birefringence within the SG 872 Range. According to Dr Nebel, based on William S Gornall, "Interferometry Determines Wavelengths Precisely" (1997) Laser Focus World, etalons *must* have a birefringence of less than 7.7×10^{-5}, and this falls within the SG 872 Range. [note: 97] In reply, Prof Newton merely stated that Dr Nebel's calculation was "unsubstantiated", but did not *explain* the basis for his view. In the circumstances, I prefer Dr Nebel's evidence that etalons must have a birefringence within the SG 872 Range. I note that this is also consistent with Dr Scarsbrook's evidence that the diamond material in WO 633/634 failed as etalons, whereas the SG 872 was suited for this purpose. [note: 98] In the circumstances, if Example 1 of SG 506 was relevant to the novelty inquiry, it would have, in my view, anticipated Claim 1 of SG 872.

142 In contrast, the *general teaching* in SG 506 does not anticipate Claim 1 of SG 872. Apart from the *specific example* taught in Example 1, there is nothing to suggest that a PSA following the broad

teaching in SG 506 would *invariably* produce a diamond that is "suited to the application of etalons", if the method used in Example 1 is not otherwise followed. In other words, Example 1 is a *particular* application of SG 506 with specific directions contained therein. The defendant could have conducted experiments to show that following the directions in SG 506, whether through the specific directions in Example 1 or otherwise, would inevitably result in a low birefringent CVD diamond within the SG 872 Range, but did not do so.

(2) Example 2 of SG 506

143 Example 2 of SG 506 reads:

> In optical applications, a key parameter is the uniformity and spread in value of properties such as birefringence and refractive index. These properties are affected by the strain fields surrounding dislocation bundles.
>
> Two {001} synthetic diamond substrates were prepared for CVD diamond growth according to the method descried in [WO 633]. A layer was grown onto this diamond to a thickness of 4 mm. The layers were characterised for dislocation direction and it was found that the mean dislocation density lay within 15° of the growth direction. Two plates were cut out of these layers such that the major faces of the plates had dimensions > 4 x 4 mm and the direction of growth was in the plane of the major faces.
>
> These layers were subsequently used for substrates in a second growth process. X-ray topography showed that the resulting growth (to a thickness of 3.5 mm) had a very low dislocation content, and that the dislocations in the new overgrowth were perpendicular to those in the original CVD layer used as the substrate. Subsequent to this second growth the samples were used in an optical application which required very low scatter and birefringence.

144 Example 2 of SG 506 is not relevant to the novelty inquiry as it was also not disclosed in the priority document GB 949. In any event, while "the samples were used in an optical application which required very low scatter and birefringence", there is no quantitative measurement of such birefringence (*ie*, it could be outside the SG 872 Range).

(3) Dr Bergonzo's evidence

145 According to the defendant, Dr Bergonzo admitted that SG 506 would result in diamonds of *lower* birefringence than SG 872. The full extract reads: [note: 99]

> COURT: The question is -- for example, you mentioned if you use 506, you flip it over and you wait for eight to 10 weeks and at the top 2mm you have very low birefringent material, but obviously this is not commercially usable because it takes so long, so expensive, you grow 10mm for 2mm, right? But are we saying that product, the 2mm, is that the same thing as what you produce from 872?

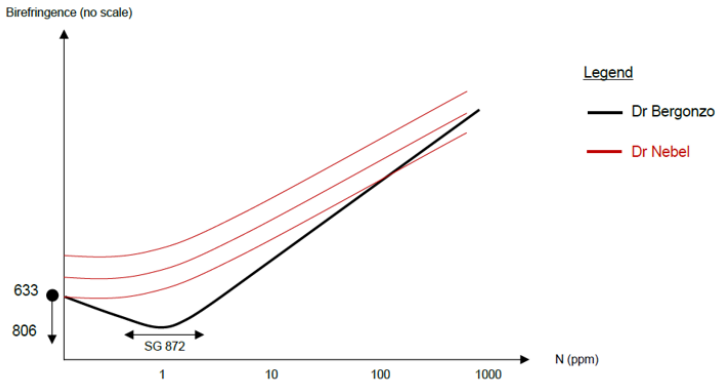
A: *I think the 506 material would have lower birefringence than a sample grown using 872, using a very random substrate.* The goal of 872 is to be able to grow good quality low birefringence material from any type of substrates … Dr Nebel was saying that 872 is using the same type of substrate as 633 or the same as 508. Basically, a substrate that exhibits less than 5000 dislocations per millimetre square, which is quite high, *it is not as good as a substrate in 506. 506 is an exceptional substrate*; difficult to fabricate, that's sure, and, therefore, we discussed yesterday it's not possibly commercially solid as a big -- it's more proof of principle.

COURT: In fact, the birefringence might be lower?

A: *The birefringence might be lower if you take a substrate that will have less defects at the substrate, yes, but it is not an economically viable system* whether 872 will enable you to take substrates, produce them more or less industrially from HPHT substrate, do the treatment and then you will be able to have reliably materials with much lower birefringence than 633 or 508.

[emphasis added]

146 Read in its proper context, Dr Bergonzo's evidence is that SG 506 relies on an extremely high quality substrate, which would not be used for SG 872. If the substrates were the same, the application of SG 872 would result in a diamond of lower birefringence than SG 506. This is evident from the chart drawn by the experts during a concurrent conference with the court and the court assessor, where Dr Bergonzo indicated using a black downwards arrow on the Y-axis for birefringence of the possible range of birefringence values for SG 506 (it is accepted by all parties that 806 refers to SG 506).



147 Therefore, Dr Bergonzo makes clear that a PSA, following the directions in SG 506, and using a superior substrate ("the birefringence might be lower if you take a substrate that will have less defects at the substrate"), would be able to produce a CVD diamond in the SG 872 Range, even without the controlled addition of low levels of nitrogen. That is entirely consistent with the express teaching in SG 506 itself, where Example 1 of SG 506 teaches the PSA to produce CVD diamond material suitable for use as etalons.

148 In the circumstances, SG 506 does not anticipate Claim 1 of SG 872 as following the general

teaching in SG 506 will not *inevitably* result in a low birefringent diamond within the SG 872 Range. Much will depend on the quality of the starting substrate (for instance, the substrates produced according to Example 1 of SG 506).

Category (c) correlations: "Same product through identical method" assertions

149 Lastly I turn to the prior art which the defendant contends must result in the product of Claim 1, because of the identical methods asserted.

(1) SG 508, JP 890, Badzian 2000, US 021

150 The defendant contends that SG 508, JP 890, Andrzej Badzian, "Synthesis of Diamond from the Gas Phase" in *Electric Refractory Materials* (Yukinobu Kumashiro, ed) (2000) ch 15 ("Badzian 2000") and US 021 all constitute prior art that would anticipate Claim 1 of SG 872. This is as they "disclose methods that are identical to the method claimed in SG 872". [note: 100] Thus, pursuant to the principle of inherent disclosure, following the directions in these prior art would lead to the growth of the same CVD diamond claimed in SG 872.

151 I reject the defendant's contention that the methods in these prior art are identical to the one in SG 872. I will discuss the differences at [235]–[252] below. It suffices here to state that while SG 872 teaches the controlled *addition* of nitrogen within a specific range (300 ppb to 5ppm), none of the other prior art disclose this.

(a) SG 508 claims a priority date of 6 September 2002 from GB Patent Application No. 0220772.8 ("GB 772"). GB 772 discloses a broad range of nitrogen concentration between 0.5ppm to 500ppm, with the most preferred range being 2ppm to 30ppm. The examples in GB 772 use the same concentration of nitrogen in the synthesis process, 10ppm, which is twice the maximum amount of nitrogen allowed in SG 872 (5ppm). [note: 101]

(b) US 021 is a patent published in the United States on 12 December 1995. [note: 102] The patent, however, teaches the PSA *to remove impurities* rather than to *add nitrogen*. In any event, the mere reference to "concentration of impurity components … is preferably not more than 500 ppm" would not inevitably lead a PSA following the directions in US 021 to use a nitrogen range of 300ppb to 5ppm (the SG 872 Range).

(c) JP 890 is a patent published in Japan on 24 October 1995. [note: 103] However, the nitrogen range disclosed in JP 890 is between 3ppm to 1000ppm. Again, there is nothing to suggest that a PSA will confine himself to a range of 300ppb to 5ppm such that a low birefringent diamond claimed by SG 872 will be produced.

(d) Badzian 2000 states that "CVD diamond growth with addition of gases like nitrogen influences step formation and eliminates twinning leading to smooth surfaces". [note: 104] However, there is no indication of whether the influence of step formation and the elimination of twinning will lead to a reduction in birefringence. In so far as qualitative terms such as "near perfect" are used, these terms should be treated with caution, in the same way as the terms "low strain" or "low birefringence".

Inventiveness

The relevant legal principles

152 I turn to the requirement of inventiveness, which is set out in s 15 of the Patents Act:

> **Inventive step**
>
> **15**. An invention shall be taken to involve an inventive step if it is not obvious to a person skilled in the art, having regard to any matter which forms part of the state of the art by virtue only of section 14(2) and without having regard to section 14(3).

153 Therefore, unlike the novelty inquiry, the relevant state of the art for the inventiveness inquiry excludes unpublished patent applications which have a priority date earlier than the invention: s 15 read with s 14(3) of the Patents Act. For example, SG 506, which was only published on 1 April 2004, is not relevant for the inventiveness inquiry. In contrast, WO 633/634, which was published *before* the priority date of SG 872 (21 November 2002) are relevant pieces of prior art.

154 The rationale of the inventiveness requirement was stated by the Court of Appeal in *First Currency Choice* at [36]:

> In reviewing the validity of a patent apropos of its obviousness, it is necessary to bear in mind the rationale underpinning the requirement of obviousness. According to Millett LJ (as he then was) in *PLG Research Ltd v Ardon International Ltd* [1995] RPC 287 ("*PLG Research*") at 313–314:
>
> > [T]he public should not be prevented from doing anything which was merely an obvious extension or workshop variation of what was already known at the priority date. … … … There are many cases in which obviousness has been held not to have been established, even though the prior art relied upon was very close … Where the prior art yields many possible starting points for further development, it may not be obvious without hindsight to select a particular one of them for the development which leads to the invention claimed. If the patentee has come up with a solution to his problem which is no more than an obvious extension or workshop variation to some piece of the prior art, he cannot have a monopoly for his solution whether or not the skilled man would be likely to have known of the prior art in question. On the other hand, if it is found that, even if he had known of it, the skilled man would not have regarded it as the obvious starting point for the solution of the problem with which he was confronted, this will usually demonstrate that his discovery was not an obvious extension or mere workshop variation of that prior art.

155 It should be stressed that when considering the question of inventiveness, it is *assumed* that the invention is novel and differs in some identifiable respect from the prior art: *First Currency Choice* at [19]. The burden is on the party resisting the patent claim to prove the absence of an inventive step: *ASM Technology* at [78]. Typically, the court engages in a four-step analysis also known as the *Windsurfing* approach, derived from the English decision of *Windsurfing International Inc v Tabur Marine (Great Britain) Ltd* [1985] RPC 59. This has been described as a "useful guide" for assessing inventiveness: *First Currency Choice* at [45]. In *ASM Technology* at [78], the Court of Appeal set out the *Windsurfing* approach as follows:

> (a) First, identify the inventive concept embodied in the patent.
>
> (b) Second, assume the mantle of the normally skilled but unimaginative addressee in the art at the priority date. Impute to such addressee the contents of the common general knowledge in the art in question as at the priority date.
>
> (c) Third, identify the differences (if any) that exist between the contents of the common

general knowledge as at the priority date and the claimed invention.

(d) Fourth, ask whether, viewed without any knowledge of the alleged invention, those differences constitute steps that would have been obvious to the skilled addressee, or whether they require any degree of invention. In doing so, the skilled addressee may, unlike in the novelty inquiry, construct a "mosaic" out of the various pieces of prior art, unless such act of constructing a "mosaic" would itself not be obvious to the notional skilled addressee (Mühlbauer at [93]).

156 On the second step, the Court of Appeal noted in *First Currency Choice* at [38] that:

> … the state of the art, as contemplated by s 15 of the Act, ought to be viewed in relation to the common general knowledge of the notional skilled person, as opposed to that of "the public" (see s 14(2)). This would exclude knowledge which is not available to the public. While this genre of knowledge (*ie*, knowledge which is not available to the public) is excluded from the common general knowledge which the notional skilled person is deemed to possess for the purpose of assessing obviousness, such knowledge is nonetheless taken into account in assessing whether an invention is novel under s 14 of the Act.

157 The observations of George Wei J in *Rohm & Haas Electronic Materials CMP Holdings, Inc (formerly known as Rodel Holdings, Inc) v NexPlanar Corp and another* [2018] 5 SLR 180 ("*Rohm & Haas*") at [145] are also pertinent:

> Even though the skilled reader is assumed to have had access to the prior art as a whole, it is well established that not all disclosures in the prior art will enjoy the same weight (*Inhale Therapeutic Systems Inc v Quadrant Healthcare plc* [2002] RPC 21 ("*Inhale*") at [47]). An assessment of inventive step is necessarily judgmental. The skilled reader, even though he is unimaginative, does have the ability to evaluate and assess the relevance and weight of the disclosures. Factors include how distant and unrelated the prior art's field of research is, and whether the prior art is directed at solving the particular problem at issue (*Inhale* at [47]).

158 The Court of Appeal in *Mühlbauer* at [101] also considered the fourth step as being the "critical question", with the first three steps "merely laying the ground work for this final question". The assessment in the fourth step is to be made without the benefit of hindsight (*ie*, without the benefit of information available after the priority date), as an "ex post facto analysis … would be unfair to inventors".

159 Unlike the novelty inquiry, it is permissible to "mosaic" the various pieces of prior art in the inquiry for inventiveness, unless the act of "mosaicing" itself is not obvious to the PSA. The mosaic "must be one which is put together by an unimaginative man with no inventive capacity": *Mühlbauer* at [93]. The court can adopt a more "global approach", rather than examine the various pieces of prior art individually *vis-à-vis* the patent: *Mühlbauer* at [96].

160 It should be noted that one way in which a patent may be inventive is if it overcomes existing prejudices held by the PSA: see *Mühlbauer* at [100]:

> As was noted by Jacob LJ in the English Court of Appeal decision of *Pozzoli SpA v BDMO SA* [2007] FSR 37 at [27]:
>
> > Patentability is justified because the prior idea which was thought not to work must, as a piece of prior art, be taken as it would be understood by the person skilled in the art. He will

> read it with the prejudice of such a person. So that which forms part of the state of the art really consists of two things in combination, the idea and the prejudice that it would not work or be impractical. A patentee who contributes something new by showing that, contrary to the mistaken prejudice, the idea will work or is practical has shown something new. He has shown that an apparent 'lion in the path' is merely a paper tiger. Then his contribution is novel and non-obvious and he deserves his patent.
>
> [original emphasis omitted]

161 Further, the simplicity of the invention does not mean that the invention is obvious, or lacking in any inventive step: *Mühlbauer* at [102].

162 For present purposes, it is useful to refer to the Court of Appeal's decision in *Merck & Co Inc v Pharmaforte Singapore Pte Ltd* [2000] 2 SLR(R) 708 ("*Merck*"). There, the product patent was for the compound Lovastatin with a dimeric impurity of less than 0.2%: *Merck* at [2]. The Court of Appeal found that the product patent was novel. The defendants failed to establish that following the teachings in the prior art would have inevitably led to the production of Lovastatin with less than 0.2% dimeric impurity: *Merck* at [42].

163 Notwithstanding, the product patent was held to lack an inventive step as it would have been obvious to a PSA working to purify Lovastatin that there were "standard" techniques which could be used to achieve that end (*Merck* at [64]–[65]):

> [64] It should be borne in mind that the skilled addressee we are here concerned with is a *process chemist, looking for ways to reduce impurities in lovastatin.* What such a skilled addressee would do would have to depend on the problem he has to resolve. Will such a skilled addressee be able to achieve his ends, using the existing state of the art? *In the light of the available techniques of purification, we would think so.* The following concluding remark of Dillon LJ in *Genentech* is extremely germane:
>
> > We have a difficult art, in which the skill consists in a substantial degree of an ability to solve problems. It must, I consider, follow from this that the hypothetical skilled man must be credited with that particular ability in the appropriate degree.
>
> [65] *In the present case, the trial judge after reviewing the evidence found that numerous techniques, "myriad of processes", were available to reduce the dimeric impurity present in the Lovastatin compound referred to in claims 16–21 and concluded that those claims were invalidated and should be revoked for lack of an inventive step.* This is a finding of fact (see, *eg Genentech*) and in the light of the evidence which were presented to court as we have outlined above, there is hardly any basis for us to say that the trial judge's finding was plainly wrong, warranting the intervention of this appellate court. Indeed, we are inclined towards the view of the trial judge. There is evidence that supports the trial judge's finding that *using the standard techniques, such as recrystallisation or activated carbon, would have been obvious to any person skilled in the art working to purify a compound like Lovastatin.* We would agree that a person, skilled in the art, faced with impurities in a compound, would naturally use those techniques to reduce the impurities. In our opinion, what the appellants have achieved in the alleged patent is a discovery. It does not amount to an invention.
>
> [emphasis added]

Conflation of the novelty inquiry with the inventiveness inquiry

164 Before turning to the inquiry proper, I should point out that the defendant has conflated its arguments between the novelty inquiry and the inventiveness inquiry, so far as Claim 1 of SG 872 is concerned. In asserting that Claim 1 of SG 872 is obvious, the defendant contends that "[i]t would have been obvious to a PSA looking at the state of the art before the priority date of [SG 872] that a low birefringent CVD diamond *already existed*". [note: 105] An example of an argument made by the defendant in the inventiveness inquiry is as follows: [note: 106]

> According to Dr Nebel, a PSA, armed with the common general knowledge of how these properties relate to each other would then read WO '633, WO '634, Isberg and Bruzzi and *find it obvious that the diamond described therein would have low strain or low optical birefringence like the SG '872 Diamond.* [emphasis added]

165 However, as stated at [155] above, when considering inventiveness, it is *assumed* that the invention is novel and differs in some identifiable respect from the prior art: *First Currency Choice* at [19]. The defendant here, relying on Dr Nebel's evidence, appears to have made the same error as the defendant in *ASM Technology*, by contending that the product claim does not involve an inventive step simply because it is anticipated by the prior art. That is the wrong approach: see *ASM Technology* at [80].

166 Dr Nebel's evidence on the lack of inventiveness for Claim 1 of SG 872 was summarised by the defendant in its closing submissions. [note: 107] I reject the following arguments on the basis that they are premised on a finding that SG 872 is not novel:

(a) Claim 1 of SG 872 is obvious because:

> A PSA reading Sumiya 1997 together with [WO 633] and [WO 634] would then expect that the diamond grown using the method of [WO 633] and [WO 634] would similarly have very low strain and therefore very low birefringence.

(b) Claim 1 of SG 872 is obvious because:

> A PSA reading Sumiya 1997 together with Badzian 2000 and US 021 will expect that the diamond grown using these processes will similarly have very low strain and therefore very low birefringence.

(c) Claim 1 of SG 872 is obvious because:

> A PSA, having understood this relationship between carrier lifetime and optical birefringence will know that the 'electronic grade' diamonds disclosed in Bruzzi and Isberg with a carrier lifetime of more than 1 µs will definitely have optical birefringence of less than 10^{-4}.

I deal with the remaining arguments below.

The Windsurfing approach

167 In my view, the proper basis to determine if Claim 1 of SG 872 is inventive is to apply the *Windsurfing* approach, on the premise that the claim is novel.

168 Applying the four-step *Windsurfing* approach, the inventive step in Claim 1 of SG 872 is a CVD diamond of low optical birefringence within the SG 872 Range and of the requisite thickness (at least

0.5mm). The PSA seeking to reduce the optical birefringence of a CVD diamond would have regard to prior art such as WO 633/634. The difference between that prior art and Claim 1 of SG 872 is that the claimed CVD diamond is of a *lower* optical birefringence than the prior art.

169 The ultimate question, then, is whether the steps to be undertaken, in order to obtain a CVD diamond within the SG 872 Range, would have been obvious to a PSA. As with the PSA working on reducing impurities in Lovastatin in *Merck*, were there standard techniques available which could be used to reduce the optical birefringence of a CVD diamond to the SG 872 Range?

(1) Sumiya 1997 and JP 890

170 According to Dr Nebel, "[a] PSA would understand the need of using low defect density seeds and control of nitrogen in the growth atmosphere from Sumiya 1997". In addition, JP 890 "teaches a PSA that growing a diamond with [a] 'controlled low level of nitrogen' will reduce the defects" [original emphasis omitted]. [note: 108] In other words, Sumiya 1997 would teach the need to select a substrate with low defect density, and JP 890 would teach the addition of trace amounts of nitrogen.

171 Therefore, according to Dr Nebel, "a PSA will know from reading Sumiya 1997 and JP 890 that a diamond grown with a good quality seed and low nitrogen will have very low strain and therefore very low birefringence". [note: 109]

172 I reject Dr Nebel's assessment, as it is not clear how a PSA would be able to obtain the nitrogen range of 300ppb to 5ppm from Sumiya 1997 and/or JP 890. In fact, as the plaintiff rightly points out, a PSA reading JP 890 would add nitrogen concentration *above 30ppm* and not between 300ppb and 5ppm. [note: 110] JP 890 is primarily concerned with growth rate; it teaches the PSA how "[t]o synthesize high quality diamond in a vapour phase at a high rate of synthesis". The growth rate discussed in JP 890 only substantially increases when the nitrogen concentration is above 30ppm. Further, JP 890 also does not disclose that the addition of low levels of nitrogen would result in a reduction in birefringence. It would thus not have been obvious to a PSA to add nitrogen in the range of 300ppb to 5ppm to obtain a low birefringent CVD diamond in the SG 872 Range.

(2) Sumiya 1997 and US 412

173 Next, Dr Nebel relies on both Sumiya 1997 and US 412 (published on 19 December 2000) [note: 111] to contend that Claim 1 of SG 872 is obvious. Dr Nebel's argument is that Sumiya 1997 "discloses that a diamond with less than 0.1 ppm nitrogen content will have very low strain due to the absence of defects introduced by nitrogen". [note: 112] As for US 412, it "teaches a PSA that to achieve a diamond with nitrogen content of less than 0.2 ppm, the nitrogen in the synthesis gas phase should not exceed 1ppm". [note: 113]

174 Therefore, according to Dr Nebel, a PSA reading Sumiya 1997 and US 412 together, would "understand that to achieve a low birefringent CVD diamond, one should use a low defect density seed and limit the nitrogen in the synthesis gas phase to below 1 ppm to achieve a low strain and low birefringent diamond". [note: 114]

175 I reject Dr Nebel's contention. It is hard to see how Sumiya 1997 read with US 412 would teach the PSA that adding low levels of nitrogen between 300ppb and 5ppm would result in a reduction of birefringence. As Dr Bergonzo noted, US 412 states: [note: 115]

… when the methane gas concentration was constant, the quality of the diamond film was quickly *deteriorated* as the nitrogen gas concentration was increased, and the diamond film was black which was seen by naked eyes …

When the nitrogen gas concentration in the reaction gas was high, the *deterioration* of the diamond quality was prevented by the decrease of the methane gas concentration.

[emphasis added]

176 Far from teaching the PSA that the deliberate addition of nitrogen will reduce birefringence, US 412 would have, consonant with the common general knowledge, taught the PSA that the addition of nitrogen would result in a "deterioration of the diamond quality". In my view, it would not have been obvious to a PSA reading Sumiya 1997 and US 412 that the deliberate addition of nitrogen would result in a reduction of birefringence. A PSA reading US 412 would instead do the converse (*ie*, remove instead of add nitrogen).

(3) US 430 and combinations

177 According to the defendant, US 430 "teaches a PSA that annealing a diamond will reduce its optical birefringence". [note: 116] A PSA reading US 430 with WO 633, WO 634, Isberg, Bruzzi, US 021, Badzian 2000, JP 890 and US 932 "will know that annealing the diamonds disclosed in these prior art will further reduce the optical birefringence of these diamonds". [note: 117]

178 It is not necessary for me to deal with this contention at length, as Dr Nebel's evidence in cross-examination was that a PSA would *not* anneal a diamond to reduce its birefringence. Instead, the PSA would look to the *quality of the substrate* instead: [note: 118]

MR YEO: Thank you. Let me take items (16) to (23) together. They are all combinations of US 430, which is the patent on annealing, with either the different method claims for growing CVD diamonds or the Bruzzi and Isberg and WO 663, WO 664 on electronic diamonds. How would the combination of the annealing patent with this other what you call prior art make it obvious to the PSA CVD material with low birefringence? How does this combination with the annealing patent make a difference?

A: I try to explain it again because annealing is the first idea you get into mind when you want to remove defects. If it is possible to remove these defects by annealing is something which is complex and, therefore, you again look into the literature to find out what has been published about annealing. And if you know annealing works or not, you do it or not -- I mean, the dislocation annealing is not helpful because dislocations, unfortunately, do not move. A lot of defects, like vacancies, propagate. Yeah, you get NV centres or you split, depending on the temperature of the NV centres, so you can do a lot with respect to annealing but you -- unfortunately, you cannot remove dislocations by annealing. *And, therefore, again if a PSA gets immediately the idea, "I do annealing to get the best diamond", he will sooner or later end up with a problem that the dislocation density does not disappear and, therefore, he will need to find out where these dislocations come from and then he will end up with the substrate as a source for the dislocations growing into the material*. So the annealing is nothing which is very far out. It's the immediate way to do a [*sic*] improvement of material in semiconductor physics and technology.

[emphasis added]

(4) Improving the quality of substrates

179 Next, I consider the argument that Claim 1 of SG 872 lacks inventiveness because a PSA would improve the quality of substrates to grow low birefringent CVD diamonds in the SG 872 Range. To be clear, the defendant did *not* raise this argument in its closing submissions. However, as Dr Nebel alluded to this possibility in cross-examination (see [178] above), I deal with this for completeness.

180 In my view, a PSA might have known that improving the quality of substrates would lead to a low birefringent CVD diamond in the SG 872 Range. However, *the obtaining of that high quality substrate would in and of itself have involved an inventive step*. This is because no substrate of the requisite quality was available at that date. The PSA, being an "unimaginative" technician, would not be expected to make that inventive step.

181 Prof Newton accepted that a PSA using a high quality substrate could obtain a low birefringent CVD diamond in the SG 872 Range. *But such a substrate was not available as of the priority date of SG 872, and it would not have been obvious how such a substrate could be obtained.* [note: 119] This was not refuted by the defendant, save that it asserts that such a substrate preparation is found in in SG 506, which teaches a two-stage growth process, and specifically Example 1 of SG 506. To recapitulate, SG 506 is a method of improving the quality of substrates by growing a CVD diamond using the method claimed in WO 633/634 and cutting a CVD plate from the grown diamond parallel to the growth direction. By repeating this method of growing and cutting the substrate, *the dislocation density of the resulting substrate will be reduced*. Thereafter, a low birefringent CVD diamond can be grown on top of this high quality substrate using WO 633/634.

182 A PSA who has read SG 506, *and specifically Example 1* of SG 506, would have known how to obtain low birefringent CVD diamonds within the SG 872 Range. This is because Example 1 teaches that the diamond material produced from that method are suitable for use as etalons, and I have

accepted that etalons must have a birefringence within the SG 872 Range. Nevertheless, and importantly, SG 506 was only published on 1 April 2004. *It would thus not have been obvious to a PSA as of the priority date of SG 872 (21 November 2002) how to obtain this high quality substrate through the technique taught in Example 1 of SG 506*. SG 506 is itself a valid patent and there is no contention by the defendant that it lacks novelty or an inventive step.

183 In this context, I deal with two articles cited also for novelty, despite their being made after the priority date.

(A) Friel 2009

184 To prove that WO 633 anticipated SG 872, Dr Nebel cites Friel *et al*, "Control of surface and bulk crystalline quality in single crystal diamond grown by chemical vapour deposition" (2009) 18 Diamond & Related Materials 808 ("Friel 2009") where the samples fell within the SG 872 Range. [note: 120] Dr Nebel relies on a reference to endnote 16 to WO 633 and WO 427 (on which SG 872 is based). Dr Nebel points out that this means that *either* the method claim in WO 633 or SG 872 would result in low birefringent diamonds within the SG 872 Range. However, Prof Newton points out that Friel 2009 discloses a two-stage process of growing diamonds. While both WO 633 and WO 427 were cited, it is unclear that *either* would have resulted in a low birefringent diamond within the SG 872 Range. Another way of reading endnote 16 is that one or both of the two stages in Friel 2009 involved WO 427, which would explain the low birefringent diamonds in the SG 872 Range. In any event, even if the defendant's interpretation of the reference to endnote 16 is right, Prof Newton also highlighted that the *substrate* used in Friel 2009 would not have been available as of the priority date of SG 872. This meant that a PSA, following the directions in WO 633/634 would not have been able to produce a low birefringent diamond in the SG 872 Range. Dr Nebel agreed that the substrate in Friel 2009 would not have been available as of the priority date of SG 872: [note: 121]

> Q: Let me give you one difference. In Friel 2009, they were using new substrates that were not available in 2002; agreed?
>
> A: If you know, then I agree, yes. I agree.
>
> Q: You are the one citing Friel and you are the diamond expert.
>
> A: Yeah, but, once again, I said I need to read the paper, but if he states it, that's the case, then I agree, yes.

(B) Tallaire 2017

185 Dr Nebel relied on Tallaire *et al*, "Thick CVD diamond films grown on high-quality type IIa HPHT diamond substrates from New Diamond Technology" (2017) 77 Diamond & Related Materials 146 ("Tallaire 2017") to prove that WO 633/634 would result in a low birefringent diamond in the SG 872 Range. However, as with the substrate used in Friel 2009, the New Diamond Technology ("NDT") substrate is new and was not available as of the priority date of SG 872, such that a PSA following the directions in WO 633/634 would not inevitably produce a low birefringent diamond in the SG 872 Range. Dr Nebel accepted that the NDT substrate was new in cross-examination: [note: 122]

MR YEO: … On Tallaire 2017, Professor Newton had said that was using substrates, new substrates from NDT which weren't available in 2002. I wondered whether, factually, Dr Nebel could confirm whether he agrees with that statement?

A: If it has been written in Tallaire's paper and he says he has new diamond technology substrates then I don't oppose because he used then NDT material, which is a Russian company selling high pressure high temperature substrates, so I have no reason to say "no".

(5) Commercial success

186 Commercial success may be used as a relevant factor in determining inventiveness: see *Mühlbauer* at [107]. It is clear from the prior art discussion that the product fulfilled a need in the optical applications market. As I have held that the product in SG 872 is inventive on other grounds, I do not deal with this issue.

Sufficiency

187 The "enabling disclosure" or "sufficiency" requirement is found in s 25(4) of the Patents Act:

> The specification of an application shall disclose the invention in a manner which is *clear and complete for the invention to be performed by a person skilled in the art*. [emphasis added]

188 Section 80(1)(*c*) of the Patents Act provides that the patent may be revoked if s 25(4) is not satisfied.

189 In *First Currency Choice*, the Court of Appeal adopted the two-stage test set out by Lord Hoffmann in *Kirin-Amgen Inc v Hoechst Marion Roussel Ltd* [2005] RPC 9 at [103]: *First Currency Choice* at [61]–[62]:

> [61] A two-step test was postulated by Lord Hoffmann in *Kirin-Amgen* ([25] *supra*) at [102]–[104] to determine whether the specification of a patent was sufficient:
>
> > [T]he disclosure must enable the invention to be performed to the full extent of the monopoly claimed: see *Biogen Inc v Medeva plc* [1997] RPC 1 [at] 48.
> >
> > Whether the specification is sufficient or not is highly sensitive to the nature of the invention. The first step is to identify the invention and decide what it claims to enable the skilled man to do. Then, one can ask whether the specification enables him to do it. …
> >
> > It seems to me that a good deal of the argument in this case about sufficiency, like the argument about infringement, really turns on a dispute over exactly what the invention is … But in order to decide whether the invention has been fully enabled, you first have to decide what the invention is.
>
> [62] The two-stage test as laid out above can be supplemented by two further considerations. First, the specification of the patent must embrace an embodiment of the invention asserted in each of the claims with sufficient particularity to enable the invention to be understood and

carried into effect by those in the industry without making further inventions or prolonged study of the matter. The specification must be set out clearly and fairly so that any individual desirous of carrying out the invention may obtain full knowledge of its practical aspects. *But, it is not necessary that the specification be so detailed that this notional individual can perform the invention without any trial or experiment at all.* Second, the description of the invention should not be unnecessarily difficult to follow, and must not contain any traps or seriously misleading statements which the reader cannot correct (see Halsbury's Laws of Singapore vol 13(3) (LexisNexis, 2007) at para 160.367).

[emphasis added]

190 In addition, the following principles are also relevant:

(a) Whether the specification of a patent discloses the invention clearly enough and completely enough for it to be performed by a PSA is a question of degree. The question of the sufficiency of the disclosure is a matter of fact, depending on the nature of the invention and the other circumstances of the case: *First Currency Choice* at [60].

(b) It is insufficient for the party seeking to invalidate the patent to merely highlight ambiguities in the claims. Instead, the burden of proof is on that party "to show that those ambiguities would render the invention unworkable from the point of view of a person skilled in the art who is trying to give practical meaning to the patent specification": *Rohm & Haas* at [158], citing Susanna H Leong, *Intellectual Property Law of Singapore* (Academy Publishing, 2013) at para 16.271). The PSA possesses common general knowledge and common sense as befits the area of technology in question: *Rohm & Haas* at [159].

(c) The breadth of the claims is relevant to an assessment of the sufficiency requirement. If the invention discloses a principle capable of general application, the claims may be in correspondingly general terms: *First Currency Choice* at [60].

191 The defendant relies on s 25(5) of the Patents Act, which states as follows:

(5) The claim or claims shall —

(*a*) define the matter for which the applicant seeks protection;

(*b*) be clear and concise;

(*c*) be supported by the description; and

(*d*) relate to one invention or to a group of inventions which are so linked as to form a single inventive concept.

192 This "clarity" requirement is not, however, a ground for revocation under the Patents Act (see *First Currency Choice* where the Court of Appeal made clear at [72] that, "where the specification of a patent is sufficient, any potential ambiguity or undue breadth of a claim is not in itself a ground of revocation"). What is important is whether the claim discloses the invention sufficiently for a PSA to perform it.

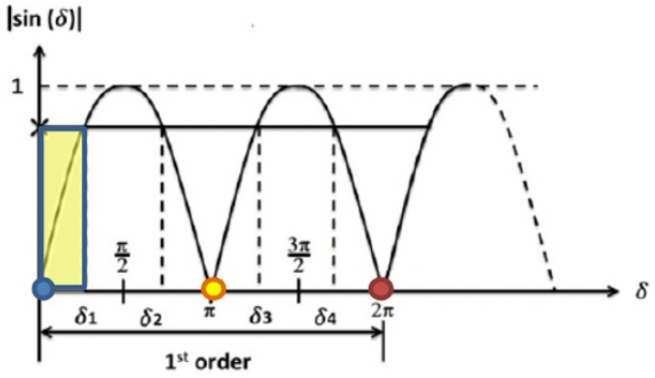
193 I now turn to the defendant's contentions on why Claim 1 of SG 872 is insufficient.

Determining whether delta does not exceed π/2

194 The diamond material claimed in Claim 1(ii) of SG 872 requires the mod sine delta "for at least 98% of the analysed area of the sample" to *remain in first order* (where delta does not exceed π/2) and *for the mod sine delta not to exceed 0.9*.

195 However, according to the defendant, a PSA using the Metripol will not be able to identify whether the optical birefringence of the diamond is in first order (defined as delta not exceeding π/2). [note: 123] This is because the Metripol only measures mod sine delta as an absolute value, and it is "impossible" to determine from the value of mod sine delta whether delta does not exceed π/2 because the value of mod sine delta repeats itself at every interval of π and each range of π has two possible values of delta. [note: 124]

196 This alleged problem can be illustrated through the following diagram produced by Dr Kaminsky:



197 The defendant notes that this was an issue that was already foreseen by Dr Glazer and Dr Kaminsky when they co-wrote the first publication for the Metripol (then known as Deltascan) in 1996, "An Automatic Optical Imaging System for Birefringent Media" (2996) 452(1955) Proc R Soc Lond A 2751("Glazer 1996): [note: 125]

> Finally, it should be realized that, because it is |sin δ| that is obtained at any point in the image, it is not possible to know how many periods (known as the order) of the sine function have been passed through, unless other information is supplied. *The easiest way to solve this is to use a standard compensating plate with white light. A quick observation of this type will then suffice to determine the order within which the retardation value lies. Carrying out measurements at two or more wavelengths can also be used to help in determining the order.* [emphasis added]

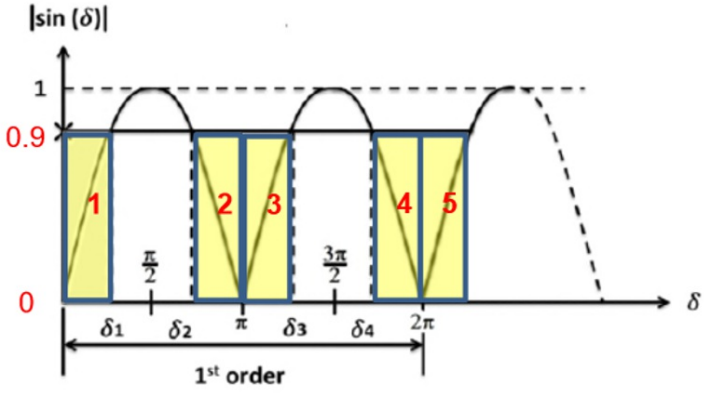
198 Notwithstanding the solution identified in Glazer 1996, Dr Kaminsky's evidence was that this would not be "sufficient advice" to determine the order as the "[m]ethods applied in polarized light microscopy referred to in [Glazer 1996] are insufficient to identify δ < π/2 in highly heterogeneous samples".

199 The plaintiff advances several responses to Dr Kaminsky's criticism. First, it contends that since first order is expressly defined in SG 872 as delta not exceeding π/2, the PSA would only need to look at the value indicated in the first quadrant. But, in my view, this somewhat circular response does not directly address Dr Kaminsky's point; it does not provide an *explanation* as to how the PSA can determine that the optical birefringence of the diamond is in first order.

200 Second, Dr Glazer provided the following solution, which he claimed the PSA would have known:

With regard to [127] of 1st WK, the PSA would know that perfect diamond is optically isotropic and as a result would expect |sin δ| = 0. The PSA would understand that *if the measured |sin δ| map of an area of a sample shows regions in which |sin δ| is close to zero without significant spatial variations associated with defects causing strain, these regions correspond to being close to 0 (the value for perfect [optically isotropic] diamond).* The PSA would further understand that *if the range of |sin δ| values extends upwards from close to zero but does not extend close to 1 the only possible interpretation of the range of values of |sinδ| is that it corresponds to one continuous range of values extending from close to 0 to a value that is less than π/2.* … [emphasis added]

201 The defendant, however, submits that this solution is unworkable, relying on the following image:



202 According to the defendant, each of the five yellow boxes would satisfy Dr Glazer's requirement where the values for mod sine delta range from 0 upwards to 1 but does not extend close to 1. However, only "Box 1" will satisfy the requirement where delta does not exceed π/2. [note: 126] Dr Glazer's explanation was as follows: [note: 127]

A: … In other words, we have lots of values between 0 and up to some value less than 1, and that's the thing. Then there's a gap from that top value to 1. The problem is if we were in a higher order -- don't worry about what that means, "a higher order" -- *you would expect to find values filling in also the values between that top value and 1. Very unlikely that you would have a gap and then some other values higher up, because these features we are looking are at smoothly varying, very continuous features of strain.*

…

MR SINGH: Okay, let's start at 0. Let's say we go up and we hit 0.3.

A: Yes.

Q: Looking at your paragraph 75, it reads "The PSA would further understand that if the range of [mod sine delta] values extends upwards from close to zero but does not extend close to 1 ..." That would include the 0.3, yes?

A: That's what I'm saying, yes.

Q: "... the only possible interpretation of the range of values of [mod sine delta] is that it corresponds to one continuous range of delta values extending from close to zero to a value that is less than [pi 2]."

A: Yes, in this case, because the *birefringence here is caused by strain, which is a continuous function.*

Q: But how is it that's the only possible interpretation of the range of values?

A: Because it's very difficult to imagine any other situation.

Q: But you would have a line drawn from 0.3 right across the X or just above the X-axis, and you would have an interpretation which is equally plausible that it is in order 2?

A: As I have just said, *the gap at the top tells you that something has to be looked at and this is the point of the person skilled in the art looking at that and drawing a conclusion.*

Q: What is he supposed to look at beyond that number 0.3 to draw that conclusion?

A: The fact there are no values there.

Q: But that mere fact there are no values there applies in the second and the third order as well?

A: *But then if you start higher up in the series of orders, you then work backwards to 0 because 0 is where the pure perfect diamond is. Then you would have gaps all over the place for no scientific reason. It just would not make sense. It would not make scientific sense.*

Q: With respect, Dr Glazer, that answer would apply to that same gap and to the same value right into the first, second and third order, that in and of itself; do you agree?

A: *No, not in this case because, as I've just explained to you, a person skilled in the art of looking at diamond, realising these patterns they get are due to strain, would start off at true 0 and then increase, and would say, "There's a gap above that and if there's a gap above that, what happens then?" If you are now jumping into the next order and saying there are values there, you have to explain why there are no values in between.*

[emphasis added]

203 Dr Glazer further explained: [note: 128]

Q: Do you agree it is possible that the gapless values could also relate to values all in the same second order?

A: But then you would still have –

Q: Can you answer that question and then qualify it?

A: No, I don't agree with you.

Q; Do you want to add anything?

A: If I understand you correctly, you are saying that if we were in, say, the second order and then there was a gap -- *well, there wouldn't be a gap because you've got to go back to 0 somehow and that means you have to go back into first order at some stage, continuously.* You can't -- it's not logical to have a sudden gap in the middle of it. So it is an exercise in logic.

Q: But the second order also has 0; correct?

A: Yes, it does.

Q: So if you went back to 0, you could still be in the second order?

A: But the evidence is from the histogram that we have values of [mod sine delta] which are populated from 0, close to zero, up to a maximum value, let us say 0.4, for example, and then there is nothing above that. *Now, if we were in a higher order, given that strain starts from a perfect diamond and is added on, you would expect to have values going backwards from the second order into the first order, going over the top, and you'd have value above 0.4, and if you don't see those, you have to explain that gap in a situation where we're dealing with strain. And that's the logical answer to that.*

[emphasis added]

204 I accept the logic of Dr Glazer's explanation. In essence, Dr Glazer's explanation is that birefringence is a "continuous function". Once presented with a gap between the mod sine delta value nearest 1 and 1, the PSA would understand that this "corresponds to one *continuous* range of [delta] values extending from close to 0 to a value that is less than π/2" [emphasis added]. The patent makes this expectation clearer by specifying that the mod sine delta is to remain in the first order where delta does not exceed π/2. Conversely, if delta extended to the second order and beyond, *the PSA would expect there to be values in those gaps*. The presence of the gaps would thus "not make scientific sense" if delta exceeded π/2.

205 Relatedly, the defendant contends that there is an "inherent flaw" in the Metripol as it is incapable of displaying mod sine delta values close to one. [note: 129] The gap in mod sine delta values, which Dr Glazer refers to, is not because delta is limited to less than π/2, but because the Metripol has an "incurable fault". For this contention, the defendant relies on Dr Kaminsky's evidence. But it is clear that Dr Kaminsky made no such argument. I accept the plaintiff's reply that Dr Kaminsky's evidence was referring to the mod sine delta values of Sample 2, which he alleged was a multi-layer sample causing depolarisation, rather than to the Metripol generally. [note: 130] Dr Kaminsky stated as follows: [note: 131]

… the maximum value readable in this sample is less than 1 due to depolarization effects and overlapping extinctions of different orientations, and thus, values exceeding π/2 smoothly blend

into |sin δ | of presumably lower birefringence.

206 Finally, the defendant also relies on the Metripol results for Samples 2, 3 and 4 to prove that Dr Glazer's solution is unworkable. [note: 132] In the Metripol measurements of Samples 2, 3 and 4, the values of mod sine delta range from 0 upwards to 1 but do not extend close to 1. According to the defendant, this means that the *whole* of Samples 2, 3 and 4 would have birefringence in the first order where delta is less than π/2. In fact, this is an inaccurate characterisation of the Metripol tests, which were completed within the analysed area of Claim 1(ii) of SG 972.

Depth of field

207 I turn to Dr Kaminsky's argument that the Metripol is unable to measure birefringence for samples thicker than 0.25mm, as the objective of the microscope used for the Metripol has a depth of field of only 0.25mm. [note: 133] Given that Claims 1(ii) and 1(iii) of SG 872 require the diamond material to have a minimum thickness of 0.5mm, it is alleged that the Metripol would not be able to measure the birefringence accurately across the thickness of the diamond material. [note: 134] According to Dr Kaminsky: [note: 135]

> … CVD diamonds are everything but homogenous and different parts of a sample can have very different strain and birefringence patterns … the strain patterns in diamonds are randomly distributed [and] birefringence caused by strain will change perpendicular to and along the light path …

208 In response to Dr Kaminsky's evidence, the plaintiff points out that single crystal CVD diamond i s *homogeneous* along the light path so that any birefringence along that light path remains approximately constant. In Dr Glazer's words: [note: 136]

> … birefringence in single crystal CVD diamond mainly results from strain associated with dislocations that are grown into the material with a line direction that is *close to parallel* to the growth direction and the strain fields tend to show little variation through the depth of a sample. [emphasis added]

209 Consequently, the entire depth of the sample being analysed does not have to be in focus.

210 Dr Kaminsky's evidence on the lack of homogeneity in CVD single crystal diamonds ought to be seen in the light of his candid acceptance in cross-examination that he had not "touched a diamond" for 30 years, [note: 137] and that he could not comment on dislocations in diamonds. [note: 138] I accept Dr Glazer's evidence, which is further confirmed by the following points.

(1) Whether dislocations spread outwards as the diamond grows thicker

211 The defendant points out that Dr Glazer did not account for the fact that while dislocations propagate generally in parallel to the growth direction, *they spread outwards as the diamond grows thicker*. [note: 139] This, according to the defendant, is evidenced by Claim 46 of SG 872, which Dr Nebel had referred to in his presentation to the court for the proposition that "dislocations do not grow straight":

> A CVD single crystal diamond material according to any one of the preceding claims, in the form of a plate having opposed major faces, which is prepared for use with an average dislocation direction in the plate more than 30° from normal to the major faces.

212 In my view, Dr Nebel and Dr Glazer are in fact in agreement that dislocations run close to parallel to the growth direction in CVD diamond: see also Prof Newton at [51]. Notwithstanding that Dr Nebel had referred to Claim 46 of SG 872, this was not meant to qualify the general proposition that dislocations run through the diamond "nearly perpendicular" to the growth direction. In fact, Dr Nebel doubted whether CVD single crystal diamond material could have an "average dislocation direction in the plate more than 30° from normal to the major faces", as stated in Claim 46. Dr Nebel's evidence that "dislocations do not grow straight" ought to be seen in the context of the following passage from cross-examination: [note: 140]

MR YEO: … On this point you said about dislocations, I have you, at [draft] page 121 of the transcript, when you were giving your explanation … "Dislocations, we're coming back to the general discussion of the application of diamond arise from the substrate. I pointed this out. They grow up, as you can see here. These are dislocation lines, *nearly perpendicular to the growth direction but not 100 per cent*. There is a distribution of these lines with an angle and, therefore, let's say this is interesting how they propagate, schematically shown in this picture."

…

Q: … I think your point was you do say they grow in the growth direction but not 100 per cent perpendicular*. I think you said "nearly perpendicular".*

A: Yes, yes.

Q: Thank you. Interestingly, while we're on this slide, Dr Nebel, what was the purpose of your referring to claim 46 in this slide?

A: We have obviously a discussion about the tilt angle of the growing dislocations.

Q: Dr Nebel, you are aware that claim 46 is not an issue in these proceedings; right?

A: I'm aware of that. Claim construction has left it out.

Q: That's right. *How dislocation propagates, you don't derive that from a particular claim in a patent, do you?*

A: It's a question to me?

Q: Yes, that's right.

A: So, yeah, yeah --

Q: If you see claim 46, that doesn't tell you --

A: No, it's a claim -- it's a claim. I think there's the meaning behind I haven't found or so. I mean, ***I could not follow this claim. I only wanted to have it here, because what you see in the picture, and there are manifold in the literature, the tilt angle is somehow not 30 degree.*** But, as I said, the claim has been formulated. Therefore, if you look into papers and pictures, you can immediately estimate if this falls into this definition or not.

Q: Right, but since claim 46 isn't a subject of this claim, then I, myself, was wondering why you included it.

A: Just to have a full picture of what is ongoing.

[emphasis added in italics and bold italics]

213 That the experts are in agreement on this point is also evidenced by the following:

(a) In C Holly *et al*, "Monocrystalline CVD-diamond optics for high-power laser application" (2016) , a paper co-authored by Dr Nebel, it is stated that:

> A few dislocations in the crystal induce characteristic stress fields which lead to birefringence. The dislocations are typically line dislocations which run through the diamond (mainly along the growth direction.

(b) Dr Nebel also confirmed in cross-examination that "dislocations grow in the direction of growth", which could be checked by x-ray topography. [note: 141]

(c) Dr Kaminsky accepted in cross-examination that "for single crystal CVD diamonds, the growth is basically in one direction, the vertical direction, from seeds or substrates which are placed in the CVD reactor". [note: 142] Further, the direction of growth could be confirmed with x-ray topography. [note: 143]

(2) Whether Dr Newton contradicted Dr Glazer's evidence

214 The defendant also raises several other points relating to the depth of field, which I reject and deal with briefly.

215 First, the defendant claims that Dr Newton contradicted Dr Glazer's evidence by stating "dislocations can multiply during growth. As growth means increasing thickness, it is apparent that dislocations multiply with increasing thickness". [note: 144] In my view, there is no contradiction between Dr Newton and Dr Glazer's evidence. It is one thing to say that dislocations multiply *during* growth, and therefore the dislocations between a sample of, for example, 0.25mm, might vary from one that is 0.5mm. But that does not detract from the point that in a given CVD diamond, in Prof Newton's own words, "the dislocations typically run approximately paralleled and in the growth direction": see [51] above. Consequently, the strain fields tend to show little variation through the depth of a sample.

(3) Whether the direction the sample is cut is material

216 The defendant also claims that taking Dr Glazer's points at their highest, the PSA is required to

know in which direction the sample has been cut with respect to the growth direction. According to the defendant, a diamond plate that is cut 90° to the growth direction of the diamond will have dislocations that are different from a diamond that is cut at any angle to the growth direction of the diamond. [note: 145] In my judgment, this point is neither here nor there. Even if one assumes that the defendant is right, it simply means that the resulting diamond material may not satisfy the requirements of Claim 1(ii) or 1(iii) of SG 872, and therefore not be infringing. This argument has no relevance to the depth of field, and whether Claim 1 satisfies the enabling disclosure or sufficiency requirement.

(4) The experiments conducted by the experts

217 Finally, I turn to the experiments conducted by Dr Glazer and Dr Kaminsky to prove their respective hypothesis. On Dr Glazer's part, he conducted an experiment on sample NL 719-05 (single crystal CVD diamond), with a thickness of 0.52mm. By measuring the top, middle and bottom of this sample, Dr Glazer concluded that "the fact that the sample thickness is significantly greater than the depth of field of the microscope objective has no significant effect on the [mod sine delta] maps for such samples". [note: 146] As for Dr Kaminsky, he conducted a similar experiment on a 1.9mm *thick salt crystal*. Dr Kaminsky measured the top, middle and bottom of the salt crystal by changing the focal height of the microscope, and found that there was a "marked difference" in the details of the salt crystal at each focal height. [note: 147]

218 It is telling that Dr Kaminsky decided to do his experiment on table salt rather than diamonds. Given that the subject matter at hand was CVD diamonds, and Dr Kaminsky could have obtained CVD diamonds from the defendant, one would have thought that it would have behoved Dr Kaminsky to conduct his experiment on CVD diamonds instead. On this point alone, one is able to place more weight on the results of Dr Glazer's evidence.

219 Further, as would have been plain to Dr Kaminsky, the atomic structure between diamond and table salt (*ie*, sodium chloride) is different. The refractive index of salt is also lower such that there is no optical equivalence, resulting in more defocussing in salt. The sample used by Dr Kaminsky was also several times thicker than the CVD diamond material disclosed in the specifications of SG 872 (1.99mm vs 0.5–0.8mm). [note: 148] It is therefore unsurprising that Dr Kaminsky had referred to this experiment as "a very extreme case". [note: 149]

Other claims within SG 872

220 I have decided Claim 1 is valid. It will also be clear from the infringement analysis, at [456], that the Claim 62 process with a higher level of nitrogen incorporation leaves a marker within the product. For example, WO 633 and WO 634 state that the concentration of single substitutional nitrogen in the diamond is in a range below 7.04 x 10^{15} atoms/cm^3 (*ie*, below 40ppb) and below 1.76 x 10^{16} atoms/cm^3 (*ie*, below 100ppb). [note: 150] However, the nitrogen concentration in a SG 872 diamond is higher given that there is more nitrogen incorporation. This is reflected in Claims 57 and 58 of SG 872 which claim for a range of below 5 x 10^{17} atoms/cm^3 (*ie*, below 2.84 ppm) and below 2 x 10^{17} atoms/cm^3 (*ie*, below 1.136ppm) respectively. Therefore, Claims 57 and 58, which make clear the difference in nitrogen structure between WO 633/634 diamonds and SG 872 diamonds, are also valid product claims read with Claim 1.

221 I do not deal with any other claims save for Claim 62, which was fully canvassed at trial.

Validity of SG 872 Claim 62

Inventive concept

222 I turn to Claim 62, which states as follows:

> 62. A method of producing a CVD diamond material suitable for optical applications and according to any one of the preceding claims, which method includes the steps of:
>
> - providing a substrate substantially free of crystal defects,
>
> - providing a source gas,
>
> - dissociating the source gas to produce a synthesis atmosphere which contains 300 ppb to 5 ppm nitrogen, calculated as molecular nitrogen, and
>
> - allowing homoepitaxial diamond growth on the surface which is substantially free of crystal defects
>
> wherein the surface damage of the substrate is minimised by including a plasma etch on the surface on which homoepitaxial diamond growth is to occur, whereby a density of defects at the surface of the substrate is such that surface etch features related to the defects is below 5 x $10^3/mm^2$,
>
> wherein the level of nitrogen is controlled with an error of less than 300 ppb (as a molecular fraction of the total gas volume) or 10% of the target value in the gas phase, whichever is the larger,
>
> and wherein the level of nitrogen is selected to be sufficient to prevent or reduce local strain generating defects whilst being low enough to prevent or reduce deleterious absorptions and crystal quality degradation, thereby producing a CVD single crystal diamond material meeting the requirements of one or more of claims 1 to 61.

223 The plaintiff frames the inventive concept of the process claim in SG 872 as follows: [note: 151]

> SG 872 also claims a novel method of producing the aforesaid diamond material which comprises substrate preparation which includes a plasma etch to minimise surface damage such that defect density at the surface of the substrate is below 5 x $10^3/mm^2$, and the deliberate and controlled addition of nitrogen such that the synthesis atmosphere contains between 300 ppb to 5 ppm of molecular nitrogen. [emphasis in original]

Priority date

224 There is no dispute that the priority date of Claim 62 is 21 November 2002. [note: 152]

Novelty

225 It is common ground between the parties that Claim 62 has three essential integers (with non-essential integers being irrelevant in deciding whether there is infringement, see *First Currency Choice* at [77]): [note: 153]

(a) A *substrate* substantially free of crystal defects, whereby the density of defects at the surface of the substrate is below 5 x $10^3/mm^2$;

(b) The substrate undergoes a *plasma etch* on the surface on which homoepitaxial diamond growth is to occur; and

(c) A provision of a source gas and dissociating the source gas to produce a synthesis atmosphere which contains *300ppb to 5ppm nitrogen*, calculated as molecular nitrogen.

Anticipation of ranges

226 I deal preliminarily with the treatment of anticipation of ranges as it is relevant to the approach to be taken to the prior art alleged. Claim 62 of SG 872 teaches the deliberate and controlled addition of nitrogen in the *range* of 300ppb to 5ppm. The defendant, in approaching the prior art, asserts that it is sufficient if a prior art discloses a single value that falls within the Claim 62 range. Where there is an overlap in ranges but no specific example in the range of overlap, on the basis of the IPOS Examination Guidelines paragraphs 3.50-2, it asserts there is anticipation if a PSA would have seriously contemplated applying the prior art in the region of overlap.

227 This issue of anticipation of ranges was dealt with the English Court of Appeal in *Jushi*, where the invention claimed was a glass fibre or "strand" for inclusion as reinforcement in other materials such as glass-reinforced plastic. The relevant claim, Claim 1, read as follows (*Jushi* at [6]):

1. A glass reinforcement strand whose composition comprises the following constituents in the limits defined below, expressed as percentages by weight:

SiO_2	58-63%
Al_2O_3	12-20%
CaO	12-17%
MgO	6-12%
CaO/MgO	≤2, preferably ≥1.3
Li_2O	0.1-0.8%, preferably ≤0.6%
BaO + SrO	0-3%
B_2O_3	0-3%
TiO_2	0-3%
$Na_2O + K_2O$	52%
F_2	0-1%
Fe_2O_3	51%

wherein the composition has an $Al_2O_3 + MgO + Li_2O$ content equal to 23% or higher.

228 The prior art that was considered by the English Court of Appeal, and referred to in the patent itself, was US Patent 4 199 364 ("Neely"). Neely disclosed boron and fluorine-free glass compositions for producing glass fibres. The relevant table was as follows (*Jushi* at [17]–[18]):

TABLE IV

INGREDIENTS	**PERCENT**
SiO_2	55-61
Al_2O_3	12-18
MgO	4-10
CaO	14-18
Na_2O	0.1-1.5
Li_2O	0.1-1.5
BaO	0.0-1.0

229 It was common ground in *Jushi* that the range of each of the constituents in Table IV either *fell within* or *overlapped* with the corresponding ranges in Claim 1 of the patent: *Jushi* at [19]. The question was whether Table IV deprived Claim 1 of novelty.

230 The English Court of Appeal noted the following principles as being pertinent:

(a) In general, a broad generic disclosure in the prior art does not take away the novelty of a claimed more specific one, citing *Dr Reddy's Laboratories (UK) Ltd v Eli Lilly and Co Ltd* [2010] RPC 9 ("*Dr Reddy*") at [28]–[29]. In *Dr Reddy*, a broad disclosure of *tens of thousands of chemical compounds* did not take away the novelty of a claim to a *single compound*. This was because when one had "a patent for a particular chemical compound and a prior art general disclosure, performance of the general disclosure *(which means no more than using anything within it)* does not necessarily result in infringement of the patent" [emphasis added]: *Dr Reddy* at [30]–[32].

(b) The issue of whether the prior art contains a disclosure of the invention will often depend on how the prior art would be understood by the PSA, taking account of the common general knowledge: *Jushi* at [47].

231 In *Jushi*, Floyd LJ expressed reservations about the serious contemplation test which I have referred to at [226]. Referring to his previous decision in *H Lundbeck A/S v Norpharma SpA* [2011] RPC 23, he explained at [49] that there is no disclosure of the narrower range. If no specific individual value is disclosed, there would be no clear directions to use a value within the narrower range. A person carrying out the disclosure of the prior range will not inevitably fall within the claim of the later patent.

232 Ultimately, the English Court of Appeal held that the serious contemplation test does not materially differ from the conventional approach to novelty expounded in *Synthon BV v Smithkline Beecham plc* [2006] RPC 10 and *Dr Reddy*. However, it was preferable to treat the latter cases as the

relevant yardstick: *Jushi* at [51]. That being the case, the court noted that the plaintiff did not point to anything in the prior art which taught the PSA *that they should operate in the area of combined overlap of those ranges*: *Jushi* at [52].

233 The English Court of Appeal then dealt with the question of whether it could be said that each and every combination of values had been disclosed in Neely, and at least of fraction of those combinations would fall within Claim 1 of the patent. As a matter of law, however, this submission was inconsistent with the principle in *Dr Reddy* – that a broad disclosure does not take away the novelty of a claim to a specific example or recipe: *Jushi* at [53]. Further, on the facts, the PSA would not have understood Neely to be telling them that one could indiscriminately choose any combination of values in Table IV: *Jushi* at [54]. Accordingly, the invention in Claim 1 of the patent remained concealed or hidden in the disclosure of Neely: *Jushi* at [56].

234 I adopt the same approach as *Jushi* in the present case. When dealing with overlapping ranges, the question to be asked is whether the prior art taught the PSA that they should operate in the area of the combined overlap of the ranges. Turning to the present case, the question to be answered for the novelty inquiry is thus whether carrying out the directions in the prior art will *inevitably result* in an infringement of Claim 62.

SG 508

235 I turn to the prior art cited by the defendant in its closing submissions. First, the defendant claims that SG 508 anticipated Claim 62 of SG 872. While SG 508 relates to a method of changing the colour of CVD by annealing (which I discuss in detail below), the specifications of SG 508 teach the growth of a CVD diamond "using the same process" as claimed in SG 872. [note: 154]

236 Although SG 508 was published after the priority date of SG 872, it is citable as prior art as it claims priority from GB 772, which has a priority date of 6 September 2002: see s 14(3) Patents Act.

237 According to the defendant, a PSA who uses the process described in GB 772 and SG 508 would have infringed Claim 62 of SG 872. The dispute here centres on the range of nitrogen disclosed in SG 508 which states as follows:

> [At the "Summary of the Invention"] In order to achieve reproducible results and tailor the final product the N in the process needs to be controlled. Typical concentrations in the gas phase (all nitrogen gas phase concentrations in this specification are based on the N_2, for example one N_2molecule is equivalent to 2 NH_3molecules) are *0.5 ppm – 500 ppm, more preferably 1 ppm – 100 ppm, and more preferably 2 ppm – 30 ppm*, but those skilled in the art will understand that the uptake of nitrogen is very sensitive to the process conditions such as temperature, pressure, and gas phase composition, so the invention is not confined to these limits. [emphasis added]

238 I also note that the defendant has cited two examples in SG 508, where the gas mixture is said to include 2.5ppm (Example 4) and 3.8ppm (Example 6) respectively. [note: 155] However, these two examples are *not disclosed* in the priority document GB 772. [note: 156] They are therefore not relevant to the novelty inquiry: see the analysis at [136]–[139].

239 SG 508 in fact only contains three examples which were disclosed in GB 772 (Examples 1 to 3). In these examples, nitrogen was introduced into the growth process at a concentration of 10ppm. [note: 157] The relevant question then is whether a PSA reading SG 508/GB 772 would be taught to add a nitrogen concentration in the combined region of overlap (*ie*, 0.5ppm to 5ppm). In my view,

given that that most preferred range of nitrogen was stated to be between 2ppm and 30ppm, and that the examples expressly stated that nitrogen was introduced at 10ppm, this would have *pointed the PSA away from operating at the combined region of overlap* (*ie*, 0.5ppm to 5ppm). There is nothing in SG 508 which teaches the PSA *not to use* nitrogen above 5ppm. To the contrary, the PSA would be taught by Examples 1 to 3 of SG 508 to use nitrogen at 10ppm.

240 SG 508 therefore does not anticipate Claim 62 of SG 872.

Badzian 2000

241 Badzian 2000 was concerned with the growth of "nearly perfect crystals". So far as the addition of nitrogen is concerned, it is stated as follows: [note: 158]

> [At p 352] The change in morphology of diamond crystals from cube to octahedron involves intermediary form such as a [cuboctahedron]. The growth rates depend on growth mechanisms, which are different for different crystallographic directions. *One can change morphology by the addition of small amounts of nitrogen or by a change of temperature*.
>
> …
>
> [At p 355] How can we improve the growth of nearly perfect crystals of diamond? Two approaches are anticipated … The second possibility is the *addition to the gas phase of gases such as O_2 and N_2* and molecules such as … These gases and their derivatives participate in growth process by influencing step formation and elimination of twinning. Smooth surfaces have been obtained in such processes. It is not clear, at this moment, which process parameters and gas concentrations these observations validate.
>
> [emphasis added]

242 According to Dr Nebel, the "addition of small amounts of nitrogen" described in Badzian 2000 is the equivalent of the addition of 300ppb to 5ppm in SG 872. [note: 159] I reject this contention. There is no nitrogen range set out in Badzian 2000, let alone one that overlaps with Claim 62 (as in SG 508). Following *Dr Reddy*, the generic disclosure of the addition of nitrogen does not take away the novelty of the specific range claimed in SG 872. There is nothing in Badzian 2000 which teaches the PSA to confine the use of nitrogen to the range of 300ppb to 5ppm.

243 Accordingly, Badzian 2000 does not anticipate Claim 62 of SG 872.

US 021

244 US 021 relates to a technique for producing CVD diamonds which can be used for semiconductor material, electronic and optical components. [note: 160]

245 There was some debate between the experts, Dr Bergonzo and Dr Nebel, over whether the teaching in US 021 was to *remove* nitrogen altogether, or to *add* nitrogen as a source gas. In any event, the nitrogen range which is referred to in US 021, found in Example 1, teaches the PSA to add nitrogen between 5 and 20ppm. However, the range in Claim 62 is 300ppb to 5ppm. There is nothing in US 021 which would confine the PSA to only use nitrogen at 5ppm and not a higher concentration.

246 Thus, US 021 does not anticipate Claim 62 of SG 872.

JP 890

247 I have dealt with JP 890 at [172] above in the context of the inventiveness of Claim 1 in SG 872. JP 890 is a patent which teaches the PSA how to grow high quality diamonds "at a higher rate of synthesis". The references to the addition of nitrogen ought to be seen in that context. For present purposes, the defendant highlights the following quotations from JP 890: [note: 161]

> [At p 2] Diamond vapour phase synthesis can provide a higher quality diamond at a higher rate of synthesis *by using a trace amount of nitrogen as a raw material gas.*
>
> [At p 5] However, the use of single crystal diamond is necessary for diamond applications that require a particularly smooth surface such as when used for ultra precise tools, optical components, and semiconductors and the like.
>
> [At p 6] The present inventors have discovered that by *adding a trace amount of nitrogen* to the feed gas when growing single crystal diamond on a diamond substrate from a gas phase, the growth rate of {100} epitaxial growth can be increased by five times or more without a loss of film quality, and the film quality by {111} epitaxial growth can be improved while doubling the growth rate … The first invention of the present application relates to a diamond synthesis method that epitaxially grows single crystal diamond from a gas phase using a feed gas comprising at least carbon (C), hydrogen (H), and nitrogen (N), wherein [N]/[H] in the feed gas is 3 ppm or higher and 1000 ppm or lower [according to the defendant, where "[N]/[H] in the feed gas is 3 ppm or higher and 1000 ppm or lower", this translates to the equivalent of molecular nitrogen in the synthesis gas of 1.5ppm to 500ppm.]
>
> [At p 9] If the amount of nitrogen added is low, the rate of diamond growth will be slow, but the film quality such as the transparency of the diamond obtained will be improved. If the amount of nitrogen added is too high, the rate of diamond growth will be fast, but the film quality of the diamond will be inferior. This effect of adding nitrogen was discovered by the inventors. Therefore, the optimum amount of nitrogen to add can be determined by the application and the price.
>
> [emphasis added]

248 Table 1 of JP 890 states as follows:

[Table 1]

[N]/[H]	0 ppm	3 ppm	10 ppm	30 ppm	100 ppm	300 ppm	0.1%	0.3%	1%
Growth rate μm/h	1.1	1.3	1.8	3.9	5.8	5.7	6.0	5.2	5.8
Raman Ia/Id %	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.1	2.3
Half-width of double-crystal x-ray diffraction (s)	30	35	32	34	31	43	52	60	95

249 According to the defendant: [note: 162]

> The quotes and table above prove that the alleged discovery in [SG 872] to speed up the growth of the diamond by adding nitrogen without compromising on the quality of the grown diamond was completely anticipated by JP 890.

250 JP 890 merely teaches the PSA to add a "trace amount of nitrogen" to "provide a higher quality diamond at a higher rate of synthesis". The nitrogen concentration is quantified in the "first invention of the present application" as being 1.5ppm to 500ppm. The question then is whether the PSA would confine themselves to the combined range of overlap with Claim 62 of SG 872 (*ie*, 1.5ppm to 5ppm).

251 In my judgment, there is nothing in JP 890 which teaches the PSA not to add nitrogen above 5ppm. In fact, from Table 1 of JP 890, it shows clearly that the growth rate of the CVD diamond only increases when 30ppm of nitrogen is added. This was the teaching of JP 890.

252 Accordingly, JP 890, as with SG 508, Badzian 2000 and US 021, does not anticipate Claim 62 of SG 872.

Inventiveness

253 I turn to the inventiveness inquiry for Claim 62 of SG 872. Applying the *Windsurfing* approach:

(a) Step 1: The inventive concept in Claim 62 of SG 872 is the deliberate and controlled addition of nitrogen between 300ppb and 5ppm in the synthesis atmosphere, to reduce dislocations in the resulting material which will be of lower optical birefringence.

(b) Step 2: The common general knowledge as of the priority date of SG 872 was the addition of nitrogen would speed up the growth rate of CVD diamonds. However, the common general knowledge at the material time was that the addition of nitrogen would *increase birefringence*. Indeed, this is still the view held by Dr Nebel, as illustrated in the chart drawn by Dr Nebel and Dr Bergonzo.

(c) Step 3: The difference between the prior art and the claimed invention relates to the addition of nitrogen in the synthesis atmosphere within the controlled range of 300ppb to 5ppm, in order to obtain CVD diamond material of low birefringence in the SG 872 Range.

(d) Step 4: The question, therefore, is whether it would have been obvious to the PSA seeking to obtain a low birefringent diamond in the SG 872 Range that they should add nitrogen within the controlled range of 300ppb to 5ppm in the synthesis atmosphere.

Whether the step was obvious

254 The inventive concept of Claim 62 was contrary to the common general knowledge as of 21 November 2002. As Prof Newton explained: [note: 163]

> … in CVD diamond growth it was established in the mid 1990's that nitrogen could increase the growth rate (primarily demonstrated in polycrystalline layers) and also affect the growth quality of CVD diamond, making it brown and optically absorbing. The latter was not unexpected in that it was consistent with a general principle in crystal growth; *the faster the growth rate the more defects produced in the crystal.* [emphasis added]

255 Dr Nebel confirmed that for CVD diamonds, "the thinking was [that] nitrogen causes a variety of defects to be formed or present". [note: 164] Further, it was understood as at November 2002 that "[a]dding more nitrogen would … increase strain". [note: 165]

256 Consequently, nitrogen was seen as an *impurity* or *contaminant* which ought to be reduced to

the lowest practical levels possible. [note: 166] What SG 872 taught was that *contrary to this common general knowledge*, the deliberate and controlled addition of nitrogen *between a specified window* of 300ppb to 5mm would reduce strain resulting from dislocations in the CVD material, therefore improving the optical properties in the CVD diamond material. In this regard, it is useful to refer to Dr Bergonzo's evidence: [note: 167]

> 35. … the method used to achieve this new "optical grade" was *contrary to expectation and came as a surprise.* In combination with the carefully controlled substrate preparation, made public only quite recently by the earlier Element Six patent, WO 633, SG 872 provided novelty by the deliberate introduction of finely controlled amounts of nitrogen back into the gas phase, such that the *nitrogen level was above that defining electronic grade diamond processes, but below the level where optical absorption rose significantly.* Since by this stage electronic properties were known to be very sensitive to nitrogen levels above 300 ppb, and there was an (incorrect) tendency to assume that defects which affected electronic properties would affect optical properties similarly, then this window of low nitrogen additions was unexpected. The improvement it enables for optical applications strongly differentiates these materials from electronic grade ones as materials showing high electronic performance can exhibit high stress and poor optical properties.
>
> 36. Even more unexpected was that *such low nitrogen levels had a substantial effect on the strain resulting from dislocations in the material, and indeed the mechanism for this effect is still not entirely apparent although elements can be postulated.* This enabled the process to grow CVD diamond which retains a low level of optical absorption, but also with substantially reduced strain and level of birefringence generated by the strain around dislocations. There was no teaching or prior art on this precisely because this was such an unexpected direction, both in terms of the material development and the method used to achieve it.
>
> 37. Thus SG 872 demonstrates that, in combination with carefully prepared substrates, the fine control of the nitrogen impurity content in the gas phase, at values from 0.3 to 5 ppm, or more generally in the ideal range from 0.5 to 2 ppm, governs the crystal quality in terms of its impact on optical characteristics, as well as the rate of growth of the diamond material. As mentioned above, SG 872 allows for the growth of CVD diamond which retains a low level of optical absorption, but also has a substantially reduced strain and level of birefringence generated by the strain around dislocations. SG 872 explains how this particular control of the nitrogen content also enables one to grow layers above 1mm in thickness, whilst increasing the rate of CVD diamond growth. In fact, if no nitrogen was added to the gas phase, when growing to thicknesses above about 1mm, the crystal may crack during synthesis, or post synthesis behave in a brittle fashion, being difficult to polish properly and often breaking during lapping and preparation. This problem with brittleness and cracking in colourless or near colourless CVD diamond materials made not using the teachings of SG 872 also remains true today.
>
> 38. Consequently, SG 872 genuinely enabled a range of new, more capable CVD diamond optical materials to be manufactured and provided the consistency and reliability of product and product yield necessary for these materials to be commercialised.
>
> [emphasis added]

Disputed object of nitrogen

257 The defendant disputes inventiveness not by contending that the concept was obvious, but rather, that the concept did not result in the practical effect claimed. Its assertion was that the

addition of nitrogen is *only* to increase the growth rate (*ie*, to allow for the growth of low birefringent diamonds at a commercially viable rate). [note: 168] Its position is that "the addition of nitrogen will increase the optical birefringence in the grown diamond because nitrogen will introduce defects into the diamond". [note: 169]

258 I had referred earlier to Example 9 of SG 872 which supports the inventive concept of Claim 62: see [97]. That the focus of Claim 62 was to obtain a CVD diamond of lower optical birefringence, as opposed to improving the growth rate, is also supported by JP 890, which shows that the growth rate only increases significantly when nitrogen of 30ppm is added. Dr Nebel had also referred to the relevant table in JP 890 in his 2nd AEIC, discussed in detail at [248] above. [note: 170]

259 The defendant does not attempt to disprove positively the plaintiff's contention on the effect of the addition of the small amount of nitrogen. Instead it contends that the plaintiff has made admissions to the contrary. The defendant refers to the plaintiff's own patent WO 2015/071484 ("WO 484") filed on 18 November 2014, which purportedly contains an admission from the plaintiff that nitrogen was introduced to "increase growth rates while not being so high as to unduly affect optical properties": [note: 171]

> A problem with synthesizing low defect, high purity single crystal CVD synthetic diamond material is that such material has a very low growth rate and is thus time consuming and expensive to manufacture. Furthermore, due to the extended time periods required to obtain a desired thickness of such material at low growth rates, the growth process must be very precisely controlled over extended time periods and this can be difficult to achieve in practice resulting in reduced yields. Electronic/detector grade single crystal CVD synthetic diamond material as described in W001/096633 and W001/096634 is grown using a CVD growth process in which nitrogen is essentially excluded, at least to the extent that this is practically possible (e.g. no more than 300 ppb, 200 ppb, 100 ppb, 50 ppb, or 20 ppb of nitrogen in the CVD synthesis atmosphere). ***In contrast, optical grade single crystal CVD synthetic diamond material as described in W02004/046427 [i.e. SG '872] is grown using a CVD growth process in which a low and controlled concentration of nitrogen is introduced to increase growth rates while not being so high as to unduly affect optical properties*** . However, while single crystal CVD synthetic diamond material according to this process is suitable for many optical applications, the concentration of nitrogen incorporated into the material is such that the material is not ideally suited for certain high-end optical applications and certain other applications such as electronic, radiation detector, and quantum sensing and processing applications which require higher purity material and a CVD growth process in which nitrogen is essentially excluded. Furthermore, even for applications which are not detrimentally affected by the presence of a low and controlled concentration of nitrogen in the single crystal CVD synthetic diamond material, it can be difficult to obtain consistent and reproducible optical properties, such as low absorption, utilizing a low and controlled nitrogen addition.
>
> [emphasis added in bold italics]

260 The plaintiff however points out that in another section of WO 484, it is stated as follows: [note: 172]

> In contrast to the low defect materials described above, for certain applications *it is desirable to intentionally introduce a significant but controlled quantity, type and distribution of defects into the diamond lattice structure*. For example … [emphasis added]

261 WO 484 therefore does not assist the defendant's case. It is not disputed that the addition of large amounts of nitrogen would speed up the growth of CVD diamonds. At the same time, the plaintiff's contention in Claim 62 is that the addition of a specific amount of nitrogen would lower the birefringence. The plaintiff highlights that in the defendant's own patent, WO 2016/144256, the dual effects of nitrogen are also stated: [note: 173]

> Nitrogen, according to Yan et. al. and Yamazaki, is required for two purposes. Specifically, nitrogen is used to *enhance growth rates* of CVD grown mono-crystalline diamond and to *prevent lattice defects* in electron cyclotron resonance CVD grown mono-crystalline diamond. [emphasis added]

262 The defendant also relies on purported admissions by Dr Scarsbrook, Dr Newton and Dr Bergonzo made during trial. However, read in context, it is clear that none of them had admitted that the addition of nitrogen was only to increase the growth rate of CVD diamonds.

263 First, Dr Scarsbrook's purported admission is said to be found in the following extract: [note: 174]

Ct:	Are we saying that, in theory, 506 could be used to provide the kind of diamond, the product that 872 envisages, but –
A:	No, I am not, your Honour. 506, I think, is what we call the coloured patent –
Ct:	No, no, that is 508. 506 is the 633/634.
A:	Okay. So WO 634 is the patent you are referring to. No, we did, and could, grow thicker samples, your Honour, but they were very difficult to grow. They were not consistently grown and they did tend to crack on processing. It was one of the problems that we had and still have. It is this issue that if you want a production process, it's got to be consistent. You've got to avoid the stresses associated with high purity material.
Ct:	I see.
A:	Yeah.
Prof Loh:	I would like to clarify again. When I read through 506, 633, 634, they describe a way to produce diamond that is quite thick, it's about 2mm and above 5mm, it's with very little addition of nitrogen. ***In theory, it is possible to produce very thick, optically pure diamond by not adding too much nitrogen?***
A:	***It is, Professor Loh.*** In theory, as I say, it was very difficult to do repeatably. It was generally done in very small volumes. The other problem that you have quite often is that if you have a number of stones in a process and one or two start to break, they actually disrupt the process for everything in there and so you end up having to grow very few stones at once and being very careful and they can still break.

Prof Loh:	The 872 patent seems to be more concerned with the commercial production, the speed of production.
A:	*No. So the reason why all the earlier material or the high purity material was breaking was because of the intrinsic strain caused by the dislocations. Once we had discovered that adding a small amount of nitrogen back in, then you find that that stress reduces and then you have optical applications which you could not address otherwise.*

[emphasis added in italics and bold italics]

264 It is clear, therefore, that Dr Scarsbrook did not admit that the addition of nitrogen was only to increase the growth rate CVD diamond. In fact, he had expressly stated that the addition of nitrogen would result in a reduction in strain, stress and hence birefringence. On that note, I should also highlight that Dr Scarsbrook explained that there was a distinction to be drawn between a *pure* and *perfect* diamond: [note: 175]

Dr Scarsbrook:	Ah. There is quite a big distinction between pure and perfect. "Pure" means it doesn't have any impurity atoms in. "Perfect" means it has no crystal defects.
Prof Loh:	Pure and perfect, let's put it this way.
A:	Okay, so perfect, you're right, would have no birefringence. *If it's pure but it does have dislocations, then it will have birefringence.*

[emphasis added]

265 Next, the defendant also contends that Prof Newton made a similar "admission", relying on the following passage: [note: 176]

Prof Loh:	Assuming that the 872 is not around, just for hypothetical consideration, is it not possible to produce a low optical birefringence diamond just using 633/634? Is there no chance that you will come to the window and then you end up unwittingly growing it?
A:	Professor Loh, I don't think it is unwitting, as in I would agree that the Tallaire 2017 paper, which has come 15, 16, 17 years later, has produced material -- I can't quantify the birefringence, but there are crossed-polars. It looks good material and it is good electronic material. They have used better substrates.
Prof Loh:	In principle, by the choice of substrate, which is very important, I can combine with 633 and 634 to grow a very high quality, optically high quality diamond.

A: I can't comment on the exact but, yes, as in I -- we are scientists, I know what you mean. The 2017 paper has produced material, *but it has used something, a substrate that was not available back in 2002*, this new material from new diamond technology, where they have grown high pressure high temperature material –

Prof Loh: I agree.

A: -- of exceptional material.

Prof Loh: ***In other words, it is possible by science, but from a commercial production viewpoint, 872 has its value because of speeding up the process; right?***

A: ***Yes, I agree with you.***

Prof Loh: In a laboratory, we can always grow low optical birefringence diamond by choosing a good substrate and by using the teaching from 633/634? There is a possibility of growing this diamond?

A: So, that can be done ***n o w*** *because there have been improvements in substrates and the later US 633 patent again has produced a better substrate that then the electronic grade material has got better optical properties on top of it.*

[emphasis added in italics and bold italics]

266 Thus, Prof Newton's opinion was that the prior art, being WO 633 and WO 634 could produce low birefringent CVD diamonds within the SG 872 Range *but only because of the improvement in substrates post-dating the priority date of SG 872*.

267 Dr Bergonzo's "admission" is said to be contained in the following extract: [note: 177]

MR SINGH: Thank you very much. It appears from what we have seen that before 872, it was already known that there was a process to grow low birefringent diamonds which could be used for optical applications; correct?

…

A: I agree that there was a technique reported in this patent that was probably aiming at fabricating material with low birefringence, but using a very complex approach which cannot realistically be industry-realised.

Q: We will come to that. We will come to that. When you say it cannot realistically be industry-realised, you mean cannot be commercialised; correct?

A: Okay, yeah, probably it cannot be commercialised. It could be commercialised even though it's -- I mean, it cannot be making benefit from commercialising it using this technique to fabricate it.

Q: Thank you. The answer to my question is, "Yes"; right?

A: Yes.

Q: Thank you. Therefore, what 872 was intended to do was to teach how those ***very same low birefringent diamonds*** could be grown in a way which would be commercially viable; correct?

A: I disagree, on the fact that it is using the word ***"very same low birefringent diamonds"*** because 506 doesn't give a value of the low birefringence.

Q: Let's not be controversial here. What 872 was intended to do was to teach how low birefringent diamonds could be grown in a way which would be commercially viable; correct?

A: Yes, correct.

Q: To make it commercially viable, the diamonds had to be grown faster; correct?

A: If you can do -- achieve the performance required and make it faster, then it's even more commercially viable.

Q: You start off with it not being commercially viable, okay, and then you move to a position where it is commercially viable. The difference between the two is the rate of growth of the diamonds; correct?

A: The faster you can grow diamond with the performance given in 872, the more the benefit you can make if you want to sell them. I agree with that.

268 Nowhere in this passage does Dr Bergonzo say that the only effect of the adding nitrogen is to increase the growth rate of CVD diamonds. Further, Dr Bergonzo had expressly qualified his answer and did not agree that SG 506 would result in the "very same low birefringent diamonds" as in SG 872. I should also note that there is no inconsistency in stating that the controlled addition of low levels of nitrogen reduces birefringence in the CVD diamond and therefore allows the production of diamond material suitable for optical applications in a manner that is commercially viable.

269 For completeness, I close this section with the observation that the experts' inability to explain why nitrogen would have the desired effect is irrelevant. In *Merrell Dow*, the plaintiff was able to patent terfanadine, an anti-histamine drug which did not have the side effect of making one drowsy, notwithstanding the fact that it was not understood precisely at the time of its first patent why there was no side effect: see *Merrell Dow* at [5]. The defendants' submission criticising the plaintiff's inability to explain the "strange effect" of nitrogen, in Prof Newton's words, is therefore wholly unmeritorious. The defendant bears the burden of making good its allegation that the addition of the small amount of nitrogen did not achieve its claimed effect.

Combinations cited as prior art

270 The defendant submits that it was obvious to add nitrogen to the synthesis atmosphere to speed up the growth of low birefringent diamonds. [note: 178] That is beside the point as it does not

fully account for the inventive concept in Claim 62 of SG 872. It is undisputed that it was obvious to add nitrogen to speed up the growth of low birefringent diamonds. What is in dispute is whether it would be obvious to add nitrogen, *in a controlled range*, to *obtain CVD diamonds of lower birefringence* than those that existed in the prior art. The defendant summarises Dr Nebel's evidence on the obviousness of Claim 62 in its closing submissions, with no less than 27 different combinations of prior art. [note: 179] They are not relevant because they are not directed at the inventive concept of Claim 62. I do not propose to analyse each combination in detail, and will analyse them under broad categories.

Badzian 2000 and combinations

271 I first address the combinations which include Badzian 2000. As stated above at [241], Badzian was concerned with the growth of "nearly perfect" crystals. Although the addition of nitrogen is disclosed (without any mention of a specified range), that is in the context of "influencing step formation and eliminating of twinning". There is nothing in Badzian 2000 which would make it obvious to the PSA to add nitrogen in the controlled range of 0.3ppm to 5ppm in order to *reduce birefringence* in the CVD diamond material.

272 Further, none of the prior art which Dr Nebel reads alongside Badzian 2000 render Claim 62 of SG 872 obvious. I deal with each of them briefly, save for Masahiko Mitsuhashi et al, "Dislocation of epitaxial CVD diamond and the characterization by Raman spectroscopy" (1992) 60/61 Applied Surface Science 565 ("Mitsuhashi") and Chunlei Wang et al, "Growth and characterization of hillock-free high quality homoepitaxial diamond films" (2000) 9(9-10) Diamond and Related Materials 17650 ("Wang"), which make no reference to nitrogen concentration at all. The defendant cites Mitsuhashi for the proposition that it teaches a PSA to use a substrate with a defect density of less than 400/mm^2, and Wang for the proposition that it teaches the PSA how to perform a plasma etch on the substrate to eliminate the development of hillocks.

(1) Badzian 2000 and US 430

273 According to the defendant, US 430 teaches a PSA that a CVD diamond with a nitrogen content of 0.1 to 1000ppm that is annealed will have low stress and therefore low birefringence. [note: 180] The relevant passage in US 430 reads:

> A preferred starting CVD diamond film for optical applications is a non-opaque or transparent or translucent and may contain oxygen in atomic percent greater than 1 part per billion. Undesirable impurities in the form of catalyst material, such as iron, nickel, or cobalt are preferably present in amounts less than 10 parts per million in atomic per cent. These impurities are typically associated with competing high-pressure high-temperature diamond synthesis processes. Nitrogen may be present in the CVD diamond film in atomic per cent from between 0.1 to 1000 parts per million.

274 This passage says nothing about the controlled *addition* of nitrogen to reduce birefringence. It only says that nitrogen *may be present* in the CVD diamond film. By way of a certain incorporation ratio, Dr Nebel extrapolates this to mean that nitrogen must be added in the range of 300ppb to 5ppm. In my view, there is no basis for this extrapolation. In any event, US 430 was concerned enhancing the toughness of CVD diamonds; it was not concerned with annealing to reduce the birefringence of CVD diamonds. Furthermore, Dr Nebel's evidence in cross-examination was that annealing a CVD diamond would *not* reduce its birefringence: see [178] above.

(2) Badzian 2000 and US 412

(2) Badzian 2000 and US 412

275 The defendant point out that US 412 teaches a PSA that to achieve a diamond with a nitrogen content of 0.2ppm, the nitrogen in the synthesis atmosphere should be limited to 1ppm, which is within the limits of Claim 62. [note: 181] There is nothing in US 412 that would even suggest *adding* nitrogen to reduce birefringence; in fact, as stated at [175]–[176], US 412 teaches the PSA to *remove* nitrogen and to limit it to no more than 1ppm.

(3) Badzian 2000 and Bruzzi

276 The defendant contends that Bruzzi describes the diamond claimed in WO 633 and WO 634. Bruzzi discloses that such a diamond has a nitrogen content between 6ppb to 60ppb. According to the defendant, a PSA would know that this requires the diamond to be grown in a synthesis atmosphere of between 300ppb and 5ppm. However, Bruzzi does not suggest adding nitrogen to remove birefringence. The addition of nitrogen would in fact have contradicted WO 633/634 which taught the removal of nitrogen.

(4) Badzian 2000 and JP 890

277 JP 890, which I have discussed in detail at [247]–[252], teaches the PSA to add a "trace amount of nitrogen" to "provide a higher quality diamond at a higher rate of synthesis". It does not suggest to the PSA to add nitrogen to reduce the birefringence in CVD diamond.

Isberg and combinations

278 Next, the defendant relies on Isberg, and combinations between Isberg and other prior art, to argue that Claim 62 of SG 872 is obvious. I do not propose to deal with each combination individually, as the respective combinations simply substitute Badzian 2000 with Isberg. The reliance on Isberg is even weaker than that of Badzian 2000 as the defendant itself acknowledges that Isberg taught the PSA to eliminate nitrogen in the synthesis atmosphere "as much as possible". [note: 182]

US 021 and combinations

279 According to the defendant, US 021, *inter alia*, teaches the PSA to grow CVD diamond in an atmosphere where the concentration of the nitrogen is *between 5ppm and 20ppm*. The defendant then submits that by combining US 021 with other pieces of prior art (specifically, US 430, US 412, Bruzzi, or JP 890), the PSA would further limit the nitrogen range disclosed in US 021. I have dealt with these prior art above. It suffices to state that US 021, US 430, US 412, Bruzzi and JP 890 do not contain any reference to birefringence. They do not contain any suggestion that an addition of nitrogen, let alone a controlled amount of nitrogen, would reduce birefringence. I therefore do not consider that US 021 or any of its combinations renders Claim 62 of SG 872 obvious.

WO 633/634 and combinations

280 The defendant also submits that WO 633/634, read with US 430, US 412, Bruzzi and JP 890 would render Claim 62 of SG 872 obvious. To the contrary, WO 633/634 is in fact evidence of the inventiveness in Claim 62, in so far as WO 633/634 taught the PSA to *remove nitrogen* from the synthesis atmosphere. Page 18 of WO 633 states that:

> More particularly, the diamond growth must take place in the presence of an atmosphere containing substantially no nitrogen, i.e. less than 300 parts per billion (ppb, as a molecular

fraction of the total gas volume), and preferably less than 100 parts per billion.

JP 890 and combinations

281 Next, the defendant contends that Claim 62 of SG 872 is obvious in the light of JP 890, read with Bruzzi, Mitsuhashi, Wang, US 430 or US 412. But JP 890 is concerned with the addition of nitrogen to increase the growth rate of CVD diamonds, and Table 1 of JP 890 shows that the nitrogen has to be added at least 30ppm before the growth increase shows significant increase. In the circumstances, it does not make the teaching in Claim 62, *ie the controlled addition of nitrogen within a specific range*, obvious.

Sufficiency

282 According to the defendant, Claim 62 insufficiently discloses the claimed invention. I deal with its arguments in turn.

283 First, the defendant contends that a PSA will not know how to select the appropriate nitrogen concentration because the PSA would not know the quantitative relationship between the addition of nitrogen in the synthesis atmosphere and the reduction or control of dislocation density or strain in the resulting diamond. [note: 183] This is wholly unmeritorious. Claim 62 itself states the nitrogen concentration to be between 300ppb and 5ppm, and that the addition of a controlled amount of nitrogen within this range, along with the other steps in Claim 62, will lead to a low birefringent CVD diamond in the SG 872 Range.

284 Second, the defendant also submits that a PSA would not be taught how to calibrate the other growth parameters to ensure that the level of nitrogen is kept consistently at the desired level of concentration during the period of growth. [note: 184] For example, while Example 1 of SG 872 discloses the pressure, temperature and gas flow rate for a process which uses 1ppm of nitrogen, it does not disclose the required geometry of the reaction chamber, the appropriate microwave power for those growth conditions or the geometry of the molybdenum substrate holder.

285 As stated at *Rohm & Haas* at [158], it is not sufficient for the party seeking to invalidate the patent to merely highlight ambiguities in the claims. The burden of proof is on that party "to show that those ambiguities would render the invention unworkable from the point of view of a person skilled in the art who is trying to give practical meaning to the patent specification". In this regard, the PSA possesses common general knowledge and common sense as befits the area of technology in question. I prefer Dr Bergonzo's evidence that the missing details, such as the geometry of the substrate holder, would be within the knowledge of the PSA skilled with working knowledge of the research and development of CVD diamond synthesis. Even if there are indeed ambiguities, as stated in *First Currency Choice* at [62], "it is not necessary that the specification be so detailed that this notional individual can perform the invention without any trial or experiment at all".

286 Third, the defendant claims that Claim 62 is insufficient due to the overlap of *examples* in SG 872, SG 508 and GB 115 (specifically, Examples 1 and 14 of SG 872, Examples 4 and 6 of SG 508 and Examples 1 and 5 of GB 115). [note: 185] Although all the relevant examples are grown in a synthesis atmosphere where the nitrogen concentration is between 300 ppb to 5 ppm, the resulting grown diamonds have different qualities. SG 872 discloses the growth of a low birefringent diamond, SG 508 discloses the growth of a coloured diamond that is annealed into a desired colour and GB 115 claims the growth of a diamond that is coloured. [note: 186] The argument that is being run is that a PSA reading the relevant examples would expect the diamonds grown using these methods to be identical.

The fact that they are not identical shows that Claim 62 is insufficiently disclosed. [note: 187]

287 It is not clear how the mere fact that the examples in the three patents overlap make it such that Claim 62 of SG 872 is insufficiently disclosed. The plaintiff has explained that there are other parameters which vary between the three patents which would render the resulting material different (*eg* higher gas flows in SG 508 and GB 115 and higher methane concentration in SG 872 than SG 508). [note: 188] The defendant's rebuttal is that the *significance* of these different parameters are not taught to the PSA in SG 872. In my view, Claim 62 of SG 872 needs to be clear and complete such that it can be performed by a PSA. Merely because the plaintiff has not stressed the significance of certain parameters which are different from other patents does not mean that Claim 62 is insufficiently disclosed. These other parameters do not constitute the inventive concept of SG 872.

288 Even if I assume that a PSA following the relevant examples in SG 508 and GB 115 would produce a low birefringent CVD within the SG 872 Range, that is a matter for the novelty and inventiveness inquiries, rather than a question of sufficiency.

Validity of SG 508

The Claim 1 invention

289 So far as the dispute over the validity of SG 508 is concerned, the dispute centres on Claim 1 of SG 508, which the plaintiff concedes is the only independent claim of the patent. Claim 1 reads:

> A method of producing single crystal CVD diamond of a desired colour includes the steps of providing single crystal CVD diamond which is coloured and heat treating the diamond under conditions suitable to produce the desired colour.

290 Under the "Summary of the Invention", it is stated that the starting colour of the CVD diamond, typically brown, can upon annealing "be converted into any one of a number of desirable colours including colourless and near colourless, and particularly fancy colours [*eg* fancy green, fancy pink]". The alleged invention in Claim 1 was thus particularly useful for gemstones. [note: 189]

291 For reasons explained below, I find SG 508 neither novel nor inventive.

Priority date

292 There is no dispute that the priority date of Claim 1 of SG 508 is 6 September 2002. [note: 190]

Novelty

293 In my view, Claim 1 of SG 508 lacks novelty, as it is anticipated by several pieces of prior art. It should be noted that Claim 1 is drafted in a general manner without specified parameters. So long as a prior art discloses and enables a process of annealing CVD diamonds to produce a desired colour, Claim 1 will lack novelty.

WO 406

294 I begin with WO 01/72406 ("WO 406"), a patent owned by De Beers which was published on 4 October 2001 which is concerned with annealing in order to change colour. Under the heading "Description of Embodiments", WO 406 is described as follows:

> In the present invention, a brown type IIa diamond crystal, *which will generally be natural diamond*, is annealed under a pressure which prevents significant graphitisation in order to modify the structural deformation which gives rise to the brown colouration and thereby reduce the brown colour and produce a colourless diamond. … [emphasis added]

295 Claims 1 and 2 of WO 406 read as follows:

> 1. A method of changing the colour of a *brown* ***type IIa diamond*** from brown to colourless includes the steps of:
>
> (i) creating a reaction mass by providing the diamond in a pressure transmitting medium which completely encloses the diamond, and
>
> (ii) subjecting the reaction mass to a temperature in the range 2200°C to 2600°C under a pressure of 7,6GPa to 9GPa for a suitable period of time.
>
> 2. A method according to claim 1 wherein the diamond is a *natural diamond*.
>
> [emphasis added in italics and bold italics]

296 Based on a plain reading of Claims 1 and 2, it is clear that Claim 1 relates to brown type IIa diamonds *of all origins*, including CVD diamonds. As stated by Prof Newton himself: [note: 191]

> Although developed for natural diamonds, the Type Classification system can also be applied to synthetic diamonds. *CVD diamonds typically contain a relatively low level of nitrogen and thus are classified as Type IIa diamonds*. [emphasis added]

297 The plaintiff, however, denies that WO 406 anticipates Claim 1 of SG 508. Its sole contention is that WO 406 is only concerned with natural diamonds. The example in WO 406 deals with natural diamonds and there is no mention of CVD or even synthetic diamonds anywhere in the patent. The plaintiff asserts that the defendant's reading of WO 406 bears the hallmark of an "overmeticulous verbal analysis". [note: 192]

298 I reject the plaintiff's submission. First, if one were to accept the plaintiff's contention that Claim 1 of WO 406 is only limited in scope to natural diamonds, that essentially renders Claim 2 otiose. Second, the description of WO 406 states that the diamond will "generally be a natural diamond". This must mean that the scope of Claim 1 of WO 406 is not restricted to natural diamonds. A PSA reading the two claims together would conclude that the method is also claimed for CVD and HPHT diamonds. In this context, this case may be distinguished from *Dr Reddy*, where it was held that disclosure of a large class does not result in disclosure of every member of it. In *Dr Reddy*, a PSA would not have inferred the specific disclosures because the claims in that case disclosed tens of thousands of chemical compounds. In the present case, a PSA reading Claims 1 and 2 would recognise that Claim 1 was also intended to cover CVD and HPHT diamonds as they were the only other categories of diamonds outside of that claimed in Claim 2. Accordingly, a PSA following the teachings in Claim 1 of WO 406 on a CVD diamond would *inevitably* apply the method, and achieve the result, taught in Claim 1 of SG 508. Both claims teach the PSA to anneal a diamond in order to change its colour: the difference is that Claim 1 of WO 406 refers to Type IIa diamonds (which I have found includes CVD diamonds) while Claim 1 of SG 508 refers specifically to CVD diamonds.

EP 482 and US 430

299 In any case, European Patent Application No 0671482A1 ("EP 482") and United States Patent No 5451430 ("US 430") are General Electric ("GE") patents published in 1995 that deal specifically with CVD diamonds and reveal the same process.

300 I should first clarify that following the rule against mosaicing, I compare EP 482 and US 430 individually against SG 508. However, both parties accept that the processes described in EP 482 and US 430 are substantially similar and the reasoning below therefore applies equally to both EP 482 and US 430.

301 EP 482 describes a process where CVD diamonds could be *annealed* in order to reduce the size of voids and reduce strain, so as to obtain enhanced properties (optical transmission, toughness, strength, wear, uniformity of wear properties). [note: 193] Claim 1 of EP 482 states as follows:

> A process for producing a diamond body having reduced density and stress gradients comprising treating a chemically vapor deposited diamond body of the type having voids at sufficient temperatures and pressures wherein diamond is the thermodynamically stable phrase of carbon to reduce the size of the voids to form a diamond body of reduced density and stress gradients.

302 US 430 describes a similar process of annealing in order to enhance the properties of CVD diamonds described above. Claim 1 of US 430 reads as follows:

> A process for stress relieving CVD diamond comprising annealing said CVD diamond at temperature of above about 1600 to about 1900 degrees Centigrade in a gaseous non-oxidizing atmosphere at a pressure less than about 5 atmospheres and for a period of time which decreases with increasing annealing temperature from a time of less than about 10 minutes at a temperature of about 1600 degrees to a time of less than about 15 seconds at about 1900 degrees for preventing excessive graphitisation of said diamond.

303 In the present case, it is common ground between Prof Newton and Dr De Weerdt that the annealing process *per se* is substantially similar for SG 508, EP 482 and US 430. For example, there is an overlap with regard to the temperature ranges. [note: 194]

304 The plaintiff's case, however, is that both patents do not mention colour, teach annealing of a coloured CVD diamond to change its colour and/or indicate any change of colour in the CVD diamond pre- and post- annealing. [note: 195] Rather, the teaching in both EP 482 and US 430 was how CVD diamonds could be annealed to enhance its properties, and in particular, its toughness. [note: 196]

305 I accept that there was no *express* disclosure that annealing a CVD diamond would result in a change in colour. The plaintiff is right that the colour of the CVD diamonds, let alone a change in colour, was not observed or mentioned in EP 482 and US 430. [note: 197]

306 However, I consider that there is *inherent* disclosure in EP 482 and US 430 that a coloured CVD diamond which is annealed under suitable conditions would change to a desired colour. The plaintiff accepts that the annealing processes in EP 482, US 430 and SG 508 are, for all intents and purposes, the same. That being the case, there is no reason why a PSA, following the directions contained in EP 482 and US 430, will not inevitably apply the method taught in Claim 1 of SG 508, with the effect of producing a CVD diamond of a desired colour. As noted by Lord Hoffmann in *Merrell Dow* at [47], whether a PSA is working an invention is an independent fact of what he knows or thinks about what he is doing.

307 Further, as Dr De Weerdt points out, EP 482 and US 430 are concerned with improving the properties for CVD diamonds so that they could be used in applications such as laser windows and heat sinks. Such products are known to require the diamond to be colourless (in the case of laser windows) or at least near-colourless (in the case of heat sinks), which fall within the meaning of "desired colours" in Claim 1 of SG 508. [note: 198]

308 That EP 482 and US 430 anticipated Claim 1 of SG 508 is also supported by the following two papers.

309 In Thomas Overton and James Shigley, "A History of Diamond Treatments" Gems & Gemology, Vol 44, No 1, pp 32–35 ("Overton"), the authors stated at p 42: [note: 199]

> *In the early 1990s*, GE researchers apparently also discovered that HPHT treatment could be used to strengthen (i.e., improve strength and hardness by reducing lattice defects) colorless CVD synthetic diamond, which is type IIa (i.e., without detectable nitrogen and boron) and *incidentally also reduce the color in stones with a brown component* [EP 482 and US 430]. [emphasis added]

310 The second paper is authored by Dr Karl Schmetzer in 1999, titled "Clues to the Process Used by General Electric to Enhance the GE POL Diamonds" *Gems & Germology*, Vol 35, No 4, pp 186–190 ("Schmetzer"). [note: 200] According to Schmetzer, EP 482 described a process where CVD diamonds are brought into high-pressure, high-temperature conditions. After cooling and the release of pressure, Schmetzer states that:

> [T]he result is a diamond with fewer defects, reduced density gradients, and lower stress – that is, with improved optical properties. If color centers related to defects are responsible for a brown coloration, and such defects are present, one can also assume that the removal of such defects will "remove" or lighten the original color. [emphasis added in italics and bold italics]

311 In my judgment, both Overton and Schmetzer support the fact that there was inherent disclosure in EP 482 and US 430 that annealing a CVD diamond under suitable conditions would change its colour. Claim 1 of SG 508 is therefore not novel.

Schmetzer

312 Schmetzer itself is a prior publication that anticipates Claim 1 of SG 508. Schmetzer teaches that the original brown colour of CVD diamonds can be "removed" or "lightened" through EP 482. There is thus express disclosure of Claim 1 of SG 508.

313 The defendant contends that the focus of Schmetzer was to find out the HPHT treatments that GE had practiced or carried out on natural diamonds. That however is beside the point as it does not deal with the express disclosure in Schmetzer. In fact, the law concerning anticipation is strict to the patentee and it is immaterial if anyone knew or inspected the express disclosure in Schmetzer: *Institut Pasteur* at [188].

314 The effect of EP 482, US 430 and Schmetzer may be summed up in the following exchange with Prof Newton: [note: 201]

Ct:	The other issue is Dr De Weerdt's evidence really is that 482 and 430, the processes spelled out there are the same as 508. Do I frame you correctly?
Dr De Weerdt:	Yes, your Honour is correct.
Ct:	What would your view on that be, Dr Newton?
Dr Newton:	Your Honour, *clearly the annealing temperatures overlap with the range of the annealing temperatures in 508. I would not argue with that*.
...	
Ct:	Right. You are simply saying that the colours, to you, were unexpected but the process is the same.
Dr Newton:	The process is annealing, no argument –
Ct:	Right.
Dr Newton:	-- but the colour change is unexpected because, as I said, from those GE patents, looking at the data, which is limited on optical properties, I think those diamonds would have been grey and the grey would have been reduced and that is –
Ct:	That would be your expectation, but we are here talking about the process being different or inventive, right, and the process is the same. It's just that your expectation was something different.
Dr Newton:	Your Honour, the inventive step is the fact that the single crystal coloured CVD diamonds against expectation change colour and the colours can be lightened –
Ct:	Right. This is on the basis that from optical transmission, we cannot deduce colour change and *that may well have been the deduction that Schmetzer made in his article.*
Dr Newton:	From those GE early patents, we cannot deduce those are colour changes and I made the point that GE were working on colour change by annealing on natural diamonds and the patents they felt are full of colour this, colour that, because they were driving the colour change. I think in the early work on the polycrystalline material, and they do mention single crystal in the patents, I agree, once or twice, they did not see a colour change because the material was grey.
Ct:	Schmetzer came to an opposite hypothesis in his article.
…	
Dr Newton:	*I think that, based on the evidence he was using, he came to the wrong conclusion*.

[emphasis added]

315 Therefore the plaintiff dismisses Schmetzer as "merely speculating on unclear and/or doubtful bases". As events unfolded, Schmetzer's "speculation" was indeed borne out by SG 508. It was the plaintiff's theory that annealing CVD diamonds would cause them to become darker or turn black, which I discuss below, that was speculative.

Inventiveness

316 In any event, even if Claim 1 is novel, it fails to satisfy the inventiveness requirement.

317 To begin, the plaintiff accepts that the process of annealing would have been known to the PSA as of the priority date. SG 508 itself acknowledged that the colour of brown natural diamonds could be changed by annealing:

> It is also known that the colour of brown natural diamond can be annealed by annealing at high pressures and temperatures. For example, natural type IIa diamond can be made colourless by annealing at very high temperatures under stabilising pressure or it may be turned pink by annealing at rather lower temperatures, again under stabilising pressure. …

318 The plaintiff, however, contends that the inventiveness of SG 508 lies in the *application* of the process of annealing to CVD diamonds. The process of annealing *per se* is not inventive. This is because once the PSA learned that annealing could be done on a CVD diamond, the PSA would have "no difficulty performing the invention", as the process of annealing was "well-known to the PSA". [note: 202]

319 This was allegedly counter-intuitive given that the thinking as at the material time was that annealing CVD diamond would worsen its colour. Briefly, the plaintiff, relying on the evidence of Prof Newton, makes the following assertions:

(a) Prior to and as at the priority date, a PSA would know the relationship between on the one hand, defects and impurities in diamond, and on other hand, colour and annealing behaviour. [note: 203]

(b) A PSA would be aware of the different theories that explain the brown colourisation of diamonds.

(i) For natural diamonds, any brown colourisation was believed to be caused by plastic deformation of the diamond after formation by geological processes ("the plastic deformation theory"). [note: 204] However, even up until today, the exact cause is not still fully understood. [note: 205]

(ii) For HPHT diamonds, the brown colourisation was known to be associated with higher concentrations of single substitutional nitrogen than present in CVD diamonds ("the nitrogen impurity theory"). [note: 206]

(iii) Neither the plastic deformation theory nor the nitrogen impurity theory could explain the brown colourisation in CVD diamonds. CVD diamonds are not exposed to conditions which can give rise to plastic deformation. Further, CVD diamonds contain less nitrogen impurities than HPHT diamonds. [note: 207]

(iv) Instead, the brown colourisation in CVD diamonds was believed to be caused by sp2

or non-diamond carbon defects, which are much more numerous than the quantity of nitrogen impurities typically found in CVD diamonds.

(c) Accordingly, the alleged prevailing view was that if a PSA were to anneal CVD diamonds, it would result in further degradation of the non-diamond carbon. The presence of sp2 or non-diamond carbon defects (*ie*, carbon that is not fully bonded) was believed to make the diamond more unstable and susceptible to conversion to graphite at higher temperatures, causing the diamond to darker or become black ("the graphitisation theory"). [note: 208]

(d) However, as SG 508 proved, the "deleterious effect of annealing to treat CVD diamonds to change their colour" was an "inherent misapprehension". [note: 209] SG 508 overcame a "mental prejudice" against the use of annealing for CVD diamonds to improve their colour. [note: 210]

320 As summed up by Prof Newton, the alleged inventiveness of SG 508 was as follows: [note: 211]

> … The invention resides in the *unexpected realisation* that applying heat treatment, such as high pressure high temperature (HPHT) annealing, or low pressure annealing in an inert atmosphere, results in changing the colour of coloured CVD single crystal diamond to a more desired colour. *Once this realisation has occurred, the method by which* [the] *heat treatment is carried out is well known to the PSA, and the PSA would have no difficulty performing the invention.* Because a variety of desired colours may be obtained depending upon a number of factors, including the colour of the starting CVD diamond and the heat treatment conditions applied, general teaching on the method is provided at pages 7-10 of the Patent followed by a more detailed description from page 13 and in the 8 specific examples. [emphasis added]

321 The inventiveness of SG 508 therefore stands or falls on whether the PSA would not anneal a diamond due to concerns about it becoming darker or turning black. I reject this frame of the paradigm at the time: its sole support is Dr Newton's unsubstantiated evidence. Instead, the prior art such as Schmetzer would have informed the PSA that annealing a CVD diamond under the suitable conditions would, as with natural and HPHT diamond, result in a change in colour.

322 I note that the plaintiff suggests that Dr De Weerdt had accepted Prof Newton's opinion about the prevailing view, relying on the following passage. [note: 212]

> MR YEO: Professor Newton also states that prior to September 2002, prior to the 508 patent, the view was that if you heat treated the CVD diamond, the brown colour being attributed to the presence of non-diamond carbon, this would cause further degradation of the non-diamond carbon and possibly make the diamond black. I am going to ask you whether you accept that as a fair statement of the prevailing view prior to September 2002.

A: Your Honour, I think I heard Dr Newton say this, that's correct, but I have to add something to this. It's also true that I believe in the statement it was said it's polycrystalline diamonds. Maybe we can look that up in the transcripts, I don't know. But polycrystalline diamond also has grain boundaries and grain boundaries are known to graphitise under such conditions, so it's not clear if the graphitisation or the black colour of your polycrystalline diamonds would come from the graphitisation of the grain boundaries or if it would come from the diamond's bulk becoming black.

Q: With that additional qualification you make about polycrystalline diamonds, you would accept that statement from Professor Newton?

A: Well, the statement of Professor Newton is indeed correct, that it would become black. I am not going to argue with Professor Newton on this -- because he saw the diamond, I did not – but the only thing I can say is if it doesn't work for polycrystalline and GE makes a patent for polycrystalline and single crystal, doesn't it mean that it only works for single crystal?

This does not appear to me be a clear acceptance that a PSA would refrain from annealing CVD diamond due to the possibility of it turning dark or becoming black. Dr De Weerdt's position on the lack of inventiveness in SG 508 was clear in his AEIC and, in my view, withstood scrutiny:

> … since all models for cause of brown in diamond whether CVD or natural were hypothesis or conjectures (and there were a number of them), it is not likely that the PSA would take such hypothesis or conjectures into consideration. The PSA would depend on his practical experience first. For example, if a brown diamond was presented to him to remove the brown he would simply ask himself the following question – Is it type IIa? If the answer to this question is yes he would simply heat treat it.

Sufficiency

323 The defendant contends that SG 508 did not teach the PSA how to anneal a diamond in order to obtain all "desired colours", such as purple. [note: 213] In my view, the PSA would understand the phrase "desired colour" in Claim 1 of SG 508 to be limited to colours that can actually result from using annealing the CVD diamond (*eg*, colourless, near colourless, green, pink).

324 Next, the defendant contends that SG 508 does not teach a PSA how to calibrate the annealing conditions to achieve a specific colour. [note: 214] SG 508 does not contain the relevant information, such as the temperature, pressure and time, that will teach a PSA how to anneal a CVD diamond such that it changes to a desired colour. I reject the defendant's contention. As the plaintiff points out, SG 508 contains eight examples which specify the colour of the starting diamond, the treatment(s) applied and the resulting colour. There is also discussion in SG 508 of the various colour changes achievable and the annealing conditions used. [note: 215] Further, this also contradicts the defendant's case, and indeed the evidence of all the experts, that there was nothing inventive in the annealing conditions taught in SG 508. In line with my finding that a PSA would not find this novel or inventive, a PSA could easily follow SG 508 to change a CVD diamond to a desired colour.

Related arguments that do not affect validity

325 I deal under this heading with a miscellany of objections that relate to but do not affect the validity of the claims which I have considered valid.

Foreign amendments, post-grant amendments, misrepresentations to IPOS

326 For SG 872, Mr Dean focused on the UK, European and Japanese patents which were derived from WO 427. He concluded that in all three jurisdictions, the product and process claims were narrower than those in SG 872. The same analysis was conducted for SG 508 and the patents in the UK, Europe and Japan which originate from WO 821.

327 In response, the plaintiff relied on the evidence of Dr Matthew Benedict David Mitchell, a qualified United Kingdom and European patent attorney who is the Senior IP Manager for the Element Six group of companies. Dr Mitchell explained that claims can be amended for a variety of reasons, and it was not unusual for the scope of a patent claim to differ from one country to another. [note: 216] While Dr Mitchell accepted that there were some claims in foreign jurisdictions which were narrower than SG 872 and SG 508, he highlighted that there were also other examples where the corresponding foreign patents were equivalent or broader to SG 872 and SG 508, such as in China or Israel.

328 These assertions about foreign patents are not relevant to the issue of the Singapore patents. As stated by Lord Hoffmann in *Kirin-Amgen Inc and others v Hoechst Marion Roussel Limited and others* [2005] RPC 169 at [35], patentees may choose to amend their proposed patents even if they disagree as to the merits of the patent examiner's objection. It is possible that the patentee might agree to narrow the claim solely on the basis of commercial expediency.

329 Secondly, the mere fact that a foreign patent *appears* narrower on a literal reading does not aid the discussion. As a matter of *fact*, the scope of protection might still be the same if the item removed is not an "essential element of the claim" (which must be identified in order to prove infringement). It may also be narrower because of patent law. For example, the doctrine of equivalents does not apply in Singapore (see the Court of Appeal's judgment in *Lee Tat Cheng* at [36]) but it does exist in jurisdictions such as the US, Japan and the UK post-*Actavis UK Limited and others v Eli Lilly and Company* [2017] UKSC 48.

330 Associated with this, the defendant contends that the plaintiff had a duty to ensure the patentability of SG 872 and 508, because these patents were granted under the self-assessment scheme. This contention appears to be related to and does not add anything further to the argument on foreign amendments. There was a contention that misrepresentations had been made, but no specific misrepresentation was identified or explained.

331 For SG 872, there is an additional contention under s 80(1)(*e*) of the Patents Act that post-grant amendments ought not to have been allowed because of substantial delay, and that this is therefore a ground for revoking SG 872. [note: 217] In the first place, it is unclear why any substantial delay will have the consequence of revoking the entire patent, as opposed to the amendments wrongly granted. Claim 62, as it originally stood before the amendments, would have been valid. In any event, there was also no evidence before the court to show that there was any unreasonable delay. In so far as the defendant is seeking to challenge the post-grants amendments *per se*, only Claim 62 is affected by this contention, and the defendant itself appears to be out of time to make an objection.

Relevant claims in SG 872 and 508 and Sunseap

332 The trial focused on primarily three claims, Claims 1 and 62 of SG 872, and Claim 1 of SG 508. The defendant characterises Claim 1 of SG 872 and Claim 1 of SG 508 as invalid independent claims, and relies on the Court of Appeal's decision in *Sunseap Group Pte Ltd and others v Sun Electric Pte Ltd* [2019] 1 SLR 645 ("*Sunseap*") at [70] for the proposition that "[i]f the court finds in the defendant's favour that the independent claims are invalid, it follows that the dependent claims must also fall". [note: 218]

333 In respect of SG 872, I have decided that Claims 1 and 62 are valid. As such, *Sunseap* is distinguishable in the present case.

334 I should mention that the plaintiff appears to accept in its closing submissions that the independent claims of SG 872 are Claims 1(ii) and (iii) only, drawing a distinction with independently valid claims, of which Claim 62 is one. [note: 219] The distinction in nomenclature was not defined in the submissions nor in the pleadings, although in a 13 August 2015 letter to the Intellectual Property Office of Singapore the plaintiff contended that "[t]he independent method Claim 62 has … been made dependent upon producing the material of any of Claim 1 and the dependent product claims". [note: 220] As Wei J noted at [103] of *Lee Tat Cheng v Maka GPS Technologies Pte Ltd* [2018] 3 SLR 1334 ("*Lee Tat Cheng (HC)*"), these terms, such as independent and dependent claims, do not appear in the legislation, and at [104], such terms "should not distract the court from the enquiry which it is tasked to undertake, which is whether the elements or features in the subsequent claim(s) taken together with the invention as set out in the preceding claim meet the requirements of novelty." Claim 62 stands alone as the main process claim of SG 872, to which Claims 63-71 add features. It does not add to or limit Claim 1. An assumption that Claims 62 and 1 could be distinctly delineated from each other and have separate potentially inventive concepts appears also to have been made by the experts and parties at trial, and I have proceeded on this basis. In addition, I held at [220] that Claims 57-58 reflect new distinguishing features to the product in SG 872. In *Lee Tat Cheng (HC)* at [104], which the Court of Appeal in *Sunseap* referenced specifically at [70], Wei J accepted that features in a subsequent claim, *taken together* with the invention as set out in a preceding claim, could meet the requirements of novelty. My holding in respect of Claims 57-58 is on this basis.

335 In respect of SG 508, I have decided that Claim 1 is invalid. The plaintiff's entire case regarding the inventiveness of SG 508 rests on the concept of applying annealing to CVD diamonds. The other dependent claims asserted are in respect of the nitrogen concentration of the annealed diamond (Claims 8-10, 12-14), colour of the annealed diamond (Claims 18, 24-25), reduction/removal of the absorption band in the annealed diamond (Claim 41) and the temperature ranges of the annealing process (Claim 44-45). [note: 221] This is the scenario *Sunseap* at [70] is targeted towards. In my judgment, these features would lack novelty and/or inventiveness when read together with Claim 1. This is unlike Claims 57 and 58 of SG 872, where *even if* low birefringent CVD diamonds in the SG 872 range existed, the product described in Claims 57 and 58 could still have been patentable (*ie*, low birefringent CVD diamonds with a *higher* nitrogen content than the prior art given the deliberate addition of nitrogen taught in SG 872).

Part II: Infringement

3 3 6 **Aside from copies released to the confidentiality club, parts of this judgment that reveal the defendant's confidential process have been redacted and are represented by [square brackets] below.**

Provenance and chain of custody

337 For the purposes of proving infringement, the plaintiff relies on three samples: Sample 2, Sample 3 and Sample 4 (collectively, "the Samples"). Each of the Samples were shipped to (or in the case of Sample 3, brought to) and centrally held at the De Beers Technical UK facility in Maidenhead ("the Maidenhead Facility"). [note: 222] When Samples 2, 3 and 4 arrived at the Maidenhead Facility, they were marked "NL625-03", "NL702" and "NL719-06" respectively. [note: 223] The Samples were kept in a specially secured room, known as the Strong Room, unless they were taken out for DiamondView fingerprinting or internal/external tests to test for infringement. The fingerprints here refer to the various DiamondView images, cross-polarised images and weights and dimensions of the Samples which go towards showing that there was no break in the chain of custody of the Samples. The internal tests were conducted in-house by various scientists and technicians employed by De Beers UK Limited. The external tests were conducted by Dr Steven Huband and Dr Ben Breeze at the University of Warwick and by Lazer Zentrum Hannoever e.V. ("LZH"). [note: 224] The movements of the Samples in and out of the Strong Room were recorded in daily checkout lists ("DCL"). It is the plaintiff's case that the fingerprints, along with the DCLs and other contemporaneous documents, demonstrate that the Samples were properly tracked, handled and fully accounted for at all material times. [note: 225]

338 The defendant denies that the Samples originated from it. Further, the defendant also claims that the plaintiff has not proven an unbroken chain of custody for the Samples. [note: 226]

339 As I explain below, I find the defendant's contentions on provenance and chain of custody to be wholly without merit. Some of the propositions advanced were based on principles from criminal law which, as I shall explain, should have no applicability in civil cases. Serious allegations such as evidence tampering and witness collusion were also made without any regard to the strength and cogency of the evidence nor the fact that the law requires compelling evidence where such allegations are made (see *Tang Yoke Kheng (trading as Niklex Supply Co) v Lek Benedict and others* [2005] 3 SLR(R) 265 at [14]).

340 I first address the applicable principles on provenance.

The legal principles on provenance

341 In order for the plaintiff to succeed on infringement, it must prove that infringing Samples originated from the defendant. Parties do not dispute guidance given by the Court of Appeal in *Britestone Pte Ltd v Smith & Associates Far East, Ltd* [2007] 4 SLR(R) 855 at [60]:

> To contextualise the above principles, at the start of the plaintiff's case, the legal burden of proving the existence of any relevant fact that the plaintiff must prove and the evidential burden of adducing some (not inherently incredible) evidence of the existence of such fact coincide. Upon adduction of that evidence, the evidential burden shifts to the defendant, as the case may be, to adduce some evidence in rebuttal. If no evidence in rebuttal is adduced, the court may conclude from the evidence of the plaintiff that the legal burden is also discharged and making a finding on the fact against the defendant. If, on the other hand, evidence in rebuttal is adduced, the evidential burden shifts back to the plaintiff. If, ultimately, the evidential burden comes to rest on the defendant, the legal burden of proof of that relevant fact would have been discharged by the plaintiff. The legal burden of proof – a permanent and enduring burden – does not shift. A party who has the legal burden of proof on any issue must discharge it throughout. Sometimes, the legal burden is spoken of, inaccurately, as "shifting"; but what is truly meant is

that another issue has been engaged, on which the opposite party bears the legal burden of proof.

342 A recurring argument made by the defendant is that there is "a need for persons with personal knowledge to testify to the alleged provenance". This is "especially when it relates to the selection and handling of samples that are the subject of experiments and when the case turns on the experiments conducted on the samples". [note: 227] In support of this proposition, the defendant cites several cases which I discuss briefly. In my view, none of these cases stand for the proposition that in order to prove provenance, the plaintiff *must* call persons with personal knowledge to testify. There is nothing to prevent the plaintiff from adducing other evidence, including documentary evidence, to prove the provenance of the Samples.

343 In *Alliance Management SA v Pendleton Lane P and another and another suit* [2008] 4 SLR(R) 1 ("*Alliance Management*"), a court order was made for the defendants to produce and return by a stipulated date an original hard disk ("the Hard Disk Order"). The purpose of the Hard Disk Order was to facilitate discovery and production for inspection of certain electronic documents stored in the hard disk. The defendant failed to comply with the Hard Disk Order. On that basis, the plaintiff applied to strike out the defence: *Alliance Management* at [1]–[3].

344 Belinda Ang Saw Ean J held that there was a deliberate and persistent disregard of the Hard Disk Order and that such conduct fell within the category of contumelious conduct justifying a striking out of the defence: *Alliance Management* at [28].

345 For present purposes, it is relevant to note that Ang J was prepared to consider the fact that the defendants had allegedly produced a *clone* of the hard disk ("the Hitachi hard disk") as part of the overall circumstances the court would consider in exercising its discretion to strike out the defence. The Hitachi hard disk was said to be sent to the first defendant in October 2005 by one Ms Joseph. However, in the hard disk that was produced in court (which was said to be the Hitachi hard disk), the manufacturer's label and warranty label indicated that it was manufactured in November 2005 and sold in December 2005. Under those circumstances, Ang J held that "the provenance of the Hitachi hard disk had not been made out and remained dubious": *Alliance Management* at [36]–[40].

346 It is unclear how the defendant derives, from *Alliance Management*, the proposition that there is a need for persons with personal knowledge to testify as to provenance. In *Alliance Management*, the reason why the provenance of the Hitachi hard disk was not made out was because the dates on it which it was manufactured and sold contradicted the first defendant's account of when he obtained the Hitachi hard disk. There were glaring inconsistencies which could not be explained. It was not because Ms Joseph, who provided the Hitachi hard disk to the first defendant, had failed to testify.

347 Next, in *Kalzip Asia Pte Ltd v BFG International Ltd* [2018] SGHC 152 ("*Kalzip*"), there was a dispute between the plaintiff contractor and the defendant sub-contractor over alleged defects in roof panels that had been installed in a development. The panels were constructed of glass fibre-reinforced skins that enveloped an aluminium honeycomb. The dispute concerned whether and to what extent the inner skins of the panels had "delaminated" (*ie*, come apart) from the aluminium honeycomb and whether the panels met the fire safety requirements of the contract: *Kalzip* at [1].

348 The defendant relied on representative samples derived from panels produced in 2010 (the relevant date) to prove that the panels complied with the contractual specifications. The plaintiff casted doubt on the provenance of the panels. It alleged that the defendant's expert, Mr Wymond, did not personally investigate the provenance of the panels and appears to have accepted from photographs showing tag markings of the panels that they were panels from 2010. Quentin Loh J

rejected the plaintiff's contention. He noted that another of the defendant's expert, Mr Maurieschat, had confirmed that he had visited the defendant's facility before the preparation of the samples and "personally saw those panels onsite labelled with their production notes": *Kalzip* at [187]–[188]. The defendant in the present case claims that implicit in Loh J's reasoning was that "if a claimant fails to call a witness to personally identify and account for a sample, the Court should not accept the claimant's case on provenance". [note: 228]

349 I see no merit to this contention. It appears to me that Loh J was not making a general proposition that a party must call a witness to personally identify and account for a sample if it seeks to rely on it. Loh J had simply found, on the facts of *Kalzip*, that the defendant had satisfied its burden of showing provenance.

350 Finally, the defendant relies on the case of *Contour Optik Inc and others v Pearl's Optical Co Pte Ltd and another* [2002] SGHC 238 ("*Contour Optik*"). There, the plaintiff sued the defendants for patent infringement, with the relevant patents being in respect of spectacle frames. The plaintiff trap purchased several spectacles frames from the defendants. Lee Seiu Kin JC (as he then was) held that while the plaintiff had called expert witnesses to give evidence on spectacle frames *alleged* to be the trap purchase, they did not call the person who made the trap purchase, or anyone who may have witnessed it, to *identify* an exhibit as the trap purchase. The plaintiff's case therefore failed on the basis due to the "break in the chain of evidence": *Contour Optik* at [52]–[53], [83], [85].

3 5 1 *Contour Optik* is distinguishable. It appears that there was *no other evidence*, such as documentary evidence, in *Contour Optik* which could have identified the provenance of the spectacle frames in that case. In fact, one might perhaps be able to place greater weight on contemporaneous documentary evidence, as opposed to witness testimony, in cases such as the present when the relevant samples are not identifiable by naked eye inspection alone. [note: 229]

The legal principles on chain of custody

352 The plaintiff accepts that it has the burden of proof in respect of proving the chain of custody of the samples. In this context, I am of the view that it suffices for the plaintiff to prove that it is more likely than not that the samples remained the same between the time they were purchased from the defendants and underwent the relevant tests. [note: 230]

353 According to the defendant, "a break in the chain [of custody] or a movement or handling *that is not accounted for* is fatal to the claimant's case. Each link, movement or handling of each of the Samples in the chain must be accounted for by admissible evidence". [note: 231] However, I am not satisfied that this proposition is borne out by the cases relied on by the defendant, whereby the court declined to rely on evidence on the basis of a break of chain in custody.

354 First, in *Ecooils Sdn Bhd v Raghunath Ramaiah Kandikeri* [2014] 7 MLJ 44 ("*Ecooils*"), the plaintiff commenced an action against the defendant arising from the defendant's breach of the terms of a confidentiality clause in his letter of appointment. The plaintiff led forensic evidence of documents and emails contained in the defendant's computer. The defendant challenged the plaintiff's forensic evidence, with one of the grounds being that there was no evidence in respect of the chain of custody, care, control and usage of the computer from the date the defendant left the employment of the plaintiff until it was handed over for forensic examination. The relevant time period was almost three years. It was held that "[t]he plaintiffs did not make any attempt to *adduce any evidence of the proper measures or procedures adopted to secure [the computer's] integrity*" during that period: *Ecooils* at [62]–[63].

355 In my view, *Ecooils* does not stand for the proposition that "[e]ach link, movement or handling of each of the Samples in the chain must be accounted for by admissible evidence". In fact, *Ecooils* suggests that it suffices for the plaintiff to adduce evidence of the proper measures or procedures adopted to secure the chain of custody of the Samples. *Ecooils* ought also to be seen in the context of the three years gap between the date the defendant left the plaintiff's employment and the forensic examination.

356 Next, in *Exim & Manufacturing Holdings Pte Ltd v Fintex Industries Pte Ltd* [2007] SGHC 220 ("*Exim*"), the plaintiff sued the defendant for breach of contract; specifically, it was alleged that the defendant had failed to "bake" screws according to specification. The plaintiff relied on experiments conducted by its expert, Dr Huang on the screws. Lee Seiu Kin J held that the plaintiff had not proven, on a balance of probabilities, that the defendant had not properly baked the screws on the basis of Dr Huang's evidence. A reason, at [27], was that the plaintiff had not proven the chain of custody in respect of the samples sent to Dr Huang for testing. But nowhere in *Exim* does it state that the plaintiff must account for "[e]ach link, movement or handling of each of the Samples", and that a failure to do so will be "fatal" to the plaintiff's case. [note: 232]

357 Finally, I turn to the case of *Mohamed Affandi bin Rosli v Public Prosecutor and another appeal* [2019] 1 SLR 440 ("*Affandi*"). According to the defendant, *Affandi* stands for the principle that if there is a doubt as to the identity of an exhibit, then every single witness who handled the exhibit must be called to establish the chain of custody. [note: 233]

358 In *Affandi*, the question was whether the drug samples tested by the Health Sciences Authority were the same samples seized from the accused. The Court of Appeal made the observation at [39]–[42] that it is incumbent upon the prosecution in such cases to account for the movement of exhibits from the point of seizure to the point of analysis.

3 5 9 *Affandi* ought to be seen in its context as a criminal case, where the burden is on the Prosecution to *prove beyond a reasonable doubt* that the relevant exhibits were the ones seized from the accused, and there is an unbroken chain of custody. In the context of civil cases, the standard is that of a balance of probabilities: *Chua Kwee Chen v Koh Choon Chin* at [13]. The plaintiff only has to show, on a balance of probabilities, that the samples which were tested and shown to be infringing were the same samples which originated from the defendant.

360 I would conclude that it should be noted from *Affandi* that even in the criminal context, the court will not entertain "speculative arguments" about the possibility of a break in the chain of custody: *Affandi* at [41]. The defendant must raise a reasonable doubt or suspicion; it cannot sit on its heels and demand that the plaintiff prove every movement of the exhibit in question. In my judgment, the defendant's contentions, to a large extent, were founded purely on the theoretical possibility of a break in the chain of custody.

Provenance

Sample 2 (NL 625-03)

361 Sample 2 is an optical grade single crystal CVD diamond plate with the product code 2PCVD303004N purchased by Dr Jarmola from MWE, on behalf of the plaintiff under instructions from Dr Twitchen on or around 12 May 2014.

362 The defendant accepts that it sold to MWE 20 diamond plates with the product code

2PCVD303004N. [note: 234] However, it disputes the plaintiff's claim that MWE then on-sold the 20 plates to Dr Andrey Jarmola from the University of California, Berkeley ("UC Berkeley"). Further, it also disputes the plaintiff's claim that the 10 plates which Dr Jarmola sent to Dr Twitchen were the same plates that Dr Jarmola had received from MWE.

363 In my judgment, the plaintiff has established, on a balance of probabilities, that Sample 2 originated from the defendant. I place reliance on the contemporaneous documentary records, which are admissible pursuant to s 32(1)(*b*)(iv) of the Evidence Act (Cap 97, 1997 Rev Ed) ("Evidence Act") which states as follows:

> 32.—(1) Subject to subsections (2) and (3), statements of relevant facts made by a person (whether orally, in a document or otherwise), are themselves relevant facts in the following cases:
>
> …
>
> **or is made in course of trade, business, profession or other occupation;**
>
> (*b*) when the statement was made by a person in the ordinary course of a trade, business, profession or other occupation and in particular when it consists of —
>
> …
>
> (iv) a document constituting, or forming part of, the records (whether past or present) of a trade, business, profession or other occupation that are recorded, owned or kept by any person, body or organisation carrying out the trade, business, profession or other occupation,
>
> and includes a statement made in a document that is, or forms part of, a record compiled by a person acting in the ordinary course of a trade, business, profession or other occupation based on information supplied by other persons;
>
> …
>
> (3) A statement which is otherwise relevant under subsection (1) shall not be relevant if the court is of the view that it would not be in the interests of justice to treat it as relevant.

(1) The contemporaneous business records

364 The quotation issued by the defendant to MWE ("the IIa-MWE Quotation") [note: 235] and the quotation issued by MWE to Dr Jarmola ("the MWE-Dr Jarmola Quotation") [note: 236] are highly probative of the fact that the diamond plates sold by the defendant to MWE were the same diamond plates on-sold and delivered to Dr Jarmola.

365 The defendant issued a sales quotation with Quotation No IIa/QT/1314-121 dated 21 February 2014 to MWE for lab grown diamond plates. The item code on the quotation, 2PCVD303004N is identical to the product code for Sample 2. While I note the defendant's point that the product code 2PCVD303004N is a common notation not unique to diamond plates grown by the defendant, [note: 237] there are other factors which put beyond doubt the provenance of Sample 2.

366 First, UC Berkeley was indicated on the IIa-MWE Quotation below MWE's address. In cross-examination, Mr Mehta accepted that the defendant knew that "someone had communicated to IIa that there was a customer from UC Berkeley that wanted to buy certain plates and, hence those words appear in this quote to MWE". [note: 238]

367 Second, three days after the IIa-MWE Quotation was issued, MWE issued a corresponding quotation dated 24 February 2014 to Dr Jarmola of UC Berkeley. The MWE-Dr Jarmola Quotation explicitly states that "the following quotation is for Lab Grown, CVD single crystal diamond plates, produced by IIa Technologies Pte LTD …". The MWE-Dr Jarmola Quotation references the IIa-MWE Quotation, 1314-121. The same items are listed with precisely the same product/item codes, product descriptions and unit prices. Curiously, the MWE-Dr Jarmola Quotation also makes reference to "GST @0%" when no tax of the same title or abbreviation is imposed in the US. It appears that the MWE-Dr Jarmola Quotation had simply adopted this from the IIa-MWE Quotation. [note: 239]

368 Against the IIa-MWE Quotation, MWE issued a purchase order dated 7 May 2014 to the defendant for the production and shipment of, amongst others, 20 pieces of diamond plates with the Item Code 2PCVD303004N at a unit cost of US$101.00. Reference is made to the IIa-MWE Quotation, 1341-121, and the customer, UC Berkeley. A 10% distributor discount was also reflected on the MWE-IIa Purchase Order, which suggests the existence of a distributorship arrangement between MWE and the defendant.

369 Next, I turn to the invoices issued by MWE and the defendant respectively. MWE issued an invoice dated 12 May 2014 to Dr Jarmola ("the MWE Invoice") for, amongst other things, the same 20 pieces of diamond plates with the Item Code 2PCVD303004N at a unit price of US$101.00. The plates were to be shipped to UC Berkeley.

370 The defendant then issued an invoice dated 6 June 2014 to MWE ("the IIa Invoice"). The invoice was for 20 pieces of diamond plates with the Item Code 2PCVD303004N at a unit price of US$101.00. The country of origin was stated to be Singapore. The IIa Invoice also stated the customer reference as UC Berkeley. The total carat weight for the 20 pieces of diamond plates was 2.12.

371 On 9 June 2014, MWE issued a packing slip further to the MWE Invoice, which provided for delivery of 20 pieces of diamond plates with the Item Code 2PCVD303004N at a unit price of US$101, and a total weight of 2.12.

372 I find that the contemporaneous business records alone sufficiently prove that the diamond plates sold by the defendant to MWE were the same plates on-sold to Dr Jarmola. It would be wholly speculative to then suggest that Dr Jarmola tampered with or mishandled the glass plates before sending it to Dr Twitchen. The defendant's contention that the plaintiff was required to call a representative from MWE and Dr Jarmola himself is wholly unsustainable. [note: 240] Accordingly, I find that the provenance of Sample 2 is established on a balance of probabilities.

(2) The relationship between the defendant and MWE

373 For completeness, I note that the plaintiff contends that the evidence shows an exclusive supply relationship between the defendant and MWE. [note: 241]

374 The plaintiff relies on various Internet articles and presentations to prove an exclusive supply relationship between the defendant and MWE. However, on this point, I am inclined to agree with the

defendant that these articles and presentations are inadmissible hearsay evidence. In *Clark Jonathan Michael v Lee Khee Chung* [2010] 1 SLR 209 ("*Clark Jonathan Michael*"), the plaintiff had claimed against the defendant for loss of income. He had quantified this claim at $93,085.00 on the basis that a staff nurse in Portland, Oregon (where he would have worked at) would have earned this amount during the relevant period of time. In support of this amount, the plaintiff relied, *inter alia*, on statistics compiled by an online website known as "salary.com": *Clark Jonathan Michael* at [61]. Judith Prakash J (as she then was) refused to make an award for loss of income. On the statistics compiled on "salary.com", Prakash J held that such evidence was inadmissible hearsay evidence: *Clark Jonathan Michael* at [70]. I therefore do not place weight on this aspect of the evidence in determining that Sample 2 originated from the defendant.

375 The defendant in any event accepts that the MWE is one of its distributors, [note: 242] although there have been no orders since 2017. [note: 243] Mr Mehta gave evidence that he was told by Mr Richard Garard of MWE that MWE also purchases diamonds from "other growers". This relationship, taken with the documentary evidence, is sufficient to prove that Sample 2 originated from the defendant.

(3) The dimensions of the diamond plates

376 I deal now with a point made by the defendant relating to the dimensions of the diamond plates which in its view, suggests that the diamond plates did not originate from it.

377 The defendant points out that according to the quotations and invoices, the diamond plates had dimensions of 3.0mm x 3.0mm x 0.4mm. However, when the Maidenhead Facility received the 10 diamond plates from Dr Twitchen, which were then measured by Dr Cann, the dimensions of the plates differed from 3.0mm x 3.0mm x 0.4mm. For example, according to an email from Dr Cann to one Ms Ford dated 26 June 2014, Sample 2 measured 3.04mm x 3.26mm x 0.73mm. [note: 244]

378 I see no merit in the defendant's contention. Ms Susan Jane Fletcher Watts, the plaintiff's principal factual witness who is presently a consultant patent attorney for the plaintiff and its former head of intellectual property, gave evidence that the diamond plates that were delivered were thicker than its thickness stated on the invoice. [note: 245] It is "quite normal" for the diamonds received to not meet the precise specifications. [note: 246] To this end, the plaintiff disclosed on 22 March 2019 an email which sets out the measurements of all 10 diamond plates that Dr Twitchen sent to the Maidenhead Facility. [note: 247] All 10 plates had variations in dimensions in spite of their quoted dimensions. Further, the plaintiff also points out that if the 20 diamond plates had exact dimensions of 3.0mm x 3.0mm x 0.4mm, the carat weight would not have been 2.12 carats, which was the actual carat weight listed by the defendant in its invoice and by MWE in its packing slip to Dr Jarmola. [note: 248] I note that similar arguments relating to dimensions were made for the other samples and my finding here applies equally to those contentions. Ultimately, these differences in dimensions are in the region of sub-millimetres, and one should also note that the lack of precision in measurements could also be due to the inherent margins of error of the measurement tools (*ie* Vernier callipers and weighing scales). [note: 249]

(4) The defendant's decision not to inspect and examine the Samples

379 Finally, I note that it was always open to the defendant to inspect and examine the Samples and adduce *positive* evidence as to why the Samples did not originate from it. [note: 250] Instead, the defendant criticised the plaintiff for not bringing the Samples to court and chose to speculate on

holes in the plaintiff's account of the provenance and chain of custody of the Samples. In my view, this reflects an incorrect understanding of the burden of proof.

Sample 3 (NL 702)

380 Sample 3 is a single crystal CVD diamond gemstone with product code LG10225420 purchased by Dr Lawson, on behalf of the plaintiff, from PGD on or around 27 October 2015. In cross-examination, Dr Lawson explained that he had selected the stones on PGD's website, and then called his wife, Mrs Ayako Lawson to carry out the actual transaction. He was concerned that given his profile in the field, the sale might have been refused. [note: 251]

381 That Sample 3 was obtained from PGD is confirmed by various documents, including an invoice, commercial invoice, packing list, FedEx shipment document and a report from the International Gemological Institute No LG10226420 dated 18 June 2015. [note: 252]

382 The more pertinent question is whether Sample 3, which was sold by PGD, was in turn obtained from the defendant. In my view, the plaintiff has established on a balance of probabilities that Sample 3 originated from the defendant.

383 It ought to be highlighted that at all material times, both the defendant and PGD were owned by IIa Holdings Group Ltd. [note: 253] In turn, IIa Holdings Group Ltd is owned by members of the Mehta family. [note: 254] I accept that the common ownership of PGD and the defendant, in and of itself, does not mean that PGD could not obtain diamonds from other sources. However, this has to be coupled with the fact that Mr Mehta, who is presently the sole shareholder of PGD, was in a position to have PGD produce documents showing that the documents that were sold to Dr Lawson were obtained from other sources instead of the defendant. Mr Mehta confirmed this in cross-examination. [note: 255] Under these circumstances, it seems to me appropriate to draw the inference that the production of the documents would have showed that Sample 3 originated from the defendant. On a balance of probabilities, I accept the plaintiff's contention that Sample 3 originated from the defendant.

384 For completeness, I note that so far as Sample 3 is concerned, the plaintiff also relies on various Internet articles to prove an exclusive supply relationship between PGD and the defendant. Some of these articles, such as a web article from www.prnewswire.com, constitutes inadmissible hearsay evidence. Others, such as a news release on the defendant's own website only goes towards showing *a* supply relationship between PGD and the defendant, rather than an exclusive supply relationship. [note: 256] That the defendant actively advertises for PGD on its Facebook page also does not, in and of itself, suggest an exclusive supply relationship. [note: 257]

385 On the provenance of Sample 3, the defendant raises several arguments which in my view, do not go towards showing that Sample 3 did not originate from the defendant. For example, the defendant observes that the commercial invoice from PGD states that the Country of Origin of the diamond listed is China. [note: 258] I accept the plaintiff's explanation that this could equally mean that Sample 3 had passed through certain manufacturing processes (such as cutting and polishing) in China, or that the relevant supply chains from the defendant to PGD passed through China. If indeed the origin of Sample 3 was a diamond supplier in China, Mr Mehta was in a position, as majority shareholder of PGD, to produce the identity of the relevant diamond supplier with the necessary supporting documents.

Sample 4 (NL 719-06)

386 Sample 4 is an optical grade single crystal CVD diamond plate with the product code 2PCVD505005N purchased by Mr Pierra on behalf of the plaintiff directly from the defendant in Singapore in or around October 2015.

387 Mr Pierra was subpoenaed by the plaintiff. At trial, the defendant agreed to admit his evidence in his affidavit without any cross-examination. Under those circumstances, Mr Pierra's evidence that he purchased Sample 4 from the defendant and shipped it to the plaintiff remains unchallenged. [note: 259]

388 Further, Mr Pierra had also liaised directly with Ms Lin Lin, the defendant's technical marketing engineer at the material time. [note: 260] The contemporaneous business records show clearly too that Sample 4 originated from the defendant, these being a quotation dated 23 October 2015, a tax invoice dated on 8 January 2016, and a delivery order dated 8 January 2016. All three documents were issued by the defendant and the latter two documents were acknowledged by Mr Pierra by signature.

389 Accordingly, the plaintiff has proven that Sample 4 originated from the defendant on a balance of probabilities.

Chain of custody of the Samples

390 I deal briefly with whether there has been a break in the chain of custody. In my view, the plaintiff, having established that the three Samples originated from the defendant, need only prove, on a balance of probabilities, that these were the very samples tested for infringement. In the present case, the evidence of the fingerprints, along with the "traceability" system at the Maidenhead Facility render the possibility of confusion, misplacement or replacement of diamond samples no more than a theoretical one raised by the defendant.

Fingerprinting

391 In order to prove the chain of custody of the Samples, the plaintiff relies on Dr Martineau's evidence in respect of the fingerprints of the Samples. Essentially, Dr Martineau compared the DiamondView images, cross polarised images, weights and dimensions taken of the Samples at various stages. *Collectively*, these served as fingerprints showing that the same Samples moved along the chain of custody. [note: 261]

(1) DiamondView images

392 DiamondView images are taken using the DiamondView machine which is commercially available. It is, as Dr De Weerdt accepted, a reliable method for identifying CVD diamonds. [note: 262] Dr Martineau explained the operation of the DiamondView machine in the following terms: [note: 263]

> The DiamondView machine is commercially available from IIDGR, and is widely used by gemmological laboratories to identify High Pressure High Temperature and CVD synthetic diamonds. In DiamondView, stones are illuminated with short wavelength UV radiation and images are then captured of the resulting surface fluorescence and phosphorescence. *The user can distinguish synthetic diamonds from natural diamonds based on a combination of features seen*

in such images. These include the colour of the fluorescence, the fluorescence patterns that relate to the shape that the stone had at different stages of its growth, and the absence or presence of phosphorescence. [emphasis added]

393 The evidence of the DiamondView images for the Samples can be summarised as follows: [note: 264]

(a) **Sample 2:** DiamondView images were taken on 2 July 2014, 22 December 2015 and 16 January 2017. By the last date, all the relevant tests for the purposes of proving infringement had been carried out. In all three DiamondView images, Dr Martineau observed that there was a pattern of blue fluorescence along one edge (the lower edge) of the image. Further, that the image on 16 January 2017 showed predominantly orange luminescence was evidence that Sample 2 was in the same state in which it was purchased.

(b) **Sample 3:** DiamondView images were taken on Sample 3 on 26 November 2015, 14 December 2015 and 22 December 2015 respectively. In all DiamondView three images, Dr Martineau observed that there were distinctive patterns of green luminescence due to the formation of H3 defects following annealing of Sample 3.

(c) **Sample 4**: Three DiamondView images were adduced for Sample 4 dated 20 January 2016, 18 February 2016 and 16 January 2017. By the last date, all the relevant tests for the purposes of proving infringement had been carried out. In all three images, there were distinctive patterns of orange luminescence.

394 The dates in which the DiamondView images were taken are pertinent, as they put to rest many of the defendant's unsubstantiated allegations that there must have been a break in the chain of custody because the plaintiff failed to account for the movement of a sample on a given date. While I accept that the fingerprints do not track "each and every moment" of the Samples, they show, at least for the relevant dates concerned, that many of the defendant's arguments were advanced without regard to the strength or cogency of the evidence adduced.

(2) Cross-polar images

395 Cross-polar images were also taken of the Samples on various occasions. For example, cross-polar images were taken of Sample 2 on 23 June 2014. Dr Martineau highlighted that they showed "distinctive patterns of contrast" which were unique to Sample 2. These patterns of contrast were closely linked to the stitched Metripol image taken on 5 December 2015. Dr Martineau's evidence was that the various cross-polar images were from the same sample: "I can say categorically that there's no way that you can reproduce the level of detail, the spatial distribution of those strain-causing defects in a separate sample. That is just beyond the bounds of possibility." [note: 265] It should be noted that Dr Kaminsky had also candidly accepted in cross-examination that his personal opinion was that the cross-polarised images for Sample 2 were all of the same sample. [note: 266]

(3) Weight and dimension of Samples

396 The weight and dimensions of the Samples were also recorded at various dates, therefore serving as fingerprints of the Samples along the chain of custody. For Sample 2, the following measurements were recorded:

(a) 4 December 2015 (while Sample 2 was at Warwick for Metripol testing): 0.025g, 3.04mm x

3.23mm

(b) 9 December 2015 (at Warwick, prior to return of Sample 2 to the Maidenhead Facility): 0.025g, 3.02mm x 3.24mm

(c) 21 March 2016 (while Sample 2 was at Warwick for Metripol testing): 0.025g, 3.02mm x 3.24mm x 0.73mm

(d) 24 November 2016 (while Sample 2 was at Warwick for Metripol testing): 0.024g, 3.01mm x 3.22mm x 0.74mm

397 Dr Martineau concluded that the weights and dimensions above were in "reasonable agreement", and reasoned as follows: [note: 267]

> The factors that I have taken into account in reaching this judgement are as follows. The reproducibility of the measurements of sample dimensions is limited by the fact that the faces of a diamond sample tend not to be accurately parallel, causing sample dimensions to vary depending on the position of measurement. At Warwick University the sample dimensions were measured using digital Vernier callipers that are accurate to approximately +/- 0.01 mm. At Warwick University the digital scales used to weigh the sample provides figures that should be accurate to +/- 0.001 g. Figures provided by the balance used in Maidenhead are rounded to the nearest 0.01ct (0.002 g) and values reported from measurements of weight in Maidenhead are accurate to +/- 0.001 g.

(4) Veracity of the fingerprints

398 The defendant raises several general objections against the use of these fingerprints. First, the defendant points out that Dr Martineau admitted that the plaintiff does not have a "fixed protocol" for fingerprinting. [note: 268] This misses the point, which is whether the relevant fingerprints adduced by the plaintiff show that there was an unbroken chain of custody for the Samples, on a balance of probabilities. Next, the defendant contends that Dr Martineau's evidence constituted opinion evidence and was inadmissible, as he was called as a factual witness. Second, Dr Martineau was also not involved in the experiments or measurements of the fingerprints. [note: 269] It appears to me, however, that the various fingerprints are admissible as statements made in the ordinary course of trade under s 32(*b*)(iv) of the Evidence Act. Further, it would also not be correct to suggest that Dr Martineau's evidence was entirely opinion evidence as he had working knowledge of the DiamondView (see Jeffrey Pinsler, SC, *Evidence and the Litigation Process* (LexisNexis, 6th Ed, 2017) at 8.005: "the law takes a pragmatic approach by classifying direct perception of something that can be seen or heard (or directly perceived by some other sense) as evidence of a fact.") In providing his observations of, for instance, the pattern of blue fluorescence in the DiamondView images, Dr Martineau was providing factual evidence. While he went further to draw inferences based on these observations, for example, that they related to the same Sample, it ought to be recalled that Dr Martineau, while called as a factual witness, was, for all intents and purposes, an expert in CVD diamond. In this regard, I draw guidance from Tan Siong Thye J's caution in *Goh Guan Sin (by her litigation representative Chiam Yu Zhu) v Yeo Tseng Tsai and another* [2019] SGHC 274 at [97]–[101] that factual witnesses with the requisite experience and knowledge may be able to give relevant expert evidence. Such evidence should be considered with other expert evidence before appropriate weightage is given.

399 I come therefore to the evidence of Dr Nebel, who stated that "[n]on-experts cannot perform

fingerprinting, and even if it is performed by experts, it is highly unreliable and can be manipulated by image processing". [note: 270] Dr Nebel's opinion did not carry robust reasoning, and was an isolated one. Even the defendant's own expert, Dr De Weerdt, had stated that if a PSA were to apply DiamondView, it would be a reliable method for identifying CVD diamonds. I therefore hold that the collective measures of fingerprinting, which included DiamondView, are sufficiently reliable.

Conclusion on Samples 2 and 4

400 It follows from my acceptance of the fingerprinting, and in particular, DiamondView, evidence that there is no argument against Samples 2 and 4. It is only for Sample 3, for which birefringence measurements were taken at LZH and the University of Warwick after DiamondView images were taken, that any dispute remains. I deal, in this context, with the defendant's contentions regarding such external sources of testing.

Warwick and LZH testing

401 The defendant protests that the Samples were tested at Warwick and LZH. However, no one from Warwick or LZH was called to give evidence on how the Samples were handled when they were at Warwick or LZH for testing. [note: 271] While Ms Watts had provided explanations of how Warwick and LZH handed the Samples, she was not an employee of Warwick or LZH and was not in a position to give any evidence on the procedures adopted by them. [note: 272] But as stated above, it is not necessary for each and every single individual involved in the chain of custody to give evidence on behalf of the plaintiff. The defendant's bare assertion that there might have been a break in the chain of custody while the Samples were sent for testing at these external institutions is speculative.

402 The same reasoning applies to the individuals who were tasked to send the Samples to the external facilities. For example, the defendant points out that while Ms Watts had handled Sample 2 to Mr Ian Friel so that it could be sent to LZH, Mr Friel did not give evidence. [note: 273] In so far as there were shipping records proving that Mr Friel sent Sample 2 to LZH, that was inadmissible as they were not produced in the ordinary course of business. [note: 274] Be that as it may, and contrary to what the defendant suggests, the mere fact that "there is no evidence to account for what happened to Sample 2" does not amount to a break in the chain of custody. [note: 275] It still remains only a theoretical possibility that there would have been a break in the chain of custody in the intervening period between Mr Friel receiving Sample 2 and sending it to LZH.

Conclusion on Sample 3

403 I conclude therefore, that Sample 3, as tested at LZH and Warwick, is the same sample which originated from the defendant.

Traceability system

404 For completeness, I deal with the plaintiff's traceability system, only because much trial time was consumed by the defendant on this issue. Ms Watts' gave evidence as to the "traceability" system established at the Maidenhead Facility. She explained as follows in her AEIC: [note: 276]

> 118. Maidenhead has in place an established a [*sic*] traceability system for the storing and handling of diamond material. This is because of the high value of the goods, particularly natural diamonds, plus it can be difficult to tell diamonds apart using the naked eye.

119. As a general rule, all diamond material subject to Maidenhead's traceability system is stored in safes ("Strong Room Safes") located in a specially secured room in Maidenhead (Strong Room") manned by personnel from the security team ("Security"). Such samples may be taken out of the Strong Room for internal or external testing.

120. The central element of Maidenhead's traceability system is a documentation system based on daily checkout lists ("DCLs"). DCLs record all check ins and check outs of diamond material to and from the Strong Room. For any given day, there will be one or more DCLs recording all movements on that day.

405 In my view, the traceability system lends weight to the fact that there was no break in the chain of custody. It represented a proper system designed to ensure the integrity of the Samples while at the Maidenhead Facility. The fact that the system does not provide for a "perfect chain of documentation" is beside the point. [note: 277]

406 The plaintiff relies on s 32(1)(*b*)(iv) of the Evidence Act to admit the DCLs, on the basis that these are documents made in the course of business. Nevertheless, the defendant contends that the court should exercise its discretion to exclude the evidence under s 32(3) of the Evidence Act, on the basis that the DCLs are "fraught with inconsistencies and suspicious corrections". In this connection, the guiding principle for when s 32(3) ought to be exercised was set out by the Court of Appeal in *Gimpex* at [109]:

> In particular, we think that where the hearsay evidence sought to be admitted is of limited probative value, such evidence should properly be excluded. The effect of this is that the party seeking the admission of the hearsay evidence must be able to show the court that there were certain safeguards or measures that applied to that evidence which would ensure a minimal degree of reliability. Of course, the court in doing so must bear in mind the fine line between a decision not to admit hearsay evidence (under s 32(3)) and a decision to admit the hearsay evidence but to accord it less weight (under s 32(5)). *The court should not normally exercise its discretion to exclude evidence that is declared to be admissible by the EA.* [emphasis added]

407 I disagree with the defendant that the DCLs were fraught with inconsistencies and suspicious corrections. In my judgment, the inconsistencies could be explained innocently or were simply administrative errors, as I explain below. Similarly, there was nothing sinister about the corrections or amendments made to the DCLs. I therefore decline to exercise s 32(3) of the Evidence Act to exclude the evidence.

408 The defendant asserts that the plaintiff ought to have put forward a witness who had personal knowledge of the 'traceability' system. [note: 278] In particular, "the person who was in charge of the 'traceability' system … would have been a more appropriate witness". [note: 279] Ms Watts is not and never was an employee of the Maidenhead Facility. She was not involved in the filling up of the DCLs. In my view, Ms Watts' knowledge of the traceability system was derived from her visits to the Maidenhead Facility, and her evidence on the system was also supported by Dr Lawson, who is an employee of the plaintiff. [note: 280] In any event, the DCLs, as admissible evidence under the business records exception to the hearsay rule, speak for themselves.

409 I do not consider it necessary to go through all the various alleged inconsistencies and discrepancies identified by the defendant in respect of the traceability system. Instead, I highlight certain types of arguments that were made by the defendant, and explain why I find them to be without merit.

(1) Tampering of the evidence

410 The Defendant's position is that the plaintiff has "manufactured, altered and tampered with evidence to deceive [the] Court by giving it the false impression that there is a seamless chain of custody of the [Samples]". [note: 281] The defendant pointed to a number of DCLs where changes were made to the entries to assert that the plaintiff must have amended the DCLs after the fact to manufacture evidence for the suit. [note: 282] In my view, the contentions relating to tampering are wholly speculative and unsubstantiated.

411 As an example, the defendant took issue with the DCL of 4 May 2016. The first scientist who had filled in the DCL had written the date 4/4/16 in black ink, and then filled in the first four rows in black ink. The authorising signatory for his entries was entered in blue ink. Subsequently, Dr Cann filled in the next few rows in blue ink. Blue ink was also used to write over 4/4/16 such that the date read 4/5/16. It is unclear how the defendant manages to infer from the amendment of the date that there has been tampering of evidence. Either the authorising signatory or Dr Cann could have amended the date recorded by the first scientist, which was incorrect. It is not inconceivable that there will be human administrative errors in the filling up of the DCLs, which were completed by a miscellany of scientists on a daily basis as a routine matter, but to then suggest that these errors are indicative of the tampering of evidence is inappropriate.

(2) Discrepancies in the DCLs

412 Various discrepancies in the DCLs are pointed out by the defendant, which I do not discuss in detail. I am however satisfied that these discrepancies, which in any event only accounted for a small percentage of the total number of DCLs, may be explained by simple human error. For example, the 30 October 2015 DCL was not accurate as it reflected a same day check-out and check-in of Sample 2 although that was the same day where Sample 2 was returned to the Maidenhead Facility from external testing. But when presented with this alleged discrepancy, Ms Watts explained that she made an error when drafting her AEIC and proceeded to correct the discrepancy with the correct DCL (2 November 2015).

413 Another alleged discrepancy pertaining to the DCLs pertains to the colour code. In any given DCL, the colour code of the tin in which the diamonds are contained is required to be filled in. [note: 283] Ms Watts explained that synthetic diamond samples will generally be allocated a green colour code. However, the defendant has highlighted various alleged inconsistencies in the colour code entries. For instance, the DCL of 18 March 2016 shows that Dr Cann checked out Sample 1 and Sample 2 in a red box. However, the DCL of 19 June 2017 and 21 June 2017 show that Sample 1 was checked out in a blue box. But Ms Watts' evidence was only that synthetic diamonds would *generally* be allocated a green colour code. The defendant could have queried Dr Cann on why he had checked out the Samples in boxes of other colours, but chose not to. In the circumstances, I do not consider that the mere use of a different colour code suggests that there has been a break in the chain of custody for the Samples.

(3) Timing of screenshots on plaintiff's internal drive

414 The plaintiff relies on certain screenshots taken of its internal drive as contemporaneous evidence to be examined alongside the DCLs in establishing the chain of custody of the Samples. While the defendant has pointed out alleged inconsistencies in relation to the timing of the screenshots, I am satisfied that the plaintiff has provided satisfactory explanations for these discrepancies. [note: 284] For example, while the DCL of 21 July 2014 indicates that Sample 2 was

checked out of the Strong Room on 8.30am for microscopy and checked in at 4.15pm, the screenshot of the internal drive suggests that the date and time of creation of the microscopy image was 5.48pm. While Ms Watts was unable to provide an explanation for this, Dr Cann explained that the timing reflected on the screenshots had to take into account the time zone of *the computer through which the screenshots had been taken*. [note: 285] Dr Cann also stated that another explanation was that for tests which involved the processing of raw data, the time of creation of the image would reflect the time at which the data processing had been complete, which might be after the Samples were checked into the Strong Room. [note: 286]

Conclusion on provenance and chain of custody contentions

415 For the reasons above, I reject the defendant's contentions on the issues of provenance and chain of custody and find that on a balance of probabilities, the defendant is the responsible party for all three Samples.

Infringement

416 On the issue of infringement, I find that the Samples infringe Claim 1 of SG 872, based on the Metripol measurements from experiments conducted at the University of Warwick. In addition, I also find, based on the EPR measurements which were also from experiments conducted at the University of Warwick, that Claim 62 of SG 872 must have been infringed as well. For SG 508, while the width of Claim 1 is such that there was technically infringement as Sample 3 was annealed resulting in a change of colour, my finding that SG 508 is not a valid patent is a complete defence to infringement.

Infringement of Claim 1 of SG 872

417 The plaintiff's case in relation to infringement is as follows: [note: 287]

(a) For Sample 2, the plaintiff has pleaded that it infringed Claims 1(ii), 1(iii), 16(ii), 35, 41-42, 49, 57-60, 62-70, 72, and 75-77 of SG 872;

(b) For Sample 3, the plaintiff has pleaded that it infringed Claims 1(ii), 1(iii), 16(ii), 19, 35, 41-43, 47-50, 52-53, 57-60, 62-72 and 75-78 of SG 872;

(c) For Sample 4, the plaintiff has pleaded that it infringed Claims 1(ii), 1(iii), 16(ii), 19, 35, 41-42, 49, 52, 57-60, 62-70, 72 and 75-77 of SG '872.

Preliminary issues

418 Before I turn to the Samples, I first deal with the defendant's preliminary technical objections on the plaintiff's use of its technical notes and its procedural omission.

419 The plaintiff relies on various technical notes to provide infringement ("the Technical Notes"):

(a) For Sample 2, the note titled "Characterisation of an optical grade single crystal synthetic diamond (NL 625-03) supplied by Microwave Enterprises" dated 5 October 2016, authored by Dr Martineau and Dr Cann ("Sample 2 Technical Note");

(b) For Sample 3, the notes titled "Analysis of Pure Grown Diamonds Gemstones Gemstone NL 702" dated 5 October 2016, authored by Dr Martineau and Dr Cann ("Sample 3 Technical Note") and "Summary of Evidence that NL702 had been Heat Treated (Annealed) after Growth" ("Sample

3 Heat Treatment Analysis");

(c) For Sample 4, the note titled "Characterisation of an optical grade single crystal CVD synthetic diamond sample (NL719-06) supplied by IIa Technologies Pte Ltd" dated 5 October 2016, authored by Dr Martineau and Dr Cann ("Sample 4 Technical Note").

Are the Technical Notes admissible?

420 The defendant contends that the Technical Notes are inadmissible hearsay evidence, as they are "mere summaries" of the results of various experiments conducted on the Samples. [note: 288] The Technical Notes were not prepared by those who actually conducted the experiments.

421 The defendant's argument that the Technical Notes are hearsay evidence is misplaced. They were prepared by Dr Martineau, working with Dr Cann, both of whom were responsible for and able to answer queries for the experiments. Insofar as some of the records were generated by others, it would not be practicable to call each witness who generated data from the measurements or the system. Such data and raw material would have been generated in the ordinary course of business and admissible under s 32(1)(b) of the EA. This exception also covers statements based on information supplied by other persons, which would in this case then include the University of Warwick and LZH.

422 The defendant also contends that Dr Newton and Dr Glazer's expert opinion on the infringement of the product claims should be disregarded, as it was based on the Technical Notes which are inadmissible hearsay evidence. Further, neither of them were involved in or conducted any of the experiments. Given my finding that the Technical Notes are admissible, this contention falls away. Dr Newton and Dr Glazer were providing their expert opinion on the contents of these Technical Notes. Further, I should also point out that the *defendant's experts* were also content to discuss the Technical Notes to justify their expert opinion of why the Samples were non-infringing. The defendant could have, on their behalf, sought a physical examination of the Samples, of the various machines used or of the tests conducted, or asked for repeat tests or experiments to be conducted on the Samples. [note: 289] They preferred to rely instead on technical arguments.

Whether the plaintiff can rely on experiments not contained in a Notice of Experiment

423 The defendant contends that the plaintiff is not permitted to rely on experiments not contained in a Notice of Experiment, as compliance with O 87A r 6 of the Rules of Court (Cap 322, R 5, 2014 Rev Ed) ("Rules of Court") is mandatory. Order 87A r 6 of the Rules of Court states as follows:

Experiments (O. 87A, r. 6)

6.—(1) Where a party desires to establish any fact by experimental proof, he shall within 21 days after service of the lists of documents under Rule 5, serve on the other party a notice stating the facts which he desires to establish and giving full particulars of the experiments proposed to establish them.

424 In *Electrolux Northern Ltd v Black & Decker* [1996] FSR 595 ("*Electrolux*"), Laddie J stated (at 610) that the consequences of a failure to comply with O 87A r 6 (under the English provision which is *in pari materia*) was as follows:

Where a party intends to rely on experiments he must serve a notice as required by Ord. 104 r.12. The rule is mandatory not permissive. Such experiments will not be admissible in the

absence of a notice *unless, in the light of special circumstances, the court exercises its discretion to allow them in*. If a party wants to have them admitted, in the absence of agreement from his opponent, he should normally make a formal application to the court to that effect. What he should not do is introduce them by way of the witness or expert statements or in counsel's skeleton arguments. That course is unfair to the other side. *The latter may only realise at the trial what is being put forward and may thereby be deprived, in the absence of an adjournment of the trial, of the option of carrying out experiments in reply or of finding an expert who can answer the points to be made. Furthermore he will be deprived of the opportunity to have his experts witness the experiments.* [emphasis added]

425 The defendant points out that the plaintiff has relied on the following experiments that were not part of its Notice of Experiment: [note: 290]

(a) Cross-polarised images;

(b) DiamondView images;

(c) Laue-X-ray Diffraction;

(d) FTIR Spectroscopy

(e) UV/Visible Absorption Spectroscopy measurement at 360nm and 515nm absorption bands and wavelengths;

(f) Photoluminescence at 488nm excitation.

426 In closing submissions, counsel for the plaintiff pointed out that items (b) and (e) were part of its Notice of Experiment, but accepted that (a), (c), (d) and (f) were not contained in the Notice of Experiment.

427 It is clear from *Electrolux* that notwithstanding the failure to comply with O 87A r 6 of the Rules of Court, the court still retains a residual discretion to allow such experiments into evidence. In my view, it is appropriate to allow the experiments into evidence, for the following reasons. The experiments here did not catch the defendant by surprise as they were found in the Technical Notes. Further, there was no prejudice to the defendant as while one intended rationale of a Notice of Experiment is to allow for the possibility of repeat experiments, it is clear that the defendant had no intention of asking for repeat experiments.

The defendant's decision not to conduct experiments or ask for repeat experiments

428 In this context, I add that the defendant's decision not to ask for repeat experiments or to conduct its own experiments on the Samples is one that has legal consequences. First, save in exceptional circumstances, if the defendant chooses not to ask for a repeat of the notice of experiments, the court will accept that the steps described will produce the results alleged. As explained by Laddie J in *Electrolux* at 608:

When a party serves a notice of experiments and the opponent does not ask for a repeat, the account of how the experiment was conducted and the results obtained are, save in exceptional circumstances and to the extent they are set out in the notice, taken to be proved. *For the purpose of the action the court will accept that the steps described will produce the results as alleged in the notice.* The opponent can still challenge the relevance of the experiment and

whether it was appropriate to prove any issue in the trial. He can also argue, for example, that the method employed to measure results was inappropriate so that the figures, though accepted as having been accurately recorded, do not mean what the party putting them forward suggests. On the other hand when the opponent asks for the experiment to be repeated so that it can be witnessed by his own experts, primary importance and weight should be given to the outcome of the repeats. But this does not make the results as set out in the notice inadmissible. [emphasis added]

429 Second, in determining the issue of infringement, the court places weight on actual experiments conducted, given that they are "inherently more transparent than a good deal of other evidence". This was explained in *Magnesium Elektron Limited v Neo Chemicals & Oxides (Europe) Limited* [2017] EWHC 2957 at [77]–[79]:

> For experiments subject to the notice procedure, an opposing party has a right to have the experiment repeated and to witness repetition … An opposing party also has a right to undertake and seek to adduce evidence of its own experiments, including experiments in reply to those done by the other side. That also applies to experiments not subject to a notice done for preliminary purposes.
>
> Undertaking and witnessing the repetition of experiments is often a costly exercise. If it can be shown at the outset that the experiment relied on has not (for example) been sufficiently validated, an opposing party may reasonably decide not to undertake that exercise but may, instead, criticise the experiments as not being probative for that reason. There are therefore good reasons for having complete information about this at as early a stage as possible.
>
> However, conversely, precisely because experiments are subject to challenge and often formal repetition, they are very different from (for example) a single document put forward as evidencing the nature of a transaction as a whole. Even if full data relating to an experiment is not put forward, there is often nothing to stop an opposing party running the same experiment and showing that it produces different results. *Experiments are, to this extent, inherently more transparent than a good deal of other evidence.* [emphasis added]

430 It is with these two points in mind that I approach the Samples.

Whether Sample 2 infringed Claim 1 of SG 872

431 According to the Technical Notes, the Metripol measurements for Sample 2 are 0.407 (for mod sine delta max for 98% of the analysed area) and 5.39 x 10^{-5} (for delta n max for 98% of the analysed area). This falls within the SG872 Range. The Metripol, as discussed in the context of the validity of Claim 1 of SG 872, is used to obtain a quantitative measure of the birefringence of the diamond. The experiments themselves were conducted at the University of Warwick, which were then analysed in the Technical Notes. [note: 291]

432 The defendant asserts that the Metripol results for Sample 2 did not prove that Sample 2 infringed Claims 1(ii) and/or 1(iii). This is because the Metripol system is incapable of proving that delta is less than π/2 and cannot accurately measure mod sine delta for a sample thicker than 0.25mm. [note: 292] I have rejected both these contentions above: see [194]–[218] above.

433 The Metripol measurements alone suffice to prove that Sample 2 had a low optical birefringence within the SG 872 Range.

434 For completeness, I deal with the defendant's contentions on the cross-polarised images. The defendant asserts that the cross-polarised images of Sample 2 proves that it did not infringe Claim 1. All three images showed "significant areas of white", when the only colour that ought to have been seen was black, according to the Michel-Levy chart. [note: 293] In the course of the trial, a significant amount of time was also spent on a yellow streak found in one of the cross-polar images for Sample 2. However, Dr Kaminsky, the defendant's own expert, testified that the white areas were due to over-exposure. [note: 294] Dr Martineau gave evidence to the same effect. While Dr Kaminsky could not conclude what colour those areas would have been but for the exposure, and therefore concluded that the cross-polar images were unreliable, they could have revealed black areas as well. As for the yellow streak, the short answer to this is that for the purposes of the patent, the selected analysed area is defined at 1.3mm x 1.3mm of the Sample, and that is well away from where the yellow spot occurred. [note: 295]

Whether Sample 3 infringed Claim 1 of SG 872

435 According to the Technical Notes, the Metripol measurements for Sample 3 are 0.080 (for mod sine delta max for 98% of the analysed area) and 1.06 x 10^{-5} (for delta n max for 98% of the analysed area). This falls within the SG872 Range.

436 For Sample 3, the defendant refers to another cross-polarised image of Sample 3, not relied on up by Dr Newton, "which showed a significant increase in white colour across the face of the sample". [note: 296] The experts' explanation of over-exposure applies equally here.

437 The defendant also asserts that Sample 3 was tampered with by the plaintiff. Specifically, Sample 3 was processed from a gemstone into a plate such that the optical birefringence of the original sample was materially altered. [note: 297] However, Dr Nebel conceded that he did not expect the polishing of diamond to change the birefringence in the remaining material: [note: 298]

> MR YEO: … Professor Newton is essentially making the point that merely polishing Sample 3 will not significantly affect the birefringence values of the material that has not been polished away, of course. You would agree with that, Dr Nebel?
>
> A: I think, to be honest speaking, that this is a scientific question which I just not can say "Yes" or "No". I mean, how does Dr Newton know that he is not changing the birefringence? Did he measure it or did he not measure before and after polishing? *I, personally, must admit that I don't expect that birefringence is changing by polishing because we come back to the question: dislocations.*
>
> [emphasis added]

438 This is consistent with Dr Glazer's opinion that polishing a diamond sample into a parallel plate would not affect the heterogeneity of the sample given the hardness of diamond material. [note: 299]

439 Page 32 of SG 872 itself specifies that in order to take birefringence measurements, "[s]amples are prepared as optical plates of known thickness". In addition, Dr Kaminsky explained in his AEIC that it was "perfectly fine" to reshape a sample into a parallel polished plate", stating as follows:

> The experiments include to (re)-shape a sample into a plane parallel polished plate, if necessary. While it is perfectly fine to apply reshaping for testing if the sample is sufficiently homogeneous, CVD diamonds are everything but homogeneous and different parts of a sample can have very different strain and birefringence patterns.

440 Dr Kaminsky's objection was thus as to the perceived heterogeneity of strain and birefringence patterns in CVD diamonds, which I have rejected above: see [210] above.

441 There is also some contention between the parties as to whether Sample 3 was *polished* into a parallel-sided plate, or *laser sawn*. Dr Martineau's evidence was that notwithstanding the Sample 3 Technical Note stating that the plate was laser sawn, further checks on the records had revealed that Sample 3 was polished. [note: 300] This becomes relevant because Dr Nebel contended that Sample 3 could not be polished in a day. But the DCL for 24 November 2015 shows that Sample 3 was polished in a day. This is consistent with the laboratory notebook entry recording the progress of the polishing of Sample 3 in one day. [note: 301] It would be speculative to suggest that these contemporaneous documents were tampered with. Further, I also note that while Dr Nebel contended that Sample 3 could not be polished in a day, he had conceded that a diamond could be polished at up to 100 microns an hour, which contradicts his earlier evidence that it could be polished at 1 micron an hour. [note: 302]

Whether Sample 4 infringed Claim 1 of SG 872

442 According to the Technical Notes, the Metripol measurements for Sample 3 are 0.0231 (for mod sine delta max for 98% of the analysed area) and 3.22 x 10^{-5} (for delta n max for 98% of the analysed area). This falls within the SG872 Range. The defendant's contentions here again can be addressed by the over-exposure of the images which I have discussed above.

443 I therefore conclude that Samples 2, 3 and 4 infringe Claim 1 of SG 872. In the light of this conclusion, it is unnecessary to deal with Mr Mehta's rather circular arguments that the Samples could not have originated from the defendant, either because the defendant did not produce low birefringent diamonds or did not cut or polish diamonds. [note: 303] Mr Mehta also gave evidence that the defendant stopped growing optical grade diamonds in February 2015, but this was contradicted by the contemporaneous documents. [note: 304] It was, in my view, a lie concocted to distance the defendant from the Samples in the present case. Ms Lin Lin's email dated 15 October 2015, addressed to Mr Pascal Pierra in respect of the Sample 4 transaction states: [note: 305]

> Dear Pascal,
>
> Thank you for your interest in IIa Technologies. …
>
> For single crystal thermal management applications:
>
> · What will be the lateral dimension needed? (our plates range from 2mm x 2mm up to 7mm x 7mm)
>
> · Thickness: *minimum we can polish and handle* is 0.4mm for 5x5mm and below, 0.5mm for size above 5x5mm. usually 0.4-0.5 is sufficient, cheaper and easier to grow. so pls let me know your preferences. …

- Any requirement on the impurities level?

  - We have *optical grade plates*, nitrogen content range from tens to hundreds of ppb. Some Si-related color centers detectable.

  - Also we produce high quality electronic grade plates, with [N] < 1ppb. No other traceable impurities. Minimum structural dislocations …

- *Typical lead time 8-10 weeks regardless of qty, as this is the standard production cycle will require.*

…

[emphasis added]

Mr Mehta was therefore not a credible witness, and the veracity of the defendant's alleged confidential process must be seen in that light, which I now turn to.

Infringement of Claim 62 of SG 872

444 The plaintiff submits that the defendant has infringed Claim 62 of SG 872 on the basis of the test results on the Samples and Mr Mehta's evidence given in the course of the trial. [note: 306]

445 The defendant disclosed two growth processes through Mr Mehta's AEIC: the "High Purity Growth Process" and the "Standard Commercial Growth Process". For the purposes of this suit, it is the Standard Commercial Growth Process that is relevant. This process, the defendant contends, comprised trade secrets that required to be limited to a confidentiality club. For convenience, I refer to this as the Confidential Process. The plaintiff does not accept that the Confidential Process accurately sets out the process used by the defendant to grow the Samples, and its CVD diamonds generally.

The disclosure of the Confidential Process

446 It is useful to begin with a chronology of the relevant events which led to the disclosure of the Confidential Process. [note: 307]

447 Initially, the defendant did not disclose any documents pertaining to its manufacturing process voluntarily in general discovery. This led to the plaintiff's application for specific discovery in Summons No 1478 of 2018. That application resulted in a discovery order being granted on 27 August 2018 against the defendant to disclose various items, including its "method(s) of manufacturing the diamond material having product code no. 2PCVD50500N". [note: 308]

448 On 28 September 2018, Mr Mehta filed an affidavit (the 30th affidavit), stating in the main that the defendant did not have and never had the documents it was ordered to produce. The plaintiff then filed Summons No 4960 of 2018 which sought, *inter alia*, an unless order for the defendant to comply with the discovery order.

449 On 30 November 2018, I rejected the plaintiff's prayers for the defence and counterclaim to be struck out and for judgment to be entered against the defendant. In this regard, I digress from the issue of infringement to explain briefly why I rejected these prayers. The applicable principles in deciding whether to grant a striking out order was summarised in *Grande Corp Pte Ltd v Cubix*

International Pte Ltd and others [2018] SGHC 13 at [76]:

> It is well established that the classic case for striking out an action under O 24 r 16 of the ROC is where there is a real or substantial risk that a fair trial will no longer be possible as a result of the failure to provide discovery (*Mitora Pte Ltd v Agritrade International (Pte) Ltd* [2013] 3 SLR 1179 ("*Mitora*") at [48], citing *Singapore Civil Procedure 2013* vol 1 (G P Selvam eds) (Sweet & Maxwell Asia, 2013) at para 24/16/1). It is also clear, however, that the impossibility of a fair trial is neither a determinative factor nor a pre-requisite for striking out, and that a court may order a striking out even if a fair trial is still possible (*K Solutions Pte Ltd v National University of Singapore* [2009] SGHC 143 ("*K Solutions*") at [126]). However, the Court of Appeal in *Mitora* (at [48]) stated that this would take place in "exceptional circumstances", where the breach is "inexcusable" (at [47]).

450 In my view, the present case was not one in which such exceptional circumstances could be said to exist. More importantly, there were multiple issues which had to be canvassed at trial, and the issue of the defendant's process was relevant only to infringement. If the patents were invalid, the defendant would in any event have a defence to infringement.

451 In the circumstances, I instead ordered for the defendant to explain in an affidavit its reasons for not having the relevant documents in its possession, custody or power. I highlighted that the non-compliance with the discovery order ought to be a matter dealt with in cross-examination at trial. Further, the failure to disclose might lead to an adverse inference being drawn against the defendant.

452 Against this backdrop, the defendant's Confidential Process was finally revealed in Mr Mehta's AEIC dated 1 February 2019. According to Mr Mehta, "[t]he formulas and descriptions of [the defendant's] secret methods … [were] reproduced in written form for the first time. Prior to this, [the defendant] had never documented its secret processes". [note: 309]

453 I disbelieve Mr Mehta's statement that the defendant's method of manufacturing CVD diamonds had not been documented before. The defendant's own account was that these secret processes were the result of research and development for seven years between 2005 and 2012. It involved complex formulae and graphical representations. The defendant was a commercial entity with a turnover of US$90m. [note: 310] Yet, the defendant claimed that no documentation was necessary and that it had relied solely on Dr Misra and Mr Mehta's memory to remember its Confidential Process and to key them into the scientific calculators and machines.

454 In my judgment, the defendant did not want to risk the possibility of the drawing of an adverse inference from the non-disclosure of its process. However, as will be evident from the points below, its process to grow the Samples infringed Claim 62 of SG 872. Under these circumstances, it designed a Confidential Process that [rest of sentence redacted]. This was contrived so as to avoid liability for infringement.

The range of nitrogen used in the Confidential Process

The EPR measurements

455 One key contention is the nitrogen concentration used by the defendant in its Confidential Process. In this regard, I place weight on the EPR measurements of the samples, which provide an objective indicator of the amount of nitrogen that has been present in the synthesis atmosphere when the Samples were grown. The EPR is a spectroscopic method employing magnetic fields and microwaves to study materials and molecules with unpaired electrons. In the present case, the EPR

experiments were conducted by the University of Warwick and the measurements were then analysed in the Technical Notes. [note: 311]

456 According to the EPR measurements of the Samples, the concentrations of neutral single substitutional nitrogen within Samples 2, 3 and 4 are 118ppb, 460ppb and 130ppb respectively. [note: 312] Referencing back to [220], these values are, as expected, below those prescribed by Claims 57 and 58, being 2.84 ppm and 1.136ppm respectively. Those *product* claims are therefore infringed as well. Dr Bergonzo explained that while there is no precise correspondence between nitrogen concentration in the *solid* phase and in the *gas* phase, the nitrogen concentration in the gas phase will always exceed the concentration of nitrogen incorporated in the diamond by a factor of 5 (*ie*, incorporation ratio of 0.2). As for Dr Nebel, he stated in his expert report that "[n]itrogen in diamond can be indicative of the used range of nitrogen in the gas atmosphere … The reported incorporation rates are spreading from 0.2 to 0.0001". [note: 313] While the defendant points out that Dr Nebel was "referring to an incorporation ratio of nitrogen atoms to carbon atoms in the synthesis atmosphere into the grown diamond", [note: 314] it is not clear how this can be read into Dr Nebel's statement.

457 The plaintiff notes that by Dr Nebel's own incorporation ratios, Samples 2, 3 and 4 must have been grown with at least 590ppb, 2ppm and 650ppb of nitrogen in the synthesis atmosphere respectively. The defendant's response to this is to refer to a mismatched fraction, which I deal with at [459]–[459] below.

458 The EPR measurements alone therefore show that Samples have been grown with a process that had a nitrogen range of between 300ppb to 5ppm in the synthesis atmosphere. I note that in respect of the EPR measurements, Dr Nebel asserted that the results were unreliable because the experiments were not properly calibrated. For example, the reference sample that was used to calibrate the experiment for Sample 2 was only 0.44 carats whereas Sample was only 0.13 carats. [note: 315] Dr Newton's response to this was that both the reference sample and Sample 2 are parallel-sided plates and their sizes were similar enough, such that the reference sample could be used with confidence. [note: 316]

Even on the Defendant's Confidential Process, the range of nitrogen used was between 300ppb and 500ppm

459 [[459] – [466] redacted]]

Substrate and plasma etching

467 [[467] – [471] redacted]

Infringement of SG 508

472 The plaintiff's case on infringement of Claim 1 of SG 508, based on the test results for Sample 3, is that collectively, the test results as stated in the technical notes on Sample 3 show that Sample 3 was annealed. [note: 317]

(a) FTIR Spectroscopy was conducted on Sample 3 internally. The presence of certain absorption lines would be indicative of the presence or absence of certain point defects in CVD diamond. [note: 318] In the present case, the spectrum produced contained, *inter alia*, a weak line at 1341cm^{-1}. This line was previously only observed for CVD synthetic diamond that had been

exposed to heat treatment which has removed or reduced brown colour. Further, no absorption feature was observed at 3123cm^{-1}, which is consistent with post-growth annealing at high temperature.

(b) Sample 3 was also internally tested using DiamondView and a photoluminescence spectrometer, which showed that Sample 3 was heat treated after growth. In particular, the combination of green fluorescence and blue phosphorescence for the DiamondView images is "often seen for nitrogen doped CVD synthetic diamond that has been heat treated (annealed) to improve its colour". As for the photoluminescence spectra, which give an indication of the method used to produce the material and whether this involves high temperature treatment after growth, [note: 319] the detection of H3 defects (comprising two nitrogen atoms and a vacancy) suggested that Sample 3 had been annealed after growth. The presence of the N3 defect at 415.1nm and 427.7nm wavelengths also supported a finding that Sample 3 has been annealed as these lines are not seen in as-grown material.

473 The defendants contends that the plaintiff has not proven annealing to change the colour on various grounds. I reject these contentions for the following reasons:

(a) While the defendant claims that the Technical Notes are inadmissible, I have earlier explained, in the context of SG 872, that they are admissible pursuant to s 32(b)(iv) of the Evidence Act: see [420]–[422] above.

(b) The defendant points out that in SG 508 itself, it is stated that the observation of the 3107cm^{-1} line in CVD diamond is indicative that the material has been annealed according to SG 508. However, it is undisputed that no such line was observed. [note: 320] In response, the plaintiff, relying on Dr Newton's evidence, states that the presence of the 3107cm^{-1} line is only *indicative* that the diamond has been annealed. The absence of the line does not mean that the diamond has not been annealed, as it could be due to other factors such as the amount of hydrogen in the sample. [note: 321] I accept Dr Newton's explanation on this point which was not contested by Dr De Weerdt.

(c) The defendant also contends that the plaintiff has not proved that Sample 3 was coloured before it was annealed. [note: 322] But the line at 1341 cm^{-1} is evidence that the diamond was originally of a brown colour: see [472(a)] above.

474 Nevertheless, whilst the Samples have been annealed, in view of my finding on validity, the defendant has a defence to infringement. This infringement of SG 508 could also point to infringement of WO 406, EP 482 or US 430 or Schmetzer, for that matter, given that I have found that these pieces of prior art would have taught the PSA that a CVD diamond could be annealed to change its colour

475 I add a note on the defendant's described confidential process of annealing. [Remainder of [475] – [476] redacted]

477 Indeed the premise of the defendant's case against the validity of SG 508 is that the annealing process is the same for all kinds of Type IIa diamond, quite regardless of their nitrogen content, and nitrogen structure and content differs across the three kinds of Type IIa diamond.

Conclusion

478 I therefore make the following orders:

(a) A declaration that SG 872 is valid and has been infringed;

(b) An injunction to restrain the defendant, whether by themselves, their directors, officers, servants, agents from (a) making, disposing of, offering to dispose of, using, importing and/or keeping products which infringe SG 872, and/or (b) using or offering for use in Singapore processes which infringe SG 872;

(c) An order for the delivery up and/or destruction, to be verified upon oath, of all products or articles which infringe SG 872;

(d) A declaration that SG 508 is invalid and has not been infringed; and

(e) An order for SG 508 to be revoked.

479 I shall hear counsel on costs. Regarding the prayer for an inquiry as to damages or an account of profits, this is to be dealt with in a second stage as provided for by Wei J's order of court dated 31 March 2017 bifurcating the action to deal with validity and infringement issues first. The plaintiff may apply at the appropriate time.

480 I conclude with a note of appreciation to Prof Loh Kian Ping, who assisted the court as an assessor in this case.

[note: 1] Plaintiff's closing submissions for first tranche ("PCS1") para 2.

[note: 2] Plaintiff's closing submissions for second tranche ("PCS2") para 31.

[note: 3] Plaintiff's opening statement for second tranche ("POS2") para 4.

[note: 4] PCS1 para 12a.

[note: 5] PCS1 para 12b.

[note: 6] PCS1 para 12c.

[note: 7] POS2 para 57.

[note: 8] BAEIC15 6394.

[note: 9] BAEIC6 788.

[note: 10] NE 030419 70/19.

[note: 11] AB2 1377.

[note: 12] PCS2 para 593.

[note: 13] NE 290719 81/19-82/1.

[note: 14] AB1 598.

[note: 15] DCS2 outline para 23.

[note: 16] Defendant's closing submissions for second tranche ("DCS2") para 219.

[note: 17] PCS2 para 265(c).

[note: 18] NE 250719 76/16-78/7; PCS2 para 623.

[note: 19] DCS2 para 228.

[note: 20] NE 250719 150/2.

[note: 21] DCS2 outline, Annex A.

[note: 22] NE 071119 24.

[note: 23] NE 071119 49/18-20.

[note: 24] DCS2 10.

[note: 25] DCS2 para 22.

[note: 26] DCS2 para 17.

[note: 27] NE 071119 83/25.

[note: 28] BAEIC7 1206.

[note: 29] BAEIC7 1206.

[note: 30] BAEIC7 1203.

[note: 31] BAEIC11 3688-3689. NE 071119 83.

[note: 32] NE 250719 157/5.

[note: 33] DCS2 para 22.

[note: 34] DCS2 para 25. NE 071119 8/28-30.

[note: 35] NE 071119 9/1-5.

[note: 36] DCS2 paras 29 and 31.

[note: 37] DCS2 para 33.

[note: 38] PCS2 para 538(f)(g).

[note: 39] NE 080819 102/21-103/16.

[note: 40] NE 250719 6/10-14.

[note: 41] PCS2 para 619.

[note: 42] NE 300719 144/10.

[note: 43] DCS2 para 43.

[note: 44] DCS2 para 44.

[note: 45] PCS2 para 630.

[note: 46] PCS paras 627-628.

[note: 47] NE 240719 9/6.

[note: 48] DCS2 para 62.

[note: 49] NE 071119 2.

[note: 50] DCS2 outline, Annex A, S/N 4.

[note: 51] DBD10 6284.

[note: 52] BAEIC11 3692.

[note: 53] NE 250719 154.

[note: 54] NE 071119 91/25-27.

[note: 55] BAEIC11 3706 para 239.

[note: 56] DBD17 10491.

[note: 57] DBD17 10312.

[note: 58] DCS2 outline, Annex A, S/N 6.

[note: 59] BAEIC23 10826 para 289.

[note: 60] BAEIC23 10827 para 290.

[note: 61] DBD15 9586.

[note: 62] DBD15 9592.

[note: 63] BAEIC23 10829 para 294.

[note: 64] BAEIC11 3706 para 330.

[note: 65] DBD17 10497.

[note: 66] BAEIC11 3713 para 360.

[note: 67] DBD16 9862.

[note: 68] NE 260719 37/4-13.

[note: 69] PCS2 para 595.

[note: 70] P 13 of SG 872.

[note: 71] NE 220719 15/2-18.

[note: 72] NE 250719 54/17-55/1-2 and 62/11-17.

[note: 73] NE 310719 102.

[note: 74] P 54 of SG 872.

[note: 75] DCS2 para 182.

[note: 76] AB4 2632.

[note: 77] NE 010819 187/6–11.

[note: 78] Page 5 of WO 633.

[note: 79] DCS2 outline, Annex A, S/N 2.

[note: 80] NE 220719 30/10-12.

[note: 81] DBD10 6620.

[note: 82] BAEIC25 12241.

[note: 83] AB3 1885.

[note: 84] PCS2 para 698; BAEIC11 3687 para 245.

[note: 85] BAEIC29, 14757.

[note: 86] AB4 2662.

[note: 87] NE 290719 16/14–17/9.

[note: 88] DCS2 paras 87–89.

[note: 89] DBD10 6542.

[note: 90] DBD14 8879.

[note: 91] NE 220719 67/2-69/7, 74/20-76/5.

[note: 92] AB9 732.

[note: 93] PCS2 para 770.

[note: 94] AB4 2751.

[note: 95] DCS2 para 94.

[note: 96] PCS2 para 57(b).

[note: 97] BAEIC23 paras 247-258.

[note: 98] PCS2 para 597; NE 220719 50.

[note: 99] NE 010819 159/21-161/8.

[note: 100] DCS2 para 149.

[note: 101] PCS2 para 779.

[note: 102] PCS2 para 804.

[note: 103] PCS2 para 810.

[note: 104] PCS2 para 817.

[note: 105] DCS2 para 232.

[note: 106] DCS2 para 261.

[note: 107] DCS2 pp 127-131.

[note: 108] DCS2 128.

[note: 109] DCS2 128.

[note: 110] PCS2 para 1256.

[note: 111] AB3 2252.

[note: 112] DCS2 129.

[note: 113] DCS2 128-129.

[note: 114] DCS2 129.

[note: 115] AB3 2256.

[note: 116] DCS2 129.

[note: 117] DCS2 130.

[note: 118] NE 260719 196/4-197/18.

[note: 119] NE 290719 53.

[note: 120] DBD15 9767.

[note: 121] NE 010819 78/3-6.

[note: 122] NE 290719 58/20.

[note: 123] DCS2 para 311.

[note: 124] DCS2 para 314.

[note: 125] DCS2 para 312.

[note: 126] DCS2 para 319.

[note: 127] NE 220719 123/23-127/5.124

[note: 128] NE 220719 141/3.

[note: 129] DCS2 para 321.

[note: 130] PCS2 outline para 60.

[note: 131] BAEIC38 19646 para 146b.

[note: 132] DCS2 para 322.

[note: 133] DCS2 para 348.

[note: 134] DCS2 para 349.

[note: 135] BAEIC38 19610 para 18. BAEIC44 23834 para 29.

[note: 136] BAEIC5 306 para 16.

[note: 137] NE 240719 38/10.

[note: 138] NE 240719 112/1.

[note: 139] DCS2 para 352.

[note: 140] NE 250719 147/12--..

[note: 141] NE 010819 6/18-21.

[note: 142] NE 240719 118/1-6.

[note: 143] NE 240719 119/6-17.

[note: 144] DCS2 para 354.

[note: 145] DCS2 para 356.

[note: 146] BAEIC5 302 para 6(d).

[note: 147] DCS2 para 359.

[note: 148] PCS2 para 922.

[note: 149] NE 240719 145/23.

[note: 150] PCS2 para 837(a)(iii).

[note: 151] PCS2 outline para 4.

[note: 152] PCS2 para 267.

[note: 153] DCS2 para 364.

[note: 154] DCS2 para 368.

[note: 155] DCS2 para 370.

[note: 156] AB1 644.

[note: 157] AB1 672.

[note: 158] AB3 2175.

[note: 159] DCS2 para 383c.

[note: 160] AB3 2078.

[note: 161] DCS2 para 395.

[note: 162] DCS2 para 397.

[note: 163] BAEIC7 1222 para 128127.

[note: 164] NE 010819 28/19-22.

[note: 165] NE 010819 29/9-10.

[note: 166] PCS2 outline para 69.

[note: 167] BAEIC17 7756 paras 33-38.

[note: 168] DCS2 para 201.

[note: 169] DCS2 para 152.

[note: 170] Confidential Bundle Tab 9 para 66(3).

[note: 171] DCS2 para 205.

[note: 172] AB5 3554.

[note: 173] PBD13 576.

[note: 174] NE 290719 21/25.

[note: 175] NE 290719 28/17-25.

[note: 176] NE 290719 53/23.

[note: 177] NE 310719 135/24-138/1.

[note: 178] DCS2 para 402.

[note: 179] DCS2 194-211.

[note: 180] DCS2 para 412

[note: 181] DCS2 196.

[note: 182] DCS2 200.

[note: 183] DCS2 para 423.

[note: 184] DCS2 para 428.

[note: 185] DCS2 para 440.

[note: 186] DCS2 para 433.

[note: 187] DCS2 para 441.

[note: 188] PCS2 outline para 40.

[note: 189] PCS2 outline para 116.

[note: 190] Particulars of Objections (Amendment No 6) para 162.

[note: 191] BAEIC7 1201 para 55.

[note: 192] PCS2 para 1546.

[note: 193] EP 482, p 2 ln 46–56.

[note: 194] NE 070819 75.

[note: 195] PCS2 para 1518.

[note: 196] PCS2 para 1519.

[note: 197] PCS2 outline para 117.

[note: 198] DCS2 para 681.

[note: 199] DB15 9753.

[note: 200] DB19 10676.

[note: 201] NE 070819 74/818-77/8

[note: 202] NE 060819 1/3-15.

[note: 203] PCS2 para 1479.

[note: 204] PCS2 para 1480(a).

[note: 205] PCS2 para 1483(a).

[note: 206] PCS2 para 1480(b).

[note: 207] PCS2 para 1480(c).

[note: 208] PCS2 para 1488.

[note: 209] PCS2 para 1491.

[note: 210] PCS2 para 1492.

[note: 211] BAEIC11 para 1155.

[note: 212] PCS2 para 1484.

[note: 213] DOS2 para 761.

[note: 214] DCS2 para 764.

[note: 215] PCS2 para 1614.

[note: 216] BAEIC12, 3949.

[note: 217] DCS2 para 476.

[note: 218] DCS2 para 283.

[note: 219] PCS2 para 247.

[note: 220] AB2 1280.

[note: 221] PCS2 para 100.

[note: 222] PCS1 para 16.

[note: 223] PCS1 para 17.

[note: 224] PCS1 para 17.

[note: 225] PCS1 para 18.

[note: 226] DCS1 paras 22–23.

[note: 227] DCS1 para 49.

[note: 228] DCS2 para 52.

[note: 229] PCS1 para 183.

[note: 230] PCS1 para 145.

[note: 231] DCS1 para 67.

[note: 232] DCS1 para 67.

[note: 233] DCS1 para 68.

[note: 234] DCS1 para 76.

[note: 235] PCS1 para 190.

[note: 236] PCS1 para 191.

[note: 237] DCS1 para 112.

[note: 238] NE 030419 207/10 to 208/1.

[note: 239] PCS1 para 191.

[note: 240] DCS1 para 78.

[note: 241] PCS para 198.

[note: 242] DCS1 para 159.

[note: 243] DCS1 para 162.

[note: 244] DCS1 para 118.

[note: 245] DCS1 para 122.

[note: 246] DCS1 para 125.

[note: 247] Exhibit P2.

[note: 248] PCS1 para 215.

[note: 249] PCS1 para 362.

[note: 250] PCS1 para 37.

[note: 251] PCS1 para 19.

[note: 252] PCS1 para 220.

[note: 253] PCS1 para 223.

[note: 254] PCS1 para 227.

[note: 255] PCS1 para 14.

[note: 256] PCS1 para 239.

[note: 257] PCS1 para 242.

[note: 258] PCS1 para 265.

[note: 259] PCS2 para 15.

[note: 260] PCS1 para 277.

[note: 261] PCS2 para 1694.

[note: 262] NE 080819 103/1-14.

[note: 263] BAEIC15 6311 para 43.

[note: 264] PCS2 para 1696.

[note: 265] PCS2 para 1713.

[note: 266] NE 300719 141/15-21.

[note: 267] BAEIC15 6381 para 159.

[note: 268] DCS2 para 565.

[note: 269] DCS2 para 564.

[note: 270] DCS2 para 566.

[note: 271] DCS1 para 179.

[note: 272] DCS1 para 181.

[note: 273] DCS2 para 232.

[note: 274] DCS2 para 238.

[note: 275] DCS1 para 239.

[note: 276] DCS1 para 170.

[note: 277] DCS1 para 290.

[note: 278] DCS1 para 171.

[note: 279] DCS1 para 175.

[note: 280] PCS1 para 295.

[note: 281] DCS1 para 15.

[note: 282] PCS1 para 321.

[note: 283] PCS1 para 317.

[note: 284] PCS1 para 310.

[note: 285] PCS1 para 312.

[note: 286] PCS1 para 313.

[note: 287] DCS2 para 485.

[note: 288] DCS2 para 487.

[note: 289] PCS2 outline para 92.

[note: 290] DCS2 para 515.

[note: 291] BAEIC15 6348 para 91.

[note: 292] DCS2 para 520.

[note: 293] DCS2 para 526.

[note: 294] NE 300719 105.

[note: 295] PCS2 outline para 98(d).

[note: 296] DCS2 para 533.

[note: 297] DCS2 para 540.

[note: 298] NE 310719 42.

[note: 299] PCS2 para 99.

[note: 300] BAEIC15 6294.

[note: 301] PCS2 para 1009.

[note: 302] PCS2 para 1011.

[note: 303] Transcript 020419, 89/14-91/4 and 62/3-5 respectively.

[note: 304] NE 020419 112/11-14.

[note: 305] AB3 1742.

[note: 306] PCS2 outline para 103.

[note: 307] PCS1 para 90.

[note: 308] HC/ORC 5893/2018, Annex A, S/N 11.

[note: 309] Confidential Bundle, Tab 6 para 191.

[note: 310] 1 AB 393.

[note: 311] BAEIC15 6365 para 128.

[note: 312] Confidential Bundle, Tab 19 para 1397.

[note: 313] BAEIC22 para 212.

[note: 314] DCS2 outline para 55.

[note: 315] DCS2 para 529c.

[note: 316] BAEIC11 para 786.

[note: 317] PCS2 para 1633.

[note: 318] BAEIC15 6341 para 80.

[note: 319] BAEIC15 6327 para 54.

[note: 320] DCS2 para 793.

[note: 321] PCS2 outline para 124.

[note: 322] DCS2 para 799.