II-VI Exhibit 1002

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

II-VI Incorporated
Petitioner

v.

Saint-Gobain Ceramics & Plastics, Inc.
Patent Owner

U.S. PATENT NO: 9,963,800

DECLARATION OF FRANK J. BRUNI FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 9,963,800

I, Frank J. Bruni, declare as follows:

1. I am over the age of 21 and I have been retained in this case by II-VI Incorporated ("Petitioner") as an expert witness. I have been asked in this case by Petitioner to provide my opinions as an expert. I am being compensated for my time in this proceeding at a rate of $150/hr. My compensation in no way depends on the outcome of this proceeding or the content of my opinions.

2. I have personal knowledge of the facts set forth in this declaration, and I submit this declaration in support of a petition in the Patent Trial and Appeal Board ("PTAB") in the United States Patent and Trademark Office ("USPTO") for the *inter partes* review ("IPR") of U.S. Patent No. 9,963,800 to Locher et al. ("the '800 patent"). I declare, under penalty of perjury, that the following is true and correct.

I. SUMMARY

3. I have been asked to review the '800 patent to evaluate its validity in light of relevant prior art. I have been provided guidance on patent law in the United States by The Webb Law Firm. I have relied on the prior art cited herein, the '800 patent, its prosecution history, and my education, training, experience, and personal knowledge in forming these opinions. The Exhibits relied upon in this

declaration correspond to the following Exhibits of the accompanying Petition for *Inter Partes* Review.

Exhibit	Description
1001	U.S. Patent No. 9,963,800 to Locher et al.
1003	Askinazi et al., "Development of large-aperture monolithic sapphire optical windows," Proc. SPIE 4375, Window and Dome Technologies and Materials VII, September 7, 2001 ("the Askinazi article")
1004	Schmid et al., "Current status of sapphire for optics," Proc. SPIE 10289, Advanced Materials for Optics and Precision Structures: A Critical Review, 102890A, July 28, 1997 ("the Schmid article")
1005	Locher et al., "Large Diameter Sapphire Window from Single Crystal Sheets," Proceedings of the 5TH DOD Electromagnetic Windows Symposium, Oct. 1993 ("the Locher article")
1007	LaBelle, H.E. and A.I. Mlavsky, "Growth of Controlled Profile Crystals from the Melt: Part I – Sapphire Filaments," *Materials Research Bulletin*, 6, (1971), p. 571
1008	LaBelle, H.E., "Growth of Controlled Profile Crystals from the Melt: Part II – Edge-Defined, Film-Fed Growth (EFG)," *Materials Research Bulletin*, 6, (1971), p. 581
1009	Chalmers, B. et al., "Edge-Defined, Film-Fed Crystal Growth," *Journal of Crystal Growth*, 13/14, (1972), p. 84
1010	U.S. Patent No. 3,701,636 to LaBelle et al., issued October 31, 1972 ("LaBelle '636")
1011	Patel, P.J. et al., "Transparent ceramics for armor and EM window applications," SPIE 45th Annual Meeting – The International Symposium on Optical Science and Technology, Inorganic Optical Materials II Conference, SPIE Vol. 4102-01, July 30 – August 4, 2000, San Diego, California ("the Patel article")

Exhibit	Description
1012	"Properties and Benefits of Sapphire: A Quick Reference Guide," Saint-Gobain Semiconductor, http://web.archive.org/web/20030315075922/http://www.saphikon.com/qrg.pdf, 2 pp., March 15, 2003 ("the Saint-Gobain brochure")
1013	"Industrial Ceramic Products: Products and Markets", Kyocera, https://web.archive.org/web/20010618161723/http://www.kyocera.com:80/KICC/industrial/products/crystal.htm, 4 pp., June 18, 2001 ("the Kyocera website")
1014	Locher et al., "The production of 225 x 325 mm sapphire windows for IR (1-5 μm) applications," Window and Dome Technologies VIII, Proceedings of SPIE, Vol. 5078 (2003), pp. 40-46 ("the Window and Dome article")
1015	Labelle Jr., H.E., "EFG, the Invention and Application to Sapphire Growth," *Journal of Crystal Growth*, Vol. 50, Oct. 30, 1979, North-Holland Published Company, pp. 8-17 ("the Journal of Crystal Growth article")
1016	Daniel C. Harris, "Materials for Infrared Windows and Domes: Properties and Performance," *SPIE-The International Society for Optical Engineering*, 1999, 429 pages ("the Harris article")
1017	U.S. Patent No. 3,591,348 to LaBelle, Jr., issued July 6, 1971 ("LaBelle '348")
1018	U.S. Patent No. 4,269,652 to Yancey, issued May 26, 1981

4. Based on my review, analysis, education, training, and experience, I have reached the following main opinions.

5. **Opinion I – Claims 1, 2, 4, 6, 7, and 9-13 of the '800 patent are invalid as anticipated by the Patel article**: According to my opinion, the Patel article

teaches each and every element of claims 1, 2, 4, 6, 7, and 9-13 of the ’800 patent as will be discussed in greater detail below.

6. **Opinion II – Claims 3, 5, 8, and 14-16 are invalid as being obvious over the Patel article in view of the Schmid article:** According to my opinion, claims 3, 5, 8, and 14-16 of the ’800 patent are obvious over the Patel article in view of the teachings of the Schmid article. More specifically, it was well known in the art, based on the teachings of the Schmid article, to both lap and remove bulk material from sapphire single crystal. In addition, it was well known in the art to machine sapphire single crystal into a geometric configuration for an infrared and laser guidance system, a military sensing and targeting system, or an infrared and visible wavelength vision system based on the teachings of the Schmid article.

7. **Opinion III – Claims 1, 2, 4-7, and 9-13 of the ’800 patent are invalid as being obvious over the Patel article in view of the Locher article and LaBelle ’636**: According to my opinion, claims 1, 2, 4-7, and 9-13 of the ’800 patent are obvious over the Patel article in view of the teachings of the Locher article and LaBelle ’636. The Patel article discloses each and every limitation of claims 1, 4, 6, 7, and 9-13. The Patel article further discloses such sapphire sheets are manufactured using an “edge, defined growth” (EFG) technique. (Ex. 1011, p. 12, Section 5.3). While the EFG process was very well known in the art prior to

April 2003, the details of the EFG process are not explicitly disclosed in the Patel article. The Locher article and LaBelle ’636 provide such details of the EFG technique as discussed in greater detail hereinafter.

8. **Opinion IV – According to my opinion, claims 3, 8, and 14-16 are invalid as being obvious over the Patel article in view of the Locher article and LaBelle ’636 and further in view of the Schmid article:** According to my opinion, claims 3, 8, and 14-16 of the ’800 patent are obvious over the Patel article in view of the teachings the Locher article and LaBelle ’636, and further in view of the teachings of the Schmid article. More specifically, it was well known in the art, based on the teachings of the Schmid article, to lap sapphire single crystal. In addition, it was well known in the art to machine sapphire single crystal into a geometric configuration for an infrared and laser guidance system, a military sensing and targeting system, or an infrared and visible wavelength vision system based on the teachings of the Schmid article.

9. **Opinion V – Claims 1-7 and 9-13 of the ’800 patent are invalid as being obvious over the Saint-Gobain brochure in view of the Locher article and LaBelle ’636, as evidenced by the Kyocera website, the Window and Dome article, and the Journal of Crystal Growth article**: According to my opinion, claims 1-7 and 9-13 of the ’800 patent are obvious over the teachings of

the Saint-Gobain brochure in view of the Locher article and LaBelle ’636. Following the teachings and principles disclosed in the Locher article and LaBelle ’636, it would have been obvious to a person having ordinary skill in the art to produce a crystal sheet having all of the features of claims 1-7 and 9-13 and to machine such a sheet into a sapphire component, as taught by the Saint-Gobain brochure, by scaling the process and equipment known in the art prior to April 2003, without undue experimentation. The Kyocera website, the Window and Dome article, and/or the Journal of Crystal Growth article provide evidence that many others, prior to the priority date of the application that issued as the ’800 patent, were capable of producing single crystal sapphire sheets using the EFG process having dimensions nearly identical to the dimensions required by the claims of the ’800 patent. This position will be discussed in greater detail hereinafter.

10. **Opinion VI - Claims 8 and 14-16 of the ’800 patent are invalid as being obvious over the Saint-Gobain brochure in view of the Locher article and LaBelle ’636, as evidenced by the Kyocera website, the Window and Dome article, the Journal of Crystal Growth article, and further in view of the Schmid article**: According to my opinion, it was well known in the art to machine sapphire single crystal into a geometric configuration for an infrared and laser

guidance system, a military sensing and targeting system, or an infrared and visible wavelength vision system based on the teachings of the Schmid article.

11. In summary, the Journal of Crystal Growth article (Ex. 1015) teaches that sapphire plates of the dimensions of claim 1 can be grown by the EFG process. Labelle '636 (Ex. 1010) describes the methodology, *i.e.*, hot zone design, crucible and die design, heating method, importance of a low horizontal temperature gradient across the top surface of the die, seeding and growth of a shoulder, etc., to grow rectangular plates. The Yancey patent (Ex. 1018) provided a crucial technical breakthrough for improving the quality of the sapphire plates while growing with continuous feeding of additional raw material. The Locher article (Ex. 1005) and the Schmid article (Ex. 1004) teach the prevailing technology for grinding and polishing the as-grown plate into a transparent window. The Saint-Gobain brochure (Ex. 1012) and the Kyocera website (Ex. 1013) teach that it was established art prior to the critical date to produce polished sapphire components grown by the EFG method, particularly for customized sales. The Locher article (Ex. 1005) teaches that mass production of sapphire windows polished on both sides for point-of-sale bar code scanners was well developed before the critical date. Any crystal technologist with experience in this field would have known of or known how to find all of the relevant technology in published sources or from

commercial suppliers to combine these straightforward references as described hereinbelow.

II. QUALIFICATIONS

12. I was awarded a Bachelor of Science degree in Metallurgical Engineering from the University of Pennsylvania in 1967 and a Doctor of Philosophy degree from the University of Oxford, Oxford, England, UK in 1970.

13. Between 1971 and 1973, I worked as an R&D Scientist at Oak Ridge National Laboratory, Oak Ridge, Tennessee, in the development of crystal growth techniques for various ferrite crystals as well as other oxide crystalline materials.

14. Between 1973 and 1976, I worked as an R&D Scientist for Texas Instruments Inc. in Dallas, Texas, in the development of crystal growth techniques for gadolinium gallium garnet as well as other oxide crystalline materials. Between 1976 and 1979, I worked as a Senior Engineer and later as a Group Leader R&D for Allied Chemical Corporation in Charlotte, North Carolina, in charge of garnet crystal growth. During this period, I was promoted to Group Leader and placed in charge of an EFG sapphire crystal program.

15. In 1979, I co-founded and served as an Executive Vice President for Material Progress Corporation of Santa Rosa, California, to develop, among other things, production processes for garnet crystals intended for use as epitaxial wafers

and neodymium-doped yttrium aluminum garnet (Nd:YAG) a laser material which is the primary laser for military systems such as target designators and range finders.

16. Between 1979 and 1985, I co-founded and served as an Executive Vice President for Material Progress Corporation of Santa Rosa, California, to develop, among other things, production processes for crystals intended for use as epitaxial wafers.

17. Since 1985, I have been a consultant in the area of crystal growth to, among others, II-VI Inc. Between 2009 and 2015, I successfully developed systems that could grow large plates or sheets of sapphire (50 cm × 30 cm × 1.5 cm) and simultaneously grow multiple large plates or sheets of sapphire.

18. I have authored 16 articles, some of which relate to crystal growth. I am also a named inventor on two United States patents. I have made multiple presentations at scientific conferences in the U.S. and around the world including invited talks. The two most recent invited presentations that I made were at the Fifth International Workshop on Crystal Growth Technology (IWCGT5) in Berlin, Germany in 2011 and the European Materials Research Society 2014 meeting in Lille, France. In the latter presentation on sapphire growth, I predicted that GT Advanced Technology (the successor company to Crystal Systems, the inventor of

the HEM process) could not keep scaling up their HEM machines without considering the thermodynamics of the process, which they were ignoring. Later that year, GTAT filed for chapter 11 bankruptcy protection when their plant in Tucson, Arizona collapsed trying to make sapphire faceplates for the Apple iPhone.

19. I have had clients both in the U.S. and abroad including Taiwan, Spain, Italy, Germany, Malaysia, Thailand, Canada and Korea. I have done technology transfers on the growth of sapphire by Czochralski growth, EFG, and Kyropoulos, and of alexandrite, another laser crystal with military applications. My Czochralski control software is operating on numerous systems around the world, and my EFG control software is used in two countries. In 2010, Thermal Technology LLC of Santa Rosa, California, under my direction, developed a furnace to grow 90 kg (200 lb.) sapphire crystals for the high-brightness LED market. I wrote the control software and grew the first successful crystals.

20. I consider myself skilled in the art of growing single crystal sapphire sheets. A copy of my Curriculum Vitae is attached hereto. (Ex. 1027).

21. In providing my opinions as expressed below, I rely upon my education, my experience, and my analysis of the documents cited herein. From my education and experience, I consider myself competent and able to explain the

understanding and capabilities of a person having ordinary skill in the art circa 2003.

22. The analysis, conclusions, and opinions stated herein are based on sufficient facts and data, combining my firsthand experience in the relevant field as a person having skill in the art and the specific facts and data of the Exhibits referenced herein. The scientific, technical, and specialized knowledge offered in my prior declaration are for the clearer understanding of the ’800 patent vis-à-vis the relevant prior art.

23. The conclusions and opinions stated herein are the product of reliable principles and methods often employed by my colleagues in the relevant field, including, but not limited to, examining articles, reports, and records of scientific methods of producing sapphire crystals from a melt, and combining those references with my firsthand experience in the relevant field as a person having skill in the art, to determine the viability, completeness, and anticipation of the relevant prior art.

24. As laid out in each paragraph hereinafter, I have reliably applied, and reproducibly examined and described, the teachings of the relevant cited prior art to determine individual references, or combinations of references, that anticipate or render obvious the ’800 patent. It is both routine and necessary, in my position as

an expert, to interpret the teachings of prior art references, particularly in light of my knowledge and industry understanding at a time over a year before the priority date of the ’800 patent, at the time of filing of the ’800 patent, and now. As is readily apparent by the volume of disclosed art on the first five pages of the ’800 patent, experts in the relevant field have published, shared, and reviewed such scientific findings of sapphire crystal growth for several decades.

III. INTRODUCTION TO THE EFG METHOD

A. Introduction

25. Edge-defined, film-fed growth is referred to as “EFG.”

26. Edge-defined, Film-fed Growth (EFG) process for producing sapphire, α-alumina single crystals, having the geometrical relationship, length>width>thickness was invented by Harry LaBelle and others at Tyco Laboratories in Waltham, Massachusetts in the late 1960s (*see*, *e.g.*, the article entitled “Growth of Controlled Profile Crystals from the Melt: Part I – Sapphire Filaments” to LaBelle et al. (Ex. 1007, hereinafter “LaBelle I”) and the article entitled “Growth of Controlled Profile Crystals from the Melt: Part II – Edge-Defined, Film-Fed Growth (EFG)” to LaBelle. (Ex. 1008, hereinafter “LaBelle II”))).

27. LaBelle II reports using molybdenum orifices and crucibles to grow single crystals from melts of α-alumina. (Ex. 1008 at 571, 586). A capillary tube (typically fabricated from molybdenum) is attached to the bottom of a crucible (also molybdenum) in such a way that liquid is able to enter the bottom of the capillary.

28. The original edge-defined, film-fed growth application was the production of sapphire filaments, but it quickly became obvious that many different sizes, shapes, and materials could be crystallized using this method. Figure 1 illustrates schematically the main features of the process. (*See* Ex. 1005, Figure 1). A crucible (Cr) contains a melt (M) of the material to be crystallized. A lid (L) sits on top of the crucible and a die (D) with a capillary channel (C) hangs down from the lid. A heater (H) supplies heat to the crucible. Not shown but important to the operation of the EFG equipment are various features such as the crucible support, insulation both above and below the crucible and around the heater, control equipment (either temperature or power control), and a mechanism for moving a seed crystal.

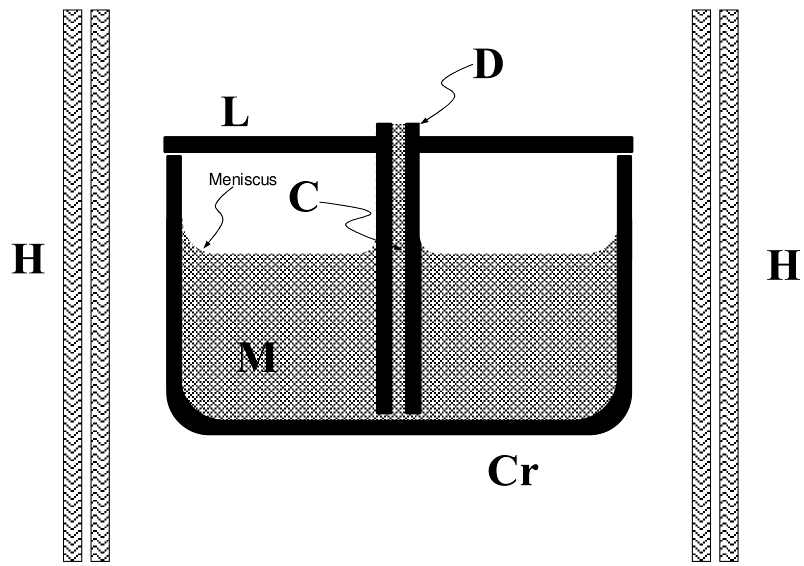


Figure 1

29. In general, the die material is selected such that it is chemically inert with respect to the liquid melt, but is wetted by the liquid melt. Wetting is indicated by the formation of a meniscus of liquid melt at the top of die (D). The size (*i.e.*, height) and shape of the meniscus is determined by the surface tension between the molten material and the solid comprising the die as well as the density of the liquid melt and gravity. The growth interface, where the crystal is formed, is at the top surface of the die. Liquid melt is delivered to the top surface of the die by capillary rise in the die. (Figure 2; *see also* Ex. 1007 at page 572).

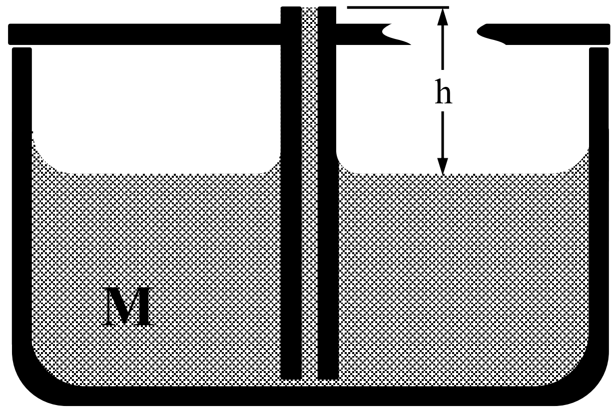


Figure 2

30. The height (h) above the surface of the liquid melt that the liquid will rise in the capillary is determined by the dimensions of the capillary, the surface tension between the melt and the die material, the density of the melt, and gravity. For a molybdenum crucible and die assembly, a common choice in EFG growth of sapphire plates and molten sapphire, the value of h can be 75 – 100 mm (3 – 4 inches) with reasonable values of capillary diameter in the case of holes, or capillary width and length (X and Y, respectively, in Figure 3) in the case of parallel plates.

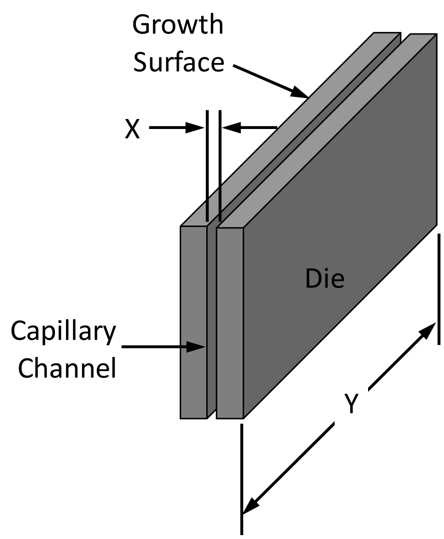


Figure 3

31. When a seed with the desired crystallographic orientation, cut from a previously grown crystal, is lowered and touched to the die, part of the end of the seed melts because the die surface is necessarily hotter than the melting point of the crystal. A vertical meniscus forms as shown in Figure 4.

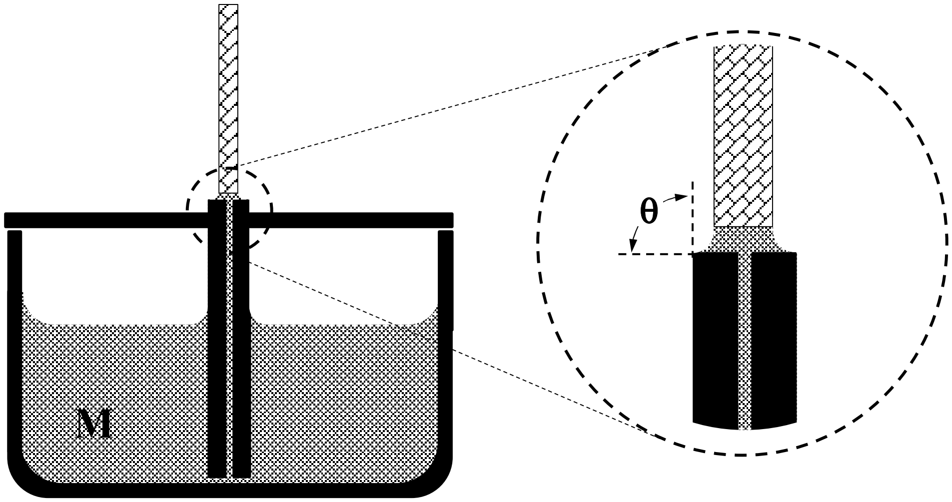


Figure 4

32. As the seed crystal is raised, the meniscus spreads across the surface of the die. The spreading is caused by the surface tension between the liquid and the die. The meniscus will spread until it reaches the edge of the die. Various physical principles prevent the meniscus from going beyond the edge of the die. As long as the angle formed by the edges of the die (Θ shown in Figure 4) is 90° or less, the meniscus will be constrained by the edge of the die. As the seed crystal is raised, the meniscus spreads across the surface of the die, and the crystal spreads as well (in both directions, along the breadth or width of the die as well as its length). When the crystal reaches the shape defined by the edges of the die in both dimensions, as shown in Figure 5, its final form is set by the edges of the die—hence the term "Edge-defined" in the name EFG.

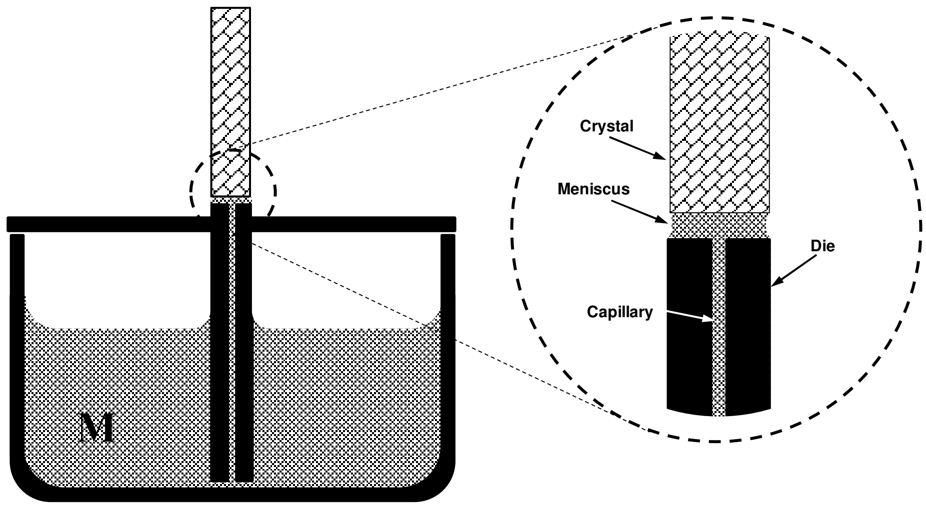


Figure 5

33. Now a steady state equilibrium is established, and, as long as liquid continues to be delivered to the surface of the die by capillary action from the melt source, a crystal of constant cross-section defined by the top surface of the die will be grown. This is the key feature of the EFG process, *i.e.*, that a crystal of constant cross-section can be grown to the near net shape of the final product that will be machined from the crystal. This minimizes the material consumed to produce the crystal as well as subsequent machining steps which can be costly for very hard materials such as sapphire. (Note: for the purposes of clarity, the meniscus height in Figures 4 and 5 is greatly exaggerated. *See* Figure 6.)

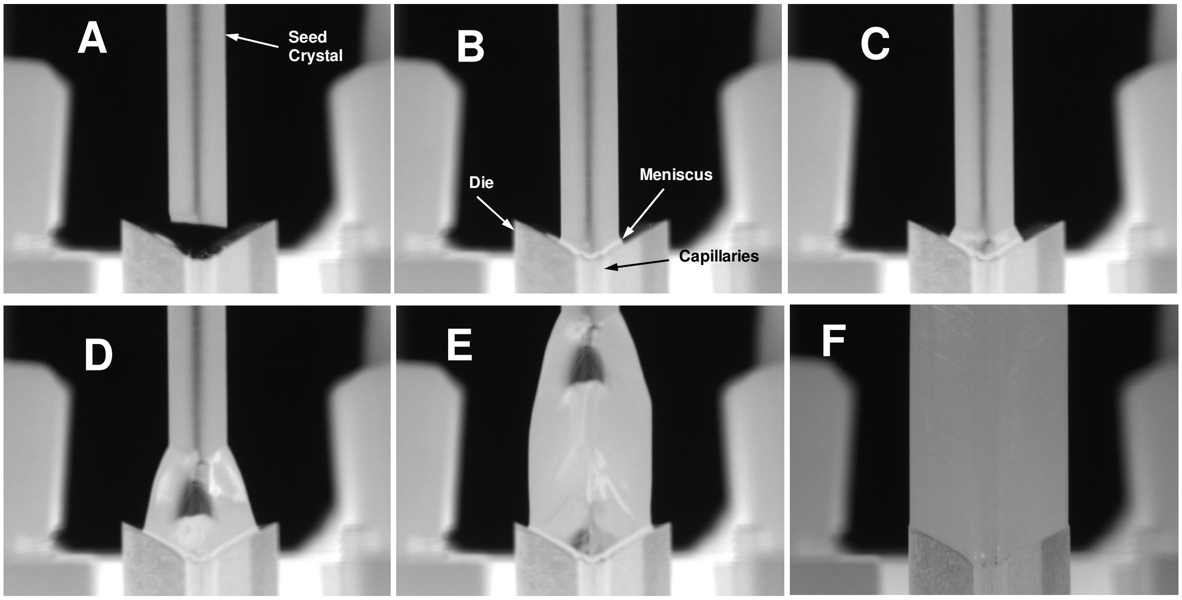


Figure 6. Sequential photographs made during the growth of a wide sapphire plate via the EFG process. A: Seed crystal being lowered to the die. B: Seed has touched the die and melted to conform to the surface of the die. The meniscus is clearly visible. C: Seed lift started; crystal is beginning to spread laterally. D: The crystal continues to spread laterally across the width of the die as the seed is raised. E: The crystal has reached the full width of the die on both sides. Note the straight sides of the crystal. F: The crystal has spread to the full width and length of the die. The intrinsic uniformity of the crystal thickness is quite evident as is the very thin meniscus layer. Die width is 15 mm and length is 200 mm.

34. Figure 6 shows a series of photos of an actual sapphire EFG process in operation. In this case, the crystal dimension (plate width) perpendicular to the plane of the photos is 20 cm and the angle Θ is 60°. The uniformity of the plate thickness, which is an inherent feature of the EFG process, can be readily appreciated.

B. Crystal Size

35. As previously noted, the crystal cross-section is determined by the top surface of the die. Exhibit 1008 describes crystals as small as filaments fractions of a millimeter in diameter as well as ribbons, rod, tubes, and plates with cross-

section dimensions of centimeters (Ex. 1008 at page 587). In addition, because of the thermal geometry, there is no upper limit to the cross-section that can be grown in this way (Ex. 1009 at abstract). The limiting factors are the following: (a) maintaining the top surface of the die (Growth Surface in Fig. 3) at a uniform temperature above the freezing point of the liquid; and (b) continuous delivery of sufficient liquid through the capillary channel. (*See*, *e.g.*, United States Patent No. 3,701,636 to Labelle et al. ("Labelle '636", Ex. 1010 at 7:32-54)).

36. Achieving the temperature uniformity of the die surface is readily accomplished with furnace manufacturing technology that has been available for at least a century. Heating large volumes by both resistance and induction is established art. Perhaps the largest example is the oven used to cure the fuselage of the Boeing 787 Dreamliner which requires achieving hundreds of degrees Fahrenheit within very tight tolerances.

37. Achieving the second criterion, continuous delivery of liquid to the die surface via capillary action, can be accomplished either by continuous feeding of raw material into the crucible while the growth of the crystal is in progress or by using a crucible of sufficient volume to contain all of the required material from the start.

38. To supply a sufficient volume of liquid to the growth interface for a large cross-section crystal, one need only create multiple capillaries formed by parallel plates as shown in Figure 6 above. This lowers the flow rate through any one individual capillary and thus alleviates the issue of viscous drag for large volumes of liquid reaching the growth interface. The use of parallel plates to form a capillary channel is suggested in LaBelle '636. (Ex. 1010, 8:9-11).

39. The third dimension of the crystal, length, has also been demonstrated for decades. LaBelle grew continuous filaments several hundred feet in length as well as rigid tubes up to 5 feet long. The longest, large, rigid EFG produced crystals that I have seen were octagons of silicon approximately 4 – 5 meters long grown by Mobil-Tyco in the 1980s.

C. Heating Methodology

40. There is nothing unique to the EFG process that requires a specific heating methodology. The method chosen will be determined by such factors as the size of the crucible/crystal, the geometry of the crucible (round, rectangular), and the power requirements. At its invention, induction heating was employed. Later systems used resistance heating elements. The difference between the two can be understood using the comparison of an ordinary cooking oven that uses resistance elements to heat a volume in which food is cooked compared to a

microwave oven where heat is induced into the food by radiating microwave energy. A hybrid approach in which induction coils are used to heat a susceptor (usually graphite in the case of sapphire growth), whereby the susceptor then acts like a resistance heating element that radiates heat to the crucible, has also been used.

41. As larger crystals have been grown, some form of "afterheater" is generally used, indeed, it is virtually required. The afterheater sits above the crucible and provides an environment in which the crystal's temperature drops gradually from the freezing point to some intermediate value below the freezing point but significantly above room temperature, say around 1800°C in the case of sapphire. Then, once growth is completed and the crystal has been separated from the die, it can be cooled down to room temperature in a controlled fashion. The afterheater can be either active or passive. A passive afterheater receives heat radiated or conducted from the hot zone containing the crucible. (*See*, *e.g.*, the '800 patent). An active afterheater has its own heat source. This can be controlled separately from the main heat source heating the crucible and thus be independent, or it can utilize the same power supply, in which case its time-temperature profile tracks that of the crucible albeit at a lower value. (*See*, *e.g.*, Ex. 1003, element 44 in Fig. 2).

42. Although round crucibles were generally used in the early stages of the development of the EFG process, Labelle ’636 describes the use of rectangular crucibles and induction heating coils for larger rectangular cross section shapes. (Ex. 1010, Figs. 2-4).

D. Atmosphere

43. The choice of atmosphere is determined by the chemical interactions between the gas phase, the crucible, the heating elements and insulation, and the molten material. For the example of a sapphire crystal being grown from a molybdenum crucible insulated with various forms of graphite, an inert atmosphere (typically formed by a noble gas such as argon) is used. However, it is not uncommon to overlook the thermodynamic interactions between sapphire and carbon at 2000°C with negative consequences. This is why the surfaces of some as-grown sapphire plates exhibit a frosted texture. They have been etched by reactions with the furnace atmosphere. (*See*, *e.g.*, Ex. 1005, Fig. 4, according to the author, “Figure 4 is a photograph of a fully annealed sheet of single crystal sapphire, ready to be manufactured into a window, note the 12 inch scale. The surface texture that can be seen in the photograph is a deposit that occurred during growth and is removed during polishing…”. The texture is <u>not</u> a deposit. It is the

result of a reaction between sapphire and the furnace atmosphere due to a lack of control of the thermodynamics of the process.).

E. Seed Lift Mechanisms

44. A mechanical apparatus must be included in any EFG system that has the capability to raise and lower the seed crystal. This is routine in many crystal growth processes such as the Czochralski and Kyropoulos methods. In fact, in some of the earliest publications, using a converted Czochralski system for the EFG process is mentioned. (Ex. 1008). The typical requirements of the seed lift capability are: (a) sufficient translation distance (vertical travel) to grow the desired length of crystal; (b) movement in both directions (up and down) for both lowering the seed into the starting position as well as pulling upward to effect growth; (c) vertical alignment (plumb) that is precise in order to keep the crystal positioned directly above the die; and (d) the ability for the lift shaft to exit the growth chamber at the top without compromising the controlled atmosphere of the chamber.

45. These are all parameters that have been mastered with other crystal growth technologies such as the Czochralski method for more than a century.

46. Additional features that are not required but add a degree of flexibility to the control of the process include: (a) an x-y stage that permits the precise

positioning of the seed above the die in the plane of the die surface; and (b) a weighing mechanism that can record the weight of the growing crystal while the process is underway. This permits active feedback control of the process based on the growth rate of the crystal determined by weight increase versus time.

IV. OVERVIEW OF THE ’800 PATENT

47. I have reviewed and understand the disclosure of the ’800 patent. The ’800 patent is entitled “Method of Making a Sapphire Component Including Machining a Sapphire Single Crystal,” and names John Locher, Steven Zanella, Ralph MacLean, and Herbert Bates as the joint inventors. The ’800 patent is a continuation of U.S. Patent No. 9,926,645, which is a continuation of U.S. Patent Application No. 14/176,437 filed Feb. 10, 2014, which has been abandoned and claims priority as a divisional to U.S. Patent No. 8,685,161, which is a continuation of U.S. Patent No. 8,157,913, which is a divisional of U.S. Patent No. 7,348,076, of which U.S. Patent No. RE43,469 is a reissued patent.

48. The ’800 patent is directed to large-sized single crystal sapphire sheets, methods and devices for producing such sheets, and machining such sheets to produce sapphire components. Specifically, independent claims 1 and 11 are directed to a method of making a sapphire component by “machining” or “grinding, lapping, polishing, or removing bulk material from” a sapphire single

crystal that has particular values for the width and the thickness of the sapphire single crystal.

49. It is my opinion that machining sapphire single crystal sheets having such values for width and thickness was known in the art more than a year prior to the earliest priority date of the ’800 patent.

V. LEGAL STANDARDS

50. I understand that under 35 U.S.C. § 102, a patent claim is not novel and anticipated by a prior art reference if the reference teaches each and every element of the claimed invention.

51. I also understand that under 35 U.S.C. § 103 a patent claim is invalid if the claimed subject matter as a whole would have been obvious to a person of ordinary skill in the art at the time the of the alleged invention. Patent claims may be found obvious in light of particular references or combinations of references. I also understand that an obviousness analysis takes into account the scope and content of the prior art, the differences between the claimed subject matter and the prior art, and the level of ordinary skill in the art at the time of the invention.

52. It is my understanding that a reference is appropriately considered in the obviousness inquiry if it falls within the relevant field of endeavor or if it is reasonably pertinent to the particular problem with which the inventor was

involved. A reference is reasonably pertinent if it logically would have commended itself to an inventor's attention in considering the problem.

53. Additionally, I understand that when a reference is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill can implement a predictable variation, Section 103 likely bars its patentability. For the same reason, if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

54. A patent claim may also be obvious if inventions arise from ordinary innovation, ordinary skill, or common sense. In this regard, a patent claim is obvious if it would have been obvious to try, or if there existed at the time of the invention, a known problem for which there was an obvious solution encompassed by the patent's claims.

55. I also understand that several rationales may support a finding of obviousness:

(A) combining prior art elements according to known methods to yield predictable results;

(B) simple substitution of one known element for another to obtain predictable results;

(C) use of known techniques to improve similar devices (methods, or products) in the same way;

(D) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

(E) choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success, *i.e.*, that it would have been "obvious to try";

(F) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; and/or

(G) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

56. I also understand that an obviousness analysis must consider additional objective evidence of patentability, *i.e.*, "secondary considerations," namely, long-felt need, unexpected results of the invention, skepticism of the invention, a teaching away from the invention, commercial success of the

invention, praise by others for the invention, copying of the invention, and/or the like. I am not aware of any such evidence that would suggest the ’800 Patent would have non-obviousness.

VI. PERSON HAVING ORDINARY SKILL IN THE ART (“PHOSITA”)

57. It is my understanding that patent claims are to be interpreted according to the perspective of a person having ordinary skill in the art (“PHOSITA”) at the time of invention.

58. It is my opinion that for purposes of the ’800 patent and this Declaration, that a PHOSITA would be an individual prior to April 2003 with at least a Bachelor’s degree in physics, engineering, or material science and five or more years of experience in the growth of any type of crystal from a melt by any method, including, without limitation, EFG growth.

59. Given my educational and industry experience, I would have qualified as a PHOSITA prior to April 2003 and I qualify as one today. In the circumstance that a finder of fact may qualify me as having extra-ordinary experience and knowledge at the time of this declaration, I remain competent and able to determine and analyze the understanding of a PHOSITA in the relevant time frames.

VII. CLAIM CONSTRUCTION

60. I understand that the scope of patent claims depends on how the claims are construed. I understand that in IPR proceedings before the PTAB patent claims are given their ordinary and customary meaning as understood by a person of ordinary skill in the art when read in the context of the specification and prosecution history. For purposes of my analysis, I have assumed that the claim terms have the plain and ordinary meaning they would have had to a PHOSITA as of the invention date.

VIII. CLAIMS 1, 2, 4, 6, 7, AND 9-13 OF THE ’800 PATENT ARE INVALID AS ANTICIPATED BY THE PATEL ARTICLE

61. It is my opinion that the Patel article discloses “machining a sapphire single crystal” into a sapphire component that includes all of the limitations of claims 1, 2, 4, 6, 7, and 9-13 of the ’800 patent and, therefore, anticipates these claims under 35 U.S.C. § 102(b).

62. With regard to claim 1, the Patel article discloses a transparent sapphire sheet grown using an edge-defined growth technique. (Ex. 1011, p. 12, Section 5.3). The Patel article further discloses that edge-defined film-fed growth (EFG) is a single crystal growth technique. (Ex. 1011, p. 4, Section 2.3.3). In addition, the Patel article describes using this material for transparent armor systems, *i.e.*, a sapphire component (Ex. 1011, p. 12, Section 5.3), and that further

applications for sapphire include ground vehicle protection, air vehicle protection, personnel protection, and sensor equipment, such as electromagnetic windows and laser igniter windows. (Ex. 1011, p. 4, Section 3.0, and p. 8, Sections 3.4.1 and 3.4.2). The Patel article describes a sheet having a length, width, and thickness. (Ex. 1011, p. 12, Section 5.3). The Patel article further describes that "[s]cale-up to larger size plates" implicates such as an increase in cost and an increase in polishing difficulties (Ex. 1011, p. 12, Section 5.3), and that machining sapphire requires diamond grinding and polishing media. (Ex. 1011, p. 12, Section 5.4). In addition, the '800 patent defines "machining" as "effected to form the single crystal into the desired geometric configurations for commercial use. Accordingly, ***grinding***, lapping, ***polishing*** and the like, or bulk material removal/shaping such as wire sawing or cleaving and the like may be utilized to manipulate the single crystal into a desired component". (Ex. 1001, 8:7-12, emphasis added). Accordingly, it was known in the art to machine the sapphire single crystal sheets since polishing and grinding such sheets is disclosed in the Patel article.

63. The Patel article also discloses a sapphire sheet having a thickness of 0.25 inches (0.635 cm), a width of 12 inches (30.48 cm), and a length of 15 inches (38.1 cm). (Ex. 1011, p. 12, Section 5.3). Accordingly, it is my opinion that the Patel article discloses machining a sapphire single crystal having a length, a width

and a thickness, wherein the length>width>thickness, the width is not less than 28 cm, and the thickness is not less than 0.5 cm into the sapphire component as required by independent claim 1 of the ’800 patent.

64. The Patel article further discloses such sapphire sheets are manufactured using an edge-defined growth technique. (Ex. 1011, p. 5, column 2). As discussed in Section III hereinabove, such a growth technique was very well known in the art prior to April 2003. In addition, the Patel article explicitly describes that edge-defined film-fed growth (EFG) is a single crystal growth technique. (Ex. 1011, p. 4, Section 2.3.3).

65. In addition, in Section 5.3 on page 12 of the Patel article, the second paragraph begins, “[a]nother manufacturer of sapphire is Saphikon, Inc., which produces transparent sapphire using an edge, defined growth technique. This produces an optically inferior material than Crystal Systems, but the cost for these sheets is significantly lower.” This should not be read to suggest that the sapphire produced by Saphikon is not a single crystal material as the Patel article clearly sets forth in Section 2.3.3 that aluminum oxide is transparent when produced in single crystal form and the edge-defined film-fed growth (EFG) is a single crystal growth technique.

66. The term “sapphire” when used in the industrial context of EFG manufactured sheets always refers to single crystal aluminum oxide. Any reference in materials science or the ceramics industry that uses the term “sapphire” refers, by general convention and accepted usage, to single crystal aluminum oxide. For example, in the book titled “Materials for infrared windows and domes: properties and performance” by Harris, published by SPIE in 1999, it is stated in Section 3.6.2, “Many studies of ***sapphire (single crystal*** Al_2O_3***)*** …” and also in Section 5.4.2, it is stated that “***Single-crystal aluminum oxide (α-***Al_2O_3***) better known as sapphire***….” (Ex. 1016, Sections 3.6.2 and 5.4.2, emphasis added). Accordingly, others intimately familiar with the material, define the word “sapphire” to mean single crystal aluminum oxide. This is further reinforced by the Patent Owner’s own admission in the ’800 patent where it is stated that “the single crystal is in the form of ***alumina single crystal (sapphire)***” (emphasis added). (Ex. 1001, 8:23-24). Accordingly, it is my opinion that the authors of the Patel article are referring to a single crystal sapphire sheet when describing “transparent sapphire.”

67. The statement that Saphikon’s material is an optically inferior material to Crystal Systems is a reference to the fact that, at the time in question, Crystal System’s HEM single crystal technique produced single crystal sapphire having a lower rate of internal defects than Saphikon’s EFG single crystal

technique. In my opinion, it is clear from Section 2.3.3 of the Patel article that both Crystal Systems and Saphikon were producing single crystal sapphire.

68. From its inception as a crystal growth technique, the purpose of the EFG method, when used with aluminum oxide, is to produce single crystal sapphire. It has, however, generally produced material with higher defect levels than some other methods. The issues with these defects were more than offset by the unique capability of the EFG method of generating crystals of near net shape (ribbons, tubes, rods, fibers, and large area plates). This overcame some of the problems of cutting and grinding parts to the final, necessary dimensions in HEM methods, resulting from sapphire's extreme hardness.

69. Accordingly, in my opinion, the Patel article discloses each and every limitation of independent claim 1 and, therefore, anticipates this claim.

70. Claim 2 depends from claim 1 and recites that machining the sapphire single crystal comprises grinding the sapphire single crystal. The Patel article describes that machining sapphire requires diamond grinding and polishing media. (Ex. 1011, p. 12, Section 5.4). Accordingly, it was known in the art to grind the sapphire single crystal sheets. Therefore, in my opinion, the Patel article discloses each and every limitation of dependent claim 2 and, therefore, anticipates this claim.

71. Claim 4 depends from claim 1 and recites that machining the sapphire single crystal comprises polishing the sapphire single crystal. The Patel article describes that "[s]cale-up to larger size plates poses several problems" including an increase in costs and an increase in polishing difficulties (Ex. 1011, p. 12, Section 5.3) and that machining sapphire requires diamond grinding and polishing media. (Ex. 1011, p. 12, Section 5.4). Accordingly, it was known in the art to polish the sapphire single crystal sheets. Therefore, in my opinion, the Patel article discloses each and every limitation of dependent claim 4 and, therefore, anticipates this claim.

72. Claim 6 depends from claim 1 and recites that machining the sapphire single crystal comprises machining the sapphire single crystal into an optical component. Patel describes a variety of applications encompassing various types of optical components. The Patel article states "Other requirements for transparent armor windows are that they are night vision compatible" (Ex. 1011, p. 1, Section 1.0) and goes on to describe using single crystal aluminum oxide (sapphire) for electromagnetic windows and laser igniter windows. (Ex. 1011, p. 8, Sections 3.4.1 and 3.4.2). A window is an optical component. The title of the Patel article is "Transparent ceramics for armor and EM window applications." An EM window is, by definition, a component that allows electromagnetic radiation to pass

through, and electromagnetic radiation encompasses the entire spectrum from cosmic rays to radio waves, including visible light. (*see* Ex. 1016, p. 2, Table 0.1). In my opinion, these items are considered to be optical components. Therefore, it is my opinion, that the Patel article discloses each and every limitation of dependent claim 6 and, therefore, anticipates this claim.

73. Claim 7 depends from claim 1 and recites that machining the sapphire single crystal comprises machining the sapphire single crystal into an optical window. The Patel article describes using sapphire single crystal material for electromagnetic windows and laser igniter windows. (Ex. 1011, p. 8, Sections 3.4.1 and 3.4.2). In my opinion, electromagnetic windows and laser igniter windows are considered to be optical windows. Accordingly, the Patel article discloses each and every limitation of dependent claim 7 and, therefore, anticipates this claim.

74. Claim 9 depends from claim 1 and recites that the sapphire single crystal is transparent in the infrared and visible wavelength spectrums. The Patel article discloses a transparent sapphire sheet grown using an edge-defined growth technique. (Ex. 1011, p. 12, Section 5.3). The Patel article further discloses that edge-defined film-fed growth (EFG) is a single crystal growth technique. (Ex. 1011, p. 4, Section 2.3.3). While the Patel article does not verbatim disclose that this sapphire "is transparent in the infrared and visible wavelength spectrums" as

recited by dependent claim 9, such a property is inherent of transparent sapphire and the applications described in Patel. Specifically, the Patel article further discloses the usefulness of such sapphire sheets for electromagnetic (EM) windows and other transparent ceramic applications that would require the single crystal sapphire sheet to be transparent in the infrared and visible wavelength spectrums. (Ex. 1011 p. 8, Section 3.4.1).

75. To emphasize the intrinsic nature of the disclosed sapphire materials in Patel being used for applications requiring transparency in the infrared and visible wavelength spectrum, consider further the below wavelength table, adapted for ease of reference from Harris (Ex. 1016, p. 2, Table 0.1), in combination with the following quotation from the Locher article: "Single crystal sapphire has been a material of choice for good optical performance in the 200 to 5000 nm range". (Ex. 1005, Section 2.0).

Electromagnetic Spectrum (Adapted from "Materials for Infrared Windows and Domes" Harris)

Type of Radiation	Wavelength, nanometers
Cosmic Rays	0.001
Gamma Rays	.001 - .010
X-Rays	.01 - 10
Ultraviolet	10 - 380
Visible	380 - 780
violet	380 - 430
blue	430 - 480
green	480 - 530
yellow	530 - 580
orange	580 - 620
red	620 - 780
MWIR[1]	3,000 - 5,000
LWIR[2]	8,000 - 4,400
Infrared (total)	780 - 1,000,000

Transparency range of sapphire

[1]Mid-Wave Infrared

[2]Long Wave Infrared

The quoted transmission range for a sapphire sheet which is the subject of Patel is from the middle of the ultraviolet range, through the visible range, and into mid-wave infrared. Therefore, the Patel window is intended for an application requiring transparency “in the infrared and visible wavelength spectrums.”

76. While the Patel article describes that an EFG-grown single crystal sheet is “optically inferior” to an HEM-grown single crystal, this in no way implies that EFG-grown single-crystal sapphire of the Patel article is not inherently

"substantially transparent in the infrared and visible wavelength spectrum." It is well known that sapphire has both a broad range and high optical transmission from the UV into the IR spectrum. (Ex. 1004, p. 150). In addition, in several places the Patel article discusses the optical requirements of transparent armor, which would require the transparent armor to be substantially transparent in the infrared and visible wavelength spectrum. (Ex. 1015, p. 8, Section 3.4.1 and p. 8, Section 3.4.2). Accordingly, in my opinion, the Patel article discloses each and every limitation of dependent claim 9 and, therefore, anticipates this claim.

77. Claim 10 depends from claim 1 and includes the further limitation that the sapphire single crystal has a thickness of at least 0.6 cm. The Patel article discloses a sapphire sheet having a thickness of 0.25 inches (0.635 cm). (Ex. 1011, p. 12, Section 5.3). Accordingly, it is my opinion that the Patel article discloses each and every limitation of dependent claim 10 and, therefore, anticipates this claim.

78. The following claim chart illustrates where each and every limitation of claim 11 can be found in the Patel article.

U.S. Patent No. 9,963,800	The Patel article
11. A method of making a sapphire component comprising grinding, lapping, polishing or removing bulk	The Patel article discloses a transparent sapphire sheet grown using an edge-defined growth technique (Ex. 1011, p.

U.S. Patent No. 9,963,800	The Patel article
material from a sapphire single crystal to form the sapphire component,	12, Section 5.3). The Patel article further discloses that edge-defined film-fed growth (EFG) is a single crystal growth technique (Ex. 1011, p. 4, Section 2.3.3). In addition, the Patel article describes using this material for transparent armor systems (*i.e.*, a sapphire component) (Ex. 1011, p. 12, Section 5.3) and that sapphire applications include ground vehicle protection, air vehicle protection, personnel protection, equipment (sensor) protection, electromagnetic windows, and laser igniter windows (Ex. 1011, p. 4, Section 3.0 and p. 8, Sections 3.4.1 and 3.4.2). The Patel article further describes that "larges plates are more difficult to polish than smaller plates" (Ex. 1011, p. 12, Section 5.3) and that machining sapphire requires diamond grinding and polishing media (Ex. 1011, p. 12, Section 5.4).
wherein the sapphire single crystal has a length, a width and a thickness, the length>width>thickness,	The Patel article discloses a sapphire sheet having a thickness of 0.25 inches (0.635 cm), a width of 12 inches (30.48

U.S. Patent No. 9,963,800	The Patel article
	cm), and a length of 15 inches (38.1 cm) (Ex. 1011, p. 12, Section 5.3).
the width is not less than 28 cm, and the thickness is not less than 0.5 cm.	The Patel article discloses a sapphire sheet having a thickness of 0.25 inches (0.635 cm), a width of 12 inches (30.48 cm), and a length of 15 inches (38.1 cm) (Ex. 1011, p. 12, Section 5.3).

79. Accordingly, it was known in the art to machine the sapphire single crystal sheets since polishing and grinding such sheets is disclosed in the Patel article.

80. It is my opinion that the transparent sapphire discussed in the Patel article is a single crystal sapphire for the reasons provided in paragraphs 61-68 above.

81. Accordingly, in my opinion, the Patel article discloses each and every limitation of independent claim 11 and, therefore, anticipates this claim.

82. Claim 12 depends from claim 11 and recites that the sapphire single crystal is formed into an optical component. The Patel article describes using this material for electromagnetic windows and laser igniter windows. (Ex. 1011, p. 8, Sections 3.4.1 and 3.4.2). Patel also states, "[o]ther requirements for transparent

armor windows are that they are night vision compatible". (Ex. 1011, p. 1, Section 1.0).

83. It is my opinion that these items are considered to be optical components. Accordingly, in my opinion, the Patel article discloses each and every limitation of dependent claim 12 and, therefore, anticipates this claim.

84. Claim 13 depends from claim 1 and recites that the sapphire single crystal is formed into an optical window. The Patel article describes using sapphire single crystal material electromagnetic windows and laser igniter windows. (Ex. 1011, p. 8, Sections 3.4.1 and 3.4.2). In my opinion, electromagnetic windows and laser igniter windows are considered to be optical windows. Accordingly, the Patel article discloses each and every limitation of dependent claim 13 and, therefore, anticipates this claim.

85. It should be noted that the Patel article is a logical combination of preexisting technology. The Journal of Crystal Growth article teaches that sapphire plates of the dimensions of claim 1 can be grown by the EFG process. (Ex. 1015). Labelle '636 describes the methodology, *i.e.*, hot zone design, crucible and die design, heating method, importance of a low horizontal temperature gradient across the top surface of the die, seeding and growth of a shoulder, etc., to grow rectangular plates. (Ex. 1010). The Yancey patent provided a crucial technical

breakthrough for improving the quality of the sapphire plates while growing with continuous feeding of additional raw material. (Ex. 1018). The Patel article teaches that Saphikon had successfully achieved production of sapphire plates by the EFG method of the sizes in claim 1 of adequate optical quality to be used as windows for transparent armor and EM windows. (Ex. 1011). The Locher article further describes the actual values of horizontal and vertical temperature gradients required to grow plates of the size in claim 1. (Ex. 1005). It can be inferred that the difference in dimensions between "Standard" and "Large" sheets in Table 1 in the Locher article is indicative of the fact that the system in question was not yet fitted with a feeder mechanism as both sizes have comparable masses and are likely to represent the growth of a fixed amount of starting material in the crucible. (*See id.*). Since the feeder concept was included in LaBelle '636 as well as the Yancey patent and its use is described in the '800 patent (Ex. 1001, 8:57 and 9:7-9), it can be inferred that the sheets described in Patel are a logical combination of preexisting technology related to LaBelle '636, the Journal of Crystal Growth article, the Yancy patent, and the Locher article. Therefore, while the Patel article alone may be considered to anticipate at least claims 1, 2, 4, 6, 7, and 9-13, the Patel article naturally lends itself to further description using, and obvious combination with, other such prior art references, as further elucidated below.

IX. CLAIMS 3, 5, 8, AND 14-16 OF THE '800 PATENT ARE INVALID AS BEING OBVIOUS OVER THE PATEL ARTICLE IN VIEW OF THE SCHMID ARTICLE

86. Claim 3 depends from claim 1 and recites that machining the sapphire single crystal comprises lapping the sapphire single crystal. Claim 5 depends from claim 1 and recites that machining the sapphire single crystal comprises removing bulk material from the sapphire single crystal. As discussed hereinabove in Section VIII, in my opinion, the Patel article discloses each and every limitation of claim 1. While the Patel article discloses that machining sapphire requires diamond grinding and polishing media (Ex. 1011, p. 12, Section 5.4), there is no explicit disclosure of lapping or removing bulk material.

87. The Schmid article discloses that diamond is used as the abrasive for cutting (*i.e.*, removing bulk material) sapphire (Ex. 1004, Section 5, page 150) and that in lapping and polishing sapphire, it is important to use polycrystalline diamond. (Ex. 1004, Section 5, page 152). Accordingly, it is well known in the art to both lap and remove bulk material from sapphire sheets.

88. In my opinion, it would have been obvious to a person having ordinary skill in the art to use the techniques of lapping and removing bulk material to machine the sapphire sheets disclosed in Patel to create finished sapphire optical components as described in the Schmid article because lapping

and removing bulk material are well-known and conventional techniques for fabricating components from single crystal sapphire sheets.

89. Claim 8 depends from claim 7 and recites that the optical window is machined into a geometric configuration for an infrared and laser guidance system, a military sensing and targeting system, or an infrared and visible wavelength vision system. Claim 14 depends from claim 13 and recites that the sapphire single crystal is formed into a geometric configuration for an infrared and laser guidance system. Claim 15 depends from claim 13 and recites that the sapphire single crystal is formed into a geometric configuration for a military sensing and targeting system. Claim 16 depends from claim 13 and recites that the sapphire single crystal is formed into a geometric configuration for an infrared and visible wavelength vision system. As discussed hereinabove in Section VIII, it is my opinion that the Patel article discloses each and every limitation of claims 7 and 13.

90. Specifically, the Patel article describes that applications for transparent armor include ground vehicle protection, air vehicle protection, personnel protection, equipment (sensor) protection, electromagnetic windows, and laser igniter windows. (Ex. 1011, p. 4, Section 3.0, and p. 8, Sections 3.4.1 and 3.4.2). While such electromagnetic windows could be used in any one of an infrared and laser guidance, a military sensing and targeting system, or an infrared

and visible wavelength vision system, there is no explicit disclosure in the Patel article of such a use. However, Patel states, "[o]ther requirements for transparent armor windows are that they are night vision compatible". (Ex. 1011, p. 1, Section 1.0). Night vision compatibility requires transparency in the infrared spectrum. The Patel article may be understood to imply at least an infrared wavelength vision system.

91. The Schmid article discloses the use of sapphire windows in reconnaissance, surveillance, targeting, and sensing applications. (Ex. 1004, Section 6, page 155). It is my opinion that such a system is considered to be at least a military sensing and targeting system as required by claims 8 and 15. In addition, the Schmid article further discloses the use of sapphire windows for use hypersonic missile windows for single and dual mode seekers. (Ex. 1004, Section 6, page 155). It is my opinion that such a system is considered to be at least an infrared and laser guidance system as required by claims 8 and 14. Finally, the Schmid article also discloses the use of sapphire windows as high quality telescope windows. (Ex. 1004, Section 6, page 155). It is my opinion that such a system is considered to be an infrared and visible wavelength vision system as required by claims 8 and 16.

92. Furthermore, to emphasize the intrinsic nature of the disclosed sapphire materials in the Patel article and the Schmid article being used for

applications requiring transparency in the infrared and visible wavelength spectrum, consider further the below wavelength table, adapted for ease of reference from Harris (Ex. 1016, p. 2, Table 0.1), in combination with the following quotation from the Locher article: “Single crystal sapphire has been a material of choice for good optical performance in the 200 to 5000 nm range”. (Ex. 1005, Section 2.0).

Electromagnetic Spectrum (Adapted from "Materials for Infrared Windows and Domes" Harris)

Type of Radiation	Wavelength, nanometers
Cosmic Rays	0.001
Gamma Rays	.001 - .010
X-Rays	.01 - 10
Ultraviolet	10 - 380
Visible	380 - 780
violet	380 - 430
blue	430 - 480
green	480 - 530
yellow	530 - 580
orange	580 - 620
red	620 - 780
MWIR[1]	3,000 - 5,000
LWIR[2]	8,000 - 4,400
Infrared (total)	780 - 1,000,000

Transparency range of sapphire (Ultraviolet through MWIR)

[1]Mid-Wave Infrared
[2]Long Wave Infrared

The quoted transmission range for the windows which are the subject of the Patel article and the Schmid article is from the middle of the ultraviolet range, through the visible range, and into mid-wave infrared. Therefore, such windows are ideal for "infrared and visible wavelength" vision systems and applications.

93. Accordingly, it is my opinion that, based on all of the advantages described in Schmid for using sapphire windows -- such as those described in the Patel article -- in the claimed applications, a person having ordinary skill in the art would have reason to combine these references and utilize the windows described in the Patel article in one of an infrared and laser guidance systems, a military sensing and targeting system, or an infrared and visible wavelength vision system.

X. CLAIMS 1, 2, 4-7, AND 9-13 OF THE '800 PATENT ARE INVALID AS BEING OBVIOUS OVER THE PATEL ARTICLE IN VIEW OF THE LOCHER ARTICLE AND LABELLE '636

94. As discussed hereinabove in Section VIII, the Patel article discloses, either explicitly or inherently, each and every limitation of claims 1, 2, 4, 6, 7, and 9-13. The Patel article further discloses such sapphire sheets can be manufactured using an edge-defined growth technique. (Ex. 1011, p. 12, Section 5.3). While the EFG process was very well known in the art prior to April 2003 as discussed hereinabove in Section III, the details of the EFG process are not explicitly disclosed in the Patel article.

95. The Locher article discloses an EFG process for producing a 30.5 cm wide by 46 cm long by 0.25 cm thick single crystal sapphire sheet by simply "scaling up" the old technology. (Ex. 1005, section 3.1). The Locher article further discloses that "even larger windows are possible." (*Id.* at Section 5.0). LaBelle '636 discloses an apparatus and method for growing "relatively large size monocrystalline plates of materials such as alumina, by the EFG process". (Ex. 1010, 1:68-71). Specifically, LaBelle '636 discloses the production of a single crystal sapphire sheet having a length>width>thickness with the thickness being 3/8 inch (0.95 cm) (i.e., within the thickness range required by claims 1, 10, and 11). (Ex. 1010, 2:2-4).

96. In my opinion, a PHOSITA, in view of the Patel article, the Locher Article, and LaBelle '636, would consider it obvious to grow a sapphire single crystal having all the limitations of claims 1, 10, and 11 because the sapphire single crystal of claims 1, 10, and 11 is nothing more than an obvious combination of dimensions of sapphire single crystals known in the prior art. Indeed, as noted above, the Patel article teaches sapphire sheets having all the limitations of claim 1, 10, and 11. Accordingly, in my opinion, claims 1, 10, and 11 are obvious in view of the Patel article, the Locher article, and LaBelle '636.

97. To this end, in my opinion, a PHOSITA would consider it obvious to scale processes and equipment known prior to April 2003 to produce a sapphire single crystal having all the limitations of claim 1, without undue experimentation.

98. The Locher article and LaBelle '636 are provided to explain the manner in which a single crystal sapphire sheet having the dimensions as disclosed in the Patel article would be made by a person having ordinary skill in the art. Specifically, it would have been obvious to a person having ordinary skill in the art to scale processes and equipment known prior to April 2003 to produce a single crystal sapphire sheet having all the limitations of claim 1, without undue experimentation.

99. Specifically, in order to scale the EFG process to larger size parts, a PHOSITA starts at the die and works outward. The following discussion is directed exclusively to larger sapphire plates. The die dimensions (length and width, which correspond to the plate dimensions width and thickness, respectively) are determinant. The die material will be either tungsten or molybdenum as indicated in LaBelle '636. (Ex. 1010, 4:7-9). The dimensions of the capillary channels (either holes or slots) are determined by the required capillary rise (as described below) and the equations in LaBelle I (Ex. 1007, top of p. 573) and Labelle '636 (Ex. 1010, 5:18-21).

100. A PHOSITA would understand that crucible dimensions are constrained by the dimensions of the die and the volume of liquid needed to produce the desired sheet(s). At a minimum, the crucible needs to be an oblong shape of sufficient length in the longest dimension to incorporate the die. Alternatively, the crucible could be round with an inside diameter larger than the long dimension of the die. The issue of crucible depth is discussed below.

101. To provide the required temperature (in excess of 2050°C), there are only two options: (a) induction heating by radio frequency using an induction coil that "couples" directly to the crucible, or (b) resistance heating. (Note: induction heating can also be used where the induced power goes into a "susceptor" as described in Labelle '636 (Ex. 1010), and the susceptor serves as a resistance heater that transfers heat to the crucible.)

102. If resistance heating is used, the choices for heating elements are largely limited to graphite or tungsten. Graphite is the preferred choice because it is cheaper and more readily fabricated into a variety of shapes. Graphite is also more robust and durable than tungsten and thus able to withstand more thermal cycles.

103. Insulation around the system, which would be between the crucible and induction coil in the case of induction heating or outside of the heating

elements in the case of resistance heating, again offers two choices: (a) graphite or (b) refractory metals (tungsten and/or molybdenum). Graphite would be in the form of a porous product such as the felt blanket or cloth as described in U.S. Patent No. 3,591,348 to LaBelle. (Ex. 1017, 5:13-18). These materials are also available in the form of boards that can be cut to the desired shape. If refractory metal parts are used for insulation, they would be in the form of radiation shields as described in LaBelle '348 (Ex. 1017, 8:30-38) and LaBelle '636 (Ex. 1010, 6:68-69). It should be noted that the use of radiation shields that are vertically disposed and run around the crucible with the same general geometry (oblong or circular) are difficult to manage because they couple with the induction coil and receive the RF energy instead of the crucible. So, porous graphite is preferable.

104. Having worked outward from the die to the crucible, to the insulation and to the induction coil, in the case of induction heating, or from the die to the crucible, to the resistance heating elements and to the insulation in the case of resistance heating, the size of the chamber required to house the furnace "hot zone" can be determined. In terms of the radial or horizontal dimensions, the chamber can be just slightly larger than the insulation in the case of resistance heating. In the case of induction heating, the chamber would have to be quite a bit larger than the induction coil in order to prevent the chamber walls from "coupling" to the coil

and parasitically consuming the energy of the induction power supply, thus reducing the amount of power available to heat the crucible (see Ex. 1015, Figure 10).

105. The chamber would have to be water-cooled to dissipate the heat that comes through the insulation. This is generally achieved by using a double-wall chamber with water flowing between the walls. (*See* Ex. 1005, Section 3.1).

106. The crucible depth calculation can be more involved than just providing sufficient volume of molten material to grow the desired mass of plates. In the case of both induction and resistance heating, the crucible wall is the entry point for heat. In the case of induction heating, the height of the crucible must be sufficiently tall to allow a large enough surface for the induction coil to couple to and generate the heat required to raise the mass of sapphire to over 2050°C.

107. Similarly, in the case of resistance heating, the heating elements radiate heat (power) to the crucible, and a sufficient area of crucible wall must be available to absorb that heat. So, in both cases, a minimum crucible depth is required.

108. In terms of insulation thickness, this is determined by the temperature of the hot zone, the thermal conductivity of the insulation, and the power available from the heating source (induction power supply or resistance heater). For

example, in Ex. 1015 §6, (3), LaBelle describes using a 75 kW induction power supply. This would have been a commercially available system well within the capabilities of the industry at the time.

109. Once these parameters (chamber dimensions, power required, etc.) are determined, the specifications could be turned over to a commercial furnace manufacturer to design and build the system. Alternatively, the specifications could have been worked out in consultation with the furnace manufacturer.

110. The last technical challenge is the crucible volume which is determined by both the cross sectional area and the depth. The design described in the '800 patent uses a crucible volume that is less than volume required for the size of plates that need to be grown. Consequently, sapphire raw material is added to the crucible while the crystals are growing. (*See* Ex. 1001, 9:7-9). The feeder mechanism goes back to the original EFG process development. (*See* Ex. 1010, 3:69-73). However, it was never possible to grow defect-free sapphire while simultaneously feeding raw material into the crucible until a technique was developed at Allied Chemical by Mr. Paul Yancey. (*See* U.S. Patent No. 4,269,652, Ex. 1018). This technique allows the added sapphire particles to melt and come to thermal and chemical equilibrium with the material already in the crucible before flowing into the main mass of liquid.

111. The methodology of the ’800 patent also requires that the crucible be fully depleted of raw material during the run. Any residual raw material remaining in the crucible will, of course, freeze when the system is cooled down to room temperature. On the next heating cycle, the large volume change between liquid and solid at the melting point (molten sapphire has a density of ~3 gm/cc vs. solid sapphire at ~4 g/cc) will deform and possibly crack the crucible in much the same way that water pipes burst when the water in them freezes. The necessity to drain the crucible of all sapphire, combined with the maximum capillary rise achievable with the die design, discussed in paragraph 100 above, is a determining factor in the crucible wall height of the ’800 patent.

112. Not mentioned in the ’800 patent is the fact that the crystal, once it is separated from the die and after a period in the afterheater, is extracted from the top of the system while the crucible is left at the operating temperature. The crystal is pulled above a gate valve, which is closed, into a bellows. The bellows are released and dropped so that the crystal can be removed and a new seed installed. This can be seen in Figs. 2 and 3 in the Locher article. (Ex. 1005). All this time, the crucible is kept hot and is being refilled with the feeder mechanism. The bellows are then closed around the new seed, flushed with argon (or whatever

furnace gas is being used), the gate valve is opened, the seed is lowered to the die, and a new crystal growth run is initiated.

113. If a large round crucible is used, which contains significantly more sapphire than is required to grow the plate(s), a method must be developed that lowers the crucible away from the die and carefully freezes the sapphire from the bottom upwards. On the subsequent heating cycle, the sapphire must be melted from the top down so that there is no lateral expansion that will deform and/or crack the crucible. (The top surface, being free, can expand upwards without deforming the crucible.) So, in this case, the crucible depth is more a function of the surface area needing exposure to the heating elements than to the capillary rise. Since the mass of liquid in the crucible is significantly greater than the mass of material crystallized into plates, no feeder mechanism is necessary.

114. LaBelle ’636 discloses EFG growth of crystals, such as α-alumina (*i.e.*, sapphire). LaBelle ’636 further discloses that in EFG growth of sapphire, a growing body grows to the shape of the liquid film which conforms to the edge configuration of a die’s end surface (Ex. 1010, 1:30-54) and that it is desirable to provide a symmetrical temperature distribution about the melt, growth zone, and growing body, and discloses means (see susceptors 40 and 44) for accomplishing such symmetrical temperature distribution. (*Id.* at 3:28-32). In addition, LaBelle

’636 describes that the susceptor (40) minimizes temperature gradients in the melt along the plane of the liquid film from which the body is grown. (*Id.* at 6:13-50). In other words, LaBelle ’636 describes that minimizing temperature gradients in the melt along the plane of the liquid film during growth enables successful growth of sapphire bodies including bodies having “a rectangular cross-section.”

115. Moreover, the Locher article discloses scaling EFG equipment and processes known prior to April 2003 to produce a sapphire sheet having a length of 46 cm and a width of 30 cm. (Ex. 1005, Section 3.1). The Locher article also discloses that vertical and horizontal temperature gradients of less than 150°C/cm and no more than 0.3°C/cm, respectively, with an overall temperature control good to 0.05% or 1°C, were used to EFG-grow a sapphire sheet 30.5 cm × 46 cm. (*Id.*).

116. Still further, the Locher article describes processes for machining a sapphire single crystal having nearly identical dimensions to the claimed sapphire single crystal and the sapphire sheet disclosed in the Patel article (Ex. 1005, Table 1 and Figure 4) into a window assembly (i.e., a sapphire component). (Ex. 1005, Figures 5 and 6). Specifically, the Locher article describes the use of cutting, polishing, and a ***conventional*** abrasive grinding technique. (Ex. 1005, Figure 5 and Section 4.0). Accordingly, while the Patel article does not provide an explicit recitation of removing bulk material from the single crystal sapphire as required by

claim 5, the Locher article clearly describes that single crystal sapphire can be cut to remove bulk material.

117. Following the teachings and principles disclosed in the Locher article and LaBelle ’636 regarding controlling/minimizing temperature gradients (desirably to zero) on the top surface of the die and/or in the melt along the plane of the liquid film, it would have been obvious, in my opinion, to a person having ordinary skill in the art to produce a crystal sheet having all of the features of claims 1, 2, 4-7, and 9-13 by scaling the process and equipment known in the art prior to April 2003 without undue experimentation.

XI. CLAIMS 3, 8, AND 14-16 OF THE ’800 PATENT ARE INVALID AS BEING OBVIOUS OVER THE PATEL ARTICLE IN VIEW OF THE LOCHER ARTICLE AND LABELLE ’636 AND FURTHER IN VIEW OF THE SCHMID ARTICLE

118. Claim 3 depends from claim 1 and recites that machining the sapphire single crystal comprises lapping the sapphire single crystal. As discussed hereinabove in Section VIII, in my opinion, the Patel article discloses each and every limitation of claim 1. While the EFG process was very well known in the art prior to April 2003 as discussed hereinabove in Section III, the details of the EFG process are not explicitly disclosed in the Patel article. Accordingly, the Locher article and LaBelle ’636 are provided to explain the manner in which a single crystal sapphire sheet having the dimensions as disclosed in the Patel article would

be made by a person having ordinary skill in the art as discussed hereinabove in Section X. While the Patel article discloses that machining sapphire requires diamond grinding and polishing media (Ex. 1011, p. 12, section 5.4), there is no explicit disclosure of lapping or removing bulk material.

119. The Schmid article discloses that diamond is used as the abrasive for cutting (*i.e.*, removing bulk material) sapphire (Ex. 1004, Section 5, page 150) and that in lapping and polishing sapphire, it is important to use polycrystalline diamond. (Ex. 1004, Section 5, page 152). Accordingly, it is well known in the art to lap sapphire sheets.

120. In my opinion, it would have been obvious to a person having ordinary skill in the art to use the technique of lapping to machine the sapphire sheets disclosed in Patel to create finished sapphire optical components as described in the Schmid article because lapping and removing bulk material are well-known and conventional techniques for fabricating components from single crystal sapphire sheets.

121. Claim 8 depends from claim 7 and recites that the optical window is machined into a geometric configuration for an infrared and laser guidance system, a military sensing and targeting system, or an infrared and visible wavelength vision system. Claim 14 depends from claim 13 and recites that the sapphire single

crystal is formed into a geometric configuration for an infrared and laser guidance system. Claim 15 depends from claim 13 and recites that the sapphire single crystal is formed into a geometric configuration for a military sensing and targeting system. Claim 16 depends from claim 13 and recites that the sapphire single crystal is formed into a geometric configuration for an infrared and visible wavelength vision system. As discussed hereinabove in Section VIII, it is my opinion that the Patel article discloses each and every limitation of claims 7 and 13. While the EFG process was very well known in the art prior to April 2003 as discussed hereinabove in Section III, the details of the EFG process are not explicitly disclosed in the Patel article. Accordingly, the Locher article and LaBelle '636 are provided to explain the manner in which a single crystal sapphire sheet having the dimensions as disclosed in the Patel article, and manufactured by the process in Patel, would be made by a person having ordinary skill in the art as discussed hereinabove in Section X.

122. Further, the Patel article describes that applications for transparent armor include electromagnetic windows and laser igniter windows. (Ex. 1011, p. 8, Sections 3.4.1 and 3.4.2). While such electromagnetic windows could be used in any one of an infrared and laser guidance, a military sensing and targeting system, or an infrared and visible wavelength vision system, there is no explicit disclosure

in the Patel article of such a use. However, Patel states, "Other requirements for transparent armor windows are that they are night vision compatible". (Ex. 1011, p. 1, Section 1.0). Night vision compatibility requires transparency in the infrared spectrum. The Patel article may be understood to imply at least an infrared wavelength vision system.

123. The Schmid article discloses the use of sapphire windows in reconnaissance, surveillance, targeting, and sensing applications. (Ex. 1004, Section 6, page 155). It is my opinion that such a system is considered to be at least a military sensing and targeting system as required by claims 8 and 15. In addition, the Schmid article further discloses the use of sapphire windows for use hypersonic missile windows for single and dual mode seekers. (Ex. 1004, Section 6, page 155). It is my opinion that such a system is considered to be at least an infrared and laser guidance system as required by claims 8 and 14. Finally, the Schmid article also discloses the use of sapphire windows as high quality telescope windows. (Ex. 1004, Section 6, page 155). It is my opinion that such a system is considered to be an infrared and visible wavelength vision system as required by claims 8 and 16.

124. To emphasize the intrinsic nature of the disclosed sapphire materials in the Patel article, the Locher article, and the Schmid article being used for applications requiring transparency in the infrared and visible wavelength

spectrum, consider further the below wavelength table, adapted for ease of reference from Harris (Ex. 1016, p. 2, Table 0.1), in combination with the following quotation from the Locher article: "Single crystal sapphire has been a material of choice for good optical performance in the 200 to 5000 nm range". (Ex. 1005, Section 2.0).

Electromagnetic Spectrum (Adapted from "Materials for Infrared Windows and Domes" Harris)

Type of Radiation	Wavelength, nanometers
Cosmic Rays	0.001
Gamma Rays	.001 - .010
X-Rays	.01 - 10
Ultraviolet	10 - 380
Visible	380 - 780
violet	380 - 430
blue	430 - 480
green	480 - 530
yellow	530 - 580
orange	580 - 620
red	620 - 780
MWIR[1]	3,000 - 5,000
LWIR[2]	8,000 - 4,400
Infrared (total)	780 - 1,000,000

Transparency range of sapphire (Ultraviolet through MWIR)

[1]Mid-Wave Infrared
[2]Long Wave Infrared

The quoted transmission range for the windows which are the subject of the cited prior art is from the middle of the ultraviolet range, through the visible range, and into mid-wave infrared. Therefore, the windows are intended for an application requiring a "geometric configuration for an infrared and laser guidance, a military sensing and targeting system or an infrared and visible wavelength vision system." This is further supported by the fact that the Locher article is marked "This document contains technical data whose export is restricted by the Arms Export Control Act," indicating capability of the Locher material to be used in a military application. (Ex. 1005).

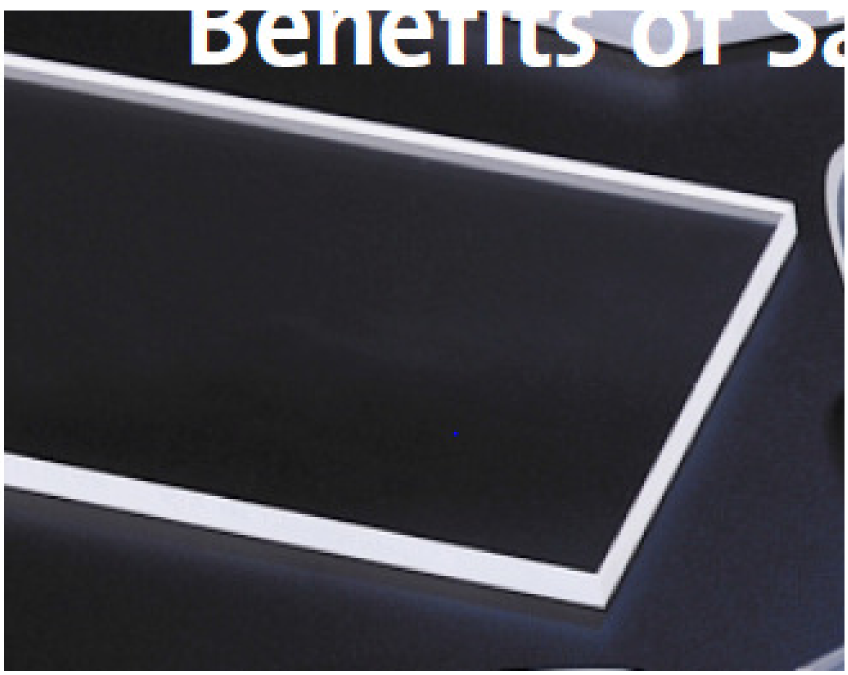
125. Accordingly, it is my opinion that, based on all of the advantages described in Schmid for using sapphire windows -- such as those described in the Patel article -- in the claimed applications, a person having ordinary skill in the art would have reason to combine these references and utilize the windows described in the Patel article in one of an infrared and laser guidance systems, a military sensing and targeting system, or an infrared and visible wavelength vision system.

XII. CLAIMS 1-7 and 9-13 OF THE '800 PATENT ARE INVALID AS BEING OBVIOUS OVER THE SAINT-GOBAIN BROCHURE IN VIEW OF THE LOCHER ARTICLE AND LABELLE '636, AS EVIDENCED BY THE KYOCERA WEBSITE, THE WINDOW AND DOME ARTICLE, AND THE JOURNAL OF CRYSTAL GROWTH ARTICLE

126. The Saint-Gobain brochure discloses sapphire sheets that can be manufactured in various sizes and shapes using a "continuous crystal growing process known as EFG (Edge defined Film fed Growth)". (Exhibit 1012, p. 2, column 1). The Saint-Gobain brochure further describes that the sapphire sheets

can be polished into components such as windows. (Exhibit 1012 page 2, column 2). The Saint-Gobain brochure also discloses that such sapphire sheets have an "As Grown" thickness of 0.15 cm to 1.27 cm (polished thickness of 0.076 cm to 0.89 cm), widths up to 30.48 cm, and lengths to 205.74 cm (Ex. 1012, p. 2, column 2). Accordingly, the single crystal sheets disclosed in the Saint-Gobain brochure have a length greater than the width greater than the thickness (see claims 1, 10, and 11 of the '800 patent).

127. The Saint-Gobain brochure describes that the sapphire sheets can be polished into components such as windows. (Ex. 1012, p. 2, column 2) (see claim 4 of the '800 patent). Such a window is shown on the front page of the Saint-Gobain brochure, which has been reproduced below.



128. The Saint-Gobain brochure also describes that the sapphire sheets can be used as viewports and site windows (i.e., optical component), as required in claims 6, 7, 12, and 13 of the ’800 patent. (Ex. 1012, p. 1, column under heading “Innovative Solutions in the following Applications”). The Saint-Gobain brochure also discloses sapphire sheets that transmit in the infrared and visible wavelength spectrums (Ex. 1012, p. 2, column 3) (see claim 9 of the ’800 patent).

129. In addition, while the Saint-Gobain brochure describes that the sapphire sheets can be polished into components such as windows (Ex. 1012, p. 2, column 2), there is no explicit disclosure that such polishing includes grinding, lapping, or removing bulk material as required by claims 2, 3, and 5 of the ’800 patent. However, in my opinion, there is an implicit disclosure in that the Saint Gobain brochure includes the following statement: “Standard available sheet product features include: • Unpolished, “As Grown”, thickness from .060" to .500" (1.5 to 12.7 mm) • Polished thickness from .030" to .35" (0.76 to 8.9 mm)”. (Ex. 1012, p. 2, column 2). From this disclosure, it is my opinion that a person having ordinary skill in the art would conclude that at least 0.030" to 0.150" of the “as grown” thickness must be removed by some process or processes to reduce the sapphire to the finished product thicknesses from the “as grown” thickness. This constitutes “bulk removal” as required by the claims of the ’800 patent.

Furthermore, as sapphire is the second hardest material in nature after diamond, there are only two materials that can be used as an abrasive to lap and grind sapphire: diamond and silicon carbide (silicon carbide is a synthetic material that is not found in nature). It would be prohibitively expensive to use "polishing" only as the method to produce the finished products described in the Saint-Gobain brochure from the as-grown crystals. Based on my own work at Allied Chemical in Charlotte, NC in the late 1970s where we produced sapphire wafers for SOS (silicon on sapphire) applications from EFG sapphire, lapping (using a silicon carbide abrasive) was a key step between growth and polishing.

130. In addition, such processes are well-known and conventional in the art as evidenced by the Locher article, which discloses finishing the sapphire sheets with a loose abrasive grinding technique (Ex. 1005, Section 4.0) and cutting (i.e., removal of bulk material) the sapphire sheet (Ex. 1005, Section 4.0), and the Kyocera website, which discloses lapping the single crystal sapphire (Ex. 1013, p. 1).

131. While the Saint-Gobain brochure discloses that such sapphire sheets can be manufactured in various sizes and shapes using a "continuous crystal growing process known as EFG (Edge defined Film fed Growth)" (Ex. 1012, p. 2, column 1) and the EFG process was very well known in the art prior to April 2003

as discussed in Section III hereinabove, the details of the EFG process are not explicitly disclosed in the Saint-Gobain brochure.

132. The Locher article discloses an EFG process for producing a 30.5 cm wide by 46 cm long by 0.25 cm thick single crystal sapphire sheet by simply "scaling up" the old technology. (Ex. 1005, Section 3.1). The Locher article further discloses that "even larger windows are possible." (*Id*. at section 5.0). LaBelle '636 was issued on October 31, 1972, more than one year prior to the effective filing date of the '800 patent, and therefore qualifies as prior art under 35 U.S.C. § 102(b). LaBelle '636 discloses an apparatus and method for growing "relatively large size monocrystalline plates of materials such as alumina, by the EFG process". (Ex. 1010, 1:68-71). Specifically, LaBelle '636 discloses the production of a single crystal sapphire sheet having a length>width>thickness with the thickness being 3/8 inch (0.95 cm) (*i.e.*, within the thickness range required by claims 1, 10, and 11). (Ex. 1010, 2:2-4).

133. In my opinion, the Locher article and LaBelle '636 explain the manner in which a single crystal sapphire sheet having the dimensions as disclosed in the Saint-Gobain brochure, and being produced by the EFG process, would be made by a person having ordinary skill in the art. Specifically, it is my opinion that it would have been obvious to a person having ordinary skill in the art to scale

processes and equipment known prior to April 2003 to produce a single crystal sapphire sheet having all the limitations of claims 1, 10, and 11 without undue experimentation. The Saint-Gobain brochure demonstrates customized, commercial sale of sapphire sheets grown using a process described in detail by the Locher article and LaBelle ’636, presenting an obvious combination of prior art references.

134. Specifically, in order to scale the EFG process to larger size parts, a PHOSITA starts at the die and works outward. The following discussion is directed exclusively to larger sapphire plates. The die dimensions (length and width, which correspond to the plate dimensions width and thickness, respectively) are determinant. The die material will be either tungsten or molybdenum as indicated in LaBelle ’636 (Ex. 1010, 4:7-9). The dimensions of the capillary channels (either holes or slots) are determined by the required capillary rise (as described below) and the equations in LaBelle I (Ex. 1007, top of p. 573) and Labelle ’636 (Ex. 1010, 5:18-21).

135. A PHOSITA would understand that crucible dimensions are constrained by the dimensions of the die and the volume of liquid needed to produce the desired sheet(s). At a minimum, the crucible needs to be an oblong shape of sufficient length in the longest dimension to incorporate the die.

Alternatively, the crucible could be round with an inside diameter larger than the long dimension of the die. The issue of crucible depth is discussed below.

136. To provide the required temperature (in excess of 2050°C), there are only two options: (a) induction heating by radio frequency using an induction coil that "couples" directly to the crucible, or (b) resistance heating. (Note: induction heating can also be used where the induced power goes into a "susceptor" as described in Labelle '636 (Ex. 1010), and the susceptor serves as a resistance heater that transfers heat to the crucible.)

137. If resistance heating is used, the choices for heating elements are largely limited to graphite or tungsten. Graphite is the preferred choice because it is cheaper and more readily fabricated into a variety of shapes. Graphite is also more robust and durable than tungsten and thus able to withstand more thermal cycles.

138. Insulation around the system, which would be between the crucible and induction coil in the case of induction heating or outside of the heating elements in the case of resistance heating, again offers two choices: (a) graphite or (b) refractory metals (tungsten and/or molybdenum). Graphite would be in the form of a porous product such as the felt blanket or cloth as described in U.S. Patent No. 3,591,348 to LaBelle. (Ex. 1017, 5:13-18). These materials are also

available in the form of boards that can be cut to the desired shape. If refractory metal parts are used for insulation, they would be in the form of radiation shields as described in LaBelle '348 (Ex. 1017, 8:30-38) and LaBelle '636. (Ex. 1010, 6:68-69). It should be noted that the use of radiation shields that are vertically disposed and run around the crucible with the same general geometry (oblong or circular) are difficult to manage because they couple with the induction coil and receive the RF energy instead of the crucible. So, porous graphite is preferable.

139. Having worked outward from the die to the crucible, to the insulation and to the induction coil, in the case of induction heating, or from the die to the crucible, to the resistance heating elements and to the insulation in the case of resistance heating, the size of the chamber required to house the furnace "hot zone" can be determined. In terms of the radial or horizontal dimensions, the chamber can be just slightly larger than the insulation in the case of resistance heating. In the case of induction heating, the chamber would have to be quite a bit larger than the induction coil in order to prevent the chamber walls from "coupling" to the coil and parasitically consuming the energy of the induction power supply, thus reducing the amount of power available to heat the crucible. (*See* Ex. 1015, Figure 10).

140. The chamber would have to be water-cooled to dissipate the heat that comes through the insulation. This is generally achieved by using a double-wall chamber with water flowing between the walls. (*See* Ex. 1005, Section 3.1).

141. The crucible depth calculation can be more involved than just providing sufficient volume of molten material to grow the desired mass of plates. In the case of both induction and resistance heating, the crucible wall is the entry point for heat. In the case of induction heating, the height of the crucible must be sufficiently tall to allow a large enough surface for the induction coil to couple to and generate the heat required to raise the mass of sapphire to over 2050°C.

142. Similarly, in the case of resistance heating, the heating elements radiate heat (power) to the crucible, and a sufficient area of crucible wall must be available to absorb that heat. So, in both cases, a minimum crucible depth is required.

143. In terms of insulation thickness, this is determined by the temperature of the hot zone, the thermal conductivity of the insulation, and the power available from the heating source (induction power supply or resistance heater). For example, in Ex. 1015 §6, (3), LaBelle describes using a 75 kW induction power supply. This would have been a commercially available system well within the capabilities of the industry at the time.

144. Once these parameters (chamber dimensions, power required, etc.) are determined, the specifications could be turned over to a commercial furnace manufacturer to design and build the system. Alternatively, the specifications could be worked out in consultation with the furnace manufacturer.

145. The last technical challenge is the crucible volume which is determined by both the cross sectional area and the depth. The design described in the ’800 patent uses a crucible volume that is less than volume required for the size of plates that need to be grown. Consequently, sapphire raw material is added to the crucible while the crystals are growing. (Ex. 1001, 9:7-9). The feeder mechanism goes back to the original EFG process development. (Ex. 1010, 3:69-73). However, it was never possible to grow defect-free sapphire while simultaneously feeding raw material into the crucible until a technique was developed at Allied Chemical by Mr. Paul Yancey. (*See* U.S. Patent No. 4,269,652, Ex. 1018). This technique allows the added sapphire particles to melt and come to thermal and chemical equilibrium with the material already in the crucible before flowing into the main mass of liquid.

146. The methodology of the ’800 patent also requires that the crucible be fully depleted of raw material during the run. Any residual raw material remaining in the crucible will, of course, freeze when the system is cooled down to room

temperature. On the next heating cycle, the large volume change between liquid and solid at the melting point (molten sapphire has a density of ~3 gm/cc vs. solid sapphire at ~4 g/cc) will deform and possibly crack the crucible in much the same way that water pipes burst when the water in them freezes. The necessity to drain the crucible of all sapphire, combined with the maximum capillary rise achievable with the die design, discussed in paragraph 135 above, is a determining factor in the crucible wall height of the '800 patent.

147. Not mentioned in the '800 patent is the fact that the crystal, once it is separated from the die and after a period in the afterheater, is extracted from the top of the system while the crucible is left at the operating temperature. The crystal is pulled above a gate valve, which is closed, into a bellows. The bellows are released and dropped so that the crystal can be removed and a new seed installed. This can be seen in Figs. 2 and 3 in the Locher article. (Ex. 1005). All this time, the crucible is kept hot and is being refilled with the feeder mechanism. The bellows are then closed around the new seed, flushed with argon (or whatever furnace gas is being used), the gate valve is opened, the seed is lowered to the die, and a new crystal growth run is initiated.

148. If a large round crucible is used, which contains significantly more sapphire than is required to grow the plate(s), a method must be developed that

lowers the crucible away from the die and carefully freezes the sapphire from the bottom upwards. On the subsequent heating cycle, the sapphire must be melted from the top down so that there is no lateral expansion that will deform and/or crack the crucible. (The top surface, being free, can expand upwards without deforming the crucible.) So, in this case, the crucible depth is more a function of the surface area needing exposure to the heating elements than to the capillary rise. Since the mass of liquid in the crucible is significantly greater than the mass of material crystallized into plates, no feeder mechanism is necessary.

149. LaBelle ’636 discloses EFG growth of crystals, such as α-alumina (i.e., sapphire). LaBelle ’636 further discloses that in EFG growth of sapphire, a growing body grows to the shape of the liquid film which conforms to the edge configuration of a die’s end surface (Ex. 1010, 1:30-54) and that it is desirable to provide a symmetrical temperature distribution about the melt, growth zone, and growing body, and discloses means (see susceptors 40 and 44) for accomplishing such symmetrical temperature distribution. (*Id.* at 3:28-32). In addition, LaBelle ’636 describes that susceptor (40) minimizes temperature gradients in the melt along the plane of the liquid film from which the body is grown. (*Id.* at 6:13-50). In other words, LaBelle ’636 describes that minimizing temperature gradients in the

melt along the plane of the liquid film during growth enables successful growth of sapphire bodies including bodies having "a rectangular cross-section."

150. Moreover, the Locher article discloses scaling EFG equipment and processes known prior to April 2003 to produce a sapphire sheet having a length of 46 cm and a width of 30 cm. (Ex. 1005, Section 3.1). The Locher article also discloses vertical and horizontal temperature gradients of less than 150°C/cm and no more than 0.3°C/cm, respectively, with an overall temperature control good to 0.05% or 1°C were used to EFG-grow a sapphire sheet 30.5 cm × 46 cm. (*Id.*).

151. Therefore, following the teachings and principles disclosed in the Locher article and LaBelle '636 regarding controlling/minimizing temperature gradients (desirably to zero) on the top surface of the die and/or in the melt along the plane of the liquid film, it would have been obvious to a person having ordinary skill in the art to perform a method to produce a sapphire single crystal and machine such a sapphire single crystal into sapphire components having all of the features of claims 1-7 and 9-13 by scaling the process and equipment known in the art prior to April 2003, without undue experimentation.

152. Still further, many others, prior to the priority date of the application that issued as the '800 patent, were capable of producing single crystal sapphire sheets using the EFG process having dimensions nearly identical to the dimensions

required by the claims of the ’800 patent. The Kyocera website, the Window and Dome article, and the Journal of Crystal Growth article all disclose large sized single crystal sheets manufactured using the EFG technique. Specifically, the Kyocera website describes a single crystal sapphire sheet grown using the EFG technique that has a maximum width of 200 mm (20 cm), a length of 300 mm (30 cm), and a thickness of up to 20 mm (2 cm). (Ex. 1013, p. 2). In addition, the Journal of Crystal Growth article discloses an as-grown sapphire crystal 30 cm wide × 1.25 cm thick × 30 cm long (Ex. 1014, p. 14, Section 6(3)). The Window and Dome article discloses a 30 cm × 30 cm × 0.95 cm as-grown sapphire crystal and discloses that the growth process was successfully scaled to produce crystals having widths up to 300 mm (30 cm). (Ex. 1015, Section 5 and Fig. 8).

153. Accordingly, while the Kyocera website discloses a single crystal sapphire sheet having a width that is slightly smaller than the claimed width, and while the Journal of Crystal Growth article and the Window and Dome article each disclose that the as-grown sapphire crystal has a width = length = 30 cm, the dimensions in these references were not limited by the structure of sheet itself or the physics/dynamics of the growth process. Rather, in my opinion, the dimensions disclosed in these references were a constraint imposed by the design of the equipment used for growth, an intentional choice in the growth of the

crystal, and/or simply a size dictated by the dimensional requirements of the finished product. For example, the Window and Dome article, section 5 discloses as-grown sapphire plates with lengths of 50 cm had been made in an R&D system.

154. The following claim chart summarizes the position for claims 1-7 and 9-13 set forth hereinabove.

U.S. Patent No. 9,963,800	**The Saint-Gobain Brochure**	**Secondary References**
1. A method of making a sapphire component, the method comprising	The Saint-Gobain brochure describes sapphire sheets that can be manufactured in various sizes and shapes using a "continuous crystal growing process known as EFG (Edge defined Film fed Growth)" (Ex. 1012, p. 2, column 1). The Saint-Gobain brochure further describes that the sapphire sheets can be polished into components such as	

	windows (Ex. 1012, page 2, column 2).	
machining a sapphire single crystal having a length, a width and a thickness,	The Saint-Gobain brochure describes a sheet having a length, width, and thickness (Ex. 1012, p. 2, column 2). The Saint-Gobain brochure further describes that the sapphire sheets can be polished into components such as windows (Ex. 1012, page 2, column 2). In addition, the '800 patent defines "machining" as "machining is effected to form the single crystal into the desired geometric configurations for commercial use. Accordingly, grinding, lapping, ***polishing*** and the like, or bulk material	

	removal/shaping such as wire sawing or cleaving and the like may be utilized to manipulate the single crystal into a desired component" (emphasis added). (Ex. 1001, 8:7-12). Accordingly, the polishing described in the Saint-Gobain brochure is considered to be machining.	
wherein the length>width>thickness,	The Saint-Gobain brochure discloses a sapphire sheet having an "As Grown" thickness of 0.15 cm to 1.27 cm (polished thickness of 0.076 cm to 0.89 cm), widths up to 30.48 cm, and lengths to 205.74 cm (Ex. 1012, p. 2, column 2).	
the width is not less	The Saint-Gobain	While the Saint-Gobain

than 28 cm, and the thickness is not less than 0.5 cm into the sapphire component.	brochure discloses a sapphire sheet having an "As Grown" thickness of 0.15 cm to 1.27 cm (polished thickness of 0.076 cm to 0.89 cm), widths up to 30.48 cm, and lengths to 205.74 cm (Ex. 1012, p. 2, column 2).	brochure discloses that such sapphire sheets can be manufactured in various sizes and shapes using a "continuous crystal growing process known as EFG (Edge defined Film fed Growth)" (Ex. 1012, p. 2, column 1) and the EFG process was very well known in the art prior to April 2003, the details of the EFG process are not explicitly disclosed in the Saint-Gobain brochure, but are disclosed on the Kyocera website. The Locher article discloses an EFG process for producing a 30.5 cm wide by 46 cm long by 0.25 cm thick single crystal sapphire sheet by simply "scaling up" the old technology. (Ex. 1005,

		Section 3.1). The Locher article further discloses that "even larger windows are possible." (*Id.* at Section 5.0). LaBelle '636 discloses an apparatus and method for growing "relatively large size monocrystalline plates of materials such as alumina, by the EFG process" (Ex. 1010, 1:68-71). Specifically, LaBelle '636 discloses the production of a single crystal sapphire sheet having a length>width>thickness with the thickness being 3/8 inch (0.95 cm) (*i.e.*, within the thickness range required by the claims (*Id.* at 2:2-4). The Locher article and LaBelle '636 are provided to explain the manner in

		which a single crystal sapphire sheet having the dimensions as disclosed in the Patel article would be made by a person having ordinary skill in the art. Specifically, it would have been obvious to a person having ordinary skill in the art to scale processes and equipment known prior to April 2003 to produce a single crystal sapphire sheet having all the limitations of claim 1, without undue experimentation. Still further, the Kyocera website, the Window and Dome article, and the Journal of Crystal Growth article all disclose large sized single crystal sheets manufactured using the EFG technique.

		Specifically, the Kyocera website describes a single crystal sapphire sheet grown using the EFG technique that has a maximum width of 200 mm (20 cm), a length of 300 mm (30 cm), and a thickness of up to 20 mm (2 cm) (Ex. 1013, p. 2). In addition, the Journal of Crystal Growth article discloses an as-grown sapphire crystal 30 cm wide × 1.25 cm thick × 30 cm long (Ex. 1015, p. 14, Section 6(3)). Still further, the Window and Dome article disclose a 30 cm × 30 cm × 0.95 cm as-grown sapphire crystal and discloses that the growth process was successfully scaled to produce crystals having widths up to 300

		mm (30 cm) (Ex. 1014, section 5 and Fig. 8).
2. The method of claim 1, wherein machining the sapphire single crystal comprises grinding the sapphire single crystal.		While the Saint-Gobain brochure describes that the sapphire sheets can be polished into components such as windows (see page 2, column 2), there is no explicit disclosure that such polishing includes grinding. However, the Locher article discloses finishing the sapphire sheets with a loose abrasive grinding technique (Ex. 1005, Section 4.0).
3. The method of claim 1, wherein machining the sapphire single crystal comprises lapping the sapphire single crystal.		The Kyocera website discloses lapping the single crystal sapphire (Ex. 1013, page 1).
4. The method of claim 1, wherein machining	The Saint-Gobain brochure describes that	

the sapphire single crystal comprises polishing the sapphire single crystal.	the sapphire sheets can be polished into components such as windows (Ex. 1012, page 2, column 2).	
5. The method of claim 1, wherein machining the sapphire single crystal comprises removing bulk material from the sapphire single crystal.		While the Saint-Gobain brochure clearly shows windows that have had bulk material removed therefrom (Ex. 1012, image on page 1), there is no explicit disclosure of removing bulk material from the sapphire single crystal. However, Figure 5 of the Locher article is a photograph of sapphire panes after cutting and polishing (*i.e.*, removal of bulk material) (see Table 1, as grown thickness of 0.3 cm, *c.f.*, p. 6, "After polishing to a thickness of 0.127 cm," indicating that more than 50% of as-

		grown thickness was removed, constituting bulk removal).
6. The method of claim 1, wherein machining the sapphire single crystal comprises machining the sapphire single crystal into an optical component.	The Saint-Gobain brochure describes that the sapphire sheets can be used as viewports and site windows (*i.e.*, optical component) (Ex. 1012, page 1).	
7. The method of claim 1, wherein machining the sapphire single crystal comprises machining the sapphire single crystal into an optical window.	The Saint-Gobain brochure describes that the sapphire sheets can be used as viewports and site windows (*i.e.*, optical window) (Ex. 1012, page 1).	
9. The method of claim 1, wherein the sapphire single crystal is transparent in the infrared and visible wavelength spectrums.	The Saint-Gobain brochure discloses sapphire sheets transmit in the infrared and visible wavelength spectrums (Ex. 1012, p. 2, column 3).	
10. The method of claim	The Saint-Gobain	

1, wherein the sapphire single crystal has a thickness of at least 0.6 cm.	brochure discloses an "As Grown" thickness of up to 1.27 cm and a polished thickness up to 0.89 cm (Ex. 1012, p. 2, column 2).	
11. A method of making a sapphire component comprising grinding, lapping, polishing or removing bulk material from a sapphire single crystal to form the sapphire component,	The Saint-Gobain brochure sapphire sheets that can be manufactured in various sizes and shapes using a "continuous crystal growing process known as EFG (Edge defined Film fed Growth)" (Ex. 1012, p. 2, column 1). The Saint-Gobain brochure further describes that the sapphire sheets can be polished into components such as windows (Ex. 1012, page 2, column 2).	
wherein the sapphire	The Saint-Gobain	

single crystal has a length, a width and a thickness, the length>width>thickness,	brochure describes a sheet having a length, width, and thickness (Ex. 1012, p. 2, column 2). The Saint-Gobain brochure discloses a sapphire sheet having an "As Grown" thickness of 0.15 cm to 1.27 cm (polished thickness of 0.076 cm to 0.89 cm), widths up to 30.48 cm, and lengths to 205.74 cm (Ex. 1012, p. 2, column 2).	
the width is not less than 28 cm, and the thickness is not less than 0.5 cm.	The Saint-Gobain brochure discloses a sapphire sheet having an "As Grown" thickness of 0.15 cm to 1.27 cm (polished thickness of 0.076 cm to 0.89 cm), widths up to 30.48 cm, and lengths to 205.74 cm (Ex. 1012, p. 2, column	While the Saint-Gobain brochure discloses that such sapphire sheets can be manufactured in various sizes and shapes using a "continuous crystal growing process known as EFG (Edge defined Film fed Growth)" (Ex. 1012, p. 2, column 1) and the EFG

	2).	process was very well known in the art prior to April 2003, the details of the EFG process are not explicitly disclosed in the Saint-Gobain brochure. The Locher article discloses an EFG process for producing a 30.5 cm wide by 46 cm long by 0.25 cm thick single crystal sapphire sheet by simply "scaling up" the old technology. (Ex. 1005, Section 3.1). The Locher article further discloses that "even larger windows are possible." (*Id.* at section 5.0). LaBelle '636 discloses an apparatus and method for growing "relatively large size monocrystalline plates of materials such as alumina, by the EFG process" (Ex.

		1010, 1:68-71). Specifically, LaBelle '636 discloses the production of a single crystal sapphire sheet having a length>width>thickness with the thickness being 3/8 inch (0.95 cm) (*i.e.*, within the thickness range required by the claims (*Id.* at 2:2-4). The Locher article and LaBelle '636 are provided to explain the manner in which a single crystal sapphire sheet having the dimensions as disclosed in the Patel article would be made by a person having ordinary skill in the art. Specifically, it would have been obvious to a person having ordinary skill in the art to scale processes and equipment known prior to

		April 2003 to produce a single crystal sapphire sheet having all the limitations of claim 1, without undue experimentation. Still further, the Kyocera website, the Window and Dome article, and the Journal of Crystal Growth article all disclose large sized single crystal sheets manufactured using the EFG technique. Specifically, the Kyocera website describes a single crystal sapphire sheet grown using the EFG technique that has a maximum width of 200 mm (20 cm), a length of 300 mm (30 cm), and a thickness of up to 20 mm (2 cm) (Ex. 1013, p. 2). In addition, the Journal of

		Crystal Growth article discloses an as-grown sapphire crystal 30 cm wide × 1.25 cm thick × 30 cm long (Ex. 1015, p. 14, section 6(3)). Still further, the Window and Dome article disclose a 30 cm × 30 cm × 0.95 cm as-grown sapphire crystal and discloses that the growth process was successfully scaled to produce crystals having widths up to 300 mm (30 cm) (Ex. 1014, Section 5 and Fig. 8).
12. The method of claim 11 wherein the sapphire single crystal is formed into an optical component.	The Saint-Gobain brochure describes that the sapphire sheets can be polished into optical components such as windows (Ex. 1012, page 2, column 2).	
13. The method of claim 12, wherein the sapphire	The Saint-Gobain brochure describes that	The Locher article further states mass production of

single crystal is formed into an optical window.	the sapphire sheets can be used as viewports and site windows (*i.e.*, optical window) (Ex. 1012, page 1).	point-of-sale bar code scanner windows. (Ex. 1005, Section 3.0)

XIII. CLAIMS 8 AND 14-16 OF THE ’800 PATENT ARE INVALID AS BEING OBVIOUS OVER THE SAINT-GOBAIN BROCHURE IN VIEW OF THE LOCHER ARTICLE AND LABELLE ’636, AS EVIDENCED BY THE KYOCERA WEBSITE; THE WINDOW AND DOME ARTICLE; THE JOURNAL OF CRYSTAL GROWTH ARTICLE; AND FURTHER IN VIEW OF THE SCHMID ARTICLE

155. Claim 8 depends from claim 7 and recites that the optical window is machined into a geometric configuration for an infrared and laser guidance system, a military sensing and targeting system, or an infrared and visible wavelength vision system. Claim 14 depends from claim 13 and recites that the sapphire single crystal is formed into a geometric configuration for an infrared and laser guidance system. Claim 15 depends from claim 13 and recites that the sapphire single crystal is formed into a geometric configuration for a military sensing and targeting system. Claim 16 depends from claim 13 and recites that the sapphire single crystal is formed into a geometric configuration for an infrared and visible wavelength vision system. As discussed hereinabove in Section X, it is my opinion that the combination of the Saint-Gobain brochure in view of the Locher article and

LaBelle ’636 as evidenced by the Kyocera website, the Window and Dome article, and the Journal of Crystal Growth article discloses each and every limitation of claims 7 and 13.

156. The Saint-Gobain brochure further describes that the sapphire sheets can be used as viewports and site windows (*i.e.*, optical window). (Ex. 1012, page 1). While it is my opinion that such a window could inherently be used in any one of an infrared and laser guidance, a military sensing and targeting system, or an infrared and visible wavelength vision system, there is no explicit disclosure in either the Saint-Gobain brochure of such a use.

157. The Schmid article discloses the use of sapphire windows in reconnaissance, surveillance, targeting, and sensing applications. (Ex. 1004, Section 6, page 155). It is my opinion that such a system is considered to be at least a military sensing and targeting system as required by claims 8 and 15. In addition, the Schmid article further discloses the use of sapphire windows for use hypersonic missile windows for single and dual mode seekers. (Ex. 1004, Section 6, page 155). It is my opinion that such a system is considered to be at least an infrared and laser guidance system as required by claims 8 and 14. Finally, the Schmid article also discloses the use of sapphire windows as high quality telescope windows. (Ex.

1004, Section 6, page 155). It is my opinion that such a system is considered to be an infrared and visible wavelength vision system as required by claims 8 and 16.

158. To emphasize the intrinsic nature of the disclosed sapphire materials in the above-cited prior art being used for applications requiring transparency in the infrared and visible wavelength spectrum, consider further the below wavelength table, adapted for ease of reference from Harris (Ex. 1016, p. 2, Table 0.1), in combination with the following quotation from the Locher article: "Single crystal sapphire has been a material of choice for good optical performance in the 200 to 5000 nm range". (Ex. 1005, Section 2.0).

Electromagnetic Spectrum (Adapted from "Materials for Infrared Windows and Domes" Harris)

Type of Radiation	Wavelength, nanometers
Cosmic Rays	0.001
Gamma Rays	.001 - .010
X-Rays	.01 - 10
Ultraviolet	10 - 380
Visible	380 - 780
violet	380 - 430
blue	430 - 480
green	480 - 530
yellow	530 - 580
orange	580 - 620
red	620 - 780
MWIR[1]	3,000 - 5,000
LWIR[2]	8,000 - 4,400
Infrared (total)	780 - 1,000,000

Transparency range of sapphire (Ultraviolet through MWIR)

[1]Mid-Wave Infrared
[2]Long Wave Infrared

The quoted transmission range for the windows which are the subject of the cited prior art is from the middle of the ultraviolet range, through the visible range, and into mid-wave infrared. Therefore, the windows are intended for an application requiring a "geometric configuration for an infrared and laser guidance, a military sensing and targeting system or an infrared and visible wavelength vision system." This is further supported by the fact that the Locher article is marked "This document contains technical data whose export is restricted by the Arms Export Control Act," indicating capability of the Locher material to be used in a military application. (Ex. 1005).

159. Accordingly, it is my opinion that a person having ordinary skill in the art would utilize the windows described in the Saint-Gobain brochure in view of the Locher article and LaBelle '636, as evidenced by the Kyocera website, the Window and Dome article, and the Journal of Crystal Growth article in one of an infrared and laser guidance systems, a military sensing and targeting system, or an infrared and visible wavelength vision system as it was well-known in the art prior to April 2003 to utilize sapphire components in such systems as disclosed in the Schmid article.

XIV. CONCLUSION

160. In conclusion, for the reasons discussed above, it is my opinion that claims 1-16 are either anticipated or would be obvious to one skilled in the art of sapphire crystal growth.

161. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

162. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed this 17th day of August, 2019 in Albuquerque NM.

Frank J. Bruni