

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO. LTD.,
SAMSUNG ELECTRONICS AMERICA, INC.,
SAMSUNG SEMICONDUCTOR, INC., and
SAMSUNG AUSTIN SEMICONDUCTOR, LLC
Petitioner

v.

CHIEN-MIN SUNG

Patent Owner

Case IPR2024-00533
U.S. Patent No. 8,974,270

**DECLARATION OF STANLEY SHANFIELD, PH.D.
ON BEHALF OF PETITIONER**

CLAIMS 1-8

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I, Stanley Shanfield, declare as follows.

I. Introduction

1. My Name is Stanley Shanfield.
2. I received a B.S. Degree in Physics *cum laude* from University of California, Irvine in 1977. I received a Ph.D. in Physics from Massachusetts Institute of Technology in 1981.
3. After obtaining my Ph.D. in 1981, I was a Staff Scientist at Spire Corporation in Bedford, Massachusetts. From 1985-1999, I worked at Raytheon Corporation. As staff and later as section manager, among many other projects, I developed reactive ion etching (RIE) processes for patterning dielectrics (silicon dioxide, silicon nitride, silicon oxynitride, etc.), conductive layers (aluminum-copper, copper-silicon, W-silicide, TaN, doped polysilicon, etc.) and organic layers (photoresist, polyimide, etc.). In 1996, I became the Manager of Semiconductor Operations at Raytheon. As Manager, I built and led a 300 employee, \$60 million revenue-generating semiconductor development, commercial system design, and electronic module manufacturing operation. I worked directly with engineers in the selection, installation, and optimization of several chemo-mechanical polishing systems (CMP), including analysis of operational maintenance and performance monitoring. The manufacturing facility eventually used multiple production CMP

systems, and I directly participated in establishing the required metrology (optical thickness monitoring) for maintaining polishing uniformity standards.

4. In 1999, I was a co-founder and became Vice President of Operations at AXSUN Technologies in Bedford/Billerica, Massachusetts and later became Director of Manufacturing and Wafer Fab Technology.

5. In 2003, I joined the Draper Laboratory in Cambridge, Massachusetts. Currently, I am the Division Leader of Advanced Hardware Development, with around 80 staff members; a Distinguished Member of Technical Staff; and Technical Director. I led the Advanced Hardware Development division in relaunching a multi-chip integrated circuit module facility. The laboratory has acquired several semiconductor-grade CMP systems for the purpose of fabricating multi-chip modules and for planarization operations in MEMS devices, and I have been involved in their operation and optimization. I invented and led the implementation of an ultra-miniature electronics fabrication technology. I also developed fabrication technology for semiconductor-based low phase noise oscillator design. I have received many awards at Draper, including the 2010 Distinguished Performance Award and the 2010 Best Patent Award.

6. I have nearly four decades of extensive experience working on and with semiconductors.

Declaration of Dr. Stanley Shanfield
U.S. Patent No. 8,974,270

7. I have authored over 25 publications in peer-reviewed academic journals, transactions and books.
8. I am a named inventor in six issued U.S. patents.
9. I am a member of multiple societies, including the IEEE and the American Physical Society (APS).
10. A copy of my curriculum vitae (“CV”) is attached as Appendix A.
11. I am familiar with the technology of U.S. Patent No. 8,974,270 (the “’270 Patent”).
12. I am familiar with the knowledge and capabilities of a person of ordinary skill in the art the time of the earliest possible priority date of the ’270 Patent – May 23, 2011.
13. I understand that the ’270 Patent was filed on May 23, 2012, as a U.S. Patent Application No. 13/479,148. I understand that this application claims priority to a U.S. Provisional Patent Application No. 61/489,074, filed May 23, 2011.
14. I have reviewed the following references in preparing this declaration, all of which I understand to be prior art to the ’270 Patent:
 - U.S. Patent Application Publication No. 2010/0022174 (“Chou”) (EX1004), which published on January 28, 2010;

- U.S. Patent Application Publication No. 2008/0096479 (“Sung’479”) (EX1005), which published on April 24, 2008;
- U.S. Patent Application Publication No. 2008/0004743 (“Goers”) (EX1006), which first published on January 3, 2008;
- Sung et al. “Polycrystalline Diamond (PCD) Shaving Dresser: The Ultimate Diamond Disk (UDD) for CMP Pad Conditioning,” *ECS Transactions*, 18 (1) 523-528 (2009) (“SungECS”) (EX1007), which became publicly available at least on March 6, 2009.

15. I have considered the following exhibits listed below in preparing this Declaration. In addition, I have reviewed and considered all other documents mentioned in my Declaration. My opinions are based on my personal knowledge of these documents as viewed from the lens of a person of ordinary skill in the art, which I am familiar with based on my technical education, training, and experience in the field.

Exhibit No.	DESCRIPTION
1001	U.S. Patent No. 8,974,270 (“’270 Patent”)
1003	File History of the ’270 Patent
1004	U.S. Patent Application Publication No. 2010/0022174 (“Chou”)
1005	U.S. Patent Application Publication No. 2008/0096479 (“Sung’479”)
1006	U.S. Patent Application Publication No. 2008/0004743 (“Goers”)
1007	Sung et al. “Polycrystalline Diamond (PCD) Shaving Dresser: The Ultimate Diamond Disk (UDD) for CMP Pad Conditioning,” <i>ECS Transactions</i> , 18 (1) 523-528 (2009) (“SungECS”)
1008	U.S. Patent No. 5,036,015

Exhibit No.	DESCRIPTION
1009	Ishizuka et al. "PCD Dressers for Chemical Mechanical Planarization with Uniform Polishing" Proceedings of International Conference on Leading Edge Manufacturing in 21 st Century: LEM21, 2007, Volume 2007.4
1010	U.S. Patent Application Publication No. 2003/0084894
1011	U.S. Patent No. 7,741,764
1013	Tsai et al., "Effect of CMP conditioner diamond shape on pad topography and oxide wafer performances," <i>Int. J. Adv. Manuf. Technology</i> , 55: 253-262 (2011)
1014	Fenna, Donald. "Hardness Numbers," <i>A Dictionary of Weights, Measures, and Units</i> , 1st ed., Oxford University Press, 2004.

16. I have additionally reviewed Petition and the Final Written Decision in IPR2014-01523.

17. I have been retained to serve as an expert for Samsung Electronics Co. Ltd., Samsung Electronics America, Inc., Samsung Semiconductor, Inc., and Samsung Austin Semiconductor, LLC (which I will collectively refer to as "Samsung") in the field of semiconductor integrated circuit processing and fabrication.

18. I am being compensated at my usual hourly rate of \$460, and the conclusions or opinions that I reach and express in my declaration have no bearing on my compensation.

19. I do not have any financial interest in the outcome of this case nor do I have any financial interest in Samsung.

20. I do not personally know Dr. Chien-Min Sung and have never had any personal contact with him.

II. Relevant Law

21. Counsel has informed me about the following aspects of patent law, which I have applied in my analysis and conclusions.

A. Person of Ordinary Skill in the Art

22. I have been informed and understand that a patent should be analyzed within the framework of a person of ordinary skill in the art (“POSITA”), which is a hypothetical individual. I have been told to assume that a POSITA would have been knowledgeable about the prior art that was publicly accessible at the time of the priority date of the patent. Here, the ’270 Patent claims priority to a provisional application, which was filed on May 23, 2011.

23. I have also been informed that factors considered in determining a level of POSITA include (1) sophistication of the technology, (2) challenges and types of problems faced within the field, (3) solutions to these problems known at the priority date of the patent, (4) levels of education of professionals actively working in the field, including that of the named inventor, (5) types of testing described in the patent and the requisite skills needed to perform those tests, and (6) the general state of the technology overall.

24. I have been informed that a POSITA is a person of ordinary creativity. A POSITA is not an automaton and would be able to consider and put together teachings from multiple prior art references.

B. Claim Construction

25. I have been informed that to determine the meaning of the terms in the claims of the '270 Patent for the purposes of the *inter partes* review, one should generally use the ordinary and customary meaning as understood by a POSITA at the time of the claimed priority date, taking into consideration the claim language and patent specification.

26. I have been informed that a patentee can include a definition of a claim term in the specification. In such instances, I understand that the claim should generally be interpreted according to that definition provided in the patent.

27. I have been informed that the patent's claims, specification, and the file history (EX1003) should be analyzed to arrive at the proper interpretation of a claim term.

C. Obviousness

28. I have been informed that a claim can be found unpatentable based on obviousness if a prior art reference, either alone or in combination with other prior art reference(s), teaches or suggests the claims.

29. I further understand that drawings and pictures can teach a claim limitation if they clearly show what is claimed.

30. I further understand that a claim limitation that covers a broad range can be taught by a prior art that teaches a specific value (or a smaller range) within that claimed range.

31. I further understand that a claim limitation that covers a range can be taught or rendered obvious by a prior art that teaches a range that overlaps with the claimed range, if the claimed range does not demonstrate any criticality, such as by demonstrating unexpectedly superior results.

32. I have been informed and understand that a patent claim is considered obvious to a POSITA in view of a single or multiple references if the differences between the subject matter in the prior art and the subject matter in the claim would have been obvious to a POSITA before the priority date of the patent. Therefore, I understand that the challenged claims of the patent should be read from the point of view of a POSITA. For example, I have been informed that a claim would have been found unpatentable for being obvious if a POSITA would have been motivated to combine the teachings of two or more prior art references to achieve the claimed subject matter, and the POSITA would have had a reasonable expectation of success to do so.

33. I have been informed that in an *inter partes* review, the Patent Trial and Appeal Board (the “Board”) evaluates obviousness of a claim under a preponderance of the evidence standard, which means that the Board determines that a claim is unpatentable for being obvious when the claim is more likely obvious than nonobvious.

34. I have been informed that the Supreme Court has held that the combination of known elements combined according to known methods that produces nothing more than predictable results is likely obvious. Additionally, I have been informed that the Supreme Court indicated that obviousness may be found if:

- there is some teaching, suggestion, or motivation in the prior art that would have led a POSITA to combine prior art reference teachings or modify the prior art to arrive at the claims;
- the modification is a combination of prior art elements according to known methods yields predictable results;
- the combination of prior art is a simple substitution of one known element for another to obtain predictable results;
- the combination of prior art elements is an application of a known technique to a known device (or method) ready for improvement to yield predictable results;

- the changed element(s) represent one of a finite number of identified, predictable solutions, and a POSITA would have a reasonable expectation of success that such modification would work.

35. I have been informed that an obviousness determination cannot be based on the benefit of hindsight gained from the patent under consideration. Therefore, the patent's claim or its description of the claimed subject matter cannot be used as a roadmap in considering combinations of prior art references.

III. Summary of Opinions

36. For the reasons explained below, I conclude that claims 1-8 of the '270 Patent are rendered obvious by the prior art.

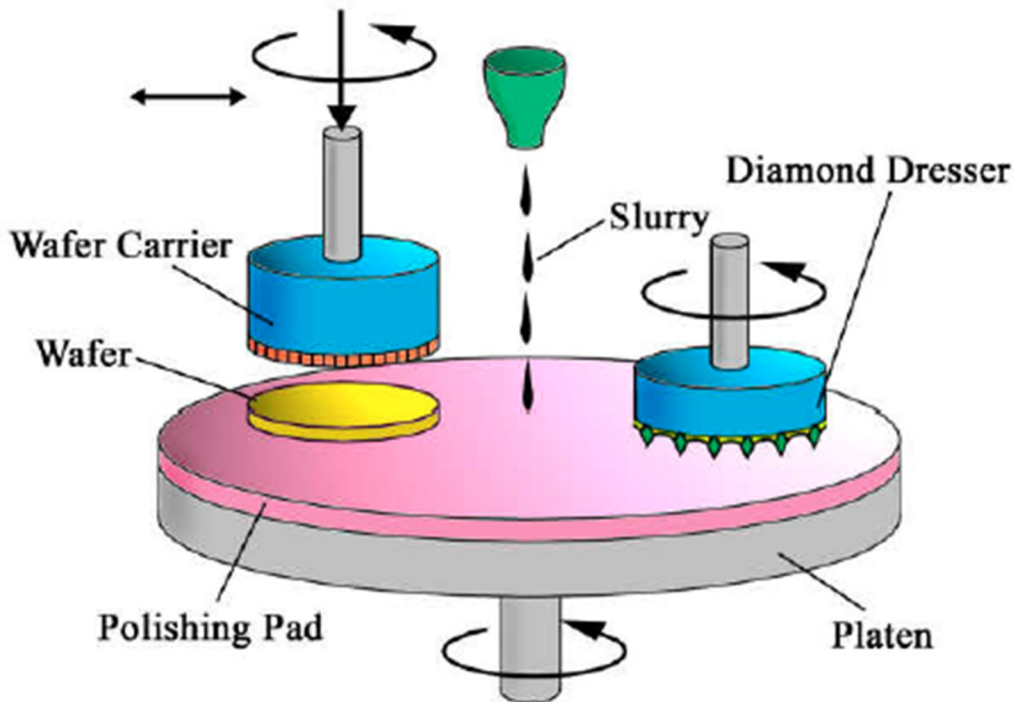
Grounds	Claims	Statutory Ground	Prior Art References
I	1, 3-8	35 U.S.C. §103	Chou in combination with Sung'479
II	6-7	35 U.S.C. §103	Chou in combination with Sung'479 and SungECS
III	2	35 U.S.C. §103	Chou in combination with Sung'479 and Goers

IV. Technology Background

A. Chemical Mechanical Planarization (CMP)

37. Chemical Mechanical Planarization or Polishing ("CMP") is a common, widely-used process that has been around since the late 1980s/early 1990s. A typical setup for this process is shown in the Figure below. The semiconductor wafer (labeled "wafer" in the Figure) is pressed against a rotating

polishing pad, also known as a CMP pad. Additionally, a chemical slurry is introduced onto the polishing pad. EX1009, FIG. 2. *See also* EX1008, 1:13-48; EX1009, 1:17-28.

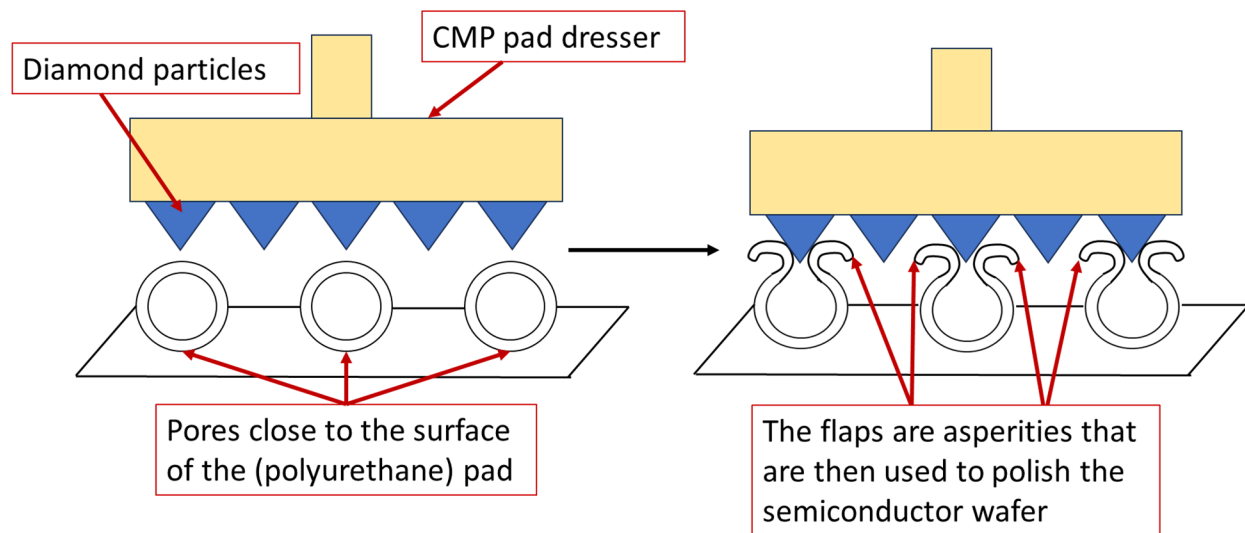


EX1009, FIG. 2.

38. The chemical slurry typically includes abrasive particles that assist in polishing the wafer surface. EX1005, [0002]. Examples of such abrasives include ceria, alumina and silica. EX1009, 1:28-29; EX1008, 1:22-24. The slurry also often includes additional agents that oxidize the wafer surface. Examples of such oxidizing agents include, *e.g.*, hydrogen peroxide. EX1009, 1:22-24.

39. The rotating polishing pad is typically made from a soft polymer. The most common polymer used for the polishing pad is polyurethane. EX1008, 1:44-46; EX1009, 1:17-18. The polishing pad can hold the slurry and polish the wafer because it contains small, micron-sized asperities on its surface. The more it is used to polish a wafer, the more wear and tear (and other factors) on the pad dulls the asperities, decreasing the CMP pad's performance. Therefore, the pad must be reconditioned by regenerating the asperities for optimal and consistent wafer-polishing performance. EX1005, [0004].

40. As schematically illustrated below, CMP pad dressers, which are also commonly called "pad conditioners," "diamond dressers," or "diamond conditioners," condition CMP pads. CMP pad dressers contain superabrasive particles (most commonly diamond particles) that protrude from the surface, and can cut the surface of the CMP pad as the pad dresser is rotated against the pad to generate new asperities. EX1005, [0004].



41. In the SEM image below, a new CMP pad with closed pores is shown in Fig. 14a. In Figs. 14d and e, the CMP pad has been conditioned by a DiaGrid® CMP pad dresser and the asperities have been generated.

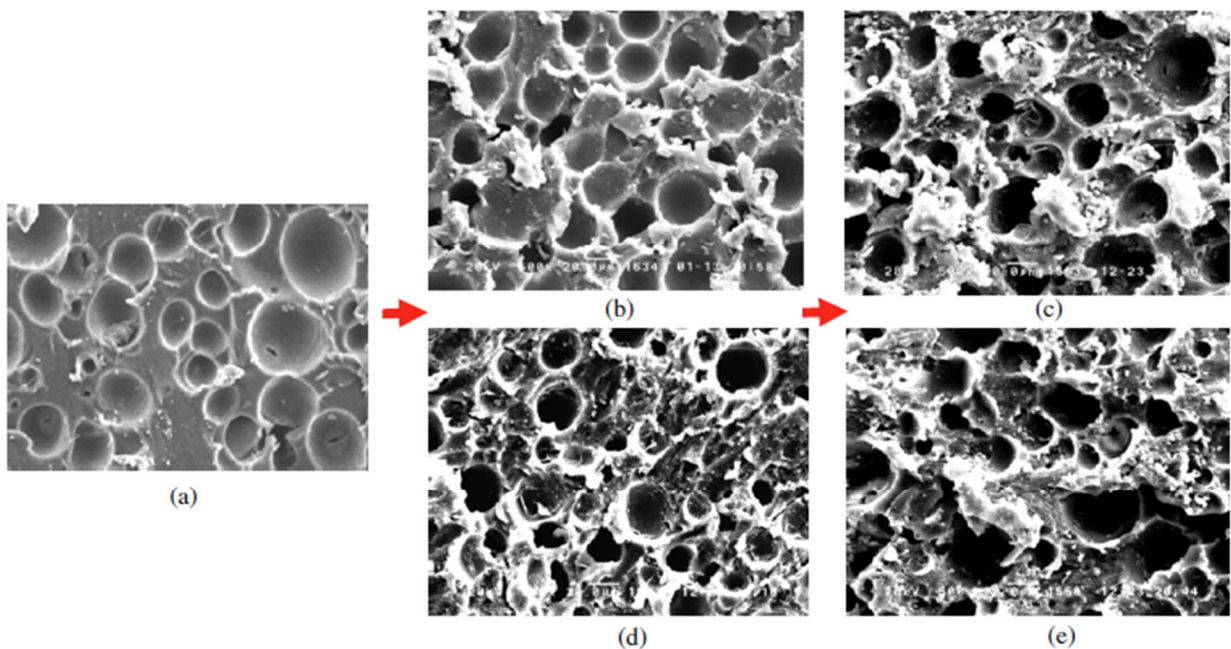
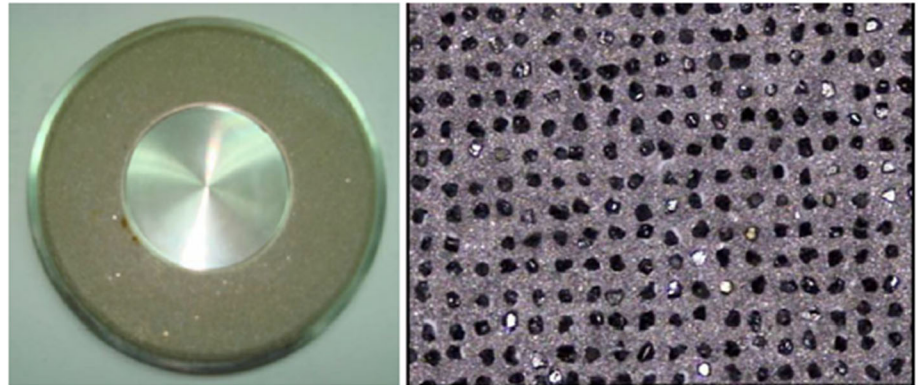


Fig. 14 SEM images of polishing pad: a new pad, b and c dressed by CDD with blocky diamond grit, and d and e dressed by DG after 1 and 20 h of conditioning, respectively

EX1013, Fig. 14.

42. A conventional circular CMP pad dresser disk having diamond particles covering at least a portion of the disk is shown below.

Fig. 3 Appearance of conventional diamond disk



EX1013, Fig. 3.

43. The diamond particles (sometimes called “grits”) can be arranged in a regular pattern with regular spacing between the diamonds, as they are in Fig. 3 of EX1013. In the above example of a DiaGrid® CMP pad dresser, the diamond particles are arranged in a grid with an inter-diamond spacing of 500 microns. *See* EX1013, 255, Fig. 3 (reproduced above).

44. CMP pad conditioners typically have thousands of superabrasive particles. For example, the DiaGrid® CMP pad dresser shown in Fig. 3 of EX1013 (reproduced above) has approximately 12,000 diamond particles across the surface of the dresser. EX1013, Fig. 3, 258 (“DG contained approximately 12,000 diamond grits...”).

45. At the time of the '270 Patent, there were multiple known CMP pad dresser fabrication methods. One such method of attaching superabrasive particles to the surface of the pad dresser is called "brazing." Brazing involves chemically bonding the superabrasive particles to an underlying substrate using a metal alloy and heat. EX1010, [0077]-[0078].

46. Because brazing involves heating and cooling, warpage can occur during fabrication, which is undesirable. Various techniques can be used to reduce the warpage of the dresser during brazing, in turn allowing better control and better leveling of the superabrasive particles. For example, the superabrasive particles can be distributed on both sides of the CMP pad dresser to prevent uneven warpage caused by shrinkage. EX1004, [0009]. Additionally, alloys with low melting points can be used for brazing to reduce the warpage of the dresser. EX1005, [0050].

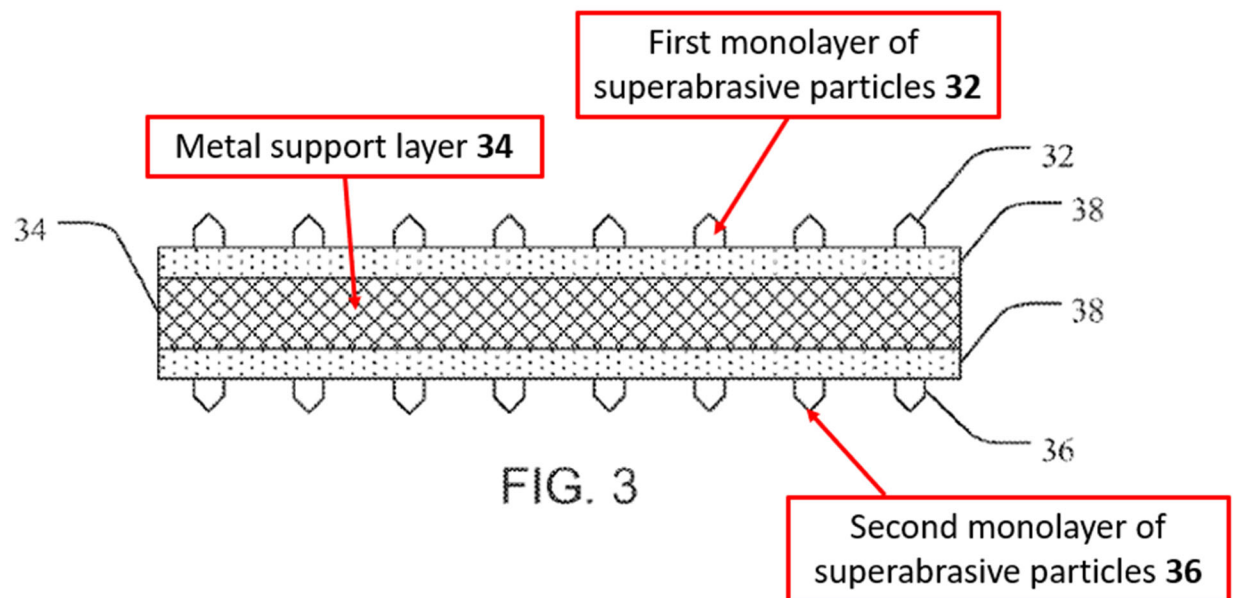
V. Overview of the '270 Patent

A. Summary of the '270 Patent

47. I have reviewed the '270 Patent's specification and claims. *See* EX1001, EX1003.

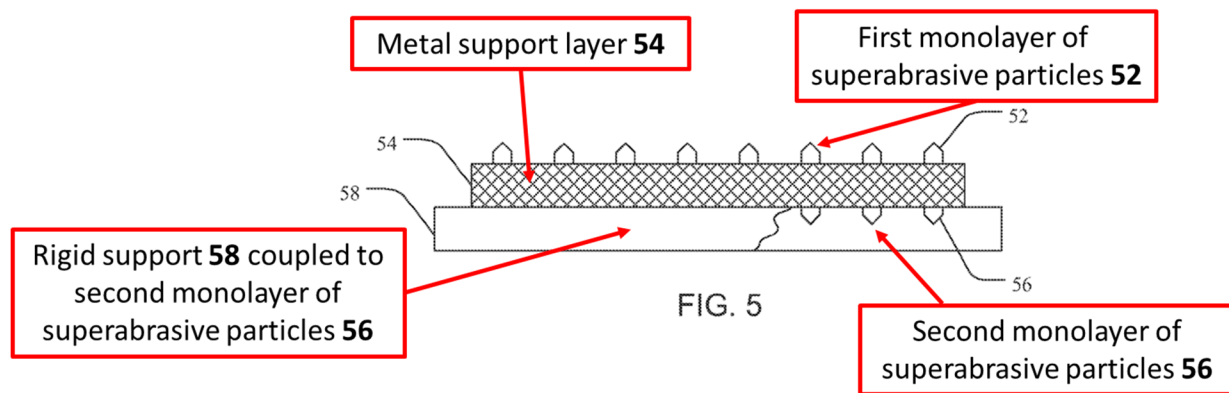
48. The '270 Patent describes CMP pad dressers with superabrasive particles. *See* EX1001, Abstract. The '270 Patent describes forming flat CMP pad dressers with reduced warpage. *See* EX1001, 6:55-7:7.

49. The '270 Patent describes a CMP pad dresser with two monolayers of superabrasive particles. In FIG. 3 below, the first and second monolayers of superabrasive particles 32 and 36 are attached to both sides of a metal support layer 34 using a bonding material 38. According to the '270 Patent, attaching the particles to both sides of the metal support layer 34 creates “symmetrical forces” to reduce the warpage of the CMP pad dresser. *See* EX1001, 2:11-26, 11:39-51. The claims specify certain protrusion height differences between the various highest, second highest, 10th highest, and 100th highest protruding tips.



EX1001, FIG. 3 (annotated).

50. Moreover, as shown in FIG. 5 below, the '270 Patent describes a rigid support substrate 58 coupled to the second monolayer of superabrasive particles 36. *See* EX1001, 13:9-10.



EX1001, FIG. 5 (annotated).

B. Summary of the Prosecution History of the '270 Patent

51. I have reviewed the file history of the '270 Patent, which I summarize below. *See* EX1003.

52. The application for the '270 Patent was filed on May 23, 2012. The application claimed priority to U.S. Provisional Application No. 61/489,074, filed May 23, 2011. *See* EX1001, Cover; EX1003, 1-2.

53. The application for the '270 Patent originally included claims 1-27. EX1003, 29-33.

54. In an Office Action dated May 15, 2014, claims 1-9, 14-15, 20, and 25-27 were rejected under 35 U.S.C. §§102 and 103 as unpatentable over Dinh-Ngoc (US2010/0248595), Goers'553 (US 7,198,553), and Telesin (US 5,380,390). EX1003, 207-213. I have read each of these references and it is my opinion that these references have substantially different teachings that Chou, Sung'479, and SungECS that I rely on in my declaration.

55. Additionally, claims 10, 14-23, and 25-26 received non-statutory obviousness-type double patenting rejection over claims 1, 12-18, and 20-21 of co-pending U.S. Application No. 13/239,198. EX1003, 214-215. This application later issued as U.S. 8,777,699 (“the ’699 Patent”).

56. In response to these rejections, the Applicant rewrote claim 10 (which later issued as claim 1) into independent form and amended claims 7-9 to depend from claim 10. The Applicant also added a new claim 28, also depending from claim 10. Claims 1-6 and 14-27 were canceled. EX1003, 1027-1032.

57. The ’270 Patent issued on March 10, 2015. EX1003, 1371, EX1001, Cover.

58. I have compared claim 1 of the ’270 Patent with claim 1 of the ’699 Patent, and believe they are substantially similar to each other, except that claim 1 of the ’270 Patent adds one additional limitation.

59. Specifically, in the Table below, I listed claim 1 of the ’270 Patent and claim 1 of the ’699 Patent side-by-side matching up the limitations that I consider to be substantially similar to each other. I further noted any differences in the claim language using bolded italics. As seen from the Table, the claim language is strikingly similar.

Claim 1 of the '270 Patent	Claim 1 of the '699 Patent
A CMP pad dresser, comprising:	A CMP pad dresser, comprising:
a first monolayer of superabrasive particles disposed on and <i>protruding from</i> one side of a metal support layer,	a first monolayer of superabrasive particles disposed on and <i>coupled to</i> one side of a metal support layer; and
<i>wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns;</i>	
a second monolayer of superabrasive particles disposed on the metal support layer on an opposite side from the first monolayer,	a second monolayer of superabrasive particles disposed on <i>and coupled to</i> the metal support layer on an opposite side from the first monolayer,
wherein the superabrasive particles of the second monolayer are positioned to have substantially the same distribution as the superabrasive particles of the first monolayer; and	wherein the superabrasive particles of the second monolayer are positioned to have substantially the same distribution as the superabrasive particles of the first monolayer; and <i>further comprising</i>
a rigid support coupled to the second monolayer of superabrasive particles opposite the first monolayer.	a rigid support coupled to the second monolayer of superabrasive particles opposite the first monolayer.

C. Overview of IPR2014-01523

60. I have also been asked to review IPR2014-01523, where Kinik company successfully challenged the patentability of the '699 Patent. Specifically, I reviewed the Petition and the Final Written Decision in IPR2014-01523. In this proceeding the Board found that claims 1-12 and 17-19 of the '699 Patent were unpatentable. *See Kinik Co. v. Chien-Min Sung*, IPR2014-01523 (“'699 Kinik IPR”), Paper 26.

61. In particular, the Board found that “claims 1-3, 5, 6, 8-12, and 17-19 are anticipated by Chou.” *Id.*, 23.

VI. Level of Ordinary Skill in the Art

62. As I noted above in Paragraph 22, I have been informed by counsel that that a patent and the prior art should be analyzed within the framework of a POSITA.

63. In my opinion, a POSITA as of the earliest claimed filing date of the '270 Patent (i.e., May 23, 2011) would have had a bachelor's degree in an engineering related field, such as material science, mechanical engineering, electrical engineering, or physics, and a minimum of two to three years of experience in the field of integrated circuit processing and fabrication techniques. I note that a higher level of education or specific skills in the industry may make up for less experience, and vice versa.

64. I met and/or exceeded these requirements for POSITA as of May 23, 2011, for at least the reasons provided above in Section I.

VII. Overview of the Primary Prior Art References

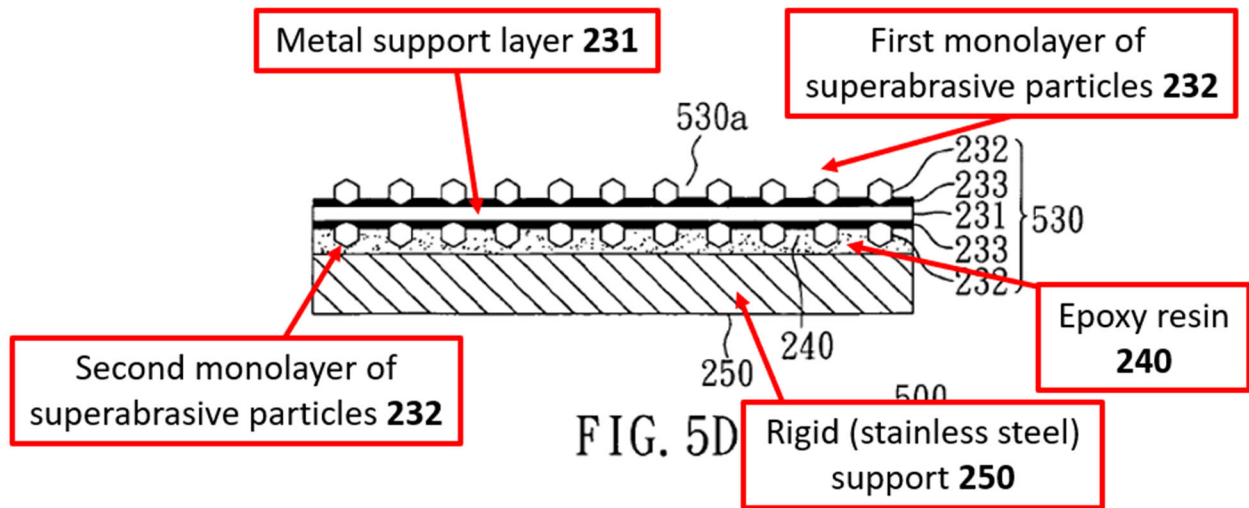
A. Overview of Chou

65. Chou is a U.S. Patent Application Publication published on January 28, 2010. EX1004, Cover. I understand that Chou is prior art to the '270 Patent.

66. Chou describes a “grinding plate” having “a soft substrate having a working surface and a non-working surface; and a plurality of abrasive particles distributed over the working surface of the soft substrate.” EX1004, [0009].

67. As shown in FIG. 5D below, Chou explains, “the soft substrate 231 is a metal, and the abrasive particles 232 are diamond particles.” EX1004, [0058].

68. Chou secures the superabrasive particles 232 to the metal support 231 by brazing. *See* EX1004, [0031] (“Herein, the grinding plate 230 comprises ... a plurality of abrasive particles 232 formed on the working surface 231a of the soft substrate 231 by brazing.”).



EX1004, FIG. 5D (annotated).

69. Chou uses two monolayers of superabrasive particles to prevent deformation of the abrasive tool, specifically warping caused by the difference of shrinkage of the opposite surfaces of the tool. EX1004, [0054] (“In the present embodiment, the deformation resulting from the difference of shrinkage between the two surfaces of the soft substrate can be inhibited since both surfaces of the soft substrate 231 have abrasive particles 232 and a combining layer 233 thereon.”), [0009]. Chou explains that “[g]rinding and polishing are ultra-precision machining technologies with the ability to make the surface of a workpiece have acceptable smoothness and flatness. ... Thereby, it is an important issue to develop various grinding tools that can meet process requirements.” EX1004, [0004]-[0005].

70. Chou couples the second monolayer of superabrasive particles 232 to the epoxy resin 240 and a rigid stainless steel support substrate 250, as shown

above in FIG. 5D. EX1004, [0056] (“Then, a backplane 250 is disposed on the surface of the adhesive layer 240, and the adhesive layer 240 is cured by a heating process so as to retain the backplane 250 on the non-working surface of the grinding plate 530.”).

71. As explained by Chou, this method of fabricating abrasive tools allows for precise height control of the superabrasive particles. This enhances the precision of the tool by enabling each superabrasive particle to participate in the tool’s function (*e.g.*, polishing a CMP pad). EX1004, [0024] (“Accordingly, by the method for fabricating a grinding tool according to the present invention, the height of the abrasive particles can be precisely controlled, and thereby each of the abrasive particles can efficiently perform machining so as to enhance the machining efficiency and precision of the grinding tool.”), [0017], [0032], [0037], [0052].

B. Overview of Sung’479

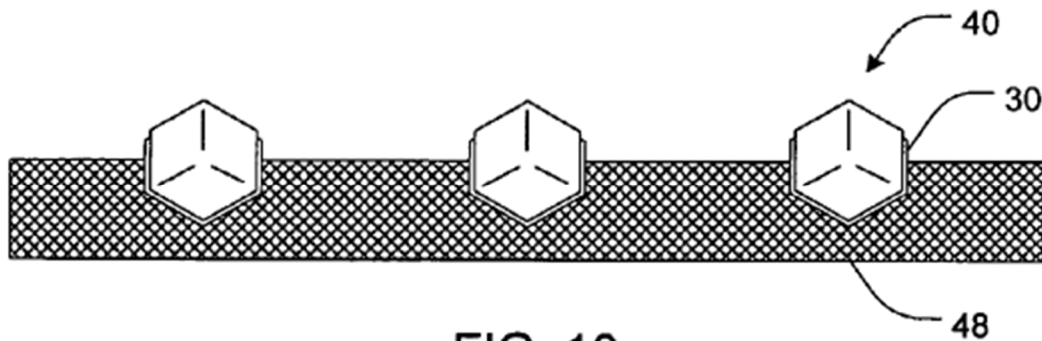
72. Sung’479 is a U.S. Patent Application Publication that published on April 24, 2008. EX1005, Cover. I understand that Sung’479 is prior art to the ’270 Patent.

73. Sung’479 describes CMP pad dressers with superabrasive diamond particles. EX1005, [0009] (“Accordingly, the present invention provides superabrasive tools and methods that are, without limitation, suitable to groom the

CMP pads used for the delicate polishing applications as recited above.”), [0004], [0055] (“In one aspect, the superabrasive particle may be diamond...”).

74. Sung’479 emphasizes that CMP pad dressers require precise superabrasive particle tip height leveling to dress CMP pads uniformly and generate asperities with consistent depths. *See* EX1005, [0005]-[0006].

75. To allow for precise leveling of superabrasive particles, Sung’479 discloses CMP pad dressers made with a low melting point braze alloy. This prevents the warpage of the CMP pad dresser. EX1005, [0050] (“[S]uperabrasive tools that are constructed with traditional molten braze materials are necessarily made at high temperatures that often warp the tool. Such warpage causes movements in the relative positions of the superabrasive particles as the tool cools. It is thus very difficult to obtain precise leveling of the tips of superabrasive particles in such tools for applications requiring very precise polishing. It has now been found that the variance between the tip heights of a plurality of superabrasive particles in a tool can be greatly reduced by utilizing a braze having a low-melting point to bond the superabrasive particles.”).



EX1005, FIG. 10.

76. FIG. 10 shows an exemplary step in the CMP pad dresser manufacturing process described in Sung'479.

77. Sung'479 specifies acceptable ranges for the difference in superabrasive tip heights. EX1005, [0072] ("superabrasive particles are arranged such that their tips vary from the designated profile by less than about 10 microns ... less than about 5 microns ... [and even] less than about 1 microns.").

78. Sung'479 further explains that the diamond particles can be disposed along one surface or along two sides of the substrate as shown in FIG. 6. *See* EX1005, [0054] ("Additionally, superabrasive particles 14 may be disposed along one surface of a superabrasive tool as shown in FIG. 5, or along multiple surfaces as shown in FIG. 6.").

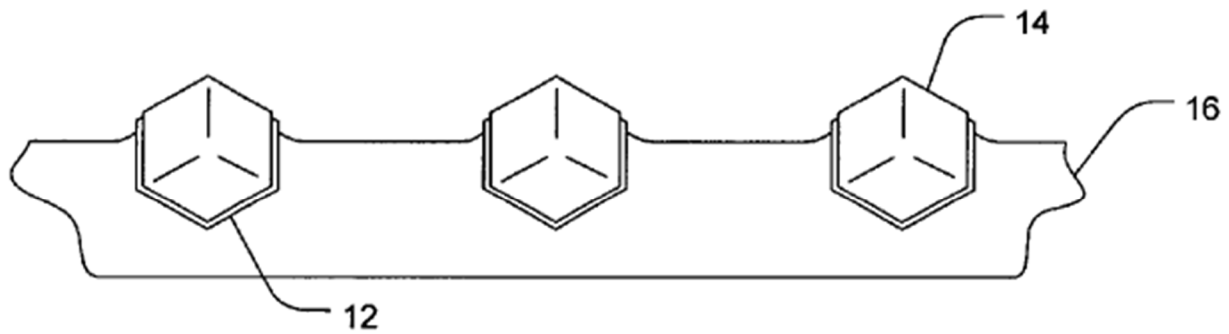


FIG. 5

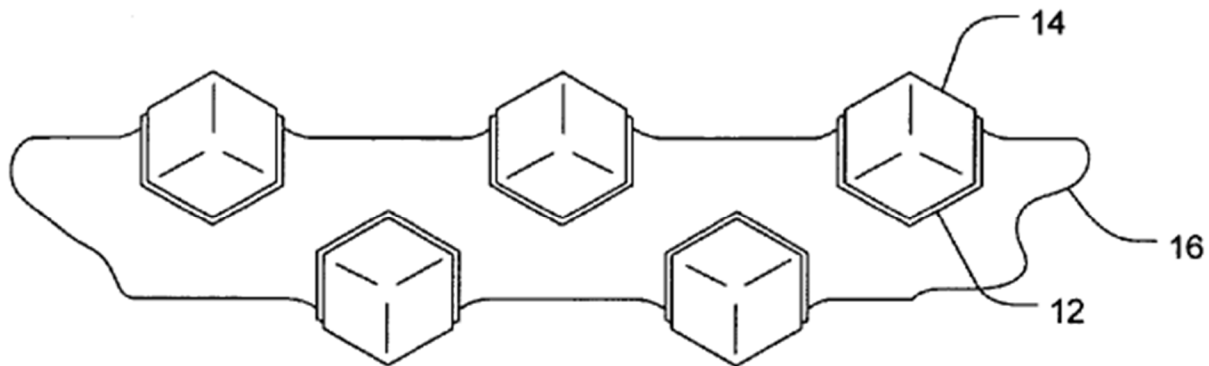


FIG. 6

EX1005, Figures 5 and 6.

VIII. Claim Construction

79. I have been asked to determine if there are any particular claim terms that should be construed for the Board to understand how the prior art references read on the challenged claims. As such, I have reviewed the claims, specification, and file history of the '270 Patent.

80. I do not believe the Board needs to necessarily construe any particular terms for the purposes of this IPR as the prior art references , but I found several

terms recited in the claims that the '270 Patent may have defined. These include the terms “superabrasive,” “protrusion,” “sharp portion,” and “attitude.” As such, I have considered these “definitions” in my analysis below.

A. “superabrasive”

81. The term “superabrasive” is used in claims 1-8. The '270 Patent defines this term as follows: “[a]s used herein, ‘superabrasive’ may be used to refer to any crystalline, or polycrystalline material, or mixture of such materials which has a Moh[s] hardness of about 8 or greater.” EX1001, 4:9-11. The '270 Patent explicitly provides that “[s]uch materials include ... diamond, polycrystalline diamond (PCD), ... as well as other superabrasive materials known to those skilled in the art.” EX1001, 4:13-17.

B. “protrusion”

82. The term “protrusion” is used in claims 1, and 5-8. The '270 Patent defines this term as follows: “for the purposes of the present disclosure, the term ‘protrusion’ refers to the height of a particle relative to some reference point.” EX1001, 8:13-15.

C. “sharp portion”

83. The term “sharp” is used in claim 3. The '270 Patent defines this term as follows: “[a]s used herein, ‘sharp portion’ means any narrow portion to which a

crystal or particle may come, including but not limited to corners, apexes, ridges, edges, obelisks, and other protrusions.” EX1001, 4:55-58.

D. “attitude”

84. The term “attitude” is used in claims 3 and 4. The ’270 Patent defines this term as follows: “[a]s used herein, ‘attitude’ means the position or arrangement of a superabrasive particle in relation to a defined surface, such as a substrate to which it is attached, or a CMP pad to which it is to be applied during a work operation.” EX1001, 5:21-24.

IX. Specific Invalidity Grounds

85. As I explained in Paragraph 36, I conclude that claims 1-8 of the ’270 Patent are rendered obvious by the prior art. In the sections below, I explain in detail how claims 1-8 of the ’270 Patent are not patentable over prior art.

Grounds	Claims	Statutory Ground	Prior Art References
I	1, 3-8	35 U.S.C. §103	Chou in combination with Sung’479
II	6-7	35 U.S.C. §103	Chou in combination with Sung’479 and SungECS
III	2	35 U.S.C. §103	Chou in combination with Sung’479 and Goers

A. Ground I: Chou in Combination with Sung’479 Renders Obvious Claims 1 And 3-8

86. In my opinion, claims 1 and 3-8 are all rendered obvious by Chou and Sung’479 for at least the following reasons.

1. Independent Claim 1

i. [1Pre] A CMP pad dresser, comprising:

87. In my opinion, Chou discloses or Chou in combination with Sung'479 renders obvious preamble [1Pre].

88. I understand that the preamble may not limit the claims. For instance, I understand that the Board previously has found that the preamble "CMP pad dresser" is not limiting. *See* IPR2014-01523, Paper 26 (Final Written Decision), 6-11 ("Accordingly, in summary, we do not construe as limiting the recitation of 'CMP pad dresser' limits independent claims 1 and 11.").

89. As I noted previously in Paragraphs 58-59, claim 1 of the '270 Patent is very similar to that of the '699 Patent, with the exception of an additional limitation "wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns." And I understand that the Board held in the '699 *Kinik IPR*, that the body of claim 1 of the '699 Patent is structurally complete and the preamble does not further limit the claims.

90. Regardless, I understand that the Board also previously found that Chou does in fact disclose a CMP pad dresser. *See* IPR2014-01523, Paper 26 (Final Written Decision), 17 ("As set forth above, we are unpersuaded that the recitation of 'CMP pad dresser' in the preambles are limiting, and even if they

were, we are persuaded that at least some of the grinding or polishing tools disclosed in Chou could be used as CMP pad dressers.”). I agree with the Board’s earlier determination.

91. Chou describes grinding or polishing tools for use in ultra-precision machining technologies, and a POSITA would have understood that these tools would be suitable for CMP processes. *See* EX1004, [0004] (“Grinding and polishing are ultra-precision machining technologies with the ability to make the surface of a workpiece have acceptable smoothness and flatness.”), [0007] (“An object of the present invention is to provide a grinding tool...”), [0008]. Indeed, the structure of the polishing tools, just like that of CMP pad dressers, includes abrasive particles distributed over the working surface. *See* EX1004, [0009] (“The grinding plate according to the present invention can comprise: a soft substrate having a working surface and a non-working surface; and a plurality of abrasive particles distributed over the working surface of the soft substrate.”).

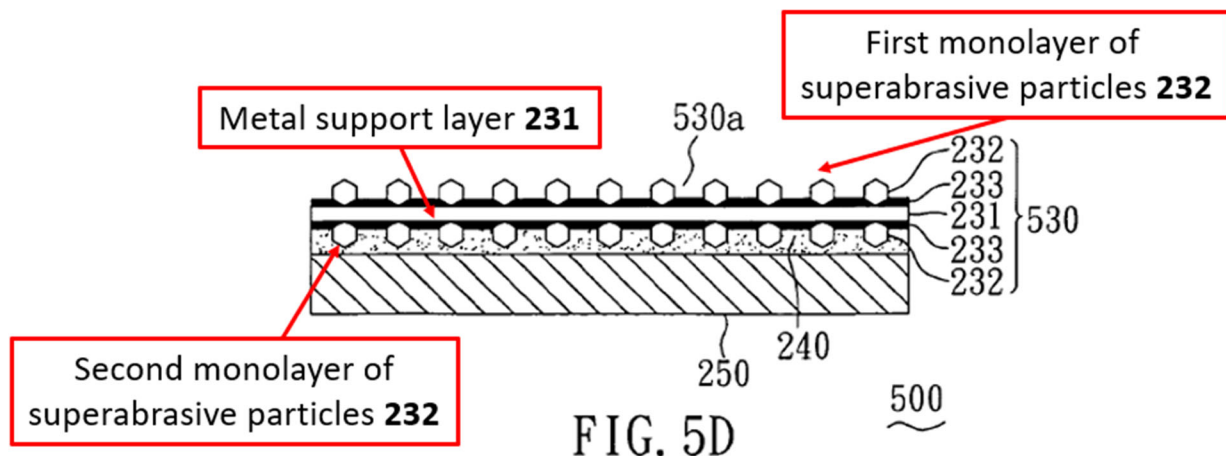
92. This is further supported by Sung’479, which the Board in the earlier ’699 Kinik IPR did not consider. For example, Sung’479 discloses a grinding or polishing pad tool that is a CMP pad dresser. *See* EX1005, claim 38 (“The superabrasive tool of claim 29, wherein the superabrasive tool is a polishing or grinding pad.”), claim 39 (“The superabrasive tool of claim 29, wherein the superabrasive tool is a CMP pad dresser.”).

ii. **[1A] a first monolayer of superabrasive particles disposed on and protruding from one side of a metal support layer**

93. In my opinion, Chou teaches limitation [1A].

94. As I already discussed in Paragraph 81, “superabrasive” means “crystalline or polycrystalline material or mixture of such materials which has a Moh[']s hardness of about 8.0 or greater.”

95. For ease of reference, I will be referring to Figure 5D of Chou, which I have reproduced below with annotations.



EX1004, FIG. 5D (annotated); *see also* EX1004, Figures 3A-3D, 5A-5C.

96. As shown above, Chou teaches a substrate 231, which meets the claimed “metal support layer.” EX1004, [0051] (“The material of the soft substrate 231 is a metal.”).

97. Furthermore, as also shown in FIG. 5D of Chou, there is a single layer of particles 232 disposed on the side of the working surface 530a of the metal

substrate 231. *See* EX1004, [0009] (“The grinding plate according to the present invention can comprise: a soft substrate having a working surface and a non-working surface; and a plurality of abrasive particles distributed over the working surface of the soft substrate.”), [0038]-[0044], [0054]-[0058].

98. FIG. 5D of Chou clearly shows abrasive particles disposed onto the metal substrate in a single layer, and as such, Chou discloses a monolayer of superabrasive particles. In fact, the Board considered this same disclosure in the ’699 Kinik IPR and arrived at the same determination. *See* IPR2014-01523, Paper 26 (Final Written Decision), 16.

99. The first monolayer of particles 232 is protruding from the working surface 530a side of the metal substrate 231. Specifically, the particles have a height relative to a reference point such as the top of combining layer 233 or the top of substrate 231. *See* EX1004, [0009] (“The grinding plate according to the present invention can comprise: a soft substrate having a working surface and a non-working surface; and a plurality of abrasive particles distributed over the working surface of the soft substrate.”), [0038]-[0044], [0054]-[0057], [0059], Figures 3A-3D, 5A-5D.

100. Lastly, Chou discloses that that the particles 232 in the monolayer are diamond particles. Diamond particles have a Moh[s hardness of about 8.0 or greater, and as such are superabrasive particles. EX1004, [0009], [0022] (“The

abrasive particles can be any material with high hardness, ... Preferably, the abrasive particles are diamond particles.”), [0058] (“The material of the soft substrate 231 is a metal, and the abrasive particles 232 are diamond particles...”); *see also* EX1001, 8:59-65 (explaining that “the superabrasive particles include diamond materials”). *See* EX1014, showing that Mohs hardness of diamond is 10.

101. Chou in combination with Sung’479 also renders obvious limitation [1A]. Sung’479 teaches in Figures 7-10 a reverse casting process that “may be utilized to manufacture the superabrasive tools and particularly the CMP pad dressers.” EX1005, [0082]. This “reverse casting” process is also described in the ’270 Patent itself as a method that “can used to accurately orient and attach the dressing segments to the rigid support.” EX1001, 14:26-33.

102. More specifically, as shown in Figure 7, a spacer layer 32 is used where the superabrasive particles 30 can be disposed against. *See* EX1005, [0082] (“As shown in FIG. 7, a spacer layer 32 may be applied to a working surface 34 of a temporary substrate 36. Intermediate layer-coated superabrasive particles 30 may be disposed at least partially into the spacer layer 32, such that they protrude at least partially from the spacer layer 32 opposite the working surface 34 of the temporary substrate 36.”)

103. Then, as shown in Figure 8, a low-melting point braze 38 is applied. *See* EX1005, [0085] (“Referring now to FIG. 8, a low-melting point braze may be

applied to the spacer layer 32 opposite the working surface 34 of the temporary substrate 36. A mold may be utilized to contain the low-melting point braze during manufacture. Upon solidifying the braze material, a low-melting point braze matrix 38 is formed, bonding at least a portion of each superabrasive particle 30. In some aspects, a permanent substrate may be coupled to the low-melting point braze matrix 38 to facilitate its use as a superabrasive tool.”).

104. Finally, as shown in Figures 9-10, the spacer layer 32 is removed to obtain a monolayer of superabrasive particles. *See* EX1005, [0086] (“As shown in FIG. 9, the spacer layer and the temporary spacer layer have been removed from the low-melting point braze matrix 38 to expose the superabrasive particles 30. This may be accomplished by peeling, grinding, sandblasting, scraping, rubbing, abrasion, etc. The distance of the protrusion of the superabrasive particles 30 from the low-melting point braze matrix 38 will be approximately equal to the thickness of the now removed spacer layer.”).

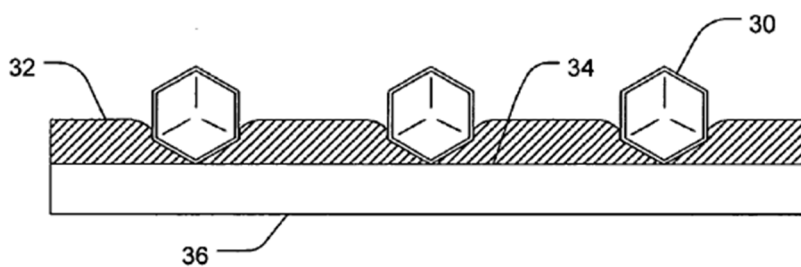


FIG. 7

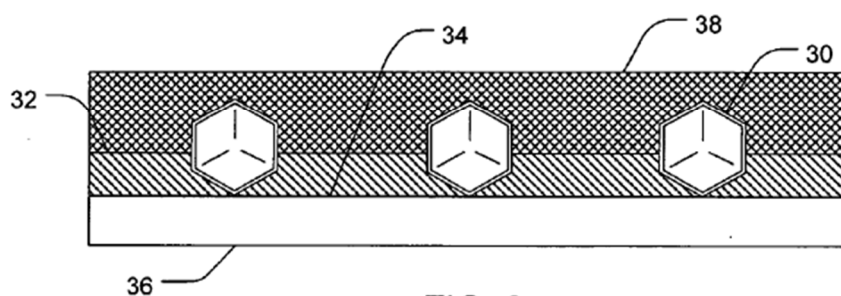


FIG. 8

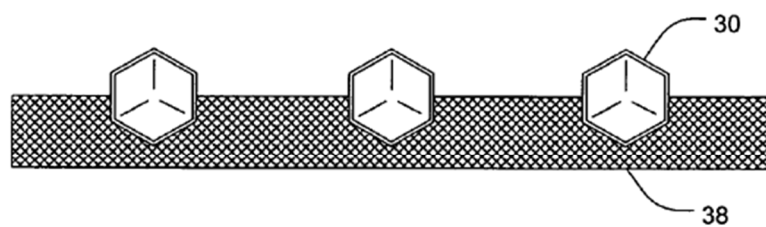


FIG. 9

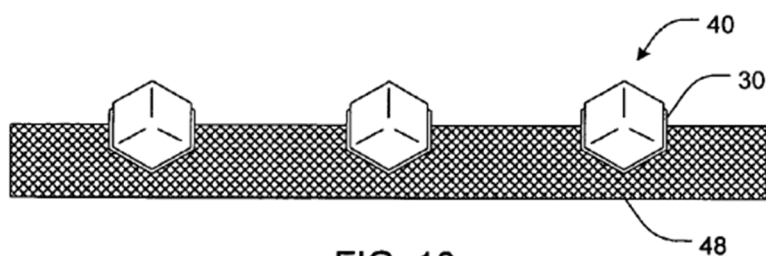


FIG. 10

- iii. [1B] wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns;**

105. In my opinion, Chou in combination with Sung'479 render obvious limitation [1B].

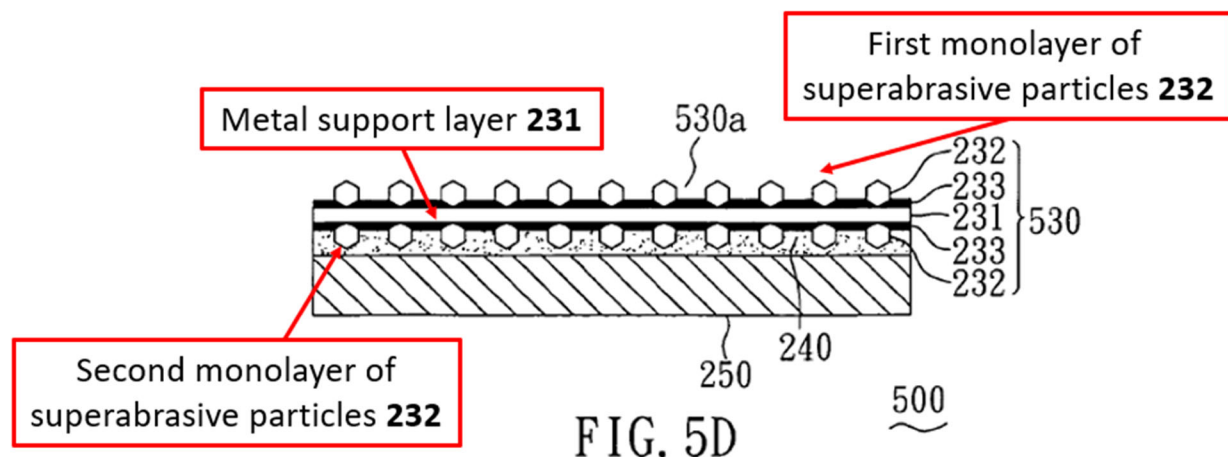
106. As I already discussed in Paragraph 82, "protrusion" means "the height of a particle relative to some reference point."

107. First, as I already explained in Paragraphs 93-100, Chou teaches a first monolayer of particles 232 protrudes from the metal support layer, *i.e.*, has a height relative to a reference point such as top of combining layer 233 or top of substrate 231. *See* EX1004, [0009] ("The grinding plate according to the present invention can comprise: a soft substrate having a working surface and a non-working surface; and a plurality of abrasive particles distributed over the working surface of the soft substrate."), [0038]-[0044], [0054]-[0057], [0059], Figures 3A-3D, 5A-5D.

108. Chou also discloses that in order to increase the efficiency and the precision of the tools, the height of the abrasive particles can be adjusted such that *all* abrasive particles can perform the machining action. EX1004, [0017] ("Accordingly, the precision of the grinding plate can be controlled well and the height of the abrasive particles can be adjusted so as to ensure the performance of

all abrasive particles in machining.”); EX1004, [0040] (“Herein, the grinding plate 330 can fit precisely on the adjustment surface of the mold due to its flexibility so as to precisely control the precision of the grinding plate 330 and adjust the height of the abrasive particles 232. Accordingly, each of the abrasive particles 232 can efficiently perform machining so as to significantly enhance the machining efficiency and precision of the grinding tool and perform precision machining.”).

109. A POSITA at the time of the earliest claimed priority date of the '270 Patent would have known that the difference in the protrusion distance of the particles should be as small as possible to ensure that all of the abrasive particles actually participate in the polishing process. Chou's Figure 5D also illustrates that the particles have the same height, *i.e.*, all particles have the same protrusion distance.



EX1004, FIG. 5D (annotated); *see also* Figures 3A-3D, 5A-5C.

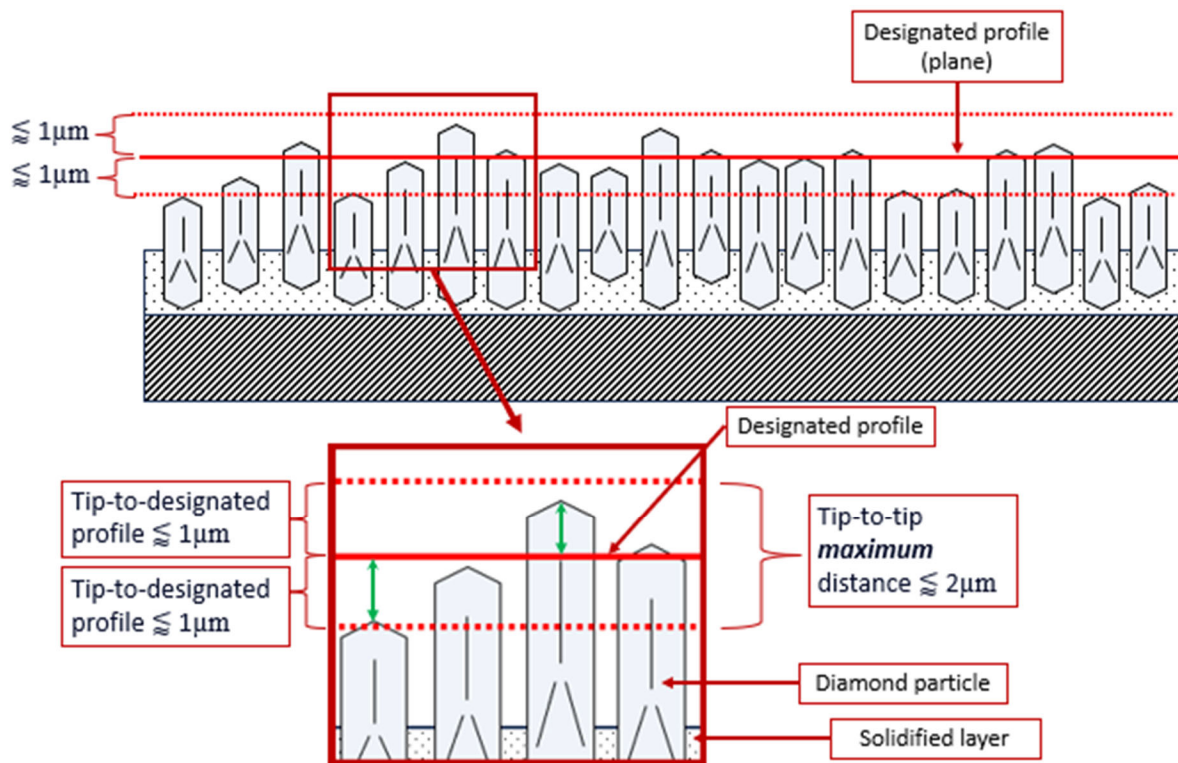
110. Chou does not mention any specific numerical values for the difference in protrusion distance between the two highest protruding tips. However, making the diamond tips to have protrusion distance difference between the two highest protruding tips to be less than or equal to about 50 microns was well-known.

111. Sung'479 specifically teaches that the tips of each superabrasive particle in the dresser align along a "designated profile" within *less than 1 micron*. See EX1005, [0072] ("[W]hile it is intended that the tips of the superabrasive particles align along the designated profile, some level of deviation may occur. ... Also, when referring to the designated profile, it should be noted that the term 'tip' is intended to include the highest protruding point of a superabrasive particle In yet another aspect, the plurality of superabrasive particles is arranged such that their tips vary from the designated profile by *less than about 1 microns*."), [0009] ("[I]n one aspect arranging the plurality of superabrasive particles may include ... disposing the plurality of superabrasive particles at least partially within the spacer layer such that a portion of *each* of the plurality of superabrasive particles contact the leveling surface."), claim 4.

112. Sung'479 additional teaches "the tips of the superabrasive particles may be leveled to an RA value of less than about 10 μm ." EX1005, [0067]. RA is a well-known term that is used to measure the roughness of a surface. For example,

Sung's other patent notes that "'RA' refers to a measure of the roughness of a surface as determined by the difference in height between a peak and a neighboring valley." EX1011, 5:63-65.

113. Sung'479 teaches that a "designated profile" is "a predetermined height" "for the superabrasive particles to protrude from the solidified braze layer." EX1005, [0069]. Sung'479 also discloses that "the designated profile may be a plane." EX1005, [0069]. To illustrate this, I have provided a scheme below showing a number of diamond particles in a CMP pad dresser, where each diamond particle protrudes to a height within 1 micron above or below the designated profile. Accordingly, the maximum tip-to-tip distance is less than about 2 microns. *See* EX1005, [0072], [0009].



114. Because Sung’479 discloses a CMP pad dresser having a maximum tip-to-tip difference of 2 microns, Sung’479 teaches that “the difference in protrusion distance between the highest protruding tip and the second highest protruding tip ... is less than or equal to about 50 microns.”

115. I consider Sung’479 to teach limitation [1B] without explicitly using the words “highest protruding tip and second highest protruding tip.” At a minimum, a POSITA would at least have found it obvious to control the protrusion distance of the diamond particles such that the protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles to be less than or equal to about 50 microns in view of

Chou and Sung'479. Chou provides that "the precision of the grinding plate can be controlled well and the height of the abrasive particles can be adjusted so as to ensure the performance of all abrasive particles in machining." EX1004, [0017]; *see also* EX1004, [0040]. Sung'479 discloses that precise leveling of the superabrasive particles improves the retention of the particles within the braze, and therefore a POSITA would have been motivated to achieve tip height variations in superabrasive tools that are as small as possible (*e.g.*, to be within the 2-micron variation that Sung'479 teaches) to improve performance of the tool. EX1005, [0050] ("precisely leveling the tips of the plurality of superabrasive particles in the tool reduces the mechanical stress impinging on any individual superabrasive particle, thus counteracting the relatively lower retention strength of many low-melting point brazes as compared to traditional braze alloys."). In fact, Sung'479 is explicit that "the highest protruding points of the superabrasive particles are intended to be substantially level." EX1005, [0069]. Furthermore, Sung'479 explains that tip height variations can be controlled to within 2 microns. *See* EX1005, [0072], [0009], claim 4. Therefore, as there is a recognition in the prior art of the benefits of a precisely leveled surface, having a dresser with the two highest protruding points with protrusion distance that are leveled within 2 microns (as taught by Sung'479) would have been obvious to a POSITA. Even more so, a

POSITA would have been able to achieve leveled CMP pad dressers with a reasonable expectation of success in light of the teachings of Sung'479.

116. In sum, since Chou discloses that the difference in the protrusion distance of the particles should be as small as possible and Sung'479 teaches and/or renders obvious that the tip-to-tip variation is less than about 2 microns for all tips of the CMP pad dresser, it would have been obvious to a POSITA that that the highest protruding tip and the second highest protruding tip would also have a protrusion height difference of less than about 2 microns, which is less than the claimed 50 microns.

a. Reasons to Combine Chou with Sung'479

117. It would have been obvious to combine Chou with Sung'479 for at least the following five reasons.

118. **First**, Chou and Sung'479 are all directed to abrasive tools and are analogous to the claims of the '270 Patent. EX1004, [0002] ("The present invention relates to a grinding tool and a method for fabricating the same and, more particularly, to a grinding tool and a method for fabricating the same that can improve the precision and lifetime of products, reduce the cost of production, and enhance the machining efficiency"); EX1005, [0009] ("Accordingly, the present invention provides superabrasive tools and methods that are, without limitation, suitable to groom the CMP pads used for the delicate polishing applications as

recited above.”), claim 39 (“wherein the superabrasive tool is a CMP pad dresser.”); EX1001, claim 1 (“A CMP pad dresser...”).

119. **Second**, Chou and Sung’479 teach leveling of the abrasive particles improves the performance of the abrasive tool. EX1004, [0017] (“Accordingly, the precision of the grinding plate can be controlled well and the height of the abrasive particles can be adjusted so as to ensure the performance of all abrasive particles in machining. Thereby, the machining efficiency of the working surface and precision can be significantly enhanced, so that the grinding tool according to the present invention is especially suitable for precision machining.”); EX1005, [0003] (“Of particular importance to the quality of polishing achieved is the distribution of the abrasive particles throughout the pad.”), [0066]-[0067] (“Though various methods of minimizing mechanical stress are possible, in one aspect the arrangement of the plurality of superabrasive particles may be configured to uniformly distribute frictional forces across substantially all superabrasive particles. ... One potentially useful parameter may include the height that the superabrasive particles protrude above the solidified braze layer. A superabrasive particle that protrudes to a significantly greater height as compared to other superabrasive particles will experience a greater proportion of the impinging mechanical forces and is thus more prone to pull out of the solidified braze layer. Thus, an even height distribution of superabrasive particles may function to preserve the integrity of the

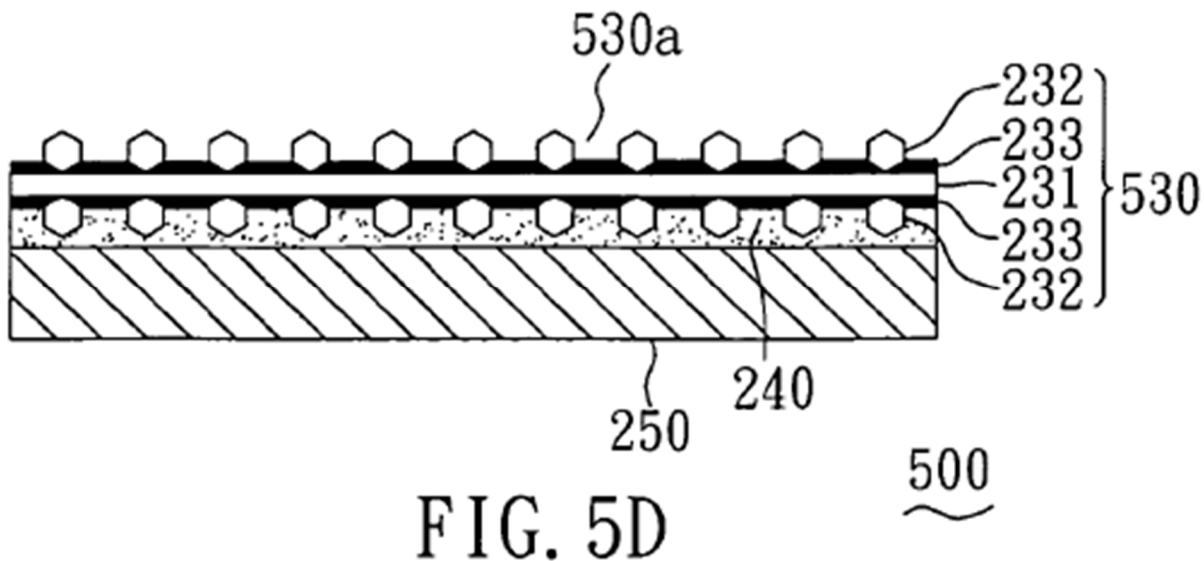
superabrasive tool more effectively as compared to tools lacking such an even height distribution. Accordingly, the superabrasive particle tips may be leveled to spread the mechanical forces impinging on the tool across substantially all the particles.”).

120. Since Chou and Sung’479 teach the benefits of having leveled height of abrasive particles, a POSITA would have been motivated to combine these disclosures. Specifically, a POSITA would have considered leveling the height of the superabrasive particles such that a tip-to-tip variation that is less than about 2 microns because Sung’479 teaches that it was possible to achieve such tip-to-tip variations. *See* EX1005, [0072] (“In yet another aspect, the plurality of superabrasive particles is arranged such that their tips vary from the designated profile by less than about 1 microns.”).

121. ***Third***, both Chou and Sung’479 teach attaching diamond particles using brazes. For example, Chou describes forming abrasive particles 232 on substrate 231 “by brazing.” EX1004, [0031]. Sung’479 similarly teaches “utilizing a braze having a low-melting point to bond the superabrasive particles” that “do not generate significant warpage due to the lower temperatures utilize to construct the tool.” EX1005, [0007], [0050]. Therefore, a POSITA would have been motivated to combine the disclosure of Chou and Sung’479 to achieve such benefits taught by Sung’479 in utilizing low-melting point brazes. For instance,

Sung'479 explains that “precisely leveling the tips of the plurality of superabrasive particles in the tool reduces the mechanical stress impinging on any individual superabrasive particle, thus counteracting the relatively lower retention strength of many low-melting point brazes as compared to traditional braze alloys.” EX1005, [0050].

122. **Fourth**, Chou and Sung'479 both disclose CMP pad dressers that include a monolayer of diamond particles on both sides of the substrate. *See* EX1004, [0054] (“In the present embodiment, the deformation resulting from the difference of shrinkage between the two surfaces of the soft substrate can be inhibited since both surfaces of the soft substrate 231 have abrasive particles 232...”); EX1005, [0054] (“Additionally, superabrasive particles 14 may be disposed ... along multiple surfaces as shown in FIG. 6.”).



EX1004, Figure 5D.

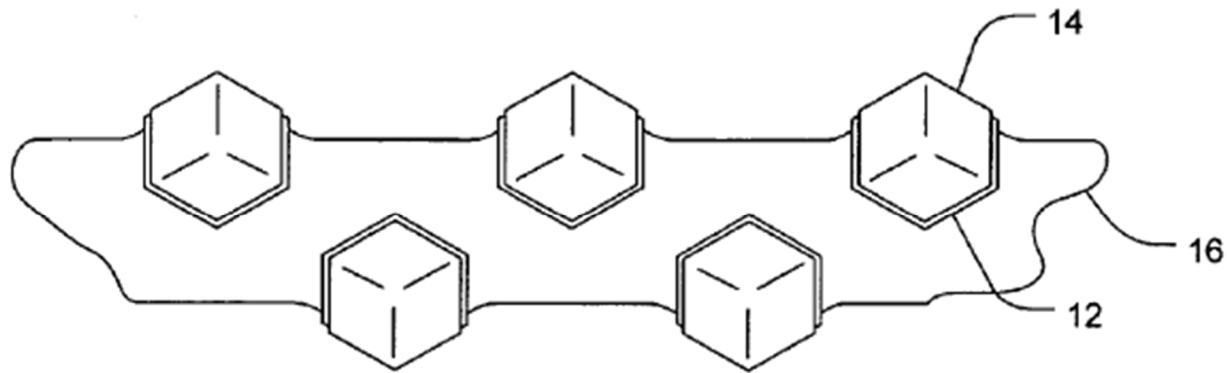


FIG. 6

EX1005, Figure 6.

123. ***Fifth***, a POSITA would have considered levelling the heights of the Chou's abrasive tool to levels disclosed by Sung'479 to be a trivial modification, because Sung'479 provides specific numeric values that were well-known to be achievable and suitable for various grinding applications, such as CMP. EX1005, [0072] ("In yet another aspect, the plurality of superabrasive particles is arranged such that their tips vary from the designated profile by less than about 1 microns."), [0013] (explaining that the use of the "low-melting braze materials" allow "the tips of the superabrasive particles [to] have an RA value of less than about 10 μm ."); EX1004, [0004] ("Grinding and polishing are ultra-precision machining technologies with the ability to make the surface of a workpiece have acceptable smoothness and flatness. Accordingly, grinding and polishing are

widely used in precision machining of the surface of an object, such as hard and brittle metals, ceramics, glass and wafers.”).

124. Chou and Sung’479 use a similar brazing method for attaching abrasive particles to the metal substrate. Therefore, a POSITA would have been able to combine the disclosures with a reasonable expectation of success. EX1004, [0039] (“Herein, the grinding plate 330 comprises: a soft substrate 231 having a working surface 231a and a non-working surface 231b and a plurality of abrasive particles 232 formed on the working surface 231 a and the non-working surface 231 b of the soft substrate 231 by brazing.”); EX1005, [0013] (“The superabrasive tool may include a plurality of superabrasive particles coated with an intermediate layer and bonded together with a braze...”).

125. Indeed, a POSITA would have recognized that a combination of Chou and Sung’479, in particular using a low melting braze, as taught by Sung’479, with Chou would have enabled a POSITA to achieve a better levelling of the diamond tips because such brazes “do not generate significant warpage due to the low temperatures utilized” and “reduces problems associated with warping.” EX1005, [0050], [0065].

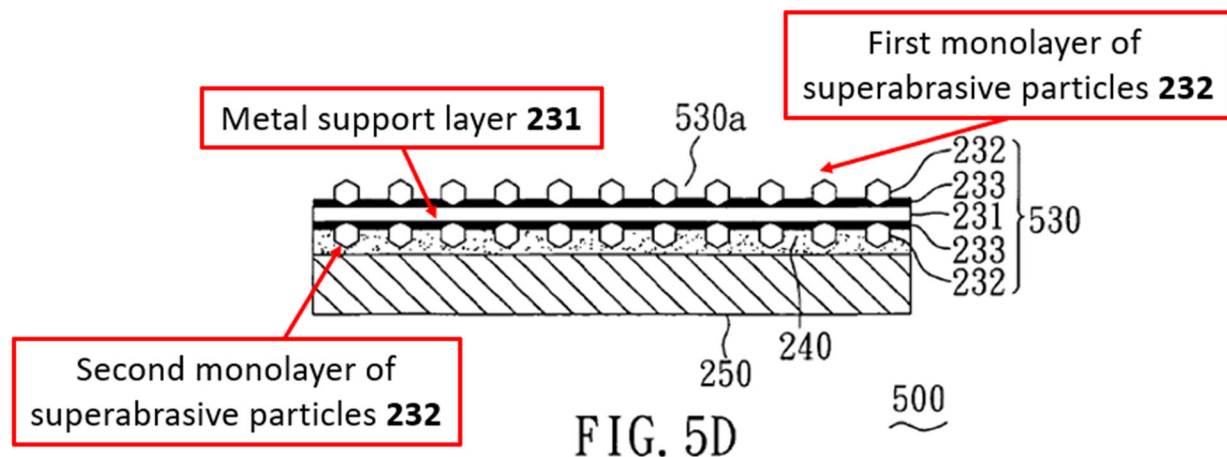
iv. [1C] a second monolayer of superabrasive particles disposed on the metal support layer on an opposite side from the first monolayer;

126. In my opinion, Chou teaches limitation [1C].

127. As I already explained in Paragraph 81, “superabrasive” means “crystalline or polycrystalline material or mixture of such materials which has a Moh[s hardness of about 8.0 or greater.”

128. Additionally, as I already explained in Paragraph 96, Chou discloses a metal support layer. EX1004, [0051] (“The material of the soft substrate 231 is a metal.”).

129. Furthermore, as shown in FIG. 5D, Chou discloses a second monolayer of superabrasive particles disposed on the metal support layer on an opposite side from the first monolayer. Specifically, as shown below in the annotated FIG. 5D of Chou, a second single layer of particles 232 is disposed on the side of 530b (“the non-working surface”) of the metal substrate 231 that is opposite the working surface 530a. *See* EX1004, [0009] (“The grinding plate according to the present invention can comprise: a soft substrate having a working surface and a non-working surface; and a plurality of abrasive particles distributed over the working surface of the soft substrate.”), [0038]-[0044], [0054]-[0058].



EX1004, FIG. 5D (annotated); *see also* EX1004, Figures 3A-3D, 5A-5C.

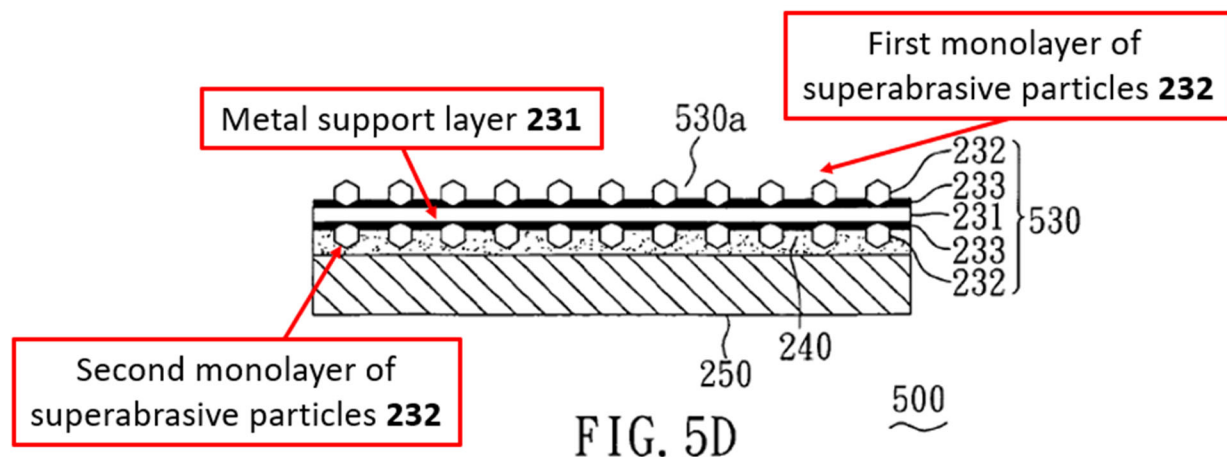
130. In fact, the Board previously concluded that this limitation is taught by Chou. *See* IPR2014-01523, Paper 26 (Final Written Decision), 16, 23.

131. Lastly, as I already explained in Paragraph 100, Chou discloses that that the particles 232 in the monolayer are diamond particles. Diamond particles have a Moh[s hardness of about 8.0 or greater, and as such are superabrasive particles. EX1004, [0009], [0022] (“The abrasive particles can be any material with high hardness, ... Preferably, the abrasive particles are diamond particles.”), [0058] (“The material of the soft substrate 231 is a metal, and the abrasive particles 232 are diamond particles...”); *see also* EX1001, 8:59-65 (explaining that “the superabrasive particles include diamond materials”).

- v. **[1D] wherein the superabrasive particles of the second monolayer are positioned to have substantially the same distribution as the superabrasive particles of the first monolayer; and**

132. In my opinion, Chou teaches limitation [1D].

133. Referring once again to FIG. 5D of Chou, can be seen that the superabrasive particles of the first and the second monolayers are positioned to have substantially the same distribution. *See* EX1004, [0038]-[0040], [0054]-[0059], Figures 3A-3D, 5A-5D.



EX1004, FIG. 5D (annotated).

134. In fact, the Board previously concluded that this limitation is taught by Chou. *See Kinik Co. v. Sung*, IPR2014-01523, Paper 26, 20 (“Figures 3A-3D and 5A-5D, if nothing else, disclose to one of ordinary skill the alignment of certain objects relative to other objects.”).

135. In addition, Chou teaches that the benefit of providing the diamond particles on the working surface 530a and the non-working surface 530b is to reduce the warpage of the substrate caused by uneven shrinkage of each surface. *See* EX1004, [0009] (“In addition, the abrasive particles can be further distributed over the non-working surface of the soft substrate. That is, the abrasive particles are distributed over the two surfaces of the soft substrate. Accordingly, the deformation resulting from the difference of shrinkage between the two surfaces can be inhibited. Herein, the abrasive particles can be directly formed on the surface of the soft substrate by brazing, sintering or electroplating.”), [0039], [0054] (“In the present embodiment, the deformation resulting from the difference of shrinkage between the two surfaces of the soft substrate can be inhibited since both surfaces of the soft substrate 231 have abrasive particles 232 and a combining layer 233 thereon.”).

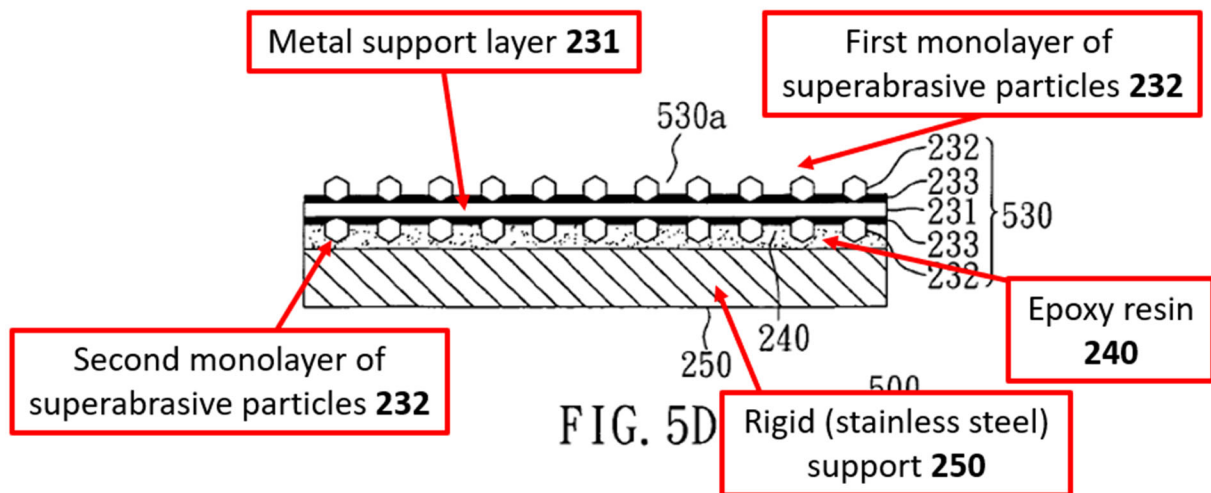
136. Notably, the '270 Patent provides an identical reason for including a second monolayer of abrasive particles opposite to the first monolayer. EX1001, 2:18-24 (“The method further includes bonding the first monolayer of superabrasive particles and the second monolayer of superabrasive particles to the metal support layer such that symmetrical forces due to the substantially similar distribution between the first monolayer and the second monolayer precludes substantial warping of the metal support layer.”).

137. As a POSITA would have known from Chou that the deformation of the abrasive tool could be reduced by having superabrasive particles with substantially the same distribution on both the working and non-working surfaces and a POSITA would have been motivated to make such an arrangement.

vi. [1E] a rigid support coupled to the second monolayer of superabrasive particles opposite the first monolayer.

138. In my opinion, Chou teaches limitation [1E].

139. Referring to FIG. 5D of Chou, the second monolayer of superabrasive particles 232 is coupled to an epoxy resin 240 and a stainless steel support 250—either or both of which meet the claimed “rigid support.” For example, the superabrasive tool (e.g., CMP pad dresser) includes a rigid support 250 made of stainless steel. A POSITA would readily recognize that stainless steel is a rigid material. The rigid support 250 is coupled to the second monolayer of superabrasive particles 232 through epoxy 240 opposite the first monolayer of superabrasive particles 232. *See* EX1004, [0012]-[0016], [0041]-[0043], [0049]-[0052], [0058] (“In the present embodiment, the material of the backplane 250 is stainless steel....”), Figures 3A-3D, 5A-5D. Epoxy is also a rigid material. *See* EX1001, 14:10-18 (“Various organic materials are contemplated for use as a rigid support... Examples of suitable organic matrix materials include ... epoxy resins...”).



EX1004, FIG. 5D (annotated).

2. Dependent Claims 3 and 4

[3] The dresser claim 1, wherein the plurality of superabrasive particles are configured in an attitude having a sharp portion oriented towards a pad to be dressed.

[4] The dresser of claim 1, wherein the plurality of superabrasive particles are substantially all configured in an attitude having either an apex or an edge portion oriented toward a pad to be dressed.

140. In my opinion, Chou with Sung'479 renders obvious claim 3 and 4.

141. As I already discussed in Paragraph 83, "sharp portion" is defined by the '270 Patent as "any narrow portion to which a crystal or particle may come, including but not limited to corners, *apexes*, ridges, edges, obelisks, and other protrusions."

142. Additionally, as I already discussed in Paragraph 84, the term “attitude” is defined by the ’270 Patent as “the position or arrangement of a superabrasive particle in relation to a defined surface, such as a substrate to which it is attached, or a CMP pad to which it is to be applied during a work operation.”

143. Sung’479 discloses the added limitations of claims 3 and 4 at least because “the plurality of superabrasive particles may be substantially configured with an *apex portion oriented towards a work piece.*” EX1005, [0074]. As such, Sung’479 discloses that a sharp portion, *i.e.*, an apex, is oriented towards the pad that is to be dressed.

144. Additionally, Sung’479 teaches the claimed “attitude” because the reference teaches the position of the superabrasive particles in relation to the work piece, *i.e.*, the “pad to be dressed” with a CMP pad. *See* EX1005, [0002] (explaining that CMP pad is a “work piece”). Sung’479 explains that “impinging frictional forces may be reduced by orienting the plurality of superabrasive particles such that their tips of apexes are substantially oriented towards the work piece.” EX1005, [0074]; *see also* EX1005, [0073], [0079].

3. Dependent Claims 5-8

- i. **[5] The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first monolayer of superabrasive particles is less than or equal to about 10 microns.**

[6] The dresser of claim 5, wherein the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip of the first monolayer of superabrasive particles is less than or equal to about 20 microns.

[7] The dresser of claim 6, wherein the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip of the first monolayer of superabrasive particles is less than or equal to about 40 microns.

[8] The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first monolayer of superabrasive particles is less than or equal to about 20 microns.

145. In my opinion, Chou in combination with Sung'479 render obvious the added limitations of claims 5-8 for the same reason that I already discussed in Paragraphs 140-144. Specifically, as Chou and Sung'479 render obvious a CMP pad dresser having *all* tips leveled to within less than about 2 microns, Chou and Sung'479 also renders obvious a 10-micron and a 20-micron difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first monolayer of superabrasive particles as in claims 5 and 8, respectively. Similarly, in my opinion, this disclosure of Chou and Sung'479 also renders obvious a 20-micron and 40-micron protrusion distance between the highest protruding tip and the 10th highest protruding tip and the highest protruding tip and the 100th highest protruding tip of the first monolayer of superabrasive

particles as in claims 6 and 7. As I explained in Section IV [Technology Background], CMP pad dressers are well-known to contain tens of thousands of diamond particles and a POSITA would have readily recognized that there are more than 100 protruding tips of diamond particles in Chou and Sung'479's tools as well.

B. Ground II: Chou in Combination with Sung'479 and SungECS Renders Obvious Claims 6-7

1. Dependent Claims 6-7

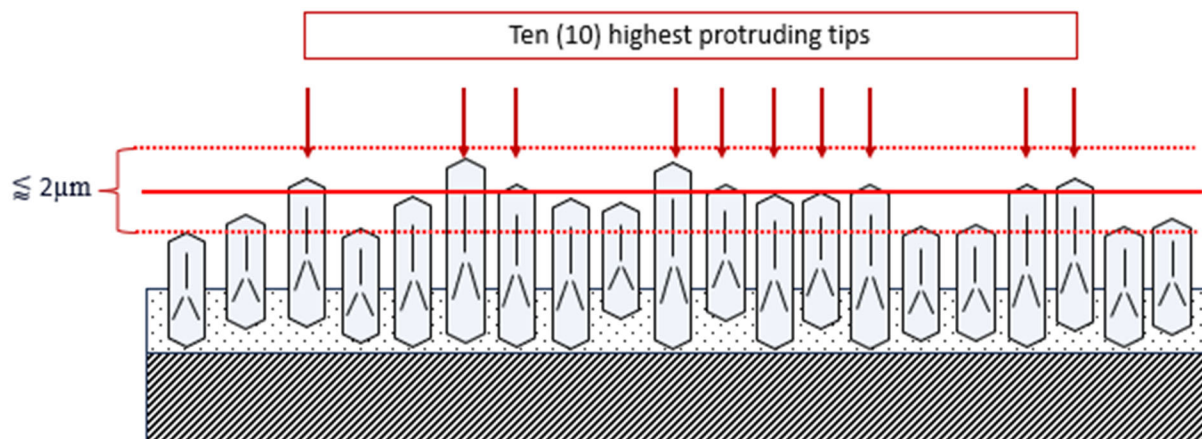
- i. **[6] The dresser of claim 5, wherein the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip of the first monolayer of superabrasive particles is less than or equal to about 20 microns.**

[7] The dresser of claim 6, wherein the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip of the first monolayer of superabrasive particles is less than or equal to about 40 microns.

146. In my opinion, Chou in combination with Sung'479 renders obvious the added limitations of claims 6-7.

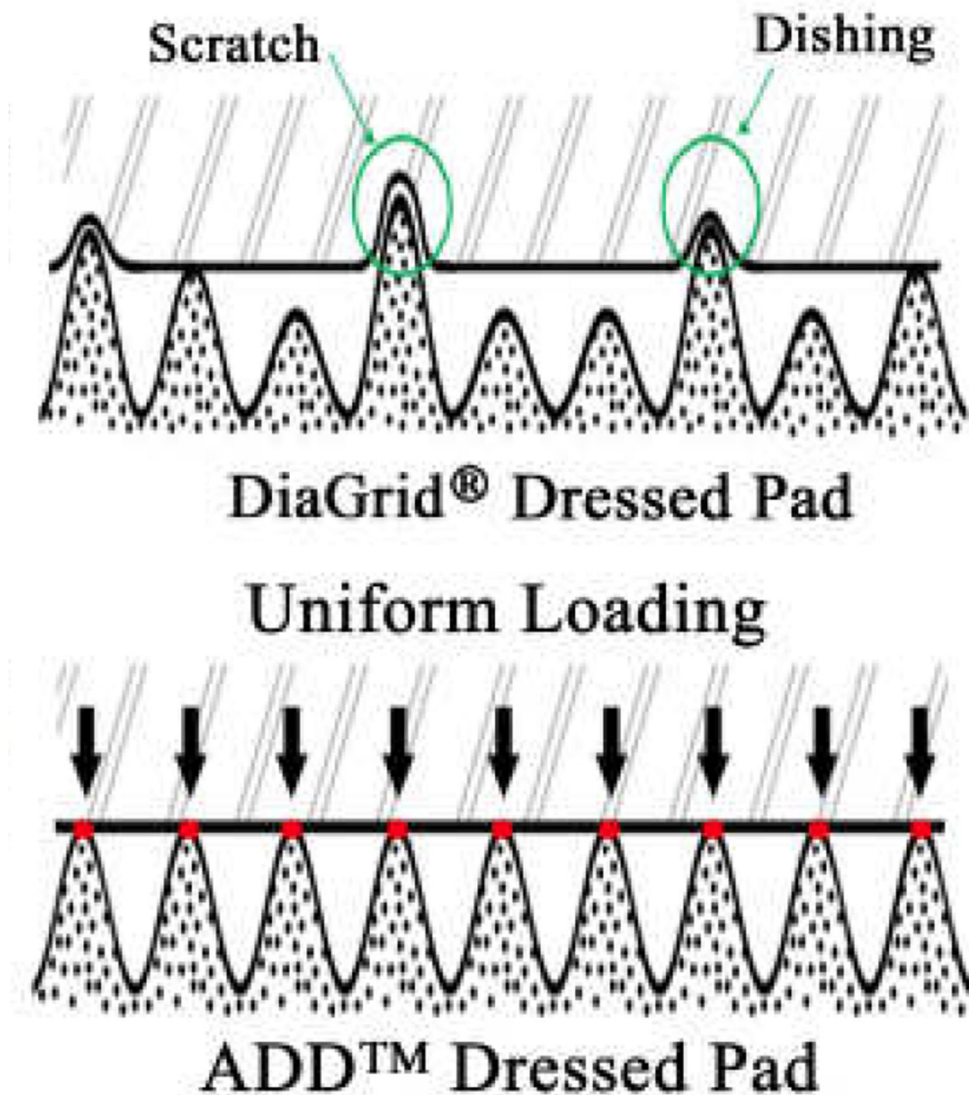
147. Specifically, Chou and Sung'479 render obvious a CMP pad dresser having *all* tips leveled to within less than about 2 microns. Accordingly, it would be obvious to a POSITA that the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip of the first monolayer of superabrasive particles is less than or equal to about 20 microns as in claim 6 and

the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip of the first monolayer of superabrasive particles is less than or equal to about 40 microns as in claim 7. For example, I am providing the schematic below illustrating this for the ten highest protruding tips.



148. Furthermore, a POSITA would have known, or at minimum readily recognized, that CMP pad dressers typically include more than 10 or 100 diamond particles. For example, SungECS provides an example of a commercial CMP pad dresser called BDD (“brazed diamond disk” with a commercial name “DiaGrid[®]”) and ADD (“advanced diamond disk”). EX1007, 524:1-3 (“BDD, [refers to] the conventional *brazed* diamond disks.”), FIG. 3 caption (“DiaGrid[®] refers to BDD pad conditioner.”), 523:1-3 (“[A]dvanced diamond disk (ADD) is made by carving a disk of sintered polycrystalline diamond (PCD) layer to form cutting tips of predetermined shape and distribution”). As shown in FIG. 3 below, the ADD type of a dresser is “fully leveled” “within a few microns” whereas the BDD has a

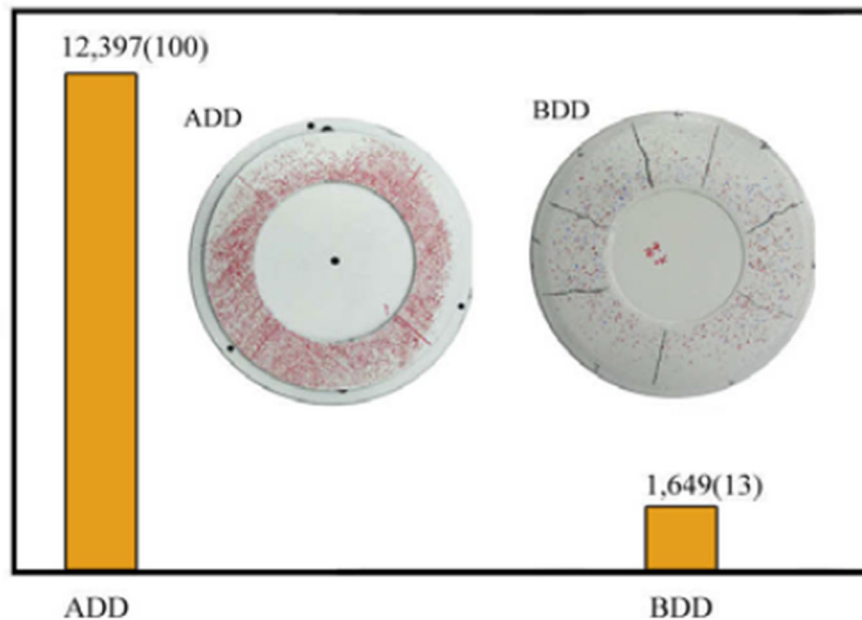
“conventional range of 50 to 100 microns for highest points of discrete diamond grits.” EX1007, FIG. 7 caption.



EX1007, FIG. 3.

149. SungECS explains that despite both discs having the same number of abrasive particles, , “the contact points on pad during dressing increases by more than tenfold compared to BDD.” EX1007, 524:1-3; *see also* EX1007, FIG. 2

caption (“Both disks have about the same number of cutting tips to begin with the test.”).



EX1007, FIG. 2.

150. As such, a POSITA would have known that typical CMP pad dressers have over 10,000 superabrasive (e.g., diamond) particles.

151. Furthermore, SungECS provides additional evidence that a POSITA would have recognized that smaller tip variations would lead to a larger number of tips contacting the CMP pad. EX1007, 524:1-3; *see also* EX1007, FIG. 2 caption. SungECS shows this with ADD and BDD disks. Like SungECS’s ADD, Sung’479 teaches that *all* diamond particles have a protrusion distance within less than about 2 μ m and, therefore, contact the CMP pad. *See* EX1005, [0072] (“[W]hile it is

intended that the tips of the superabrasive particles align along the designated profile, some level of deviation may occur. ... Also, when referring to the designated profile, it should be noted that the term ‘tip’ is intended to include the highest protruding point of a superabrasive particle In yet another aspect, the plurality of superabrasive particles is arranged such that their tips vary from the designated profile by *less than about 1 microns.*”), [0009] (“[I]n one aspect arranging the plurality of superabrasive particles may include ... disposing the plurality of superabrasive particles at least partially within the spacer layer such that a portion of *each* of the plurality of superabrasive particles contact the leveling surface.”), claim 4. Therefore, since it was known that CMP pad dressers have over 10,000 diamond particles, as taught by SungECS, and that each one of Sung’479’s diamond particles contact the CMP pad surface, the combination of Chou, Sung’479, and SungECS render obvious a CMP pad conditioner having the 10th highest protruding tip and the 100th highest protruding tip to be less than about 2 microns and meet the claimed “less than or equal to about 40 microns.”

a. Reasons to Combine Chou, Sung’479 and SungECS

152. It would have been obvious to combine Chou with Sung’479 and SungECS for at least the following reasons.

153. **First**, Chou Sung’479, and SungECS are all directed to abrasive tools and are analogous to the claims of the ’270 Patent. EX1004, [0002] (“The present invention relates to a grinding tool and a method for fabricating the same and, more particularly, to a grinding tool and a method for fabricating the same that can improve the precision and lifetime of products, reduce the cost of production, and enhance the machining efficiency”); EX1005, [0009] (“Accordingly, the present invention provides superabrasive tools and methods that are, without limitation, suitable to groom the CMP pads used for the delicate polishing applications as recited above.”); EX1007, Title (“Polycrystalline Diamond (PCD) Shaving Dresser: The Ultimate Diamond Disk (UDD) for **CMP Pad Conditioning**.”); EX1001, claim 1 (“A CMP pad dresser...”).

154. **Second**, a POSITA would have found that the combination of SungECS with Chou and Sung’479 is trivial, as SungECS merely sets forth that CMP pad dressers typically contain tens of thousands of diamond particles. As such, a POSITA would have expected that the claimed “10th highest protruding tip” and “100th highest protruding tip” would be found in the CMP pad dressers described by Chou and Sung’479. Accordingly, this combination of a typical number of particles on a CMP pad dresser with the teachings of Chou and Sung’479 would have been a trivial modification with a predictable result that a

POSITA would have been able to carry out with a reasonable expectation of success.

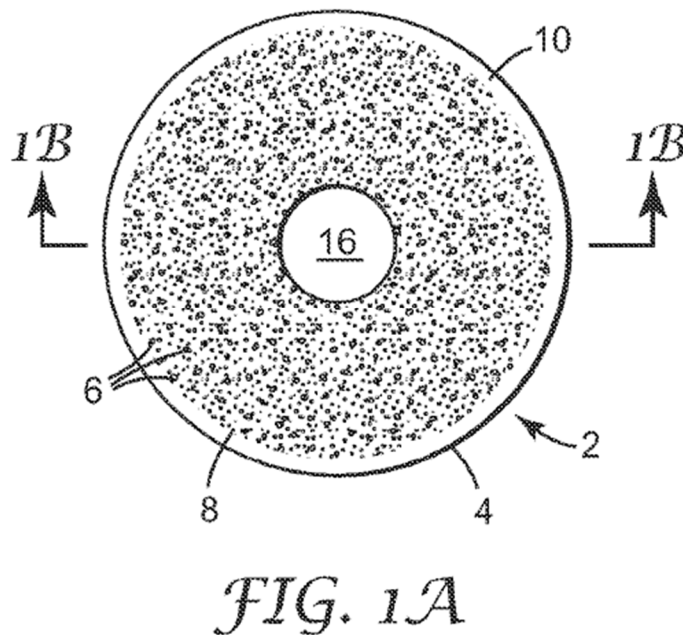
C. Ground III: Chou in Combination with Sung'479 and Goers Renders Obvious Claim 2

- i. **[2] The dresser of claim 1, wherein the plurality of superabrasive particles are arranged in at least one annular configuration having a central region devoid of superabrasive particles.**

155. In my opinion, Chou in combination with Sung'479 render obvious the added limitations of claim 2.

156. CMP pad dressers having an annular configuration having a central region devoid of superabrasive particles were well-known in the art. For example, Goers shows such a configuration in Figure 1A, which I reproduce below. *See* EX1006, [0030] (“To reduce the likelihood of abrasive particles breaking loose from the substrate 4 in the region where the substrate is formed (for example, cut) to a desired shape, and/or to permit operation of a sensor provided with the abrasive particle, a portion of the substrate may be provided free of abrasive particles. This *particle free zone may, for example, be formed near the center of the abrasive article*, or may extend a certain distance along the entire peripheral edge of the abrasive article, as shown in FIG. 1A. For a typical conditioning disk having a generally circular or annular shape, a *particle free zone may be provided both near the disk center* and at the outer peripheral edge portion of the

substrate.”). It would have been obvious to a POSITA to arrange the superabrasive particles in an annular configuration with the central region devoid of particles, as shown by Goers.



EX1006, FIG. 1A.

a. Reasons to Combine Chou, Sung’479, and Goers

157. It would have been obvious to combine Chou and Sung’479 with Goers for at least the following reasons.

158. **First**, Chou Sung’479, and Goers are all directed to abrasive tools and are analogous to the claims of the ’270 Patent. EX1004, [0002] (“The present invention relates to a grinding tool and a method for fabricating the same and, more particularly, to a grinding tool and a method for fabricating the same that can

improve the precision and lifetime of products, reduce the cost of production, and enhance the machining efficiency”); EX1005, [0009] (“Accordingly, the present invention provides superabrasive tools and methods that are, without limitation, suitable to groom the CMP pads used for the delicate polishing applications as recited above.”); EX1006, [0005] (“In general, the present invention relates to abrasive articles... Exemplary abrasive articles include polishing pads (CMP pads) and CMP pad conditioners...”); EX1001, claim 1 (“A CMP pad dresser...”).

159. ***Second***, arranging the superabrasive particles in the CMP pad dresser of Chou and Sung’479 such that they are in an annular configuration would be a trivial modification to a POSITA. For instance, Sung’479 already teaches that it can be beneficial to arrange the superabrasive particles in different configurations between the central and the peripheral regions because the particles at these locations experience different stresses. *See* EX1005, [0057] (“In a spinning disk, for example, larger superabrasive particles may be located more centrally and smaller superabrasive particles may be located more peripherally in order to counteract location-dependent variations in mechanical stress associated with rotational velocity.”), [0073] (“In another aspect, superabrasive particles in a central location of the tool may be smaller than superabrasive particles in a peripheral location on the tool. This configuration may provide benefit to

circumferentially rotating tools, where the mechanical stresses on superabrasive particles are greater at the periphery.”).

160. It would have been obvious to a POSITA to utilize a particle free zone in the central region as in Goers instead of using superabrasive particles of different sizes between the central and peripheral regions. *See* EX1006, [0030] (“To reduce the likelihood of abrasive particles breaking loose from the substrate 4 in the region where the substrate is formed (for example, cut) to a desired shape, and/or to permit operation of a sensor provided with the abrasive article, a portion of the substrate may be provided free of abrasive particles. This ***particle free zone may, for example, be formed near the center of the abrasive article***, or may extend a certain distance along the entire peripheral edge of the abrasive article, as shown in FIG. 1A. For a typical conditioning disk having a generally circular or annular shape, a ***particle free zone may be provided both near the disk center*** and at the outer peripheral edge portion of the substrate.”). In fact, such a modification would have been trivial with a predictable result that a POSITA would have been able to carry out with a reasonable expectation of success because placing diamond particles in only certain regions of a CMP pad dresser would have been a routine step that a POSITA would have been able to do in light of the teachings of Goer.

X. Availability for Cross-Examination

161. I understand that the declaration will be submitted as an exhibit in IPR2024-00533. I understand that the Patent Owner may ask to take a deposition based on my declaration. If requested, I agree to appear for a deposition, either in-person or remotely.

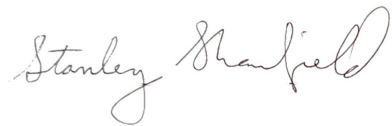
XI. Right to Supplement

162. I reserve the right to supplement my opinions in the future to respond to any arguments that the Patent Owner may raise and to take into account new information as it becomes available to me.

XII. Jurat

163. I 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.

Feb. 29, 2024
Date



Dr. Stanley Shanfield

Appendix A

Stanley Shanfield



Curriculum Vitae for Stanley Shanfield

Education:

Massachusetts Institute of Technology, Ph.D., Physics, 1981

University of California, Irvine, B.S. Cum Laude, Physics, 1977

Educational Awards:

Outstanding Research Project, U.C. Regents Award, 1977

Phi Beta Kappa, 1977

Four Year Scholarship, Tuition & Research, ERDA/DOE, 1977-1981

Hands-On Professional Expertise:

Semiconductor Physics & Chemistry

Semiconductor Fabrication: Silicon and III-V Materials

Semiconductor Device & Integrated Circuit Engineering

Semiconductor Equipment: Front & Back End

Semiconductor Packaging Design and Manufacturing

Passive Component Design and Manufacturing

RF Design and Fabrication

Digital Design & Fabrication

Semiconductor Manufacturing in Silicon and III-V Materials

MEMS Design and Fabrication: Electrical, Optical, & Sensing Devices

Fiber Optic Device Design and Fabrication

Integrated Optics & Electro-Optical Devices

Plasma Physics

Specialized Training:

Global Positioning Electronics, Systems and Components

Six Sigma Semiconductor Manufacturing

Microwave Engineering

US Patent Law in Technology

Patent Application and Prosecution

Semiconductor Plasma Processing

Thin Film Physics and Technology

MEMS-based Gyroscopes and Accelerometers

Thermoelectric Materials & Technology

Phased Array Radar Engineering

Antennas and Electromagnetic Propagation

Solid State Optical Devices

Fiber Optic Communication System Operation

HALT and HAST Reliability Testing Methods

Professional Experience:

Draper Laboratory Cambridge, MA

2003 – present

Division Leader, Advanced Hardware Development Distinguished Member of Technical Staff Technical Director

Led division (about 80 staff) in re-invigorating multi-chip integrated circuit module facility, more than doubling associated revenues in two years. By most accounts, made division a viable business & technological entity again. Invented & led implementation of an ultra-miniature electronics fabrication technology which became a top laboratory priority. Led team in realization & fabrication of a newly designed precision MEMS-based gyroscope and associated ASIC. Found funding and led team in developing a miniature power source with energy density at least two orders of magnitude higher than any source previously built. Developed fabrication technology for semiconductor-based low phase noise oscillator design, allowing for receiver operation with extremely low signal strength. Many awards received, most recently, the Draper 2010 Distinguished Performance Award, and 2010 Best Patent Award. Recent work in ASIC process design and circuit design for ultra-high performance government and space systems.

Clarendon Photonics Newton, MA

2002 – 2003

Director, Packaging & Integration

30 person photonic chip startup with \$18 million 2nd round funding. Invented and productized new, low cost and reliable semiconductor processing, packaging and pig-tailing technology for optical add-drop multiplexer. Established assembly and packaging process and developed control electronics. Partner with Micron Technologies, using their R&D semiconductor facility.

AXSUN Technologies Bedford/Billerica, MA

1999 – 2002

Vice President, Operations, Co-Founder 1999 – 2000

Initially three staff members with \$6 million funding. Designed, fabricated and productized AXSUN's micro-electromechanical (MEM) Fabry-Perot optical filter. Patents granted on semiconductor processing and control electronics. Completed facility and semiconductor processing design, then completely equipped. Raised 2nd round funding for \$36 million. Established process and fabrication facility in Belfast, Northern Ireland for producing thick oxide silicon-on-insulator material.

Director, Manufacturing & Wafer Fab Technology

2000 – 2001

After 3rd round funding, led device manufacturing, creating wafer fab and assembly infrastructure; hired 70+ people, led production. Delivered first generation product for revenue to multiple customers. Converted pure technology to dominant company revenue with high yield.

Company purchased by Volcano Technologies, San Diego.

Raytheon Corporation Lexington/Andover, MA

1985 - 1999

Manager, Semiconductor Operations

1996 – 1999

Built and led a 300 employee, \$60 million revenue 24/7 semiconductor development and manufacturing operation resulting from the consolidation of a number of smaller organizations. Key player in technological development and recipient of Raytheon's 6 Sigma Leadership training. Decision maker in Texas Instrument group acquisition, providing significant expert opinion on semiconductor and design facilities. Obtained state-of-art yields using best available steppers, deep reactive ion etching, plasma assisted CVD, and ion-implantation equipment, and disciplined design-for steppers, deep reactive ion etching, plasma assisted CVD, and ion-implantation equipment, and disciplined design-for-manufacturing circuit design and layout methodology.

Research Laboratory Manager

1992 – 1996

Leader of a 90 employee development and contract research organization in high performance semiconductor devices and circuits, measurement, assembly and wafer fab. Led a team which invented and implemented a major revenue generating technology (\$.100 million) based on semiconductor device development (pseudomorphic high electron mobility transistor). Increased outside research funding by 50% in 3 years through superior technical performance relative to competitors.

Section Manager, Semiconductors & ICs

1985 – 1992

Led a MM-Wave Circuit and Module Development program over 2 years, leading to production win of a satellite terminal electronics generating \$320 million in sales. Developed processes for fabricating high power, high frequency multi-function integrated circuits, and combining high performance digital and analog devices in a single integrated circuit.

Spire Corporation Bedford, MA

1981 – 1984

**Staff Scientist
Senior Staff Scientist**

Developed new methods for low temperature deposition of plasma-assisted CVD epitaxial silicon. Wrote joint papers with MIT professor, and had process adopted by equipment manufacturers. Built, operated and characterized ion-assisted deposition system for making coating for semiconductor and machine tool industries. Process eventually purchased by Kennametal, Inc.

Publications

Restricted Publications & Reports

Process Sequence for Formation of Ultra-High Density Multi-Chip Modules:

A high yield, low cost method for creating a system-in-a-package consisting of numerous semiconductor die, passive components, and sensors. Process formed basis for new (2008) facility.

Design and Method of Fabrication of Ultra-High Density Radioisotope Power Source:

In test, a miniature power source that achieves energy density more than 1000X the best chemical battery. Method uses planar semiconductor processing of bulk thermoelectric materials.

Design and Method of Achieving Extremely Low Crystal Oscillator Phase Noise:

Method developed for very low power refrigeration of quartz or sapphire crystal resonators, resulting in extremely low phase noise oscillators. The low phase noise allows extremely high sensitivity in digital receivers, including GPS receivers, leading to use in extremely low signal conditions.

Design, Evaluation & Production of MEMS-based Fabry-Perot Interferometer:

Design and method for ultra-compact spectral analyzer made using semiconductor and optical thin film processing.

Design & Evaluation of Ultra-Fast Control Electronics for Integrated Optical Multiplexer:

Design and performance evaluation of silicon-based integrated optical multiplexer using chip-based local heating

Design and Fabrication of Q-band MILSTAR Communications Terminal Transmitter:

Record power and efficiency 44 GHz transmitter design using new transistor design, and combined waveguide

Key Publications (selected)

Process Characterization of PSG and BPSG Plasma Deposition, J. Electrochem. Soc., Volume 131, Issue 9, pp. 2202-2203

A double-recessed Al_{0.24}GaAs/In_{0.16}GaAs pseudomorphic HEMT for Ka- and Q-band power Applications, Electron Device Letters, IEEE, Volume 14, Issue 9, pp. 456 - 458

Formation of Thick Metal Structures on GaAs MMICs Using Image Reversal Lithography and Evaporated Metal Deposition, J. Electrochem. Soc., Volume 136, Issue 9, pp. 2687-2690

Contact Hole Etching in Load-Locked Hexagonal Reactive Ion Etch System, J. Electrochem. Soc., Vol. 131, No. 8, 1984

An AlGaAs/InGaAs pseudomorphic high electron mobility transistor with Improved Breakdown Voltage for X and Ku-band power applications, Microwave Theory and Techniques, IEEE Transactions on, Volume 41, Issue 5, May 1993, pp. 752 - 759

Hot-electron-induced Degradation of Metal-Semiconductor Field-Effect Transistors, Integrated Circuit Symposium, 1994. Technical Digest 1994., 16th Annual Volume , Issue , 16-19 Oct. 1994, pp. 259

Ion Beam Deposition of Cubic Boron Nitride, J. Vac. Sci. Technol. A Volume 1, Issue 2, pp. 323-325

Patents**US Patent 6504235 - Passivation layer and process for semiconductor devices**

Method of coating semiconductor devices that prevented parametric shift in electrical performance. Solved key processing problem.

US Patent 4440108 - Ion Beam Deposition Apparatus

Design of equipment for deposition of thin films in the presence of ion bombardment. System produced thin films of interest for mechanical, electrical and optical properties and was sold as an equipment product.

US Patent 6525880 - Integrated Tunable Fabry-Perot filter and Method of Making Same

Design and method for fabricating very small, very high performance variable optical filter using semiconductor fabrication technology. In current use in fiber optical networks, chemical sensors, and 3-D medical imaging applications.

US Patent 5175020 - Boron Nitride Films and Process of Making Same

Ion assisted deposition of ultra-hard cubic boron nitride films for semiconductor and machine tool applications. Significant use in both areas.

US Patent 4526673 - Coating Method

Method for deposition of thin films used in semiconductor device fabrication. Method based on direct control of the kinetics of thin film deposition.

US Patent 7727806 - Systems and Methods for High Density Multi-Component Modules

Method for fabrication of electronic modules using multiple thinned integrated circuits, patterned multi-level interconnects, passive electronic components, and sensors

US Patent Application 2009/TBD - Devices, systems, and methods for controlling the temperature of resonant elements

Devices and systems for achieving low phase noise crystal oscillators using unique low power thermoelectric structures

Expert Witness Experience:

See attachment

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Newton, MA 02465

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Email: shanfield@alum.mit.edu