

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 IPR2024-00534
U.S. Patent No. 9,138,862

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

CLAIMS 1-20

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I, Stanley Shanfield, declare as follows.

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.

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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. 9,138,862 (the “’862 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 ’862 Patent – May 23, 2011.
13. I understand that the ’862 Patent was filed on March 13, 2013 as a U.S. Patent Application No. 13/802,112. I understand that this application is a continuation-in-part of U.S. 13/479,148 (now U.S. 8,974,270), which 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 ’862 Patent:
 - U.S. Patent Application Publication No. 2007/0060026 (“Sung’026”) (EX1004), which published on March 15, 2007;

- The Organic Diamond Disk (ODD) for dressing of Polishing Pads of Chemical Mechanical Planarization,” International Conference on Planarization / CMP Technology, 25-27 October 2007 (“SungICPT”) (EX1005), which published/ was made publicly available at least since October 28, 2007;
- U.S. Patent Application Publication No. 2008/0087644 (“Nishioka”) (EX1006), which published on April 17, 2008;
- International Patent Application Publication WO 2008/049019 (“Lin”) (EX1007), which published on April 24, 2008;
- U.S. Patent Application Publication No. 2009/0001581 (“Kim”) (EX1008), which published on January 1, 2009;
- U.S. Patent Application Publication No. 2009/0117692 (“Koyama”) (EX1009), which published on May 7, 2009.

15. I provide below the list of exhibits that I have considered in preparing this Declaration. I have reviewed and considered the following exhibits and all other documents mentioned in my declaration. Additionally, my opinions are based on my technical education, training and experience in the field.

Exhibit No.	DESCRIPTION
1001	U.S. Patent No. 9,138,862 (“’862 Patent”)
1003	File History of the ’862 Patent
1004	U.S. Patent Application Publication No. 2007/0060026 (“Sung’026”)

Exhibit No.	DESCRIPTION
1005	“The Organic Diamond Disk (ODD) for dressing of Polishing Pads of Chemical Mechanical Planarization,” International Conference on Planarization / CMP Technology, 25-27 October 2007 (“SungICPT”)
1006	U.S. Patent Application Publication No. 2008/0087644 (“Nishioka”)
1007	International Patent Application Publication No. WO 2008/049019 (“Lin”)
1008	U.S. Patent Application Publication No. 2009/0001581 (“Kim”)
1009	U.S. Patent Application Publication No. 2009/0117692 (“Koyama”)
1010	U.S. Patent No. 5,036,015
1011	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
1012	U.S. Patent Application Publication No. 2008/0292869 (Sung’869)
1013	Fenna, Donald. “Hardness Numbers,” <i>A Dictionary of Weights, Measures, and Units</i> , 1st ed., Oxford University Press, 2004.
1014	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)
1015	Pysher et al. “Design, Characteristics and Performance of Diamond Pad Conditioners”, Materials Research Society Symposium Procedures, Vol. 1249, 2010 (“Pysher”)
1016	<i>Design, Characteristics and Performance of Diamond Pad Conditioners</i> . SpringerLink. https://link.springer.com/article/10.1557/PROC-1249-E02-04
1017	Exhibit 4 of Complaint in <i>Sung v. Samsung Electronics Co., Ltd. et al</i> , 4-23-cv-00752

16. 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.

17. 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.

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

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

I. Relevant Law

20. 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

21. 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 claimed priority date of the ’862 Patent is May 23, 2011.

22. 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.

23. 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

24. I have been informed that to determine the meaning of the terms in the claims of the '862 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.

25. 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.

26. 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. Anticipation

27. I have been informed and understand a patent claim is considered "anticipated" by the prior art when each and every of the claims is found, within a single prior art reference either expressly or inherently, meaning the wording in a prior art reference does not need to match the claim. I understand that a reference is anticipatory if a POSITA, upon reviewing this single reference, would have been able to make and use the technology described in the reference in the manner claimed.

28. I further understand that a claim limitation that covers a range can be anticipated by a prior art reference that teaches a specific value (or a smaller range) within that claimed range. I further understand that a description of a single embodiment of broadly claimed subject matter can anticipate a claim. I further understand that a range disclosed in the prior art that overlaps with a claimed range may anticipate that claimed range if there is no criticality to the claimed range.

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

D. Obviousness

30. 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.

31. I further understand that a claim limitation that covers a range can be 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.

II. Summary of Opinions

36. For the reasons explained below, I conclude that claims 1-20 of the '862 Patent are anticipated and rendered obvious by the prior art.

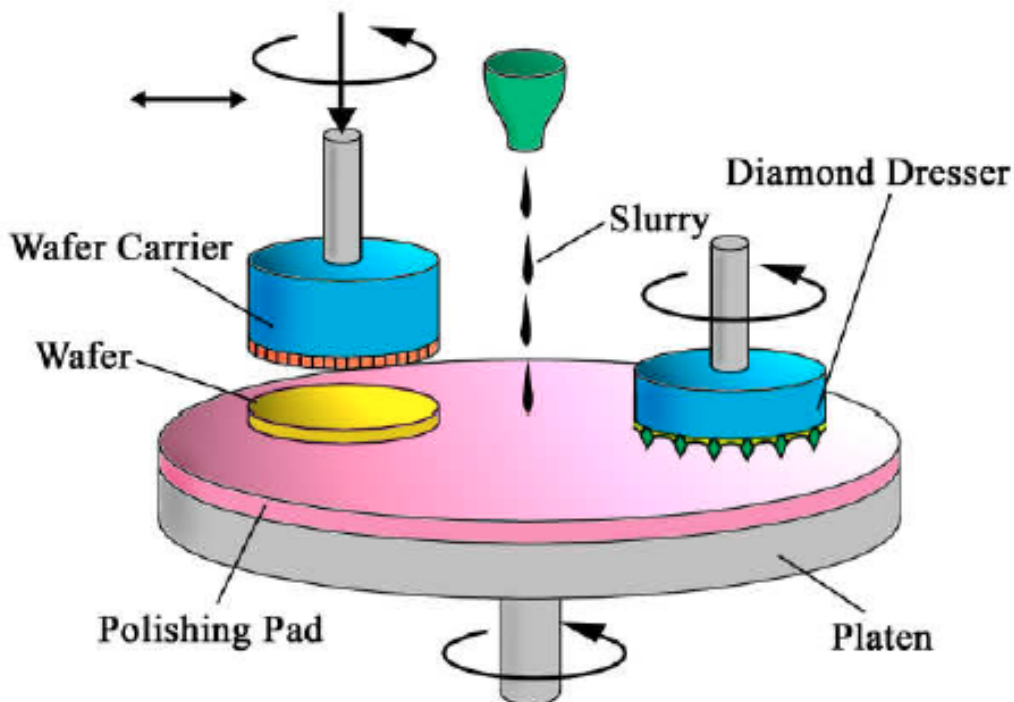
Grounds	Claims	Statutory Ground	Prior Art Reference(s)
I	1-6, 9-12, 20	35 U.S.C. §102/§103	Sung'026
II	5-10	35 U.S.C. §103	Sung'026 in combination with SungICPT
III	13, 17-19	35 U.S.C. §103	Sung'026 in combination with Nishioka
IV	14	35 U.S.C. §103	Sung'026 in combination with Lin
V	15	35 U.S.C. §103	Sung'026 in combination with Kim
VI	16	35 U.S.C. §103	Sung'026 in combination with Koyama

III. 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. EX1011, Fig. 2. *See also* EX1011, 1:17-28, EX1010, 1:13-48.



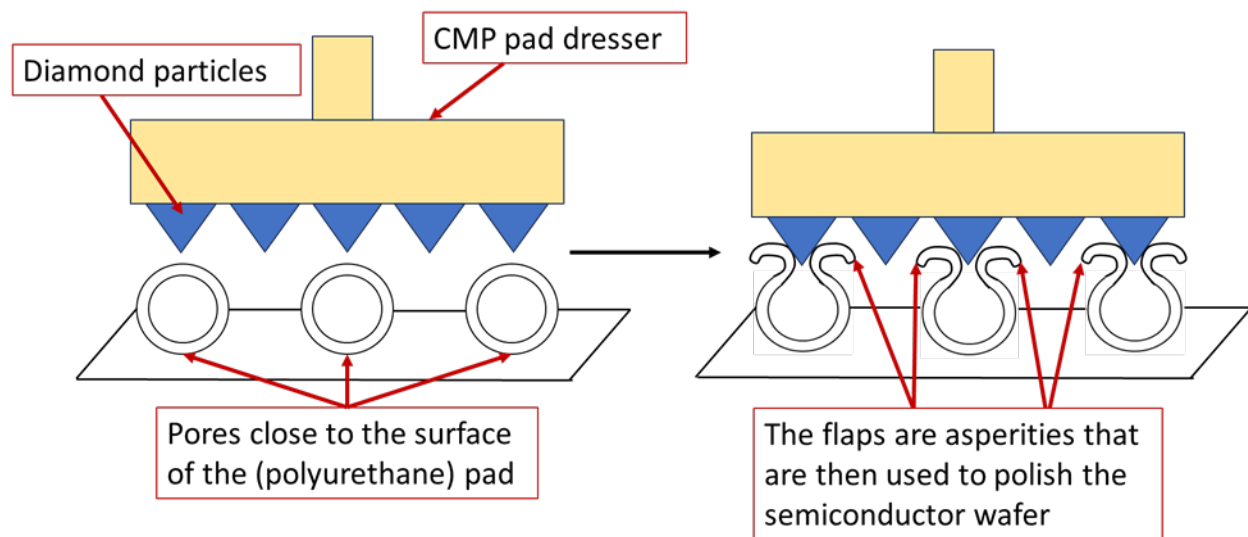
EX1011, Fig. 2.

38. The chemical slurry typically includes abrasive particles that assist in polishing the wafer surface. EX1004, [0002]; EX1006, [0055]; EX1011, 1:19-24. Examples of such abrasives include alumina and silica, and ceria. EX1006, [0066]; EX1011, 1:22-23. The slurry also often includes additional agents that oxidize the

wafer surface. Examples of such oxidizing agents include, *e.g.*, hydrogen peroxide. EX1006, [0063]; EX1011, 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. EX1004, [0002]; EX1006, [0090]; EX1011, 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. EX1004, [0004]-[0006]; EX1011, 2:7-11.

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. EX1004, [0004]-[0005].



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.

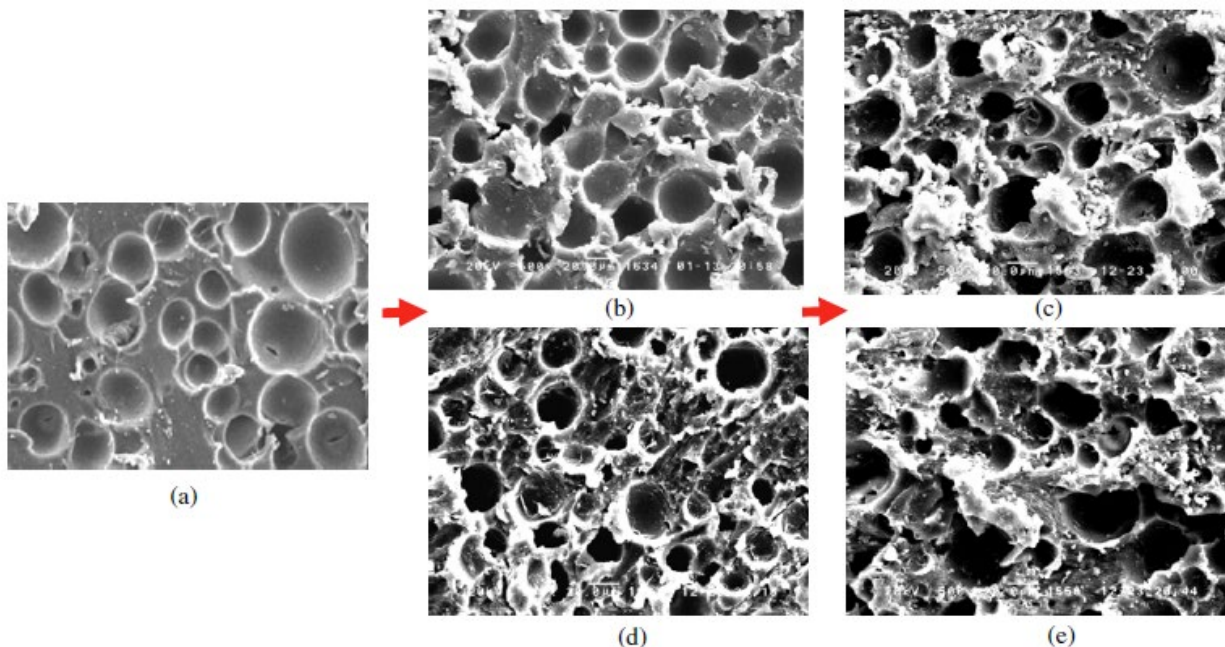
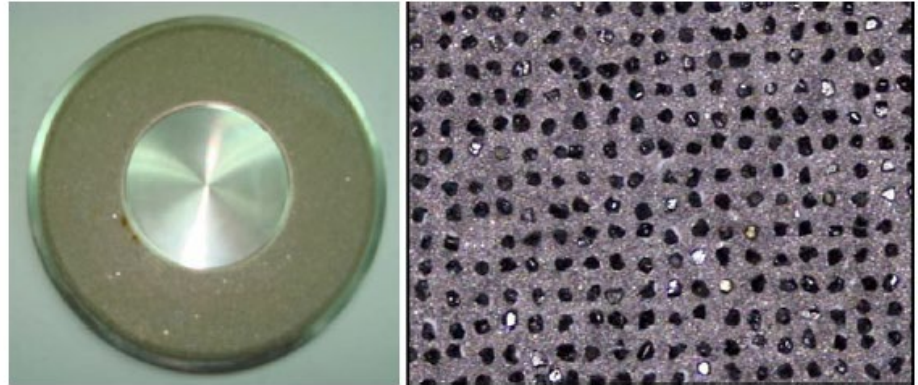


Fig. 14 SEM images of polishing pad: a new pad, b and c dressed by CDD with blocky diamond grit, and d and e dressed by DG after 1 and 20 h of conditioning, respectively

EX1014, Fig. 14.

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

Fig. 3 Appearance of conventional diamond disk



EX1014, 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. 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* EX1014, 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 EX1014 (reproduced above) has approximately 12,000 diamond particles across the surface of the dresser. EX1014, Fig. 3, 258.

45. At the time of the '862 Patent, there were multiple known CMP pad dresser fabrication methods. Of particular interest were methods that enabled

uniform protrusion of the diamond particles over the entire substrate surface. One such method is known as “reversed casting.” EX1004, [0006], [0010], [0052], [0056], [0061], [0073]; EX1005, 1:9-15, 1:30-2:4; EX1012, [0053], [0054], [0056], [0057], [0067], [0079].

46. Reverse casting involves securing superabrasive particles in a mold, pouring an organic material (typically a polymer, *e.g.* epoxy) over the superabrasive particles, attaching the solidified organic layer to a support substrate, and removing the mold. This method gives a CMP pad dresser with a single layer of substantially level superabrasive particles. The particles are held in the organic matrix layer, and protrude to a predetermined height above the support. Often, using reverse casting to manufacture CMP pad dressers allows for better control over the uniformity of tip heights of superabrasive particles, due to the pre-leveling of the superabrasive particles on the mold. EX1004, [0010], [0052], [0056], [0061]-[0063], [0073]-[0076], [0083]-[0088], [0099]-[0104]; EX1005, 1:9-15, 1:30-2:4; EX1012, [0053], [0054], [0056], [0057], [0060], [0067], [0070]-[0081], [0091], [0092], [0099]-[0104].

47. Dr. Sung —the sole named inventor of the ’862 Patent presented the “organic diamond disk (ODD),” a CMP pad dresser made by reverse casting diamond particles onto an organic matrix, at a conference in 2007. EX1005 [SungICPT], Title, Header, 1:30-2:3. First, the diamond particles are leveled on a

mold. Then, the diamond particles are covered with an organic polymer, such as epoxy. Finally, the mold is removed, exposing the diamond particles embedded in and protruding from the epoxy layer. EX1005, 1:30-2:2. Because the diamond particles are leveled on a mold in the first step in the reverse casting process, the tip-to-tip variation can be controlled to within about 20 microns. EX1005, 2:2-3.

As shown below in Figure 3, the ODD CMP pad dresser has diamond particles embedded in and protruding from the organic matrix and arranged in a grid with an inter-diamond spacing of about 500 microns. EX1005, Fig. 3.

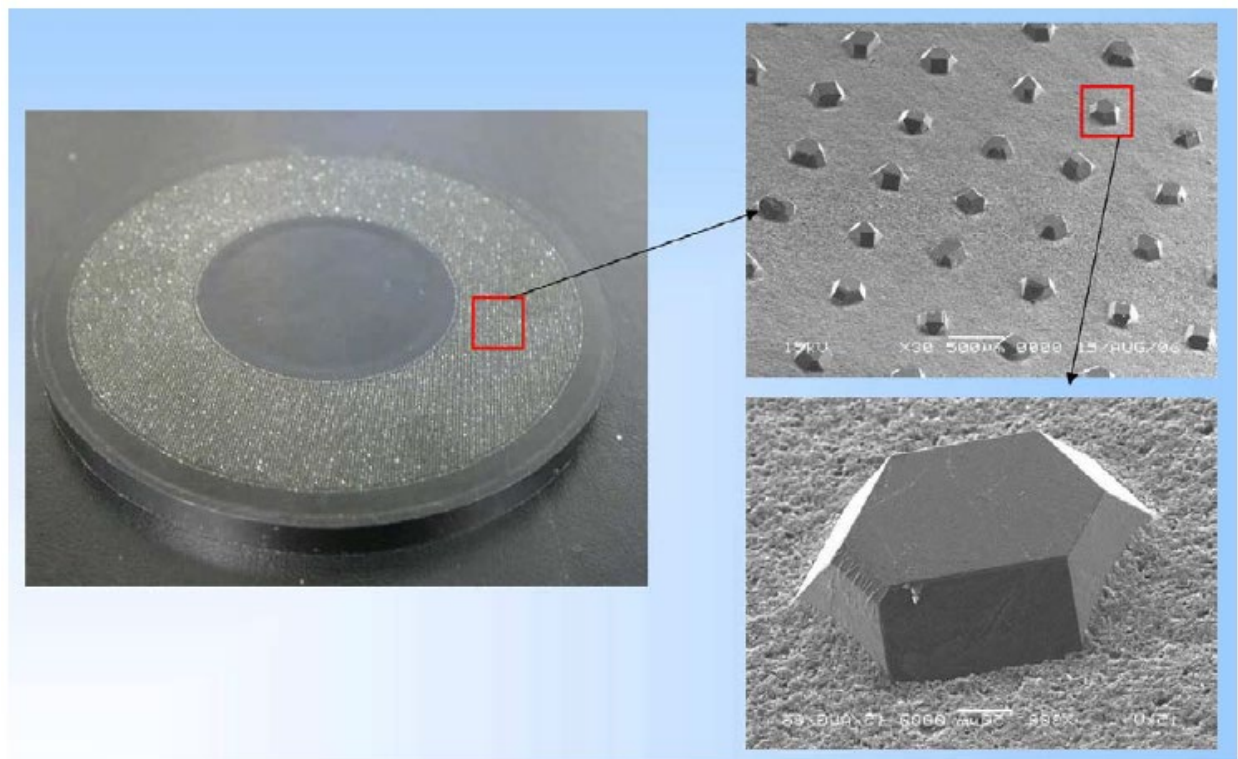
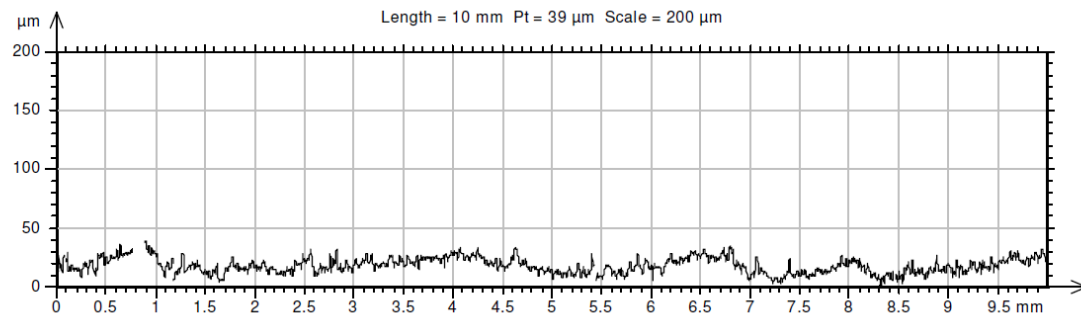


Fig. 3: The bonding conditions of diamond in the epoxy matrix.

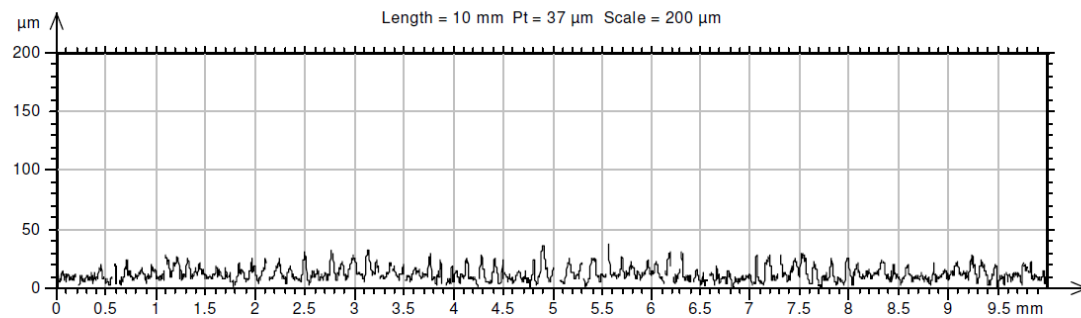
EX1005, Fig. 3.

48. Furthermore, CMP pad dressers having substantially uniform protrusion heights were known in the art before the earliest possible priority date of the '862 Patent.

49. For instance, I have reproduced Fig. 4 of EX1015 below, which shows a two-dimensional surface profile of a CMP pad dresser. EX1015, p. 3, Fig. 4. I understand that EX1015 was published on August 1, 2010, which is before the priority date of the '862 Patent. Nevertheless, I understand that Patent Owner acknowledged that Fig. 4 of EX1015 discloses “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 10 microns,” as is recited in independent claim 1 of the '862 Patent. I also understand that Patent Owner acknowledged that this Figure discloses that “the difference in protrusion distance between the highest 10 protruding tips of the monolayer of superabrasive particles are within about 20 microns or less” also recited in independent claim 1 of the '862 Patent. *See* EX1017, 8-17 EX1001, claim 1.



(a)



(b)

Figure 4. Surface profiles showing flatness of a) current and b) improved fine-finish disk designs.

EX1015, Fig. 4.

IV. Overview of the '862 Patent

A. Summary of the '862 Patent

50. I have reviewed the '862 Patent. *See* EX1001.

51. The '862 Patent describes methods of conditioning CMP pads with CMP pad dressers. *See* EX1001, Abstract. According to the '862 Patent, these CMP pad dressers should have superabrasive particles with substantially leveled tips. This leveling and overall protrusion height should be such that the CMP pad dresser produces asperities with a certain maximum cutting depth. *See* EX1001,

9:33-44, (“Thus, the relative leveling of the monolayer of superabrasive particles can greatly affect the morphology and distribution of asperities cut into the CMP pad by the dresser. For example, in one aspect, the monolayer is leveled such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 80 microns ... 60 microns ... [or] 40 microns.”).

52. The '862 Patent describes that such leveling of the tips in a CMP pad dresser can be accomplished using a “reverse casting” method. EX1001, 17:8-15 (“[S]o-called ‘reverse casting’ methods can be used to accurately orient and attach the dressing segments to the rigid support.”). First, the superabrasive particles are secured “to a substrate using a ‘mask’ material.” EX1001, 17:10-12. Then, the superabrasive particles not covered by the masking material are “attached to the rigid support.” EX1001, 17:12-14. For example, organic matrix materials like epoxy can be a rigid support. EX1001, 17:16-57. Finally, “the masking material can be removed.” EX1001, 17:14-15. The result of the “reverse casting” method is presumably what is claimed in claim 1, such as “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 10 microns” and “the difference in protrusion distance between the highest 10 protruding tips of the monolayer of superabrasive particles are within about 20 microns or less.” EX1001, claim 1.

B. Summary of the Prosecution History of the '862 Patent

53. I have reviewed the file history of the '862 Patent which I summarize below. *See* EX1003.

54. The application for the '862 Patent was filed on March 13, 2013. The application claimed to be a continuation-in-part of U.S. U.S. 13/479,148 (now U.S. 8,974,270), which claimed priority to U.S. Provisional Application No. 61/489,074, filed May 23, 2011. *See* EX1001, Cover; EX1003, 2, 7.

55. The application for the '862 Patent included claims 1-20. EX1003, 39-41.

56. In an Office Action dated November 6, 2014, claims 1-20 were rejected under 35 U.S.C. §103 over U.S. 2010/0248595 ("Dinh-Ngoc") and U.S. 2008/0292869 ("Sung'869"). EX1003, 892. I have read each of these references, and it is my opinion that these references have substantially different teachings than Sung'026, SungICPT, Nishioka, Kim, Lin, and Koyama, which I rely on in my declaration.

57. The Examiner applied paragraphs [0010] and [0057]-[0059] of Sung'869 for the teaching of "the difference in protrusion distance between the highest 10 protruding tips of the mono layer of superabrasive particles are within about 20 microns or less; and rotating the dresser against the CMP pad *such that asperities are cut into the CMP pad having a maximum cutting depth of about 60*

microns.” EX1003, 892-893 (emphasis added). Specifically, the Examiner pointed to paragraph [0010] of Sung’869, which teaches that superabrasive particles protruding to a predetermined height can produce certain cutting depths. The Examiner also relied on paragraphs [0002], [0061] and [0062] of Sung’869. *See* EX1003, 893-895.

58. The Applicant did not amend any claims. Instead, in response to these rejections stated the following: “Examiner argues that Sung[’869] discloses that superabrasive particles protruding to a predetermined height produce a cutting depth of less than 20 microns, and infers that this recitation of cutting depth reads on the claim limitation that the highest 10 protruding tips are within about 20 microns or less. *It is noted, however, that the depth to which a particle cuts into a deformable substance like a CMP pad is not necessarily a teaching of a protrusion distance of this particle.*” EX1003, 1185; *see* EX1003, 1182-1187.

59. On May 15, 2015, the Examiner issued a Notice of Allowance, allowing all claims 1-20. EX1003, 1195-1199. The ’862 Patent was issued on September 22, 2015. *See* EX1001, Cover; EX1003, 1270.

V. Level of Ordinary Skill in the Art

60. As I noted above in Paragraph 21, I have been informed by the counsel that that a patent and the prior art should be analyzed within the framework of a POSITA.

61. In my opinion, a POSITA as of the earliest claimed priority date of the '862 Patent (i.e., May 23, 2011) would have a bachelor's degree in 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.

62. I met and/or exceeded these requirements for POSITA as of May 23, 2011, for at least the reasons provided above in Paragraphs 2-12.

VI. Overview of the Primary Prior Art References

A. Overview of Sung'026

63. Sung'026 is a U.S. Patent Application Publication published on March 15, 2007. EX1004, Cover. I have been informed by counsel that Sung'026 is prior art to the '862 Patent.

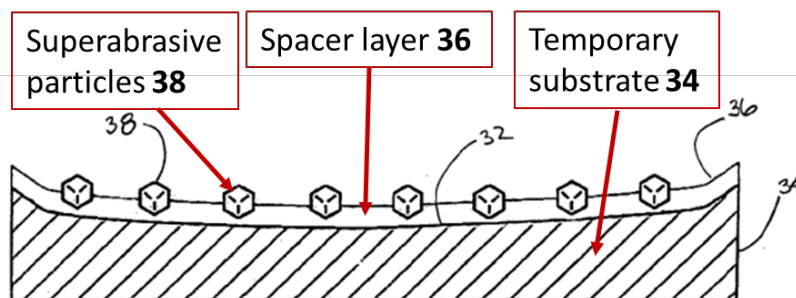
64. Sung'026 is directed to CMP pad conditioners. EX1004, [0001], [0009] ("Accordingly, the present invention provides superabrasive tools and methods that are, without limitation, suitable to groom the CMP pads used for the delicate polishing applications as recited above."). Sung's CMP pad dressers include "superabrasive particles protruding out of the solidified organic material layer." EX1004, Abstract. As is customary in the field, Sung'026 states that "‘particle’ and ‘grit’ may be used interchangeably, and when used in connection

with a superabrasive material, refer to a particulate form of such material.”

EX1004, [0033].

65. Sung discloses that such CMP pad dressers can be prepared by “reverse casting methods.” EX1004, [0083]. Such process is illustrated in Figs. 2, 5, and 6, which I have reproduced with my annotations, and the process is just like the method described in the ’862 Patent.

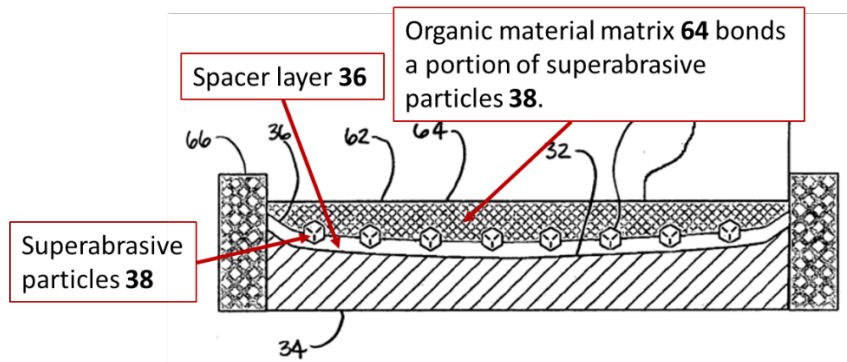
66. Referring to Fig. 2 of Sung’026, the superabrasive particles are first “disposed into a spacer layer.” EX1004, [0083]; *see also* EX1001, 17:10-12 (“Such methods can include initially securing the plurality of dressing segments to a substrate using a ‘mask’ material.”).



EX1004, Figure 2 (annotated).

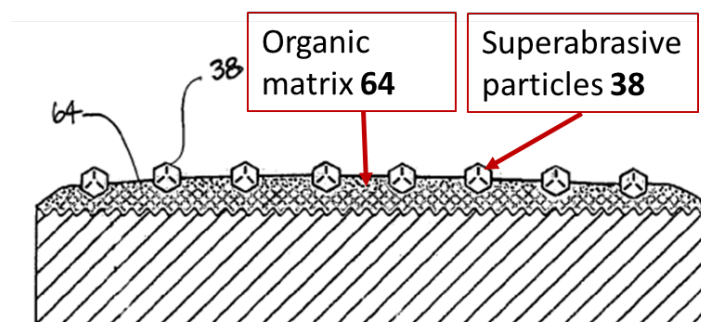
67. Subsequently, as shown in Fig. 5 of Sung’026, the organic material is applied to the spacer layer and cured to bond “at least a portion of each superabrasive particle.” EX1004, [0087]; *see also* EX1001, 17:12-19 (“The portions of the dressing segments protruding from the mask material can then be attached to the rigid support... When an organic material is utilized, methods of

curing the organic material can be a variety of processes known to one skilled in the art that cause a phase transition in the organic material from at least a pliable state to at least a rigid state.”). The cured organic material is referred by Sung’026 as either “organic material layer” and “organic material matrix.” EX1004, [0030].



EX1004, Figure 5 (annotated).

68. After that, the spacer layer is removed to reveal parts of the superabrasive particles, as shown in Fig. 6. Using the process, the “distance of the protrusion of the superabrasive particles 38 from the organic material layer 64” is “approximately equal to the thickness of the now removed spacer layer,” as shown in Figure 6, below. EX1004, [0088]; *see also* EX1001, 17:14-15 (“[A]fter which (or during which), the masking material can be removed.”).



EX1004, Fig. 6 (annotated).

69. Sung'026 discloses that this method is suitable for making CMP pad dressers with superabrasive particles "arranged such that their tips vary from the designated profile by less than about 1 microns." EX1004, [0056], [0073]. In other words, Sung'026 teaches that the superabrasive particles using this reverse casting method can be arranged so that their tips vary by less than 2 microns.

70. Additionally, Sung'026 discloses that this method can produce a CMP pad dresser with superabrasive particles that protrude sufficiently above the organic matrix such that they can "produce a cutting depth of from about 1 micron to about 20 microns when used to abrade a work piece." EX1004, [0010], [0052], claim 5.

B. Overview of SungICPT

71. SungICPT is a publication from an International Conference on Planarization/CMP Technology, held on October 25-27, 2007 in Dresden, Germany. EX1005, Header. I have been informed by counsel that SungICPT is prior art to the '862 Patent.

72. SungICPT also discloses CMP pad conditioners ("diamond pad conditioners"), which "have markedly improved the leveling of diamond tips." EX1005, 1:9-10. SungICPT refers to these CMP pad conditioners as "organic diamond disk (ODD)," which, as the CMP pad dressers disclosed by Sung'026 and

the '862 Patent, are made by “reverse casting.” EX1005, 1:9-11; EX1004, [0083]; EX1001, 17:8-15. In particular, SungICPT teaches that “[d]ue to pre-leveling of the diamond tips, their height variation is within 20 microns.” EX1005, 2:2-3. Since “because the diamond tips are leveled to a much tighter range, the distribution of the dressing stress is much more uniform,” EX1005, 3:3-4, and “all diamond grits are sharing the dressing work.” EX1005, 1:11-14.

73. SungICPT also provides photographs of a CMP pad dresser made using such reverse casting process. In particular, SungICPT shows ODD having diamond particles in the peripheral part of the disk, with the center devoid of superabrasive particles.

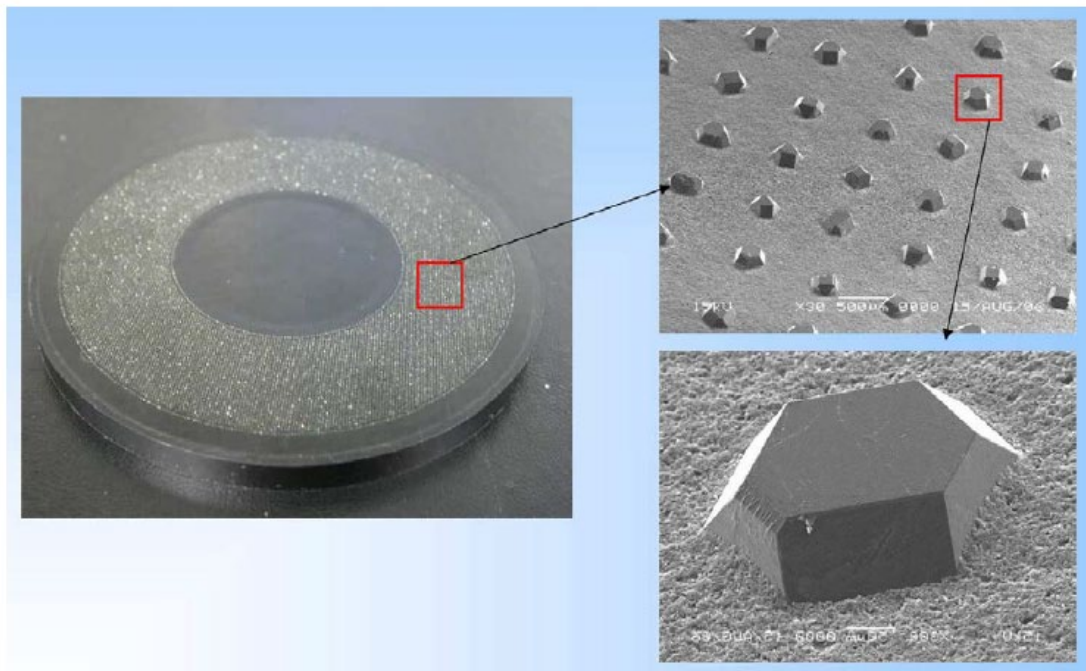


Fig. 3: The bonding conditions of diamond in the epoxy matrix.

EX1005, Figure 3.

VII. Claim Construction

74. I have been asked to determine if any particular claim terms should be construed so the Board can understand how the prior art references read on the challenged claims. As such, I have reviewed the claims, specification, and file history of the '862 Patent.

75. As I further describe below, I found specific definitions for several terms the '862 Patent recites in the claims. These include the terms “dresser,” “superabrasive,” “particles,” “protrusion,” “peripheral location,” “substantially,” and “about.”

A. “dresser”

76. The term “dresser” is used in claims 1-10. The '862 Patent defines this term as follows: “[a]s used herein, the terms ‘conditioner’ and ‘dresser’ can be used interchangeably, and refer to a tool used to condition or dress a pad, such as a CMP pad.” EX1001, 3:9-11.

B. “superabrasive”

77. The term “superabrasive” is used in claims 1-5 and 9-10. The '862 Patent 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, 3:32-34. The '862 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, 3:36-40.

C. “particles”

78. The term “particles” is used in claims 1-5 and 9-10. The ’862 Patent this term as follows: “[a]s used herein, ‘particle’ is as used herein in connection with diamond particles, and refers to a particulate form of diamond.” EX1001, 3:66-4:1.

D. “protrusion”

79. The term “protrusion” is used in claim 1. The ’862 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, 10:26-28.

E. “peripheral location”

80. The term “peripheral location” is used in claims 5-10. The ’862 Patent defines this term as follows: “[a]s used herein, “peripherally located,” “peripheral location” and the like, mean any particle of a dresser that is located in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser.” EX1001, 4:30-39.

F. “substantially”

81. The term “substantially” is used in claims 5, 9, and 10. The ’862 Patent defines this term as follows: “[a]s used herein, the term “substantially” refers to the complete or nearly complete extent or degree of action, characteristic, property, state, structure, item, or result.” EX1001, 6:9-11.

G. “about”

82. The term “about” is used in claims 1, 6-8, and 15. The ’862 Patent defines this term as follows: the term “about” is used to provide flexibility to a numerical range endpoint by providing that a given value may be ‘a little above’ or ‘a little below’ the endpoint.” EX1001, 6:29-31.

VIII. Specific Invalidity Grounds

83. As I explained in Paragraph 36, I conclude that claims 1-20 of the ’862 Patent are rendered obvious by the prior art. In the sections below, I explain in detail how claims 1-20 of the ’862 Patent are not patentable over prior art.

A. Ground I: Sung’026 Anticipates or Sung’026 Renders Obvious Claims 1-6, 9-12, and 20

84. In my opinion, claims 1-4, 11, 12, and 20 are all anticipated or at minimum rendered obvious by Sung’026 for at least the following reasons.

1. Independent Claim 1

i. [1Pre] A method of conditioning a CMP pad, comprising:

85. In my opinion Sung'026 discloses [1Pre].

86. I understand that the preamble may not limit the claims. Regardless, Sung'026 is directed to CMP pad dressers that are used to condition CMP pads. EX1004, [0004] ("CMP pad dresser can be used to revive the pad surface by "combing" or "cutting" it. This process is known as "dressing" or "conditioning" the CMP pad."), EX1004, [0009] ("the present invention provides superabrasive tools and methods that are, without limitation, suitable to groom the CMP pads used for the delicate polishing applications").

ii. [1A] pressing a CMP pad dresser against a CMP pad,

87. In my opinion, Sung'026 discloses [1A].

88. As I already discussed in Paragraph 76, "dresser" means "a tool used to condition or dress a pad, such as a CMP pad." EX1001, 3:9-11.

89. As I already discussed above in Paragraph 86, Sung'026 teaches CMP pad dressers. EX1004, [0009] ("the present invention provides superabrasive tools and methods that are, without limitation, suitable to groom the CMP pads used for the delicate polishing applications"). An example of such a CMP pad dresser is

shown in FIG. 1 of Sung'026, which illustrates a “cross-sectional view of a CMP pad dresser.” EX1004, [0019].

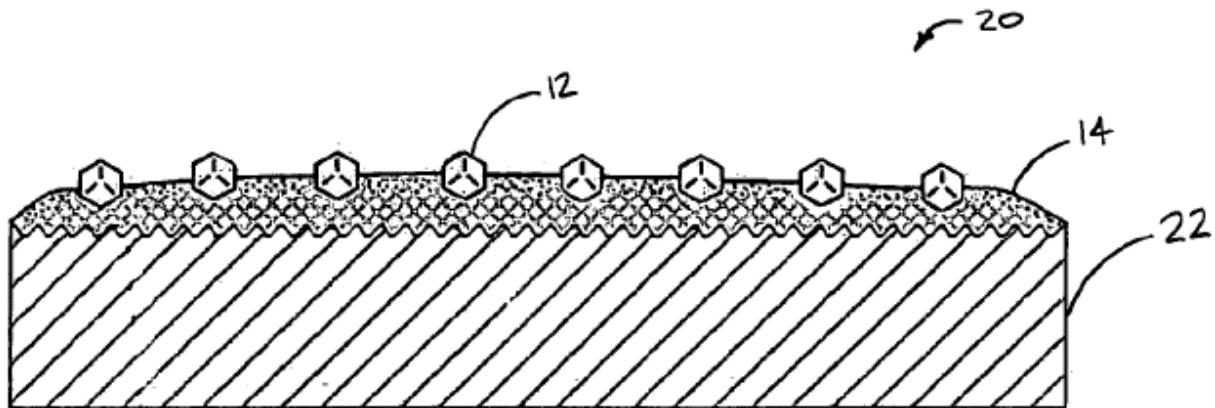


FIG. 1

EX1004, Figure 1.

90. As the name implies, the CMP pad dresser is used to condition the CMP pad. EX1004, [0004] (“A CMP pad dresser can be used to revive the pad surface by “combing” or “cutting” it. This process is known as “dressing” or “conditioning” the CMP pad.”). This conditioning process includes physical contact between the CMP pad dresser and the CMP pad; therefore, the individual particles on the CMP pad dresser experience mechanical stress. Sung'026 teaches ways to distribute the “frictional forces” across substantially each superabrasive particle to improve particle retention. EX1004, [0051]. For instance, Sung'026 teaches that the superabrasive particles can be arranged such that the mechanical

stress impinging on the protruding portion of any individual superabrasive particle is minimized when the CMP pad is abraded. EX1004, [0051]. Sung'026 also discloses that the superabrasive particles can be arranged so that the frictional forces are uniformly distributed across substantially each superabrasive particle. EX1004, [0051].

91. Since frictional forces on the CMP pad dresser described by Sung'026 can only be the result of the CMP pad being pressed against another object (e.g., a CMP pad dresser), Sung'026 discloses pressing a CMP pad dresser against a CMP pad.

iii. [1B] the dresser including a monolayer of a plurality of superabrasive particles protruding from a matrix layer,

92. In my opinion, Sung'026 teaches [1B].

93. As I already discussed in Paragraph 77, “superabrasive” means “crystalline or polycrystalline material or mixture of such materials which has a Mohs hardness of about 8.0 or greater.” Furthermore, as I already discussed in Paragraph 78, the term “particle” is used in the '862 Patent “in connection with diamond particles and refers to a particulate form of diamond.” Additionally, diamond has a Mohs hardness of 10, which meets the '862 Patent's definition of “superabrasive.” See EX1013, showing that Mohs hardness of diamond is 10. Accordingly, a diamond particle is a “superabrasive particle.”

94. Sung'026 discloses a CMP pad dresser having “a single layer of superabrasive particles in an organic material matrix.” EX1004, [0074]. See also EX1004, [0072] (“Tools may incorporate a single layer or multiple layers of superabrasive particles.”), [0001] (“The present invention relates generally to tools having superabrasive particles embedded in an organic material matrix and associated methods.”), [0099]. Accordingly, Sung'026 teaches CMP pad dressers with a “monolayer of a plurality of superabrasive particles.”

95. Additionally, Sung's superabrasive particles are diamond particles and as such, have Moh[s hardness of about 8.0 or greater. EX1004, [0016] (“For example, the plurality of superabrasive particles may include, without limitation, diamond, polycrystalline diamond...”), [0071] (“[T]he superabrasive particle may be diamond...”), [0094], [0096], [0098]-[0099], [0101]-[0104]; see also EX1001, 3:32-45.

96. Last, as I have already alluded to, Sung'026 teaches that “each of the plurality of superabrasive particles may protrude to a predetermined height above the solidified organic material layer.” EX1004, [0010]. See also EX1004, [0096] (“After hot pressing, the clay is scraped off, exposing the diamond particles protruding from the polyimide resin layer.”), [0011], [0051]-[0053], [0056], [0073], [0076], [0077], [0083], [0088], [0090], [0092], claims 1, 3, 7, 13-15, 31, 36, 41, and 42.

iv. [1C] 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 10 microns

and the difference in protrusion distance between the highest 10 protruding tips of the monolayer of superabrasive particles are within about 20 microns or less; and

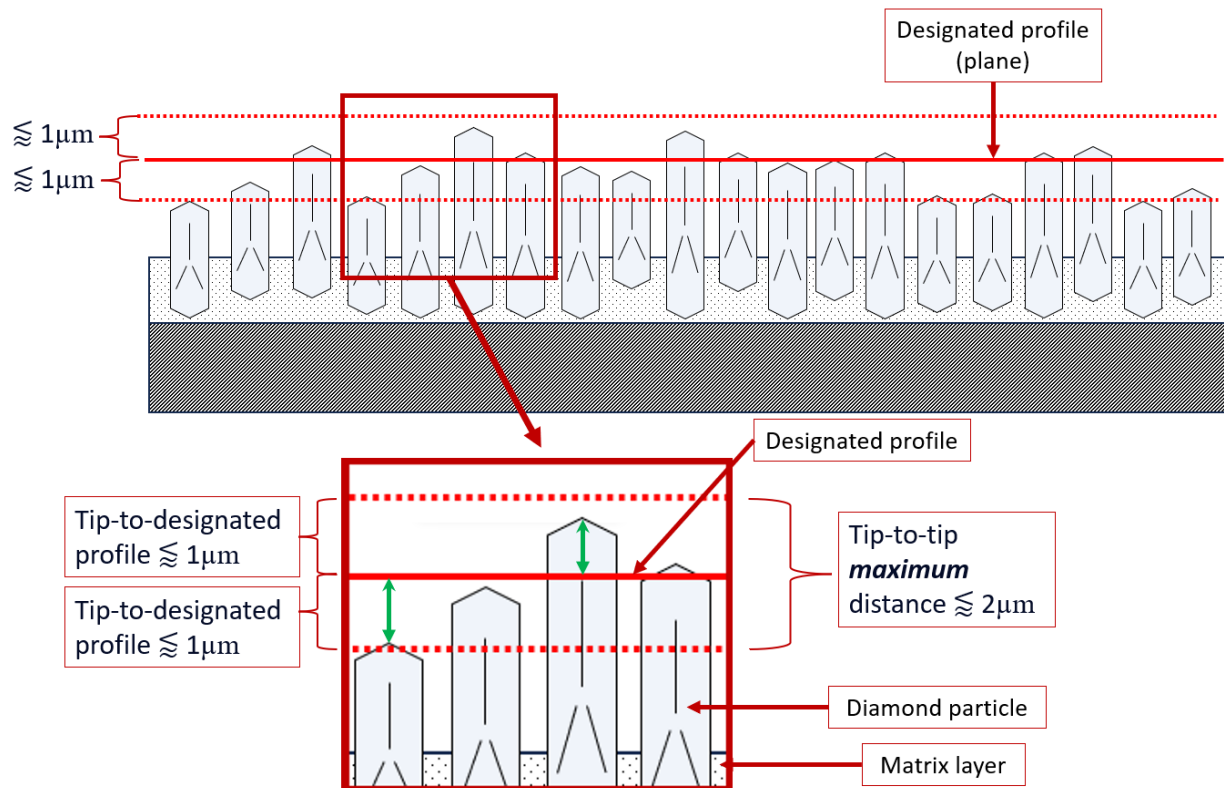
97. In my opinion, Sung'026 teaches [1C].

98. As I discussed in Paragraph 79, “protrusion” means “the height of a particle relative to some reference point.”

99. As an initial matter, Sung'026 teaches that “*each* of the plurality of superabrasive particles protrudes to a predetermined height above the solidified organic material layer.” EX1004, [0073], claim 31. In particular, the protrusion height is measured “along a designated profile.” EX1004, claim 36. This “designated profile” can be a plane. EX1004, claim 36, [0053] (explaining that “[i]t may also be beneficial for the superabrasive particles to protrude from the solidified organic material layer to a predetermined height or series of heights that is/are along a designated profile. ... In one aspect, the designated profile may be a plane.”).

100. I have provided a schematic that illustrates this further. In particular, I am showing a designated profile, which is a plane (see the horizontal line in red).

The diamond particles all protrude to a predetermined height as measured from the designated profile.



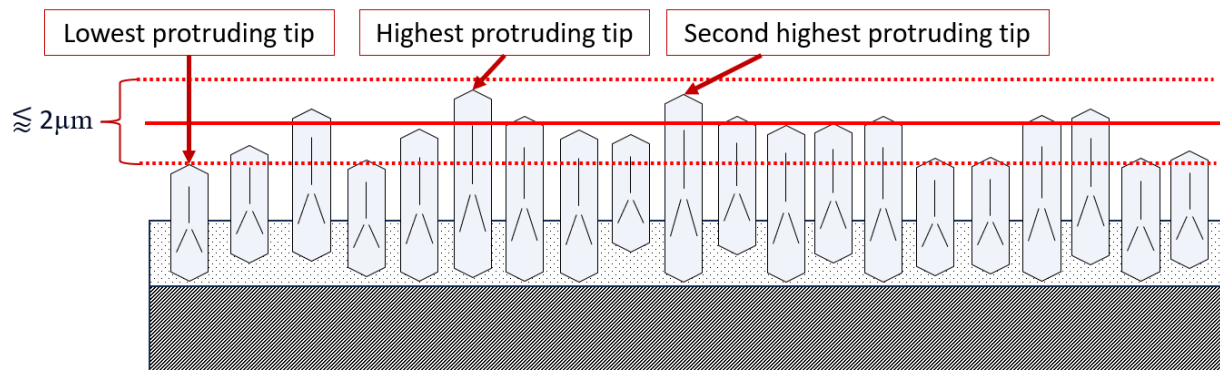
101. In the schematic above, I show that the diamond particles do not all protrude to the same height. Sung'026 teaches that in instances where the designated profile is a plane, it is intended that "the highest protruding points of the superabrasive particles are ... level"). EX1004, [0053]. Nevertheless, Sung'026 admits that some height deviation may occur due to limitations inherent in the manufacturing process. EX1004, [0053].

102. Sung'026 provides further details about the deviation from the designated profile. Specifically provides an embodiment where "*the plurality of*

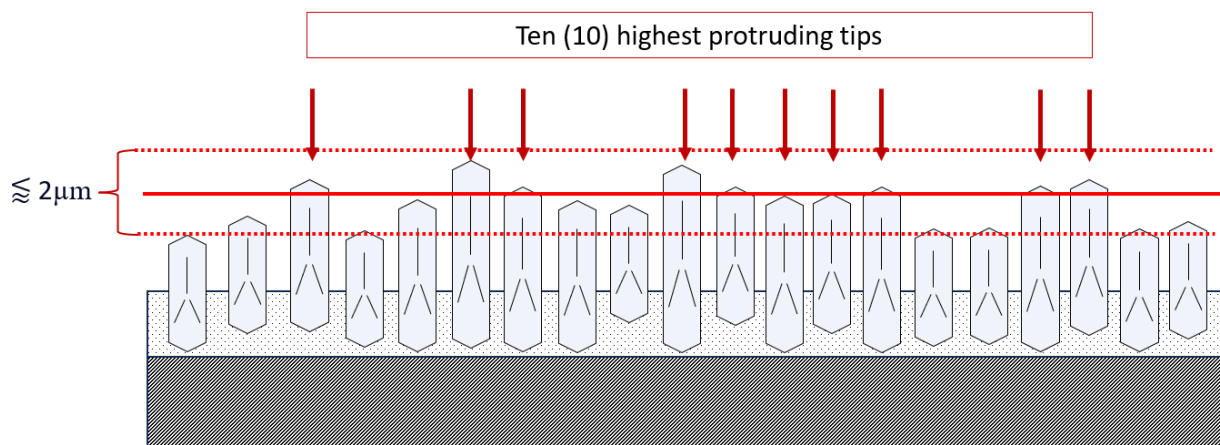
superabrasive particles is arranged such that their tips vary from the designated profile by less than about 1 microns.” EX1004, [0056]; *see also* EX1004, [0073] (“For example, in one aspect *each* of the plurality of superabrasive particles may protrude to a predetermined height above the solidified organic material layer.”).

103. The schematic above illustrates this particular embodiment, where each tip is within less than about 1 micron below or within less than about 1 micron above the designated profile. As can be seen, this produces a maximum tip-to-tip variation (i.e., the difference in protrusion distance between the highest protruding tip and the lowest protruding tip) of less than about 2 microns.

104. As I have illustrated in a second schematic below, because the maximum tip-to-tip variation between all tips is within 2 microns, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles must also be less than about 2 microns, which is within the claimed “less than or equal to about 10 microns.”



105. Similarly, as I have shown below, since the maximum tip-to-tip variation for all superabrasive diamond particles is less than about 2 microns, the difference in protrusion distance between the highest 10 protruding tips of the monolayer of superabrasive particles must also be less than about 2 microns. This is within the claimed “about 20 microns or less.”



106. As I noted in Paragraph 28, I understand that a claim is anticipated if prior art teaches a specific value (or smaller range) within that claimed range. But I also understand that this disclosure of Sung’026 would not provide written description support for this limitation because the claim limitation is claiming a concept that overlaps with or encompasses what Sung’026 teaches. In my opinion, Sung’026 anticipates [1C] because Sung’026 discloses that all superabrasive particles have a tip-to-tip variation within 2 microns.

107. Alternatively, in my opinion, a POSITA based on the teachings of Sung’026 would have found it obvious to level the diamond tips of the CMP pad

dresser as recited in [1C]. In particular, Sung'026 teaches that “the particle tip height must be precisely leveled in order to uniformly dress the pad.” EX1004, [0006]. Sung'026 also teaches that the “traditional” pad dressers with particle tip height variations of more than 50 μm are unsuitable for applications for applications where the asperity depth of 20 μm or less is desired. EX1004, [0006]. Sung'026 also discloses that “the highest protruding points of the superabrasive particles are intended to be substantially level.” EX1004, [0053]. In addition, as I explained above, Sung'026 describes that it is possible to make a CMP pad dresser with a maximum tip-to-tip protrusion difference of less than about 2 microns. EX1004, [0056], [0073].

108. Additionally, Sung'026 discloses that a “reverse casting” process can be used to achieve the desired small variation of the protrusion tip distance. EX1004, [0083] (“Various reverse casting methods may be utilized to manufacture the CMP pad dresser...”). Indeed, this is the same method taught by the '862 Patent. EX1001, 17:8-15 (“[S]o-called ‘reverse casting’ methods can be used to accurately orient and attach the dressing segments to the rigid support.”). As such, in my opinion, not only would a POSITA have been motivated to make the protrusion height difference as small as possible based on the teachings of Sung'026, but a POSITA would have been able to make such CMP pad dressers

with a tip-to-tip variation of less than about 2 microns, using the reverse casting methods, with a reasonable expectation of success.

- v. **[1D] rotating the dresser against the CMP pad such that asperities are cut into the CMP pad having a maximum cutting depth of about 60 microns.**

109. In my opinion Sung'026 discloses [1D].

110. Sung'026 characterizes the CMP pad dresser as a “rotating tool.” *See* EX1004, [0057] (“[I]n the case circumferentially *rotating tools* such as CMP pad dressers...”), [0012], [0054]. Sung'026 also teaches that the CMP pad dressers are used to condition a CMP pad and thus teaches that the CMP pad dressers are rotated against the CMP pad. *See* EX1004, [0004] (“A CMP pad dresser can be used to revive the pad surface... This process is known as ‘dressing’ or ‘conditioning’ the CMP pad.”).

111. As I explained in Paragraph 102, Sung'026 discloses that “*each* of the plurality of superabrasive particles may protrude to a predetermined height above the solidified organic material layer.” EX1004, [0010], [0052], claims 4-6. Sung'026 also discloses that this “predetermined height may produce a cutting depth of from about 10 micron[s] to about 20 microns when used to abrade a work piece.” *Id.* As I noted in Paragraph 28, I understand that a claim is anticipated if prior art teaches a specific value (or smaller range) within that claimed range.

Accordingly, in my opinion, Sung'026 anticipates [1D] because Sung'026 discloses a cutting depth within the range recited in [1D].

2. Dependent Claims 2-4

- i. [2] The method of claim 1, wherein at least 100 tips of the plurality of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.

[3] The method of claim 1, wherein at least 50 tips of the plurality of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.

[4] The method of claim 1, wherein at least 25 tips of the plurality of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.

112. In my opinion, Sung'026 discloses the added limitations in [2]-[4].

113. As I already discussed in Paragraph 110, the CMP pad dresser is a rotating tool and accordingly it rotates while cutting the asperities. EX1004, [0004], [0012], [0054], [0057].

114. Sung'026 also discloses that at least a “*majority* of the plurality of superabrasive particles may protrude to a predetermined height above the solidified organic material layer.” EX1004, [0052]. Sung'026 continues to state that such “predetermined height may produce a cutting depth of from about 1 micron to about 20 microns when used to abrade a work piece.” EX1004, [0052]; *see also* EX1004, [0076] (“The protruding superabrasive particles 12 can cut into the CMP pad to a depth that is essentially the distance of the protrusion.”), claims 3-6.

115. Even more so, as I explained in Paragraph 111, Sung'026 teaches CMP pad dressers where each superabrasive particle protrudes to a predetermined height and produces a cutting depth, *i.e.*, cut the pad. EX1004, [0010], [0052], claims 4-6 (“each of the plurality of superabrasive particles may protrude to a predetermined height above the solidified organic material layer ... [to] produce a cutting depth of from about 10 micron[s] to about 20 microns when used to abrade a work piece.”). Indeed, Sung'026 teaches specific arrangements of the superabrasive particles that distribute the frictional forces uniformly across all superabrasive particles. EX1004, [0051] (“arrangement of the plurality of superabrasive particles may be configured to uniformly distribute frictional forces across substantially *each* superabrasive particle[, and that s]uch a uniform distribution of frictional force prevents any individual superabrasive particle from being overstressed and pulling out of the solidified organic material layer.”). *See also* EX1004, [0075], claim 2. Since each superabrasive particle on the CMP pad dresser cuts to produce asperities and experiences uniform frictional force, all of the superabrasive particles contribute to cutting asperities. SungICPT confirms this by stating that “*all* diamond grits are sharing the dressing work” in ODD made by the same reverse casting process. EX1005, 1:12-13.

116. While Sung'026 does not explicitly disclose the number of diamond particles on the CMP pad dresser, Sung'026 includes parameters such as disk size

and diamond-to-diamond spacing, from which a POSITA would be able to calculate this parameter. For instance, in Example 1, Sung'026 discloses a CMP pad dresser having a 100 mm diameter and a diamond-to-diamond spacing of about 500 microns. EX1004, [0094] (“80/90 mesh diamond particles ... are arranged with a template on a 100 mm diameter, 10 mm thick flat base plate. The diamond particles form a grid pattern with an inter-diamond pitch of about 500 microns ... The final product is a pad conditioner with uniformly exposed diamonds.”). Sung'026 discloses that “‘grid’ means a pattern of lines forming multiple squares.” EX1004, [0040].

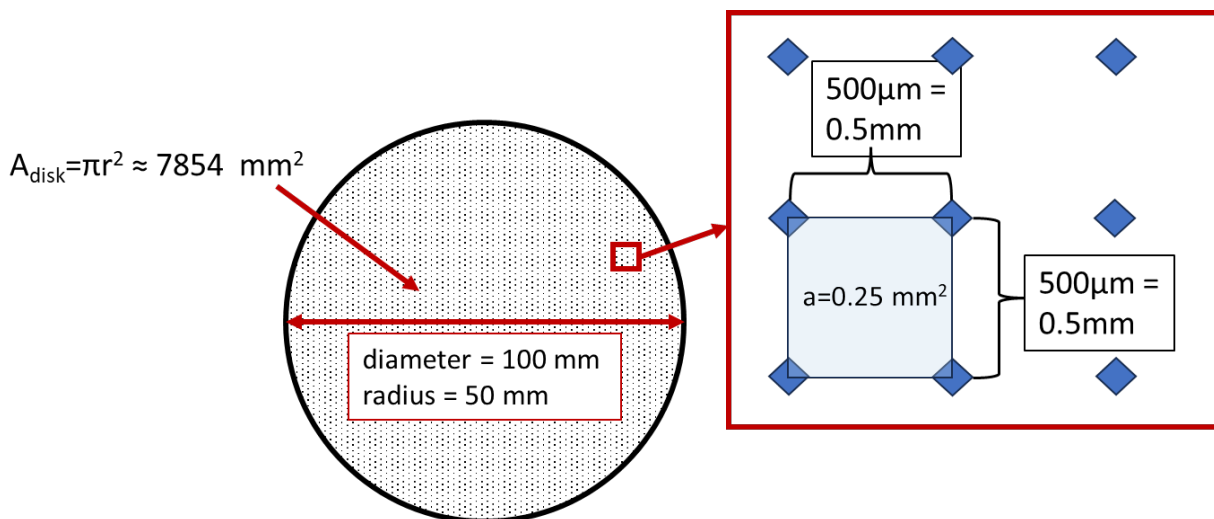
117. I have provided a schematic below showing the calculations. Since the diamonds are in a square pattern with a distance of 500 microns between them, the CMP pad dresser has one diamond grit per about 0.25 mm^2 . The total area of the disk, which is a circle, can be calculated using the formula $A=\pi r^2$, where r is the disk's radius, i.e., $\frac{1}{2}$ of the diameter. As shown in the schematic below, the total area calculated is $7,854 \text{ mm}^2$.

118. Since there is 1 diamond grit per about 0.25 mm^2 , the CMP pad dresser includes $7854/0.25 = 31,416$ *diamond particles* that cut asperities into the CMP pad.

119. As Sung'026 discloses that “a *majority* of the plurality of superabrasive particles may protrude to a predetermined height above the solidified

organic material layer” and that such “predetermined height may produce a cutting depth of from about 1 micron to about 20 microns when used to abrade a work piece,” at a minimum more than half, i.e., more than about **15,708 diamond particles** contribute to cutting asperities into the CMP pad.

120. Regardless of whether all or only a majority of the diamond particles in the CMP pad dresser cut asperities in the CMP pad as the dresser is rotated, the number of such particles in Sung’026’s CMP pad dresser is significantly larger (multiple orders or magnitude larger) than the claimed 25, 50, and 100 tips of claims 2-4. Therefore, in my opinion, Sung’026 discloses [2]-[4].



3. Dependent Claim 9

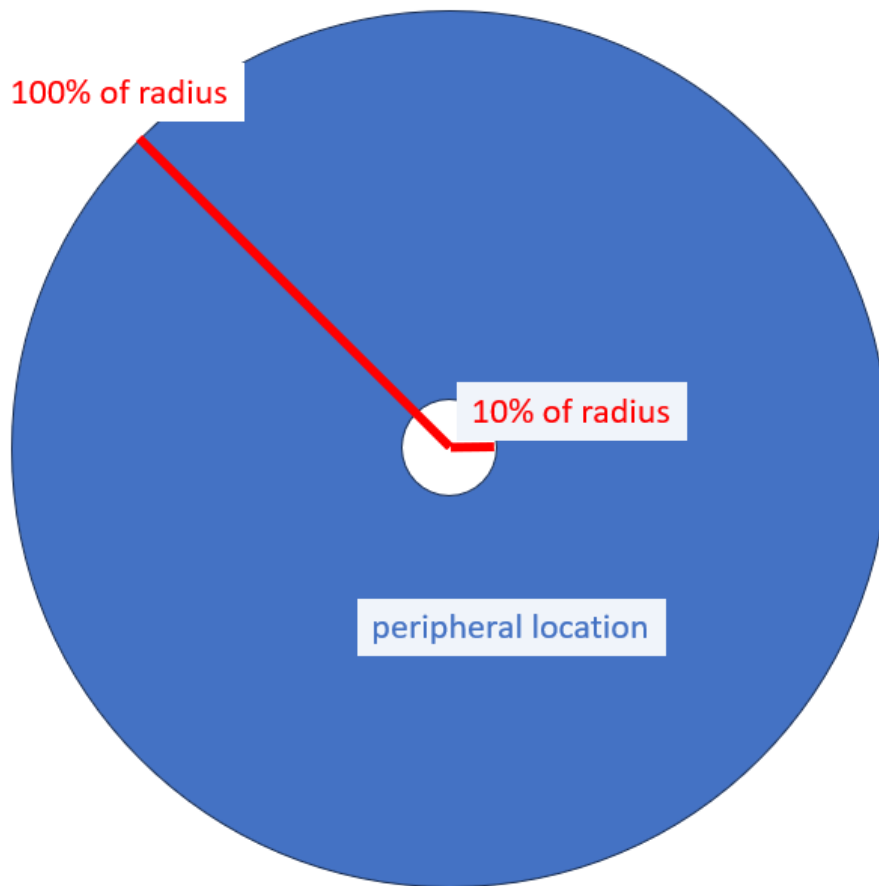
- i. [9] The method of claim 1, wherein substantially all of the superabrasive particles are located at a peripheral location of the dresser.

121. I conclude that Sung’026 discloses [9].

122. As I discussed in Paragraph 81, the term “substantially” refers to the complete or nearly complete extent or degree of action, characteristic, property, state, structure, item, or result.”

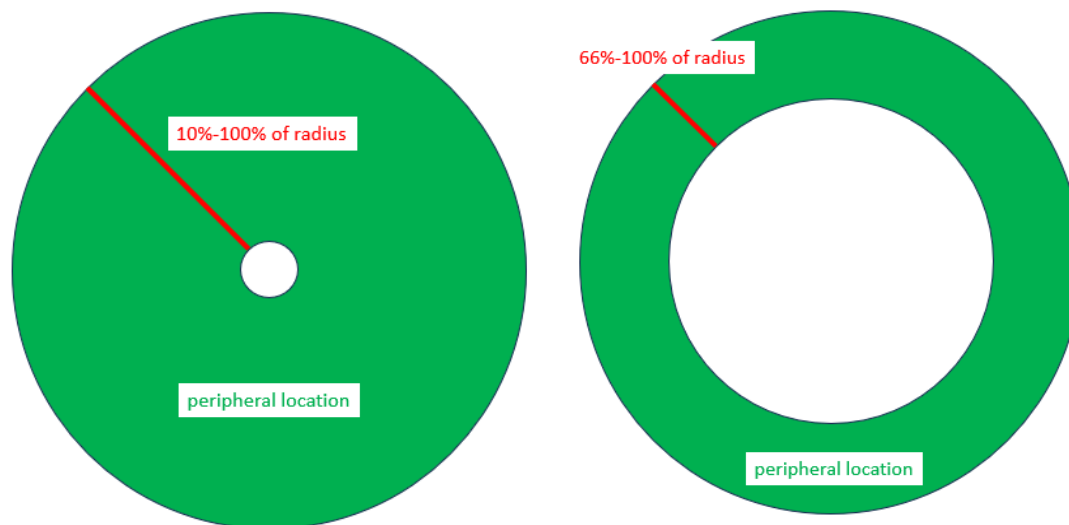
123. Additionally, as I discussed in Paragraph 80, the term “peripheral location” refers to “any particle of a dresser that is located in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser.” *See* also EX1001, 4:30-39. This means that the '862 Patent discloses that the peripheral location of the disk is the annulus that extends outwardly from about 10% to 100% of the radius. To be clear, this disclosure of the '862 Patent also includes embodiments where the annulus extends outwardly from about 20% to 100% of the radius, 33% to 100%, from about 50% to 100% of the radius etc., because it is ***up to*** 90% in the definition of the “peripheral location.” *See* EX1001, 6:41-59 (“Concentrations, amounts, and other numerical data may be expressed or presented herein in a range format. It is to be understood that such a range format is used merely for convenience and brevity and thus should be interpreted flexibly to include not only the numerical values explicitly recited as the limits of the range, but also to include all the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. As an illustration, a numerical range of “about 1 to about 5” should be interpreted to include not only

the explicitly recited values of about 1 to about 5, but also include individual values and sub-ranges within the indicated range. Thus, included in this numerical range are individual values such as 2, 3, and 4 and sub-ranges such as from 1-3, from 2-4, and from 3-5, etc.”).

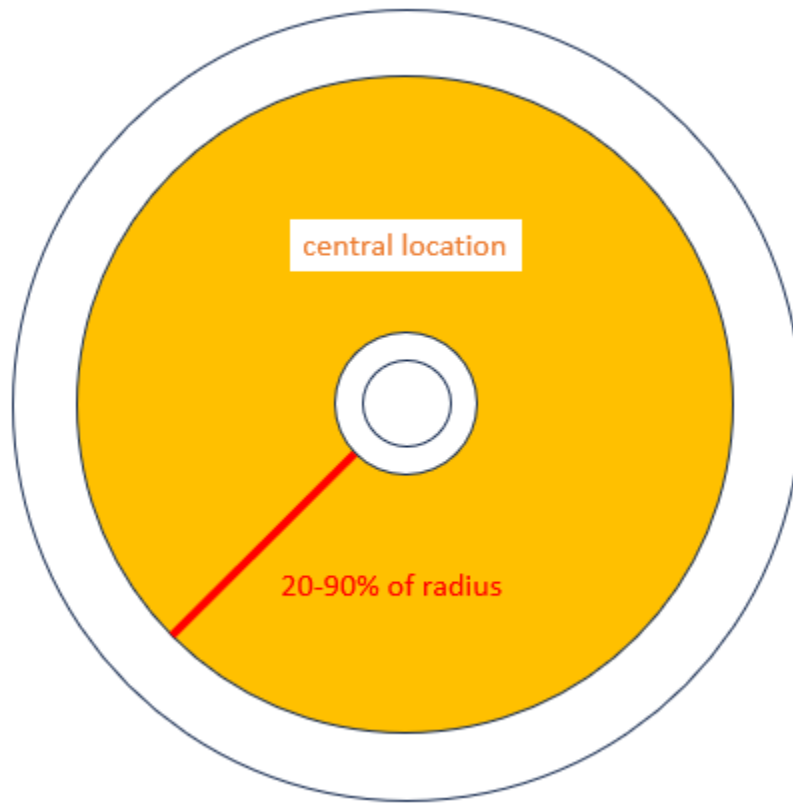


124. Sung’026 discloses an embodiment where the superabrasive particles are only in the area that extends outwardly from about 20% to 100% of the radius, which is encompassed by the definition of the peripheral location in the ’862 Patent.

125. First, Sung’026, like the ‘862 Patent teaches that a “peripherally located” particle is “in an area that originates at the leading edge or outer rim of a tool and extends inwardly towards the center for up to about 90% of the radius of the dresser. ... In yet another aspect, the area may extend out to about 33% of the radius of a tool.” *See* EX1004, [0037]. To differentiate the claimed “peripheral location” and Sung’026’s discussion of the “peripheral location,” I will color Sung’026’s discussion of peripheral location in green. As shown, Sung’026 also teaches that the peripheral location of the disk is the annulus that extends outwardly from at least about 10% to 100% or from about 66% to 100% of the radius.

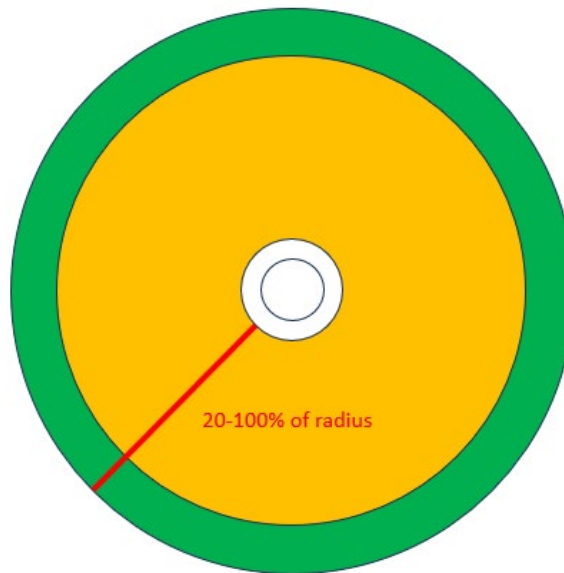


126. Second, Sung’026 teaches that a “central location” can mean an “area [that] may extend outwardly from about 20% to about 90% of the radius.” EX1004, [0036].



127. Third, Sung'026 provides multiple embodiments where the particles are located in the peripheral and central areas of the CMP pad dresser. *See* EX1004, [0012] ("In one aspect, superabrasive particles in a central location of the abrading tool may be larger in size than superabrasive particles in a peripheral location on the abrading tool."), [0013], [0014] ("In a further aspect, superabrasive particles in a central location on the abrading tool may be spaced farther apart than superabrasive particles in a peripheral location on the abrading tool."), [0054], [0057], [0058], and [0060].

128. Putting this together, and because “central location” is generally thought of as an area that is inside a “peripheral location,” Sung’026 provides an embodiment where the superabrasive particles are located in the area that extends outwardly from 20% to 100% of the radius of the CMP pad dresser. In other words, Sung’026 teaches regions colored in orange and green that have superabrasive particles and are encompassed by the claimed “peripheral location,” which, as I explained above in Paragraph 123, ranges from about 10% to 100% of the radius.



129. Therefore, Sung’026 teaches that all superabrasive particles are located within the claimed “peripheral location,” and teach the added limitation of [9].

4. Dependent Claim 5

- i. [5] The method of claim 1, wherein substantially all of the asperities are cut in the CMP pad by superabrasive particles located at a peripheral location of the dresser.**

130. As I already explained in Paragraphs 121-129, Sung'026 discloses an embodiment where “substantially all of the superabrasive particles are located at a peripheral location of the dresser.”

131. Since Sung'026 teaches a CMP pad dresser that has all superabrasive particles in a peripheral location of the disk, it necessarily follows that “substantially all of the asperities” are “cut in the CMP pad” by diamond particles that are in the peripheral location of the CMP pad dresser. In fact, Sung'026 explicitly discloses that the “protruding superabrasive particles 12 can cut into the CMP pad” EX1004, [0076].

5. Dependent Claim 6

- i. [6] The method of claim 5, wherein the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 90% of the dresser radius.**

132. As I already explained in Paragraphs 121-131, Sung'026 discloses superabrasive particles that are within “the peripheral location [that] extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 90% of the dresser radius.” For instance, Sung'026 discloses an embodiment where all superabrasive particles are located in the periphery, within the area that

extends outwardly from about 20% to 100% of the radius. EX1004, [0012]-[0014], [0026]-[0037], [0054], [0057]-[0058], and [0060]. As such, Sung'026 teaches the added limitation of [6].

6. Dependent Claim 10

- i. [10] The method of claim 1, wherein substantially all of the superabrasive particles are arranged in uniform predetermined pattern at a peripheral location of the dresser.**

133. I conclude the Sung'026 discloses or renders obvious [10].

134. As I already explained in Paragraphs 121-129, Sung'026 teaches superabrasive particles that are arranged within a peripheral location of the dresser.

135. Sung'026 also teaches that the superabrasive particles can be arranged in a regular grid pattern. EX1004, [0094] (“The diamond particles form a grid pattern with an inter-diamond pitch of about 500 microns.”); EX1004, [0040] (“As used herein, ‘grid’ means a pattern of lines forming multiple squares.”), claim 25 (“wherein the plurality of superabrasive particles are evenly spaced at a distance of from about 3 times to about 5 times the average size of the superabrasive particles.”). Therefore, Sung'026 discloses [10].

7. Dependent Claim 11

- i. [11A] The method of claim 1, further comprising: rotating the CMP pad;**

136. In my opinion, Sung'026 teaches [11A].

137. Sung’026 discloses that the CMP pad rotates during the polishing process. EX1004, [0002], (“Such polishing processes generally entail applying the wafer against a *rotating pad* made from a durable organic substance such as polyurethane. A chemical slurry is ... continually added to the *rotating CMP pad*, and the dual chemical and mechanical forces exerted on the wafer cause it to be polished in a desired manner.”), [0012], [0054], [0057].

ii. [11B] applying a slurry to a polishing surface of the rotating CMP pad;

138. In my opinion, Sung’026 teaches [11B].

139. As I discussed in Paragraph 137, “[a] *chemical slurry* is ... continually added to the rotating CMP pad.” EX1004, [0002]. Sung’026 also discloses that the “*chemical slurry* is utilized that contains a chemical capable of breaking down the wafer substance and an amount of abrasive particles which *act to physically erode the wafer surface.*” EX1004, [0002].

140. Therefore, Sung’026 discloses that the CMP pad is polished by “the dual chemical and mechanical forces exerted on the wafer.” EX1004, [0002]; *see also* EX1004, [0004]-[0005], [0081], [0098].

iii. [11C] applying a workpiece to the polishing surface such that the workpiece is polished by the asperities in combination with the slurry.

141. In my opinion Sung’026 teaches limitation [11C].

142. Sung'026 teaches that “a chemical mechanical polishing (CMP) process [is used] for polishing certain *work pieces*... [and that s]uch polishing processes generally entail applying the wafer against a rotating pad made from a durable organic substance such as polyurethane.”). EX1004, [0002].

143. Sung'026 also discloses that the wafer is polished by the combination of the asperities and the slurry. EX1004, [0002] (“chemical slurry ... is continually added to the rotating CMP pad, and the dual chemical and mechanical forces exerted on the wafer cause it to be polished in a desired manner.”).

144. Furthermore, Sung'026 explains that during polishing, the asperities “become “clogged,” “depressed and matted,” and, thus a CMP pad dresser is used to cut the pad thus maintaining effective polishing. EX1004, [0004]. And Sung'026 also discloses that the asperity depth needs to be uniform. EX1004, [0005] (“Furthermore, pad dressers that cut asperities in the pad and... that do not overdress the pad must be used.”); EX1004, [0006] (“However, such a variation would render a dresser useless if it were required to dress a CMP pad and achieve a uniform asperity depth of 20 μm or less, for example.”); [0004]. *See also* EX1005, 1:2-4 (confirming that “[t]he polishing rate of a wafer is dependent on the amplitude (height) of pad asperities. The polishing uniformity is controlled by the frequency (density) of such asperities.”).

8. Dependent Claim 12

- i. [12] The method of claim 11, wherein the workpiece is a semiconductor device.**

145. In my opinion, Sung'026 teaches claim 12.

146. Sung'026 discloses CMP pad dressers that are “suitable for dressing a CMP pad that meet the demands placed upon the CMP industry by the continual reductions in semiconductor size.” EX1004, [0008]. Sung'026 also provides additional disclosures teaching that CMP process is generally applied to semiconductors. *See* EX1004, [0002] (“Many industries utilize a chemical mechanical polishing (CMP) process for polishing certain *work pieces*. Particularly, the *computer* manufacturing industry relies heavily on CMP processes for *polishing wafers of* ceramics, *silicon*, glass, quartz, and metals. Such polishing processes generally entail applying the wafer against a rotating pad made from a durable organic substance such as polyurethane.”), [0005] (“Ultra-large-scale integration (ULSI) is a technology that places at least 1 million circuit elements on *a single semiconductor chip*... Therefore, the CMP industry has been required to respond by providing polishing materials and techniques that accommodate these advances.”).

9. Dependent Claim 20

- i. [20] The method of claim 11, wherein the CMP pad is polyurethane.**

147. In my opinion, Sung'026 teaches claim 20, at least because Sung'026 explicitly states that CMP “processes generally entail applying the wafer against a rotating pad made from a durable organic substance such as *polyurethane*.”

EX1004, [0002].

B. Ground II: Sung'026 in Combination with SungICPT Renders Obvious Claims 5-10

1. Dependent Claim 9

- i. [9] The method of claim 1, wherein substantially all of the superabrasive particles are located at a peripheral location of the dresser.**

148. As I already discussed on Paragraphs 121-129, Sung'026 discloses [9].

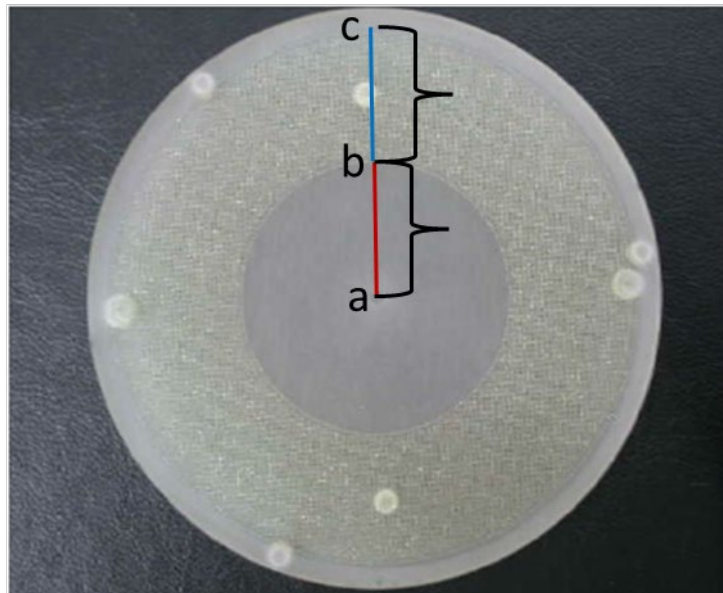
149. Alternatively, in my opinion, Sung'026 with SungICPT renders obvious claim 9.

150. As I discussed in Paragraph 80, a peripherally located particle means that a particle “is located in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser.” EX1001, 4:30-39.

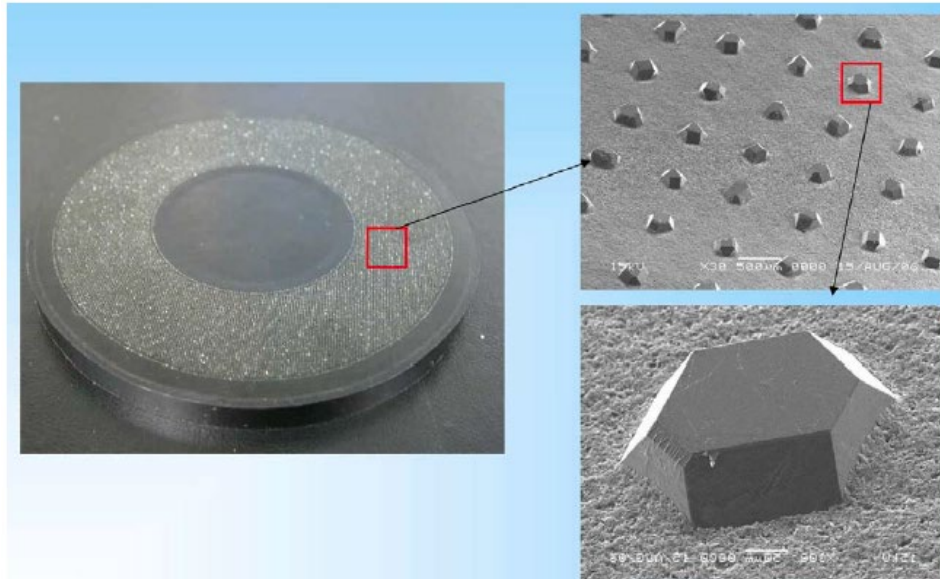
151. Sung'026 also discloses that a "peripherally located" particle is "in an area that originates at the leading edge or outer rim of a tool and extends inwardly towards the center for up to about 90% of the radius of the dresser." EX1004, [0037]. Sung'026 also discloses an embodiment where all superabrasive particles are located in the peripheral location, covering from 20% to 100% of the radius of the dresser. EX1004, [0026]-[0037].

152. In addition to this disclosure, SungICPT provides photographs of CMP pad dressers with substantially all superabrasive particles located at the peripheral location. EX1005, Figs. 1-3. For ease of reference, I have reproduced Fig. 1 of SungICPT, which shows that substantially all diamond particles of the dresser are located in the part of the dresser from the outer rim towards the center for about 50% of the radius of the dresser. I have also reproduced Fig. 3 of SungICPT below, which shows a similar arrangement of the diamond particles.

distance from a to b $\approx$ distance from b to c



EX1005, Figure 1, annotated.



EX1005, Figure 3

153. Therefore, SungICPT also provides an example where *all* of the superabrasive particles are located at a peripheral location of the dresser.

2. Dependent Claim 5

- i. [5] The method of claim 1, wherein substantially all of the asperities are cut in the CMP pad by superabrasive particles located at a peripheral location of the dresser.**

154. As I already explained in Paragraphs 130-131, Sung'026 teaches [5].

155. Alternatively, as I explained in Paragraphs 148-153, Sung'026 in combination with SungICPT teaches the limitation wherein substantially all of the superabrasive particles are located at a peripheral location of the dresser.”

156. SungICPT also discloses embodiments where all superabrasive particles in the CMP pad dresser are in the peripheral location. Therefore, it necessarily follows that all of the asperities cut by SungICPT's CMP pad dresser would be cut by the particles that are located in the peripheral area of the CMP pad dresser.

157. Both, Sung'026 and SungICPT teach that the superabrasive particles cut CMP pad. EX1004, [0076] (“protruding superabrasive particles 12 can cut into the CMP pad to a depth that is essentially the distance of the protrusion.”); EX1005, 1:12-16 (“Moreover, all diamond grits are sharing the dressing work. Consequently, the number of working grits of ODD is significantly higher than conventional designs. Moreover, because no diamond will cut pad unnecessarily, the pad life is greatly lengthened. Furthermore, due to the uniform distribution of pad asperities, the slurry will be held efficiently so the run off is avoided.”); 5:4-5

(“[T]he asperities of the pad dressed by ODD are much more uniform.”), 6:21-22

(“ODD can create densely populated pad asperities that can polish wafers fast but with high uniformity.”).

3. Dependent Claims 6-7

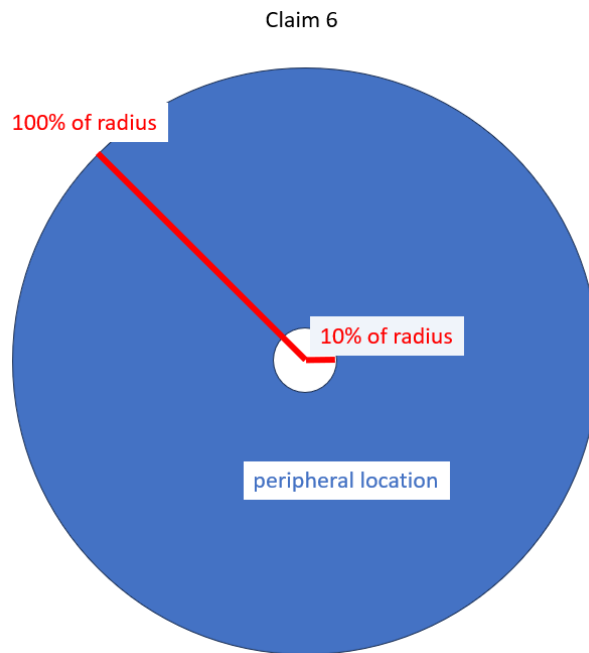
[6] The method of claim 5, wherein the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 90% of the dresser radius.

[7] The method of claim 5, wherein the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 50% of the dresser radius.

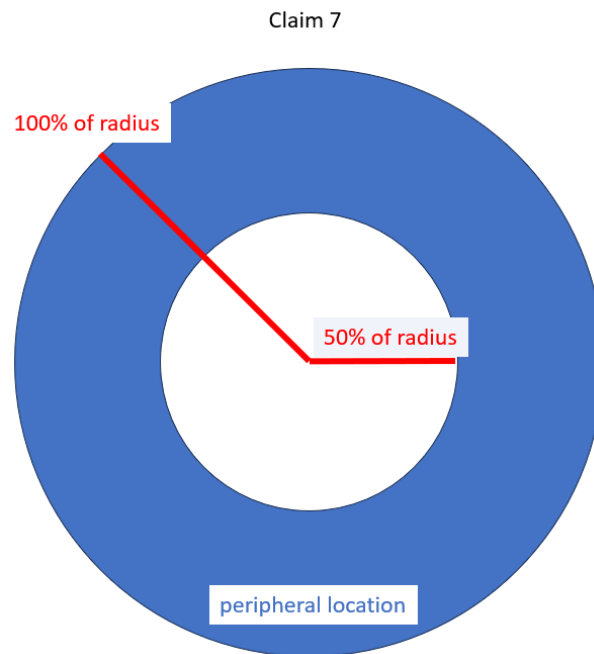
158. As I already explained in Paragraph 132, Sung’026 discloses [6].

Alternatively, Sung’026 with SungICPT renders obvious claims 6-7.

159. It should be noted that claim 6 essentially restates the definition ’862 Patent provides for peripheral location. See EX1001, 4:30-39 (““peripherally located,” “peripheral location” and the like, mean any particle of a dresser that is located in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser.”). In the Figure below, I illustrate the upper limit of the size of the peripheral annulus.

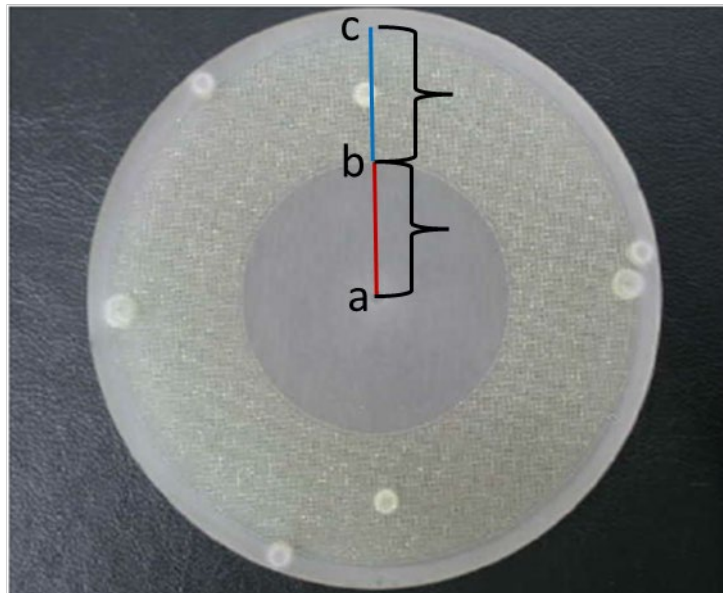


160. Claim 7 recites an embodiment where the peripheral location is smaller, i.e., where the maximum area of the periphery extends from the outer rim of the CMP pad dresser toward the center for up to 50% of the radius. I am illustrating this maximum possible area that would read on claim 7 below:



161. As I discussed above in Paragraph 152, SungICPT shows a CMP pad dresser where substantially all diamond particles are in the peripheral location, and more specifically in the part of the dresser from the outer rim towards the center for about 50% of the radius of the dresser. See EX1005, Fig. 1, which I have once again reproduced below. In my opinion, this embodiment of SungICPT teaches [6] and [7].

distance from a to b $\approx$ distance from b to c



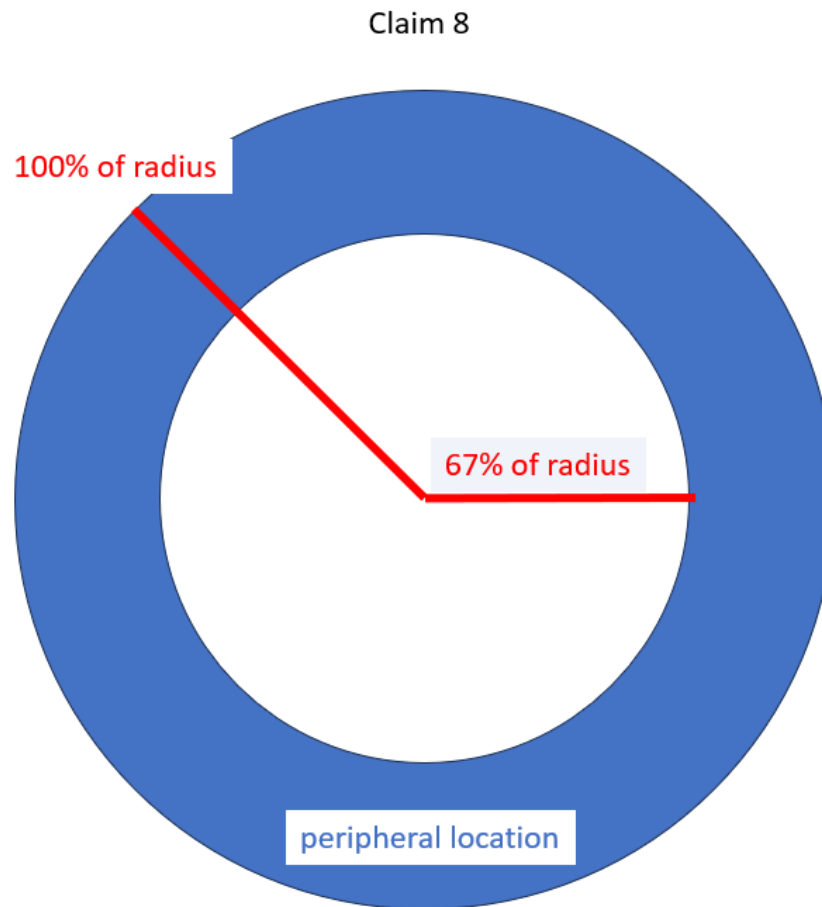
EX1005, Figure 1 (annotated).

4. Dependent Claim 8

- i. [8] The method of claim 5, wherein the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 33% of the dresser radius.

162. I conclude that Sung'026 with Sing ICPT disclose [8].

163. Claim 8 recites an embodiment where the maximum area of the peripheral location extends from the outer rim of the CMP pad dresser toward the center for up to 33% of the radius. I am illustrating this maximum possible area that would read on claim 8 below:



164. As I explained in Paragraph 152, SungICPT shows a CMP pad dresser where substantially all diamond particles are in the peripheral location, and more specifically in the part of the dresser from the outer rim towards the center for about 50% of the radius of the dresser. See EX1005, Fig. 1. SungICPT does not show a CMP pad dresser with particles only in the area that extends from the outer edge of the dresser inwardly toward a center point of the dresser for up to about 33% of the dresser radius. However, in my opinion, a POSITA would have found it obvious to make such a dresser. Specifically, Sung'026 teaches that the

peripherally located particle corresponds to not only embodiments where the particle is “in an area that originates at the leading edge or outer rim of a tool and extends inwardly towards the center for up to about 90% of the radius of the tool,” but also in an area within “about 50% of the radius” and “about 33% of the radius of a dresser.” *See* EX1004, [0037]. And as I discussed above in Paragraph 153, Sung’026 teaches various ways of arranging the superabrasive particles to account for the fact that “superabrasive particles located near the periphery will most likely experience greater frictional force than particles located more centrally due to the greater rotational velocity at the periphery.” EX1004, [0057]; *see also* EX1004, [0057], [0060], [0076]. Therefore, placing all superabrasive particles in the periphery, which SungICPT explicitly teaches, would be an obvious modification that a POSITA would have been able to do with a reasonable expectation of success.

165. In my opinion, it would have been trivial for a POSITA to change the exact boundary of the peripheral location from 50% to 33% because Sung’026 explicitly discloses 33% as an equivalent option to 50%, and it is one of only three explicit numbers provided by Sung’026. EX1004, [0037]. And because covering the area that extends from the outer rim to only about 33% of the radius instead of about 50% of the radius could be easily accomplished by, e.g., using a smaller

amount of diamond particles, a POSITA would have a reasonable expectation of success.

5. Dependent Claim 10

- i. **[10] The method of claim 1, wherein substantially all of the superabrasive particles are arranged in uniform predetermined pattern at a peripheral location of the dresser.**

166. As I already discussed in Paragraphs 133-135, Sung'026 teaches [10].

167. In the alternative, in my opinion, Sung'026 with SungICPT render obvious claim 10.

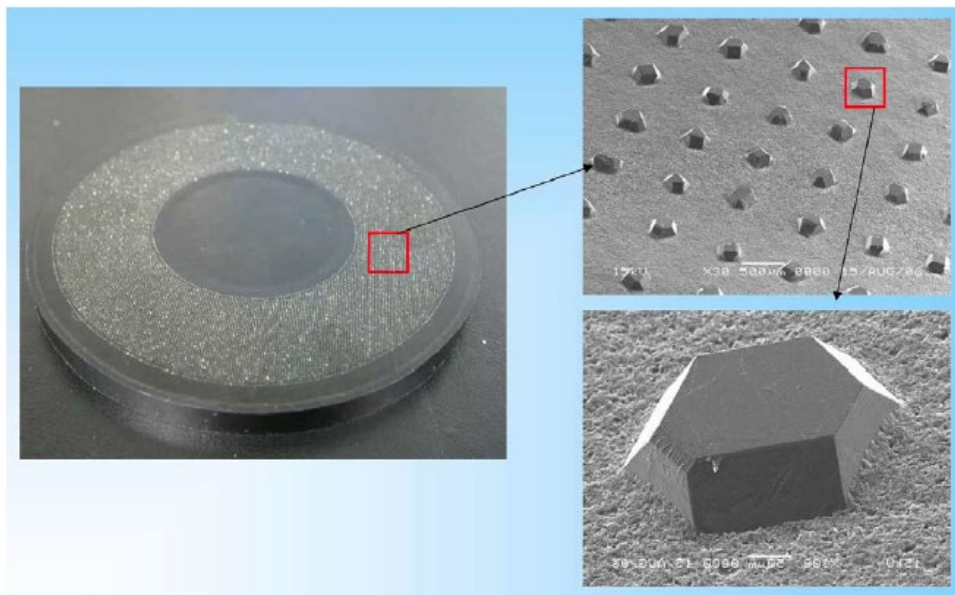
168. As I already discussed in Paragraphs 148-153, the limitation “substantially all of the superabrasive particles are ... at a peripheral location of the dresser” is rendered obvious by the combined disclosures of Sung'026 and SungICPT.

169. In my opinion, the added limitation of claim 10, which recites that the superabrasive particles are “arranged in uniform predetermined pattern,” is also rendered obvious by the combined disclosures of Sung'026 and SungICPT.

170. In particular, Sung'026 discloses that “the plurality of superabrasive particles may be arranged as a grid” and that “in one specific aspect *the plurality of superabrasive particles may be evenly spaced* at a distance of from about 2 times to about 4 times the average size of the superabrasive particles.” EX1004,

[0014], [0060]. Therefore, Sung'026 discloses a CMP pad dresser where the superabrasive particles are “arranged in uniform predetermined pattern.”

171. SungICPT shows a CMP pad dresser with diamond particles in a uniform grid pattern only in the peripheral location of the disk. *See* EX1005, Fig. 3, reproduced below.



EX1005, Figure 3.

172. SungICPT also teaches the benefits of such uniform grid spacing in its Organic Diamond Disk dresser by stating that “the uniform spacing of diamond grits and their controlled tip heights [ensure that] none of the diamond grits will be overly stressed.” EX1005, 1:11-12.

173. It would have been obvious to combine Sung'026 with SungICPT for at least the following four reasons.

174. First, Sung'026 and SungICPT are all directed to abrasive tools and are analogous to the claims of the '862 Patent. EX1004, [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."); EX1005, Title ("The Organic Diamond Disk (ODD) for Dressing Polishing Pads of Chemical Mechanical Planarization."); EX1001, claim 1 ("A method of conditioning a CMP pad").

175. Second, each Sung'026 and SungICPT discloses that the performance of the CMP pad dressers is better if the superabrasive particles are leveled. EX1004, [0056] ("In yet another aspect, the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by less than about 1 microns."), [0073] ("By minimizing the variance in the protrusion of the plurality of superabrasive particles above the solidified organic material layer, mechanical forces impinging on individual superabrasive particles can be minimized. ... In another aspect the variation from the predetermined height may be from about 1 micron to about 20 microns."); EX1005, 2:2-4 ("Due to the pre-leveling of the diamond tips, their height variation is within 20 microns. This organic diamond disk (ODD) will dress pad uniformly without excessive cutting."). In my opinion, a POSITA, seeing that both references teach the benefits of having the height of the superabrasive particles leveled, would have been motivated to combine the

teachings therein. In particular, having learned about the benefits of leveling, a POSITA would have considered preparing a CMP pad dresser with a tip-to-tip variation of less than about 2 microns.

176. Third, it would have been trivial to combine Sung'026 and SungICPT because they both disclose the same type of CMP pad conditioners made using the same methods. Specifically, Sung'026 and SungICPT disclose making CMP pad dressers with an organic matrix by "reverse casting." For instance, Sung'026 discloses that "[v]arious *reverse casting* methods may be utilized to manufacture the CMP pad dresser of the present invention."). EX1004, [0083]; *see also* EX1004, [0075] ("Referring to FIG. 1, the CMP pad dresser **20** may include an organic material layer **14** and superabrasive particles **12** held in the organic material layer **14** in an arrangement according to the various methods presented herein."). Likewise, SungICPT discloses that its CMP pad conditioners (referred to as Organic diamond disks (ODD)) with "markedly improved the leveling of diamond tips ...are manufactured by *reverse casting* of polymers." EX1005, 1:9-11. *See also* EX1005, 1:30-2:3 ("A new design by reversing the diamond attaching process is made with an organic matrix (e.g. epoxy). The diamond grits are first leveled to a mold surface. Subsequently, they are cast by covering with a polymer."). Since the methods of making the CMP pad conditioner are the same, a

POSITA would have an expectation of success that such a combination would work.

177. Fourth, because Sung’026 and SungICPT both disclose the same type of CMP pad conditioners made by the same methods, a POSITA would have been able to prepare a CMP pad dresser having a tip-to-tip variation of less than about 2 microns, with a reasonable expectation of success, and find it trivial. It would be at least obvious to try to level the tips to the variation as disclosed by Sung’026, and a POSITA would have had a reasonable expectation of success.

C. Ground III: Sung’026 in Combination with Nishioka Renders Obvious Claims 13, and 17-19

1. Dependent Claim 13

- i. [13] The method of claim 12, wherein the semiconductor device includes one or more layers of Cu, W, an oxide layer, or a combination thereof.**

178. In my opinion, Sung in combination with Nishioka renders obvious claim 13.

179. As I discussed in Paragraph 146, Sung’026 teaches that the CMP process is for polishing semiconductors. EX1004, [0002], [0005], [0008]. In particular, Sung’026 teaches that its CMP pad dressers are suitable for “[u]ltra-large-scale integration (ULSI) [which] is a technology that places at least 1 million circuit elements on a single semiconductor chip.” EX1004, [0005].

180. While Sung'026 does not disclose additional details about the semiconductor that is being polished, it would have been obvious to a POSITA that such semiconductor devices include one or more of Cu, W, or an oxide layer. For instance, Nishioka teaches that a “chemical mechanical polishing process is employed in planarization of an *inter-layer dielectric film*, a metal plug, a *metal wiring*, etc., during multi-layer wiring steps” and specifically notes that such polishing is done on a “semiconductor substrate.” EX1006, [0002], [0087].

181. Nishioka lists copper as an example of metal wiring. Specifically, Nishioka further teaches that to “prevent a problem of wiring delay,” *copper* or a copper alloy can be used in a semiconductor device as a wiring metal. EX1006, [0003], [0040].

182. Nishioka also teaches an insulating film, which is “generally used as an inter-layer dielectric film or a cap layer. A compound forming an insulating film includes an inorganic silicon compound containing a large amount of silicon (e.g., *silicon oxide (SiO₂)*.”). Therefore, Nishioka also teaches that a semiconductor device polished by the CMP process includes an oxide.

2. Dependent Claims 17-19

- i. [17] The method of claim 11, wherein the slurry includes an abrasive selected from the group consisting of silica, alumina, ceria, and combinations thereof.

[18] The method of claim 11, wherein the slurry includes an oxidative compound.

[19] The method of claim 17, wherein the oxidative compound is hydrogen peroxide.

183. In my opinion, Sung'026 with Nishioka render obvious claims 17-19.

184. Sung'026 teaches that the CMP process utilizes a “chemical slurry ... that contains a chemical capable of breaking down the wafer substance and an amount of abrasive particles which act to physically erode the wafer surface.” EX1004, [0002]. However, Sung'026 does not explicitly identify the “chemical” or the “abrasive particles” within the slurry.

185. Nevertheless, a POSITA would have readily known the chemical identity of the “chemical capable of breaking down the wafer substance” and the “abrasive particles which act to physically erode the wafer surface.” For instance, Nishioka teaches a slurry for CMP applications that “comprises a dicarboxylic acid, *an oxidizing agent*, *an abrasive*, and water.” EX1006, [0055].

186. The abrasive, according to Nishioka, “includes silica, cerium oxide, aluminum oxide.” EX1006, [0066]. As known to a POSITA, “ceria” is

synonymous with “cerium oxide,” and “alumina” is synonymous with “aluminum oxide.”

187. Nishioka’s preferred oxidizing agent is hydrogen peroxide. EX1006, [0063] (“Examples of the aforementioned *oxidizing agent* include oxygen, ozone, *hydrogen peroxide* ... Among these oxidizing agents, *hydrogen peroxide*, persulfate salts and hypochlorites, which can be simply handled, are preferred. In particular, *hydrogen peroxide* is preferred.”).

188. In my opinion, a POSITA would have been motivated to combine the teachings of Sung’026 with Nishioka for several reasons. First, Sung’026 and Nishioka are directed to CMP aspects in semiconductor manufacture. EX1004, [0005] (“In addition to the tremendous density issues that already exist, with the current movement toward size reduction, ULSI has become even more delicate, both in size and materials than ever before. Therefore, the CMP industry has been required to respond by providing polishing materials and techniques that accommodate these advances.”); EX1006, [0002] (“One typical example of the micro-processing techniques is a chemical-mechanical polishing process, which is a planarization technique. A *chemical-mechanical polishing* process is employed in planarization of an inter-layer dielectric film, a metal plug, metal wiring, etc. during multi-layer wiring steps.”), (“the present inventors have found that a *chemical-mechanical polishing* composition can preferably achieve the above-

described objects in a wide pH range.”). A POSITA would have expected that Sung’026’s CMP process could be used on semiconductors having copper, at least because Sung’026 discloses a CMP process for ultra-large-scale integration semiconductors, and Nishioka teaches that semiconductor devices having large-scale-integration use copper as a wiring metal. EX1004, [0005]; EX1006 [0002]-[0003] (“A chemical-mechanical polishing process is employed in planarization of an inter-layer dielectric film, a metal plug, metal wiring, etc. during multi-layer wiring steps. Among wiring metals, in recent years, copper or a copper alloy has been employed so as to prevent a problem of wiring delay.”). Indeed, Nishioka teaches that silicon oxide and copper are common materials used in semiconductors as inter-layer dielectric film and wiring material, respectively. EX1006, [0018] (“This document describes that the polishing liquid can polish an inter-layer dielectric film material such as silicon dioxide, a wiring material such as copper.”).

189. Additionally, it is my opinion that a POSITA would have been motivated to supplement Sung’026’s general disclosure of a CMP slurry having “a chemical capable of breaking down the wafer substance” “abrasive particles” with Nishioka. EX1004, [0002]. Nishioka teaches that a polishing composition suitable for polishing an inter-layer dielectric film [*e.g.*, SiO₂] along with a wiring metal [*e.g.*, copper] at the same time comprises also comprises “a chemical capable of

breaking down the wafer substance” (i.e., an oxidizing agent) and an abrasive.

EX1006, [0020]-[0021] (“An object of the present invention is to provide a polishing composition which allows high-speed polishing of a barrier film and an inter-layer dielectric film along with a wiring metal at the same time... the present inventors have found that a chemical-mechanical polishing composition [that] can preferably achieve the above-described objects ... compris[es] a dicarboxylic acid having 7 to 13 carbon atoms, *an oxidizing agent*, an *abrasive* and water.”). Indeed, a POSITA would, therefore, be able to use the specific well-known slurry components of Nishioka with a reasonable expectation of success. Because Sung’026 provides explicit guidance for the types of components included in the slurry, picking hydrogen peroxide and one or more of silica, alumina, or ceria would have been a trivial modification that would provide no change in the function of the slurry.

D. Ground IV: Sung’026 in Combination with Lin Renders Obvious Claim 14

1. Dependent Claim 14

- i. [14] The method of claim 12, wherein the semiconductor device has a node size of less than or equal to 28 nm.**

190. In my opinion, Sung’026 with Lin renders obvious claim 14.

191. As I discussed in Paragraph 146, Sung’026 teaches that the CMP process is for polishing semiconductors. EX1004, [0002], [0005], [0008]. In particular, Sung’026 teaches that its CMP pad dressers are suitable for “[u]ltra-large-scale integration (ULSI) [which] is a technology that places at least 1 million circuit elements on a single semiconductor chip.” EX1004, [0005].

192. However, Sung’026 does not explicitly teach the node size of the semiconductor. The node size represents a width of “a trench or [diameter of a] via [opening] located in a semiconductor substrate [which] and has a bottom, a sidewall, and an opening.” EX1007, [0028]. However, Lin describes using CMP when manufacturing semiconductors with node sizes that are 22nm and 15nm. *See* EX1007, [0035] (“Then the workpiece is subjected to conventional finishing operations of annealing and ***chemical-mechanical polishing (CMP)*** to yield a metallized ***interconnect feature*** in which the copper metallization is planar with the field of the dielectric, as shown in FIG. 1E.”), [0028] (“The ***interconnect feature*** ... has ... an opening. Typical dimensions of the opening, i.e., diameter of via opening (commonly referred to as a ***node***) ... may be as little as about 10 nm... ***Common nodes include*** 130 nm, 90 nm, 65 nm, 45 nm, 32 nm, ***22 nm, and 15 nm.***”), [0055]-[0057], [0059].

193. A POSITA would have found it obvious to combine Sung’026 and Lin for several reasons. For instance, Sung’026 and Lin disclose using CMP when

making ultra-large-scale integration (ULSI) semiconductor devices. EX1004, [0005]; EX1007, [0004], [0035], [0055]-[0057], [0059]. As the devices are of the same type, a POSITA would have had a motivation to use Sung'026's CMP process on Lin's devices with a reasonable expectation of success. To the extent there are differences, a POSITA would have at least found it obvious to try Sung'026's CMP process on Lin's semiconductor device with a node size of 22 nm or 15 nm.

E. Ground V: Sung'026 in Combination with Kim Renders Obvious Claim 15

1. Dependent Claim 15

- i. [15] The method of claim 12, wherein the semiconductor device has a line width of less than or equal to about 30 nm.**

194. In my opinion, Sung'026 with Kim render obvious claim 15.

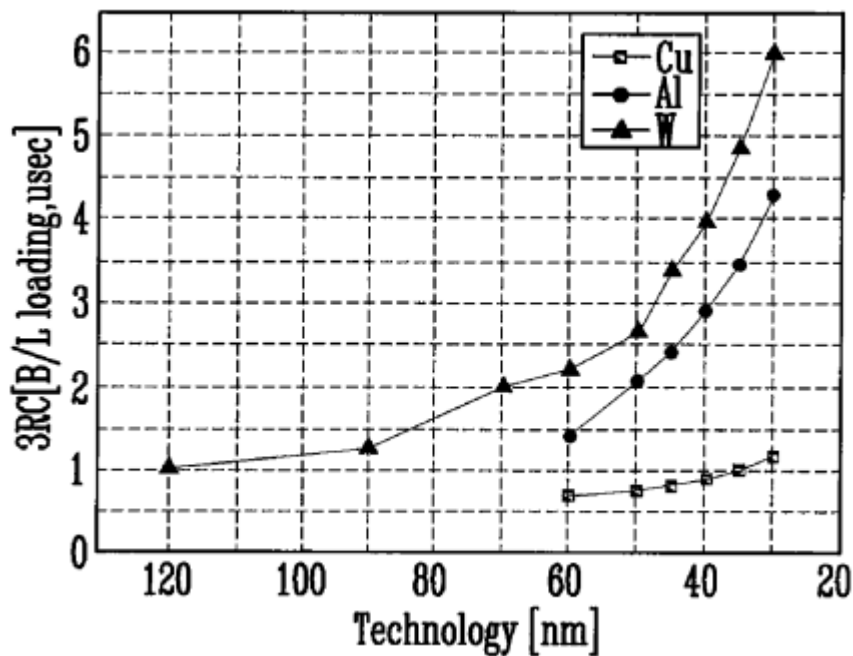
195. As I discussed in Paragraph 146, Sung'026 teaches that the CMP process is for polishing semiconductors. EX1004, [0002], [0005], [0008]. In particular, Sung'026 teaches that its CMP pad dressers are suitable for “[u]ltra-large-scale integration (ULSI) [which] is a technology that places at least 1 million circuit elements on a single semiconductor chip.” EX1004, [0005].

196. Sung'026 does not explicitly teach the line width of the semiconductor. The line width in the semiconductor represents the width of a metal

line to which the transistors' gates are connected. *See* EX1008, [0002]-[0003].

However, Kim, about four years before the earliest claimed priority date of the '861 Patent, already taught that “as the level of integration of semiconductor devices has increased, the width of the metal line has decreased (approximately 60 nm to **30 nm**) and the resistivity of the metal line has increased.” EX1008, [0022].

Kim also shows in Fig. 1 aluminum (Al) copper (Cu) and tungsten (W) metal lines with a narrow line width of 60 nm to **30 nm**. EX1008, [0024], FIG. 1.



EX1008, FIG. 1.

197. A POSITA would have found it obvious to combine Sung'026 and Kim for several reasons. For instance, both Sung'026 and Kim teach semiconductor devices with an increased level of integration. EX1004, [0005]

(“Ultra-large-scale integration (ULSI) is a technology that places at least 1 million circuit elements on a single semiconductor chip.”); EX1008, [0003] (“However, in recent years, the level of integration of semiconductor devices continuously increases.”).” In fact, since Sung’026 discloses a CMP process for a ULSI devices, which “place[] at least 1 million circuit elements on a single semiconductor chip” a POSITA would have found it obvious that these techniques would be used for semiconductors with a line with of about 30 nm because Kim teaches that “as the level of integration of semiconductor devices has increased, the width of the metal line has decreased (approximately 60 nm to **30 nm**). EX1004, [0005]; EX1008, [0022]. And since Kim teaches that CMP is used to make such devices with a line width of 30 nm, the CMP dresser and the overall process of Sung’026 would be an obvious variant to try. EX1008, [0045] (“Referring to FIG. 2H, a **CMP process is performed** to expose the capping layer 206, so that the first metal layers 212, the second metal layers 214, and the third metal layers 216 formed in the respective damascene patterns (refer to 209 in FIG. 2F) are isolated from each other.”). A POSITA would at least have a motivation to try to use the Sung’026’s CMP process when making Kim’s device.

F. Ground VI: Sung’026 in Combination with Koyama Renders Obvious Claim 16

1. Dependent Claim 16

- i. [16] The method of claim 12, wherein the semiconductor device is a wafer having a size greater than 400 mm.**

198. In my opinion, Sung’026 with Koyama render obvious claim 16.

199. As I discussed in Paragraph 146, Sung’026 teaches that the CMP process is for polishing semiconductor wafers. EX1004, [0002], [0005], [0008]. In particular, Sung’026 teaches that its CMP pad dressers are suitable for “[u]ltra-large-scale integration (ULSI) [which] is a technology that places at least 1 million circuit elements on a single semiconductor chip.” EX1004, [0005].

200. However, Sung’026 does not provide additional disclosure of the semiconductor wafer, such as the size. Nevertheless, before the earliest claimed priority date of the ‘862 Patent, CMP was used to polish wafers of various sizes, including ones with a diameter of about 450 mm. Specifically, Koyama teaches that circular wafers of various sizes, including “5 inches in diameter (125 mm), 6 inches in diameter (150 mm), 8 inches in diameter (200 mm), and 12 inches in diameter (300 mm) are available,” and highlights that “a *circular wafer which is 18 inches (450 mm) in diameter* is realized recently.” EX1009, [0062].

201. In my opinion, a POSITA would have found it obvious to use the CMP process described by Sung'026 to polish Koyama's wafer, which is 450 mm in diameter. Koyama teaches that CMP can be on wafers having a diameter of 450 mm and Sung'026's process is not size-restricted. As such, it would have been trivial, and a POSITA would have found it obvious to substitute Sung'026's "wafer" for Koyama's 450 mm wafer with a reasonable expectation of success.

IX. Availability for Cross-Examination

202. In signing this declaration, I recognize that the declaration will be filed as evidence in a 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.

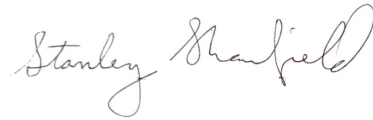
X. Right to Supplement

203. 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.

XI. Jurat

204. 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