

Declaration of Dr. Stanley Shanfield  
U.S. Patent No. 9,724,802

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 IPR2024-00535  
U.S. Patent No. 9,724,802

---

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

CLAIMS 1-21

**TABLE OF CONTENTS**

|                                                                | <b><u>Page</u></b> |
|----------------------------------------------------------------|--------------------|
| I. Introduction.....                                           | 1                  |
| II. Relevant Law .....                                         | 6                  |
| A. Person of Ordinary Skill in the Art .....                   | 6                  |
| B. Claim Construction .....                                    | 7                  |
| C. Anticipation .....                                          | 7                  |
| D. Obviousness.....                                            | 8                  |
| III. Summary of Opinions.....                                  | 11                 |
| IV. Technology Background.....                                 | 11                 |
| A. Chemical Mechanical Planarization (CMP).....                | 11                 |
| V. Overview of the '802 Patent.....                            | 21                 |
| A. Summary Of The '802 Patent.....                             | 21                 |
| B. Summary of the Prosecution History of the '802 Patent ..... | 23                 |
| C. Priority Date of the '802 Patent.....                       | 28                 |
| VI. Level of Ordinary Skill in the Art .....                   | 34                 |
| VII. Overview of the Primary Prior Art References .....        | 35                 |
| A. Overview of Tsai .....                                      | 35                 |
| B. Overview of Sung'026 .....                                  | 38                 |
| VIII. Claim Construction.....                                  | 41                 |
| A. "superabrasive" .....                                       | 41                 |
| B. "particle" .....                                            | 42                 |

|     |                                                                                                   |     |
|-----|---------------------------------------------------------------------------------------------------|-----|
| C.  | “working superabrasive particle” .....                                                            | 42  |
| D.  | “profile” .....                                                                                   | 42  |
| E.  | “support substrate” .....                                                                         | 43  |
| F.  | “tip” .....                                                                                       | 43  |
| G.  | “protrusion” .....                                                                                | 43  |
| H.  | “about” .....                                                                                     | 44  |
| IX. | Specific Invalidity Grounds .....                                                                 | 44  |
| A.  | Ground I: Tsai Anticipates or Tsai Renders Obvious Claims 1-5,<br>13, 15, and 19-21 .....         | 44  |
| 1.  | Independent Claim 1 and Dependent Claims 13 and 15 .....                                          | 44  |
| 2.  | Dependent Claims 2 and 3 .....                                                                    | 66  |
| 3.  | Dependent Claims 4 and 5 .....                                                                    | 67  |
| 4.  | Dependent Claims 19-21 .....                                                                      | 75  |
| B.  | Ground II: Tsai in Combination with Sung’026 Renders Obvious<br>Claims 1-3, 6-14, and 16-18 ..... | 79  |
| 1.  | Independent Claim 1 .....                                                                         | 79  |
| 2.  | Dependent Claims 2 and 3 .....                                                                    | 80  |
| 3.  | Dependent Claims 6, 7, and 16-18 .....                                                            | 85  |
| 4.  | Dependent Claims 8-12 .....                                                                       | 89  |
| 5.  | Dependent Claims 13 and 14 .....                                                                  | 99  |
| C.  | Ground III: Sung’146 in Combination with Sung’026 Renders<br>Obvious Claims 1-7 and 13-21 .....   | 106 |

Declaration of Dr. Stanley Shanfield  
U.S. Patent No. 9,724,802

|      |                                          |     |
|------|------------------------------------------|-----|
| X.   | Availability for Cross-Examination ..... | 114 |
| XI.  | Right to Supplement .....                | 114 |
| XII. | Jurat.....                               | 115 |

I, Stanley Shanfield, declare as follows.

**I. Introduction**

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

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

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

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

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

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. 9,724,802 (the “’802 Patent”).
12. I am familiar with the knowledge and capabilities of a person of ordinary skill in the art at the time of the priority date of the ’802 Patent – October 3, 2014.
13. I understand that the ’802 Patent was filed on October 3, 2014, as a U.S. Patent Application No. 14/506,476. I understand that this application claims priority to numerous U.S. Patent Applications dating back to May 16, 2005. I understand that the ’802 Patent’s priority date is, however, October 3, 2014.
14. I have reviewed the following references in preparing this declaration, all of which I understand to be prior art to the ’802 Patent:
  - Tsai et al. “Organic diamond disk versus brazed diamond disk for dressing a chemical-mechanical polishing pad”, *Diamond & Related*

*Materials*, 23, 2012, 144-149 (“Tsai”) (EX1004), which published January 10, 2012;

- U.S. Patent Application Publication No. 2007/0060026 (“Sung’026”) (EX1005), which first published March 15, 2007.
- U.S. Patent Application Publication No. 2012/0302146 (“Sung’146”) (EX1029), which first published November 29, 2012.

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

| Exhibit No. | DESCRIPTION                                                                                                                                                                          |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1001        | U.S. Patent No. 9,724,802 (“’802 Patent”)                                                                                                                                            |
| 1003        | File History of the ’802 Patent                                                                                                                                                      |
| 1004        | Tsai et al. “Organic diamond disk versus brazed diamond disk for dressing a chemical-mechanical polishing pad”, <i>Diamond &amp; Related Materials</i> , 23, 2012, 144-149 (“Tsai”)  |
| 1005        | U.S. Patent Application Publication No. 2007/0060026 (“Sung’026”)                                                                                                                    |
| 1006        | “The Organic Diamond Disk (ODD) for Dressing of Polishing Pads of Chemical Mechanical Planarization”, International Conference on Planarization / CMP Technology, 25-27 October 2007 |
| 1007        | Fenna, Donald. “Hardness Numbers,” <i>A Dictionary of Weights, Measures, and Units</i> , 1st ed., Oxford University Press, 2004.                                                     |
| 1008        | Tsai et al., “Effect of CMP conditioner diamond shape on pad topography and oxide wafer performances,” <i>Int. J. Adv. Manuf.</i>                                                    |

| Exhibit No. | DESCRIPTION                                                                                                                                                                                                                       |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | <i>Technology</i> , 55: 253-262 (2011)                                                                                                                                                                                            |
| 1009        | U.S. Patent Application Publication No. 2008/0292869 (“Sung’869”)                                                                                                                                                                 |
| 1010        | U.S. Patent Application Publication No. 2010/0248595                                                                                                                                                                              |
| 1011        | Declaration of Dr. [Chien-Min] James Sung In Support of Plaintiff’s Answering Brief In Opposition To Defendant’s Motion To Stay in <i>Chien-Min Sung v. Kinik Co.</i> , 1:20-cv-00247-RGA                                         |
| 1012        | Order Denying Stay in <i>Chien-Min Sung v. Kinik Co.</i> , 1:20-cv-00247-RGA                                                                                                                                                      |
| 1013        | Ishizuka et al. “PCD Dressers for Chemical Mechanical Planarization with Uniform Polishing”, Proceedings of International Conference on Leading Edge Manufacturing in 21 <sup>st</sup> Century: LEM21, 2007, Volume 2007.4        |
| 1014        | U.S. Patent No. 5,036,015                                                                                                                                                                                                         |
| 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.<br><a href="https://link.springer.com/article/10.1557/PROC-1249-E02-04">https://link.springer.com/article/10.1557/PROC-1249-E02-04</a> |
| 1017        | Exhibit 4 of Complaint in <i>Sung v. Samsung Electronics Co., Ltd. et al</i> , 4-23-cv-00752                                                                                                                                      |
| 1018        | U.S. Patent No. 9,138,862 (“’862 Patent”)                                                                                                                                                                                         |
| 1029        | U.S. Patent Application Publication No. 2012/0302146 (“Sung’146”)                                                                                                                                                                 |

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.

## **II. 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 ’802 Patent has an earliest priority date of October 3, 2014.

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 '802 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 a 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 limitation 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.

36. I understand that a range taught in the prior art that encompasses or overlaps a claimed range may render obvious the claimed range if the prior art did not teach away from the claimed range or the claimed range does not show some unexpectedly superior results.

### **III. Summary of Opinions**

37. For the reasons explained below, I conclude that claims 1-21 of the '802 Patent are anticipated and/or rendered obvious by the prior art.

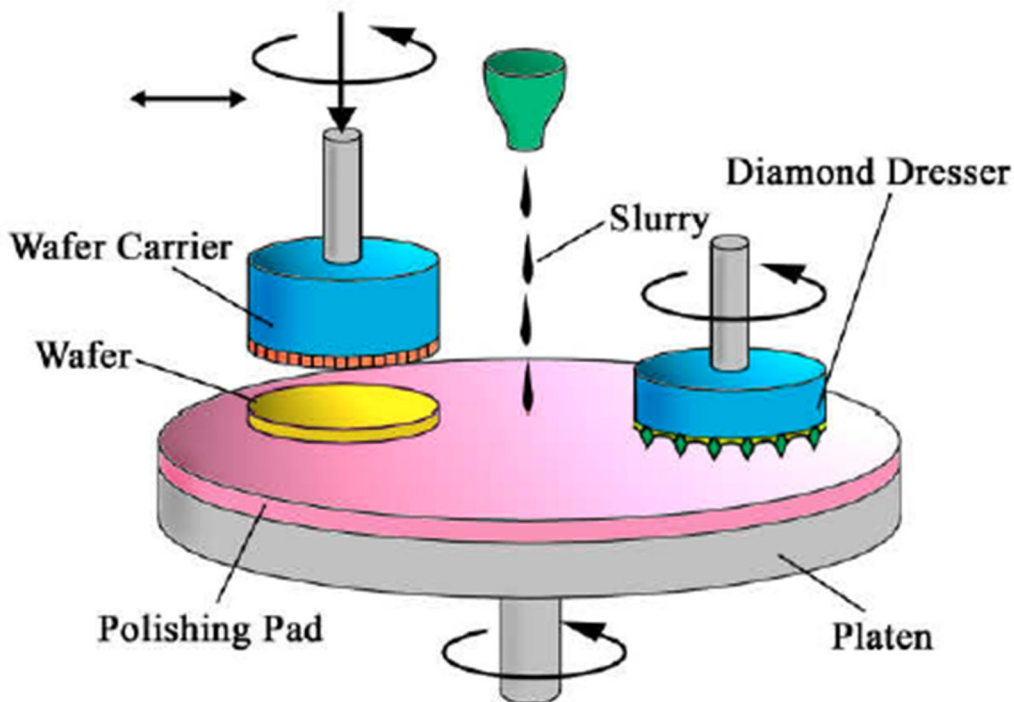
| <b>Grounds</b> | <b>Claims</b>      | <b>Statutory Ground</b> | <b>Prior Art Reference(s)</b>         |
|----------------|--------------------|-------------------------|---------------------------------------|
| I              | 1-5, 13, 15, 19-21 | 35 U.S.C. §102/§103     | Tsai                                  |
| II             | 1-3, 6-14, 16-18   | 35 U.S.C. §103          | Tsai in combination with Sung'026     |
| III            | 1-7, 13-21         | 35 U.S.C. §103          | Sung'146 in combination with Sung'026 |

### **IV. Technology Background**

#### **A. Chemical Mechanical Planarization (CMP)**

38. 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. EX1013, Fig. 2. *See also id.*, 1:17-28, EX1014, 1:13-48.



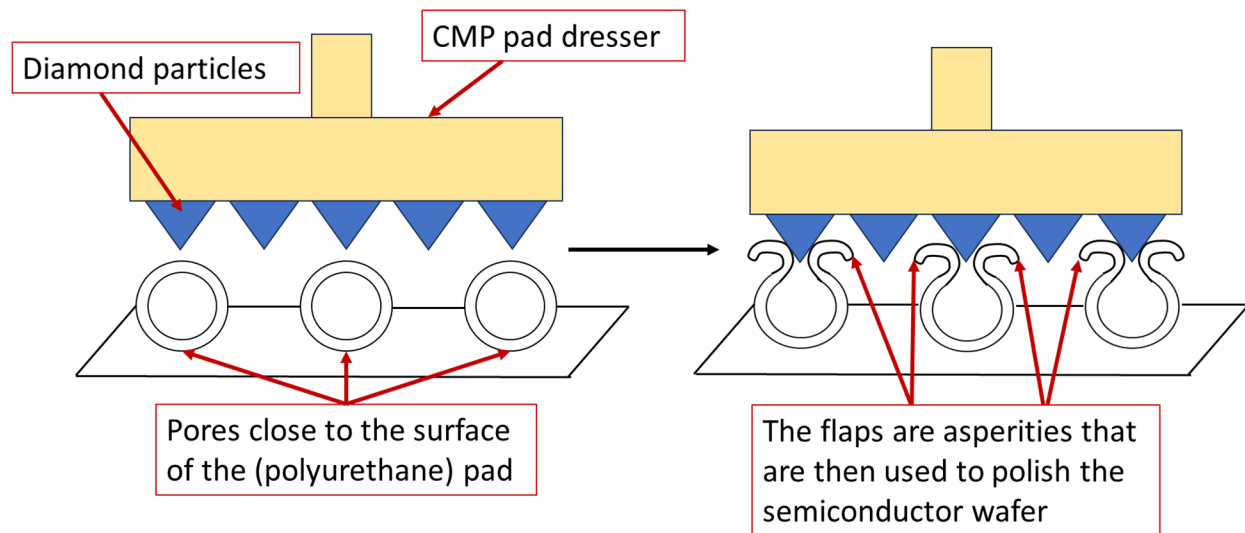
EX1013, Fig. 2.

39. The chemical slurry typically includes abrasive particles that assist in polishing the wafer surface. EX1004, 1:15-17; EX1008, 253. Such abrasives include ceria. EX1013, 1:19-24. The slurry also often includes additional agents that oxidize the wafer surface. Examples of such oxidizing agents include, *e.g.*, hydrogen peroxide. EX1013, 1:19-24.

40. The rotating polishing pad is typically made from a soft polymer. The most common polymer used for the polishing pad is polyurethane. EX1014, 1:44-46, EX1013, 1:17-18. The polishing pad can hold the slurry and polish the wafer because it contains small, micron-sized asperities on its surface. The more it is used to polish a wafer, the more wear and tear (and other factors) on the pad dulls the asperities, decreasing the CMP pad's performance. Therefore, the pad must be reconditioned by regenerating the asperities for optimal and consistent wafer-polishing performance. EX1005, [0004].

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

generate new asperities. EX1005, [0004]-[0005].



42. 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.

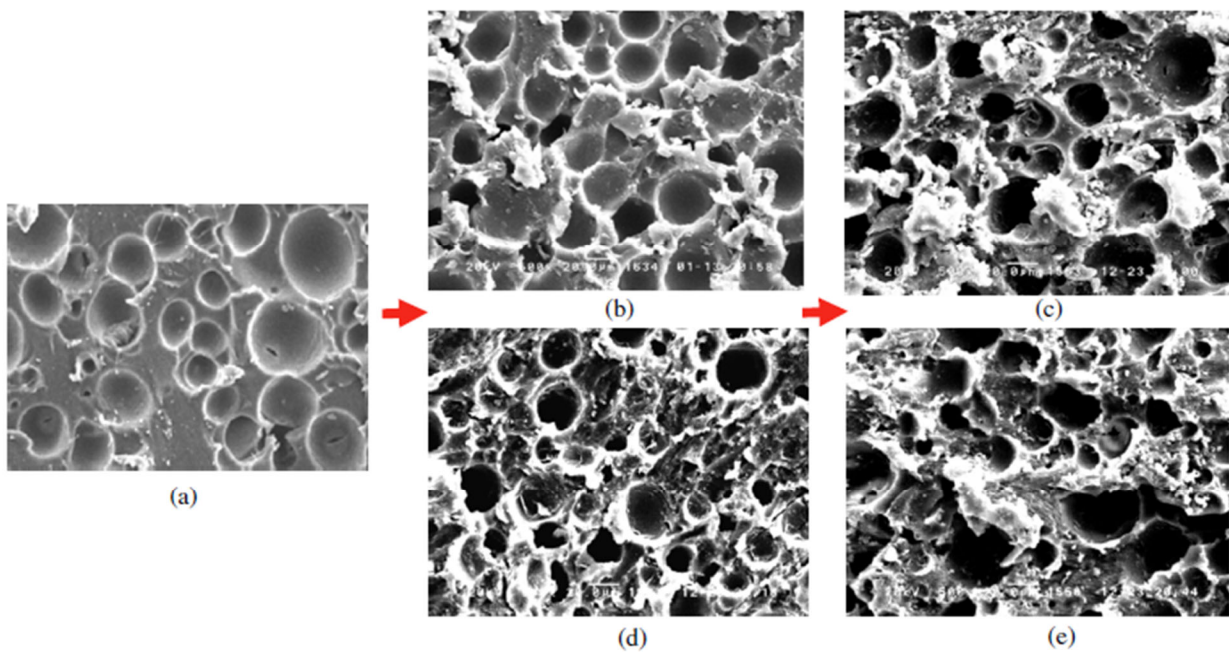
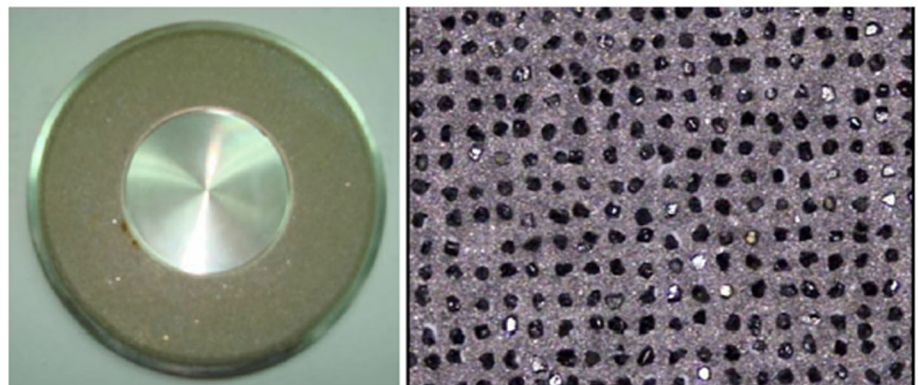


Fig. 14 SEM images of polishing pad: a new pad, b and c dressed by CDD with blocky diamond grit, and d and e dressed by DG after 1 and 20 h of conditioning, respectively

EX1008, Fig. 14.

43. 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



EX1008, Fig. 3.

44. The diamond particles (sometimes called “grits”) can be arranged in a regular pattern with regular spacing between the diamonds, as they are in Fig. 3 of EX1008. 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* EX1008, 255, Fig. 3 (reproduced above).

45. CMP pad conditioners typically have thousands of superabrasive particles. For example, the DiaGrid CMP pad dresser shown in Fig. 3 of EX1008 (reproduced above) has approximately 12,000 diamond particles across the surface of the dresser. EX1008, Fig. 3, 258.

46. At the time of the '802 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 “reverse casting.” EX1004, 3:1-4:7, Fig. 2, 5:20-6:10, 11:10-12; EX1005, [0006], [0010], [0052], [0056], [0061]-[0063], [0073]-[0076], [0083]-[0088], [0099]-[0104]; EX1006, 1:9-15, 1:30-2:4; EX1009, [0053], [0054], [0056], [0057], [0060], [0067], [0070]-[0081], [0091], [0092], [0099]-[0104].

47. 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, 3:1-4:7, Fig. 2, 5:20-6:10, 11:10-12; EX1005, [0006], [0010], [0052], [0056], [0061]-[0063], [0073]-[0076], [0083]-[0088], [0099]-[0104]; EX1006, 1:9-15, 1:30-2:4; EX1009, [0053], [0054], [0056], [0057], [0060], [0067], [0070]-[0081], [0091], [0092], [0099]-[0104].

48. Dr. Sung—the sole named inventor of the '802 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. EX1006 [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. EX1006, 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. EX1006, 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. EX1006, Fig. 3.

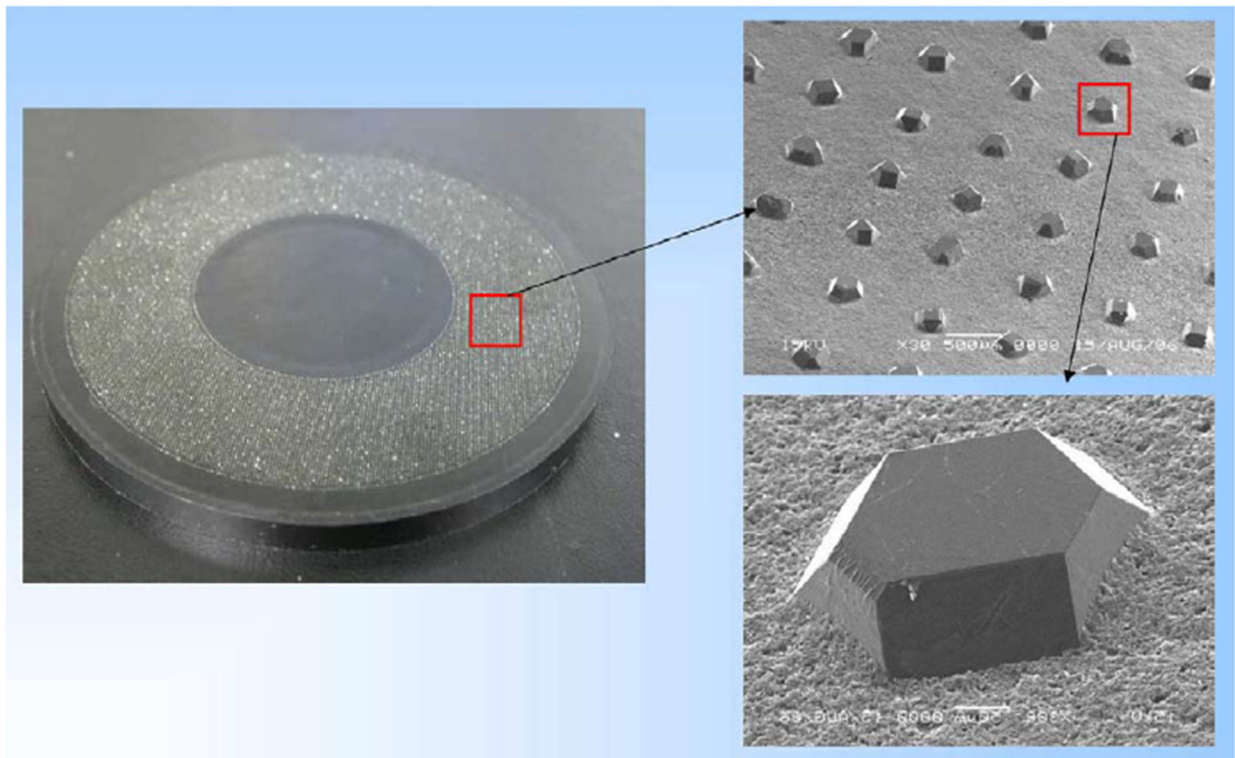


Fig. 3: The bonding conditions of diamond in the epoxy matrix.

EX1006, Fig. 3.

49. Sung again published ODD CMP pad dressers made by reverse casting in 2012. EX1004 [Tsai], Title, Header. The reverse casting process, the same published by Sung in 2007, is detailed in Figure 2 below. EX1004, Fig. 2, 5:20-6:20.

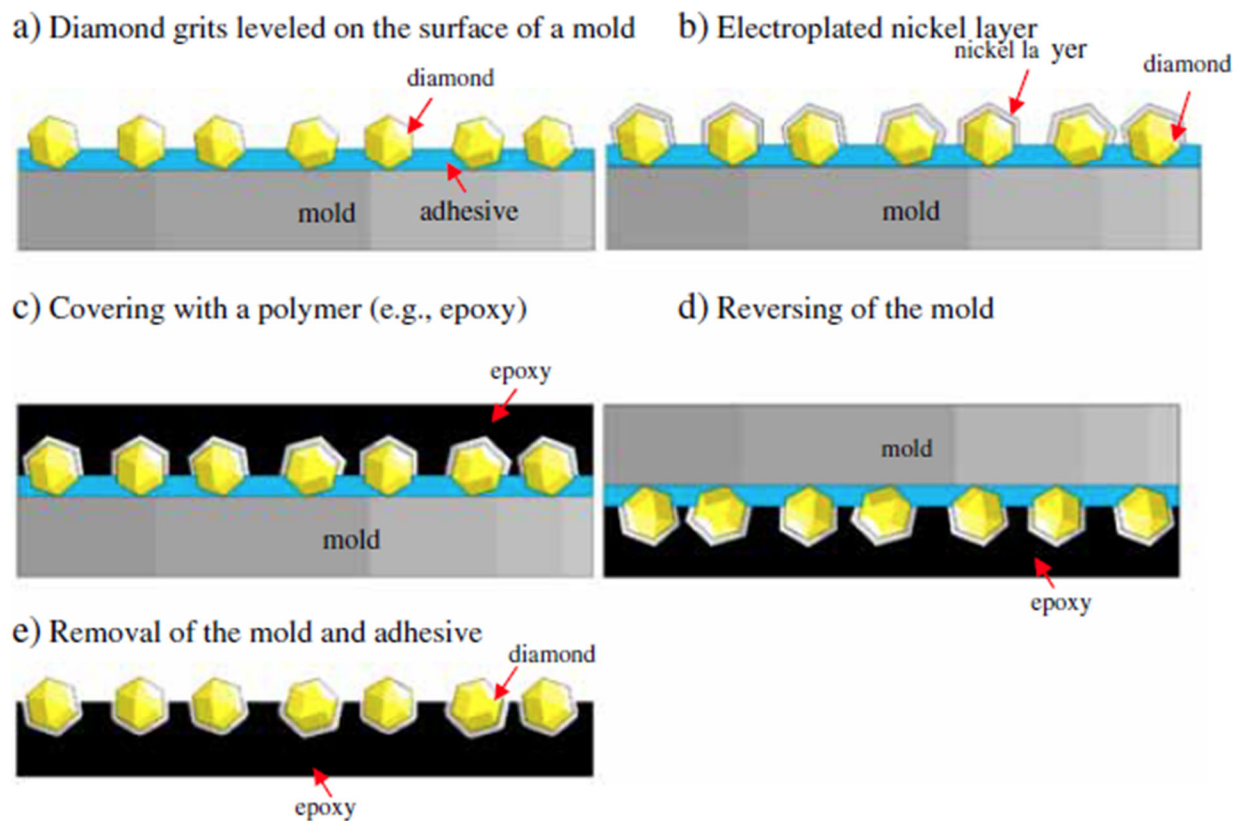


Fig. 2. Steps for manufacturing organic diamond disk.

EX1004, Fig. 2.

50. In this example, the superabrasive particles have a tip-to-tip variation of less than about 15 microns. EX1004, 8:22-24, Abstract. This is due to the pre-leveling of the superabrasive particles in the first step of the reverse casting process. EX1004, 5:23-25. The tip variation of the superabrasive particles can be further controlled by compressing the ODD with a flat plate. EX1004, 6:8-10.

51. SungICPT and Tsai both present CMP pad dressers with superabrasive particles having substantially leveled tips (e.g., 20 microns or 15

microns), which was well-known in the art. By changing the compression of the flat plate described by Tsai, different degrees of tip leveling could be achieved.

52. Furthermore, CMP pad dressers having substantially uniform protrusion heights (*e.g.*, tip variations within 80 microns, 50 microns, 40 microns, 20 microns, or 10 microns) were known in the art at the time of the '802 Patent.

53. For instance, I have reproduced Fig. 4 of EX1015 below, which shows two-dimensional surface profile of a CMP pad dresser. EX1015, p. 3, Fig. 4. I understand that EX1015 was published on August 1, 2010 (EX1016), 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 claim 1 of the '862 Patent. EX1017, 8-17; EX1018, claim 1. I understand that the '802 Patent claims priority to the '862 Patent. EX1001, Cover.

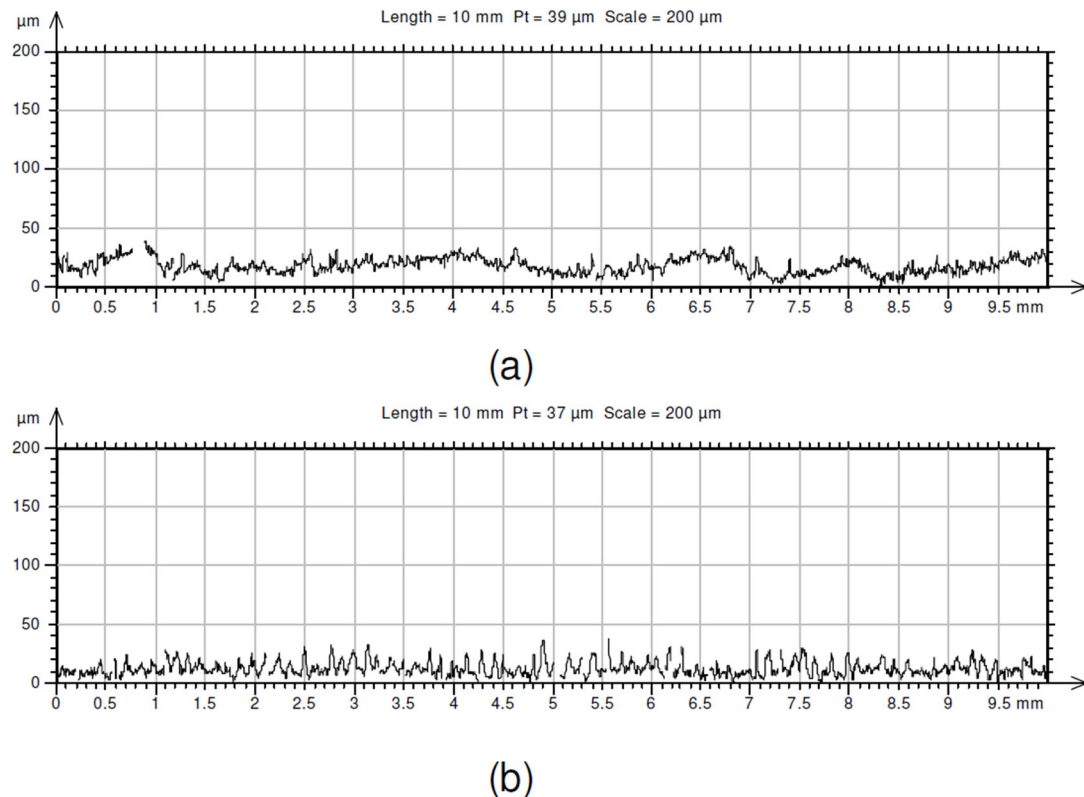


**Figure 4.** Surface profiles showing flatness of a) current and b) improved fine-finish disk designs.

EX1015, Fig. 4.

## V. Overview of the '802 Patent

### A. Summary Of The '802 Patent

54. I have reviewed the '802 Patent. *See* EX1001.

55. The '802 Patent describes CMP pad dressers with superabrasive particles. *See* EX1001, Abstract. The '802 Patent is directed to the manufacturing of CMP pad dressers that have substantially leveled tips. *See* EX1001, 9:30-33. ("Specifically, in some aspects the present disclosure concerns CMP pad dressers having superabrasive particles with substantially leveled tips.").

56. The '802 Patent describes that such leveling of the tips in a CMP pad dresser can be accomplished using a “reverse casting” method to obtain leveled tips on a CMP pad dresser. EX1001, 25:14-22. This reverse casting method is the same as I described in Paragraph 47. First, the superabrasive particles are attached to a mold, described as a “mask material” in the '802 Patent. EX1001, 25:14-18. Second, the superabrasive particles are then attached to a rigid support, and the mold is removed. EX1001, 25:14-27. The '802 Patent identifies organic materials, including epoxy, as suitable materials for the rigid support of a CMP pad dresser. EX1001, 25:23-27, 25:63-65.

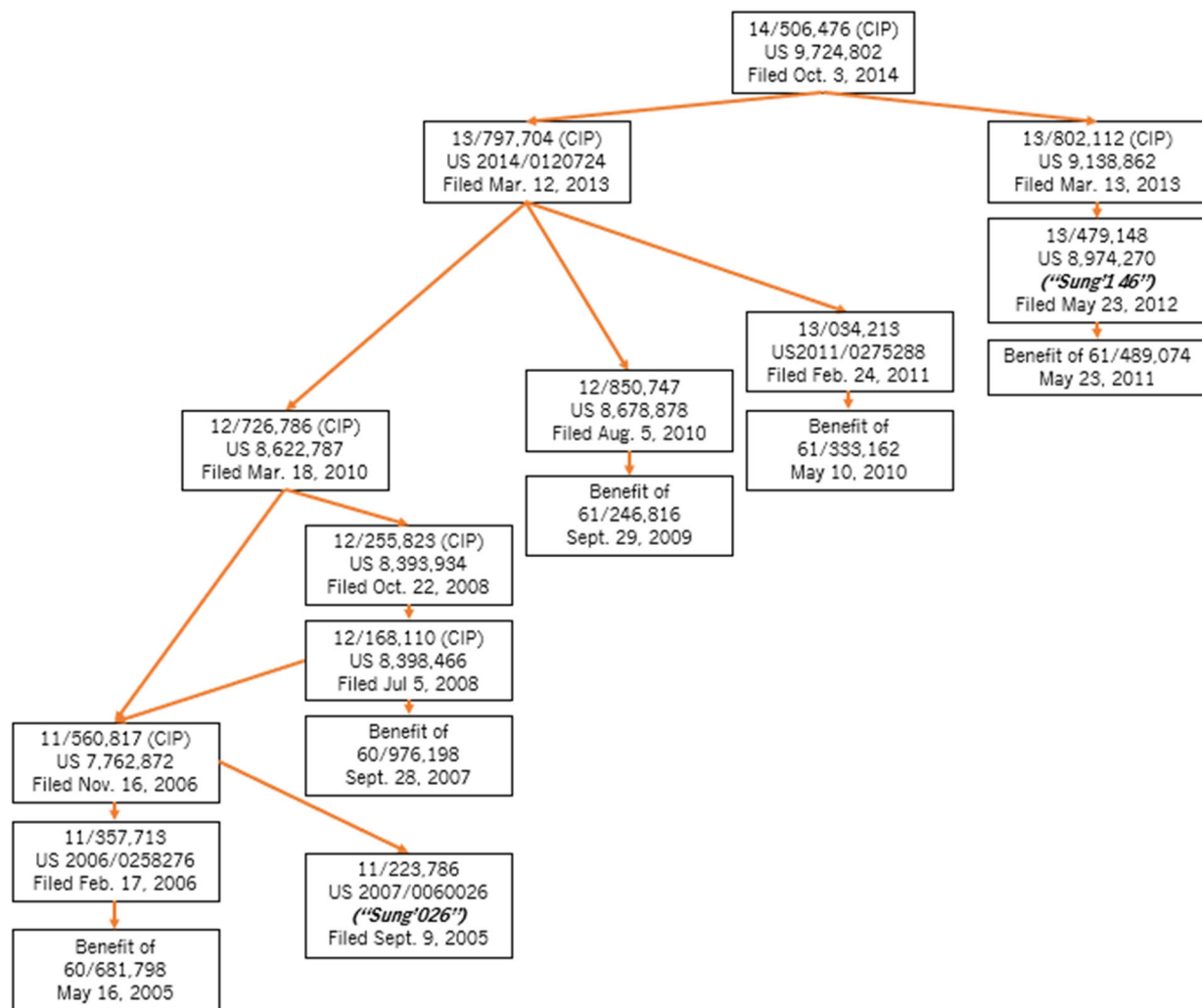
57. The reverse casting method results in substantially leveled tips, as claimed in the '802 Patent (EX1001, claims 1-5, 13-15) and described by the art at the time of the '802 Patent, as I have explained in Paragraph 47. The leveling of tips results in more superabrasive particles on the CMP pad dresser acting as “working superabrasive particles,” *e.g.*, cutting asperities in the CMP pad during conditioning. EX1001, 2:55-3:9, 4:46-54, 9:54-64, 10:40-62 (“a typical CMP pad dresser can have greater than 10,000 superabrasive particles. Of these 10,000 particles, in some cases there may only be a few working superabrasive particles...there may be a smaller proportion of overly-aggressive superabrasive particles that cut over 50% of the entire pad that is consumed during conditioning...This uneven work load distribution can cause erratic CMP

performance...A more effective normalization of work load distribution across the surface of the CMP pad dresser can lead to a more uniformly deglazed pad and more uniform asperities.”), 12:44-51 (“...the farther superabrasive particles are separated, the more the impinging forces will affect each superabrasive particle. As such, patterns with increased spacing between the superabrasive particles may benefit from a smaller variation from predetermined height.”). The working superabrasive particles can provide cutting depths of less than or equal to about 50 microns or less than or equal to about 20 microns when used to condition a CMP pad. EX1001, claims 6, 7, 16-18, 2:18-30, 2:55-3:23.

**B. Summary of the Prosecution History of the '802 Patent**

58. I have reviewed the file history of the '802 Patent, which I summarize below. *See* EX1003.

59. The application for the '802 Patent was filed on October 3, 2014. The application claimed priority to multiple U.S. Patent Applications. *See* EX1001, Cover; EX1003, 2-4. Below is a graphical summary of the priority claims of the '802 Patent.



60. The application for the '802 Patent originally included claims 1-24.

EX1003, 50-53.

61. In an Office Action dated October 30, 2015, claims 11-15 were rejected under 35 U.S.C. §112 as being indefinite. The Examiner stated that the claims are indefinite because it is “unclear how the highest 1% is determined”, referring to the claimed limitation “the protrusion difference between the highest

1% of the protruding tips are within 80 microns or less.” The Examiner also stated that the scope of the claim is unclear. EX1003, 125-126.

62. Claims 1-10 and 16-24 were rejected under 35 U.S.C. §103 as being obvious over U.S. Patent Publication No. 2010/0248595 (“Dinh-Ngoc”). The Examiner asserted that although Dinh-Ngoc does not disclose the differences in protrusion distance between the tips of the superabrasive particles or the cutting depths of the CMP pad dresser, a POSITA would have found it obvious to use the ranges claimed in the ’802 Patent in combination with the CMP pad dresser disclosed by Dinh-Ngoc. EX1003, 126-129.

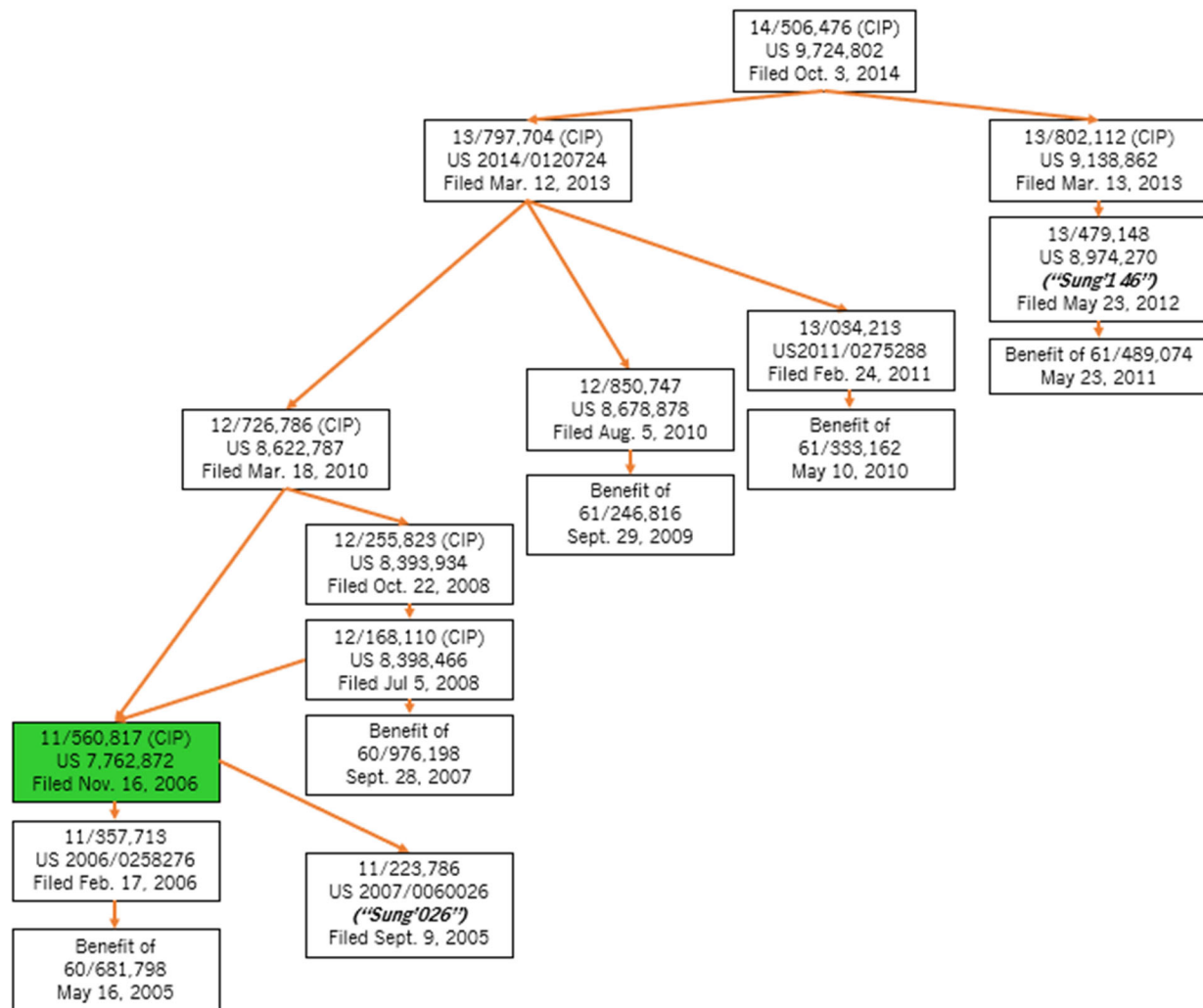
63. Claims 5-7, 11-15, and 16-24 were rejected under 35 U.S.C. §103 as being obvious over Dinh-Ngoc in view of U.S. Patent Publication No. 2008/0292869 (Sung’869). The Examiner held that Sung’869 discloses the designated profile and cutting depths claimed in the ’802 Patent, and a POSITA would have found it obvious to combine these features with the CMP pad dresser taught by Dinh-Ngoc. EX1003, 129-131.

64. In response to the 35 U.S.C. §112 rejections, the Applicant argued that the specification provides methods of determining the heights of the tips of superabrasive particles. The Applicant also explained that the height distributions between the first and second highest superabrasive particles would be narrower

than the height distributions among the highest 1% of superabrasive particles.

EX1003, 190-191.

65. In response to the 35 U.S.C. §103 rejections, the Applicant amended claim 11 to recite “wherein a tip of each of the plurality of superabrasive particles aligns along a designated profile with a tip variation of from about 5 microns to about 100 microns.” The Applicant argued that this limitation was fully supported by U.S. Patent Application No. 11/560,817, (the ’817 Application) which is one of the many that the ’802 Patent claims priority to (highlighted in green in the chart below). Relying on the filing date of the ’817 Application, which is November 16, **2006**, the Applicant argued that Dinh-Ngoc and Sung’869 are not prior art to the ’802 Patent because the ’817 Application pre-dates both references. EX1003, 191-195.



66. In an Office Action dated July 15, 2016, the Examiner found that Applicant's argument with respect to the rejections under Dinh-Ngoc were persuasive and allowed claims 11-15. But the Examiner rejected claims 1-10 and 16-24 under 35 U.S.C. §103 as being obvious over U.S. Patent Application Publication No. 2004/0048557 ("Nabeya"). EX1003, 204-207.

67. In response, the Applicant cancelled claims 1-10 and 23-24, amended claims 16-22 to depend on the allowed claim 11, and added new claims 25-33 depending from the allowed claim 11. EX1003, 236-239.

68. The '802 Patent issued on August 8, 2017. EX1003, 338; EX1001, Cover.

69. I have read Dinh-Ngoc and Sung'869 that the Examiner used in rejections for the issued claims and it is my opinion that these references have substantially different teachings compared to Tsai and Sung'026 that I rely on in my declaration.

### **C. Priority Date of the '802 Patent**

70. I understand that a continuation-in-part application may claim priority to multiple parent applications. I further understand that a claim in a continuation-in-part application is entitled to the benefit of an earlier filing date of a parent application only when all limitations of the claim, as arranged, are supported by the parent application.

71. I have concluded that the limitations of claim 1 of the '802 Patent, as arranged, are supported by a single application for the first time in the '802 Patent.

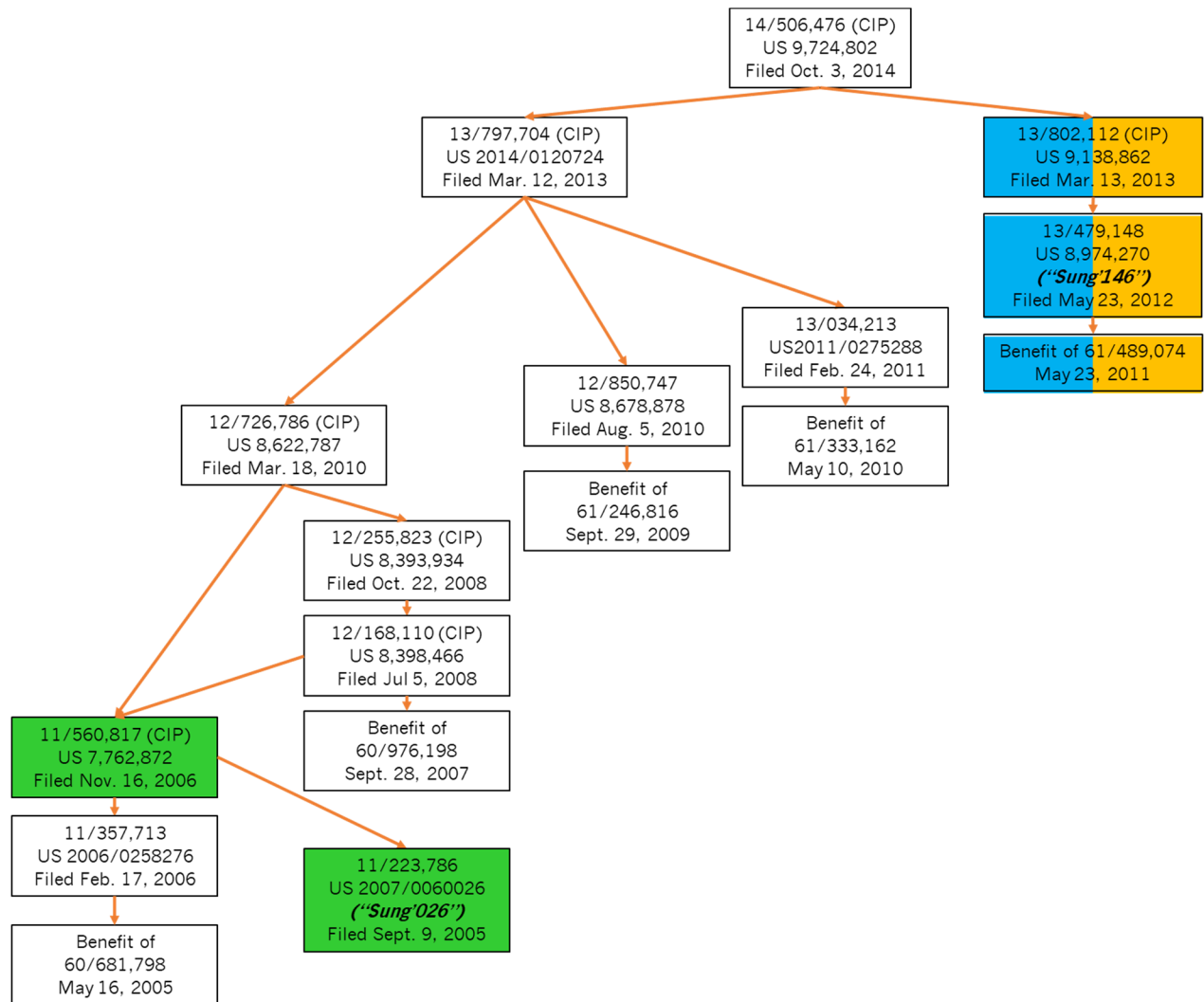
72. Specifically, the limitation of claim 1 “a tip of each of the plurality of superabrasive particles aligns along a designated profile with a tip variation of from about 5 microns to about 100 microns” is only supported by U.S. Patent No.

7,762,872 and U.S. Patent Application Publication No. 2007/0060026

(“Sung’026”) (highlighted in green below). For example, Sung’026 describes “the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by from about 5 microns to about 100 microns. ... 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.” EX1005, [0056]. And while the disclosure directed to “the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by less than about 1 microns” can anticipate, for example, “the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns,” it does not provide written description support for the full scope of this limitation.

73. In other words, the earlier filed applications colored in green below do not provide support for the following limitations of claim 1: “the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns” or “the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles are within about 80 microns or less,” (documents with support for these limitations are highlighted below in blue or yellow, respectively).

Declaration of Dr. Stanley Shanfield  
U.S. Patent No. 9,724,802



74. Because claim 1 of the '802 Patent is supported for the first time by the '802 Patent itself, the priority date of the '802 Patent is the '802 Patent's filing date (*i.e.*, **October 3, 2014**).

75. My conclusion is consistent with the litigation history of the '802 Patent. As I previously stated in Paragraph 65, the Applicant antedated Dinh-Ngoc and Sung'869 during prosecution of the '802 Patent by claiming priority to U.S. Patent Application No. 11/560,817, filed on November 16, 2006. But during

litigation against Kinik, Sung submitted a declaration to the judge stating the following:

After the joint venture [with Kinik] terminated, I continued to conduct my own research and development in CMP disk technology. During this period, I invented the subject matter that forms the basis of the patent application (the “’802 Application”) from which the ’802 Patent issued. I then filed the ’802 Application with the United States Patent and Trademark Office on October 3, 2014. I invented this new subject matter, which is claimed in the ’802 Patent, *after the joint venture with Kinik ended October 28, 2013*. This invention is not disclosed in any of the patents or patent applications to which the ’802 Patent claims priority. ... For example, neither the ’862 Patent nor the ’270 Patent discloses a designated profile with a tip variation associated with the superabrasive particles or a tip variation at, for example, about 100 microns, all of which was discovered by me after the joint venture had terminated.

EX1011, ¶¶17-21.

Further, I am the inventor of Taiwan Patent No. 101112625 (the “Taiwan ’625 Patent”). The Taiwan ’625 Patent has a related U.S. Application No. 13/797,704 (“’704 Application”). I have reviewed both the Taiwan ’625 Patent and the ’704 Application. Neither the Taiwan ’625 Patent nor the ’704 Application disclose the claimed subject matter

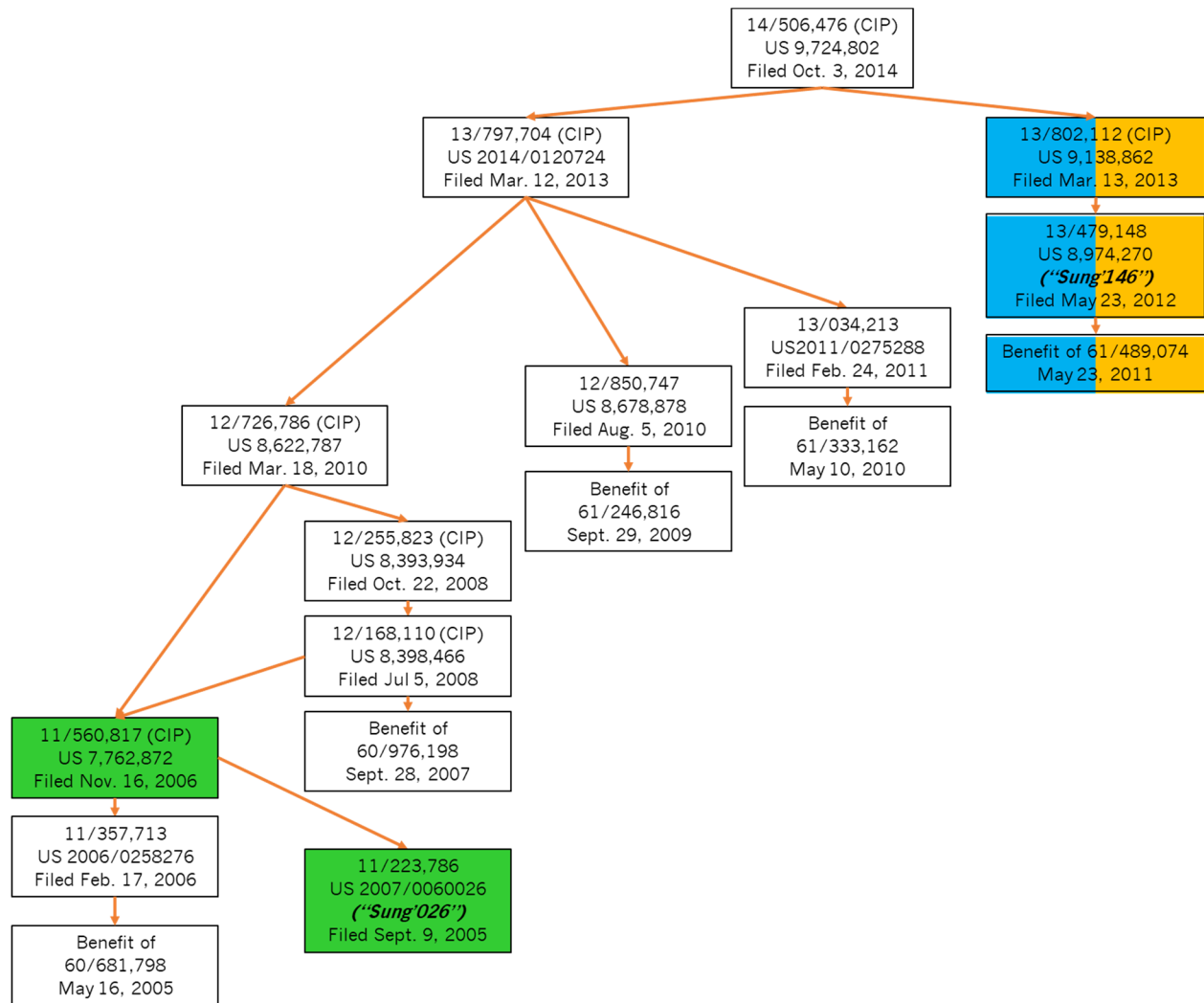
of the '802 patent. For example, the Taiwan '625 Patent does not disclose the use of a designated profile (which is recited in Claim 1 of the '802 Patent) defined by protrusion tips. By contrast, the '802 Patent discloses a profile that can be flat, planar, curved, wavy, convex, concave, or multi-tiered. For example, this is disclosed at column 6, lines 21-28 and in claim 19. With this profile, the tallest tips relative to the upper surface of the disk need not be the highest tip as measured by placing the disk on a flat plate. This invention allows the designated profile, which is one of several important features of the '802 Patent not disclosed in the Taiwan '625 Patent, to be defined by, for example, cutting tips on a slanted plane with respect to the substrate surface.

EX1011, ¶¶22-23.

76. I understand that Sung's declaration on this issue was acknowledged by the court. EX1012, 2.

Plaintiff essentially says there should be no stay here because the patent he is now asserting—the '802 patent—cannot be the subject of the joint venture because it is a continuation-in part and was filed after the joint venture ended on October 28, 2013. (D.I. 18 at 5). But although a continuation-in-part, it appears to claim priority to various provisional patent applications filed in 2011, 2007, 2005, 2005, 2009, and 2010, all of which were filed during the time of the joint venture. The present patent may have new material, but Plaintiff did not represent in the briefing that he does not claim priority back to the time of the joint venture.<sup>4</sup> Subsequent to the briefing, however, Plaintiff has clearly stated that he only claims priority to October 3, 2014. (D.I. 25; *see also* D.I. 1-1 at 2 of 23).

77. In summary, in my opinion, based on my review of earlier applications colored below, the first application that supports all the limitations recited in claim 1 is the '802 Patent itself. As such, the earliest possible filing date of the '802 Patent is the actual filing date of the '802 Patent, which is October 3, 2014.



## VI. Level of Ordinary Skill in the Art

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

79. A POSITA as of the earliest claimed filing date of the '802 Patent (*i.e.*, October 3, 2014) would have had 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.

80. I met and/or exceeded these requirements for POSITA as of October 3, 2014, for at least the reasons provided above in Section I.

## **VII. Overview of the Primary Prior Art References**

### **A. Overview of Tsai**

81. Tsai is a paper titled “Organic diamond disk versus brazed diamond disk for dressing a chemical-mechanical polishing pad,” by M.Y. Tsai, P.H. Li, and J.C. Sung (James Chien-Min Sung, the inventor and Patent Owner of the ’802 Patent). Tsai was published in *Diamond & Related Materials* in 2012, which is before the priority date of the ’802 Patent. EX1004, Title, Article Info, Header. I have been informed by counsel that Tsai is prior art to the ’802 Patent.

82. Tsai describes CMP pad dressers with diamond particles. EX1004, Title, Abstract:4-6.

83. More specifically, Tsai discloses organic diamond disks (ODDs), which are CMP pad dressers made by the “reverse casting” method described in Paragraphs 47 and 56. EX1004, Abstract:4-11. The reverse casting method results in diamond particles with substantially leveled tips embedded in an organic polymer, as shown below in Figure 2 below.

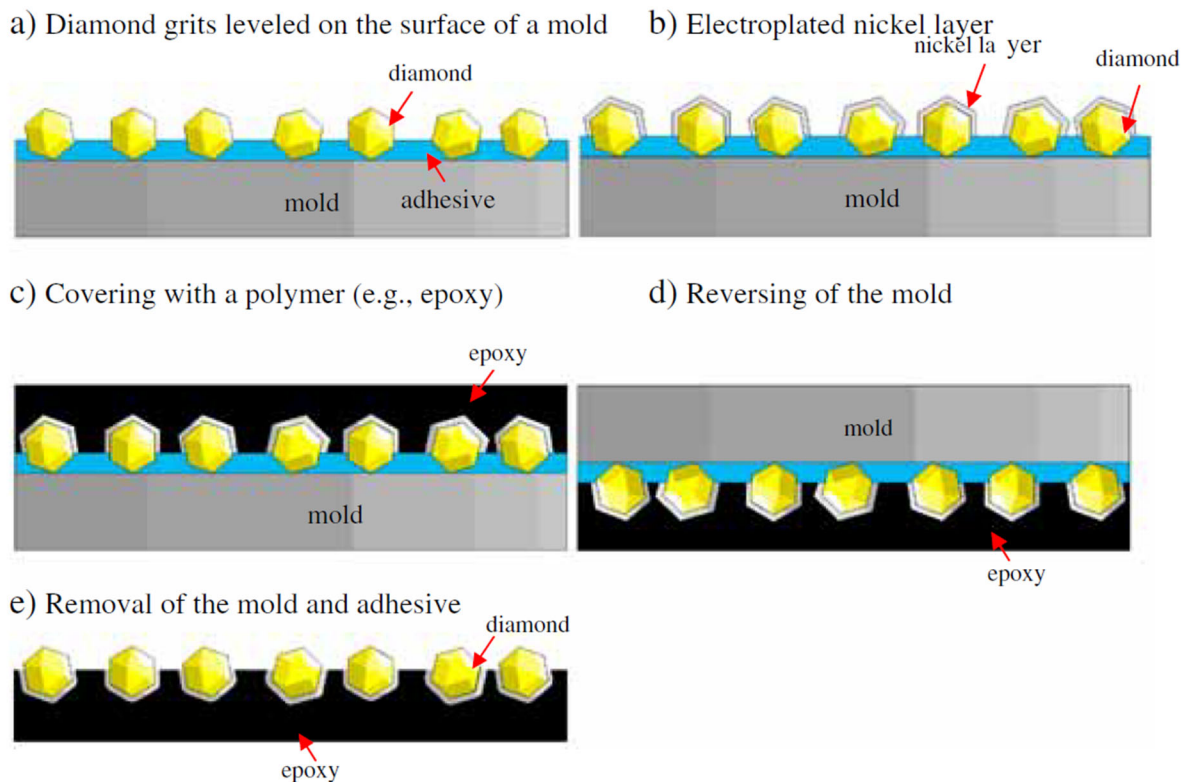


Fig. 2. Steps for manufacturing organic diamond disk.

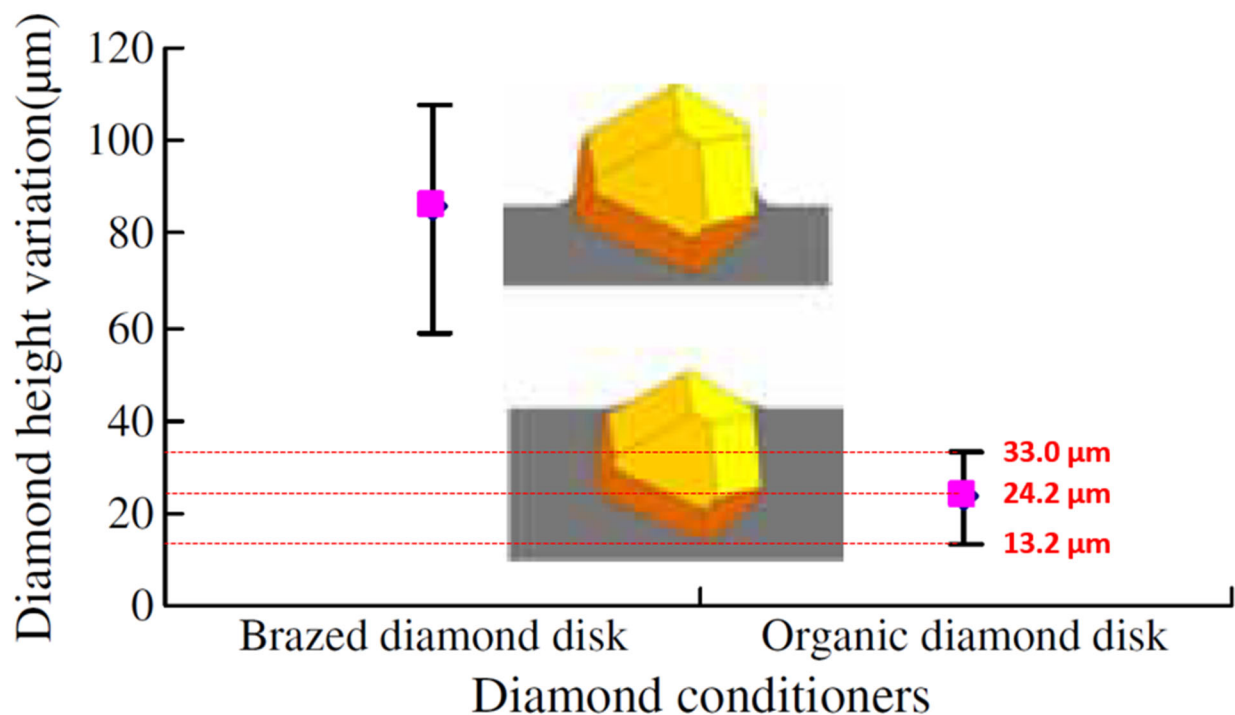
EX1004, Figure 2.

84. The diamond particles are first pre-leveled on a mold (Figure 2a). Then, a nickel layer is electroplated onto the layer of diamond particles (Figure 2b). Then, an organic polymer (such as epoxy) is deposited over the diamond particles (Figure 2c). The mold is then reversed (Figure 2d) and removed (Figure 2e), resulting in a layer of diamond particles embedded in and protruding from an organic matrix layer. EX1004, 5:20-6:6, Fig. 2.

85. Tsai's exemplary CMP pad conditioner made by reverse casting has substantially leveled tips with a protrusion height of approximately 30 microns.

Tsai discloses that tips can be leveled to less than 15 microns. Specifically, Tsai shows an example in Figure 6 of an ODD with an average protrusion height of about 24.2 microns. As determined from the scale bar on the y-axis and the error bars drawn, the protrusion heights range from approximately 13.2 microns to approximately 33.0 microns (*e.g.*, a tip-to-tip variation of approximately 19.8 microns). Additionally, Tsai explains that the leveling of the superabrasive particles allows the particles to “share an equal dressing load” when conditioning (*e.g.*, cutting) CMP pads. This results in better conditioning of the CMP pad.

EX1004, Abstract:9-14, 8:22-26, 3:7-10, Fig. 6.



EX1004, Fig. 6 (annotated).

86. Tsai uses “diamond grit” and “diamond particle” interchangeably, which is common in the art. EX1004, 5:5-11; EX1005, [0033].

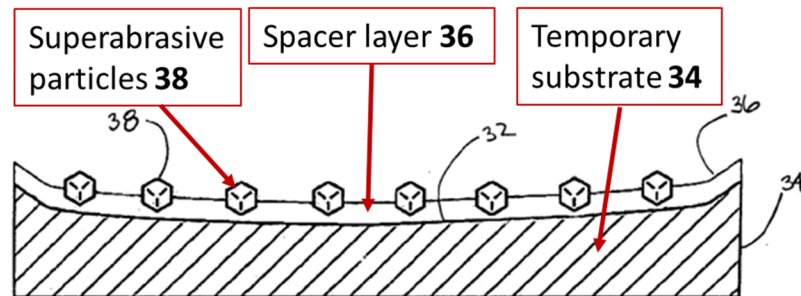
**B. Overview of Sung’026**

87. Sung’026 is a U.S. Patent Application Publication published on March 15, 2007. EX1005, Cover. I have been informed by counsel that Sung’026 is prior art to the ’802 Patent.

88. Sung’026 is directed to CMP pad conditioners. EX1005, [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’026’s CMP pad dressers include “superabrasive particles protruding out of the solidified organic material layer.” EX1005, 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.” EX1005, [0033].

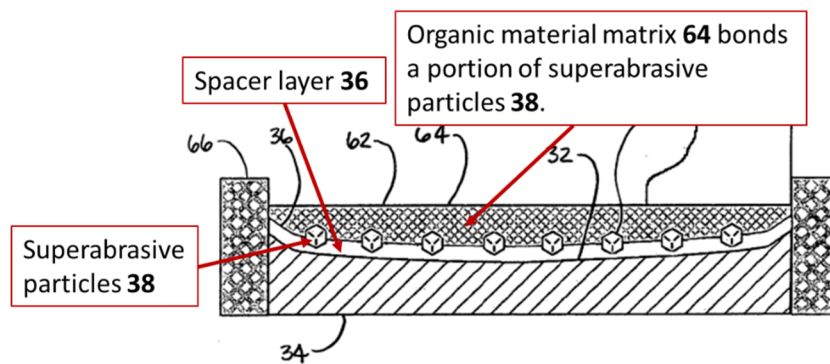
89. Sung’026 discloses that such CMP pad dressers can be prepared by “reverse casting methods.” EX1005, [0083]. Such process is illustrated in Figs. 2, 5, and 6, which I have reproduced with my annotations, and the process is just like the method described in the ’802 Patent and Tsai.

90. Referring to Fig. 2 of Sung'026, the superabrasive particles are first “dispose[d] into a spacer layer.” EX1005, [0084]; *see also* EX1001, 25:16-18 (“Such methods can include initially securing the plurality of dressing segments to a substrate using a ‘mask’ material.”).



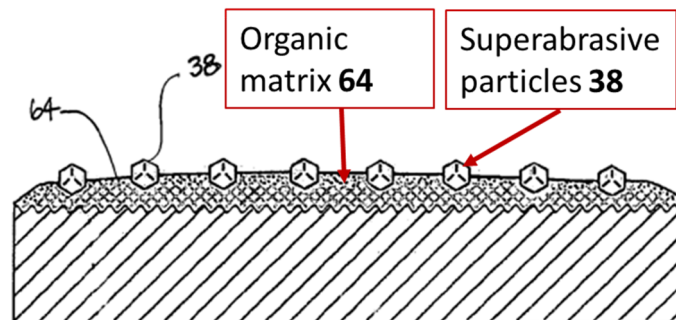
EX1005, FIG. 2 (annotated).

91. 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.” EX1005, [0087]; *see also* EX1001, 25:18-27 (“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.” EX1005, [0030].



EX1005, FIG. 5 (annotated).

92. 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. EX1005, [0088]; *see also* EX1001, 25:21-22 (“[A]fter which (or during which), the masking material can be removed.”).



EX1005, FIG. 6 (annotated).

93. 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 micron[.]” EX1005, [0053], [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.

94. 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.” EX1005, [0010], [0052], claim 5.

### **VIII. Claim Construction**

95. 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 '802 Patent.

96. Based on my review of the claims, specification, and file history of the '802 Patent, I conclude that claim terms need not be construed. But I found specific definitions for several terms the '802 Patent recites in the claims. These include the terms “superabrasive,” “particle,” “working superabrasive particle,” “profile,” “support substrate,” “tip,” “protrusion,” and “about.”

#### **A. “superabrasive”**

97. The term “superabrasive” is used in claims 1, 6, 8-18, and 20-21. The '802 Patent defines this term as follows: “[a]s used herein, ‘superabrasive’ may be

used to refer to any crystalline, or polycrystalline material, or mixture of such materials which has a Moh[s hardness of about 8 or greater.” EX1001, 4:13-16.

The ’802 Patent explicitly provides that “[s]uitable superabrasive material examples can include ... diamond, polycrystalline diamond (PCD), ... as well as other superabrasive materials known to those skilled in the art.” EX1001, 4:19-24.

**B. “particle”**

98. The term “particle” is used in claims 1, 6, 8-18, and 20-21. The ’802 Patent defines the term as follows: “[a]s used herein, ‘particle’ refers, when used in connection with superabrasive particles, to a particulate form of superabrasive particle. Such particles may take a variety of shapes, including round, oblong, square, euhedral, etc., can be either single crystal or polycrystalline, and can have a number of mesh sizes.” EX1001, 4:33-38.

**C. “working superabrasive particle”**

99. The term “working superabrasive particle” is used in claims 6 and 8-12. The ’802 Patent defines the term as follows: “[a]s used herein, ‘working superabrasive particles’ are superabrasive particles that cut or otherwise deform a CMP pad during a dressing or conditioning procedure.” EX1001, 4:46-48.

**D. “profile”**

100. The term “profile” is used in claims 1, 13-15, and 19. The ’802 Patent defines the term as follows: “[a]s used herein, the term ‘profile’ ... refer[s] to a

predetermined contour above a support substrate to which a plurality of superabrasive particles or other cutting elements are intended to align.” EX1001, 6:21-25.

**E. “support substrate”**

101. The term “support substrate” is used in claims 1, 12, and 20. The ’802 Patent defines the term as follows: “[a]s used herein, the terms ‘substrate’ and ‘support substrate’ can be used interchangeably, and refer to a portion of a pad conditioner that supports superabrasive materials, and to which abrasive materials and/or superabrasive segments that carry abrasive materials may be affixed.” EX1001, 7:59-63.

**F. “tip”**

102. The term “tip” is used in claims 1-5 and 13-15. The ’802 Patent defines the term as follows: “[a]s used herein, cutting ‘tip’ refers to a portion of a cutting element or particle that protrudes the greatest distance from the support substrate, e.g., that is the first portion of the cutting element that contacts a CMP pad when in use.” EX1001, 5:9-12.

**G. “protrusion”**

103. The term “protrusion” is used in claims 1-5 and 16-18. The ’802 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, 16:24-26.

#### **H. “about”**

104. The term “about” is used in claims 1-7, 10-18, and 21. The ’802 Patent defines this term as follows: “[a]s used herein, 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, 8:29-32.

#### **IX. Specific Invalidity Grounds**

105. As I explained in Paragraph 37, I conclude that claims 1-21 of the ’802 Patent are rendered obvious by the prior art. In the sections below, I explain in detail how claims 1-21 of the ’802 Patent are not patentable over prior art.

##### **A. Ground I: Tsai Anticipates or Tsai Renders Obvious Claims 1-5, 13, 15, and 19-21**

106. Claims 1, 4, 5, 13, 15, and 19-21 are all anticipated and/or rendered obvious by Tsai for at least the following reasons.

##### **1. Independent Claim 1 and Dependent Claims 13 and 15**

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

107. Tsai discloses the preamble [1Pre].

108. I understand that the preamble may not limit the claims. Regardless, Tsai discloses CMP pad dressers. Specifically, Tsai discloses “organic diamond disks (ODDs)” that are used to condition CMP pads. EX1004, Title (“Organic

diamond disk versus brazed diamond disk for dressing a chemical-mechanical polishing pad”), Abstract:4-6 (“In this research, we evaluated diamond conditioners manufactured using polymer-bonded diamond grits for use in CMP; these conditioners are known as organic diamond disks (ODDs).”).

**ii. [1A] a rigid support substrate; and**

109. Tsai teaches [1A].

110. As I already discussed in Paragraph 101, “support substrate” means “a portion of a pad conditioner that supports superabrasive materials, and to which abrasive materials and/or superabrasive segments that carry abrasive materials may be affixed.” EX1001, 7:59-63.

111. Tsai teaches a CMP pad dresser with an epoxy support substrate. Tsai describes a “design of a diamond disk by reversing the process of attaching diamonds using an organic matrix (*e.g.* epoxy).” EX1004, 5:20-21.

112. The epoxy support substrate is a “support substrate” within the meaning of the ’802 Patent because the epoxy support substrate forms “a portion of a pad conditioner that supports superabrasive materials, and to which abrasive materials and/or superabrasive segments that carry abrasive materials may be affixed.” EX1001, 7:59-63. For example, the manufacturing process of the ODD is shown in Figure 2. First, the superabrasive particles are leveled on an adhesive layer on a mold (shown in Fig. 2a). Next, a nickel layer is electroplated over the

diamond layer (shown in Fig. 2b). Then, epoxy is poured over the superabrasive particles (shown in Fig. 2c). The adhesive and the mold are removed (shown in Fig. 2e), and the epoxy is cured to a rigid state. EX1004, 5:23-6:6. This results in the superabrasive particles embedded in and protruding from the rigid epoxy support substrate.

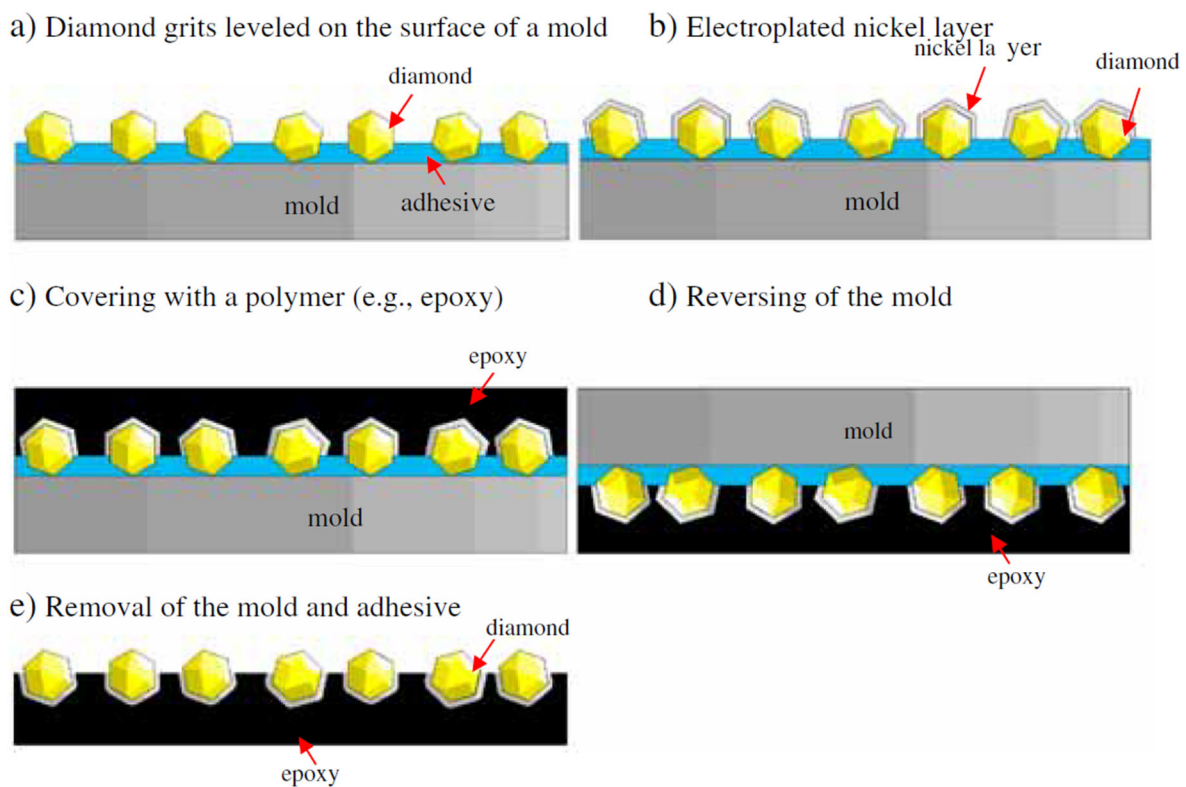


Fig. 2. Steps for manufacturing organic diamond disk.

EX1004, Fig. 2.

113. The '802 Patent states that "relatively hard polymers or other organic materials" may be used as the support substrate and specifically calls out "epoxy resin" as a suitable organic material for use as the rigid support substrate. EX1001,

8:2-5, 24:64-25:19 (“Various organic materials are contemplated for use as a support substrate ... In one specific aspect, the organic material can be an epoxy resin.”), 25:23-32.

**iii. [1B] a monolayer of a plurality of superabrasive particles coupled to the support substrate,**

114. Tsai discloses [1B].

115. As I already discussed in Paragraph 97, “superabrasive” means “any crystalline, or polycrystalline material, or mixture of such materials which has a Moh[s] hardness of about 8 or greater.” EX1001, 4:13-16. As I already discussed in Paragraph 104, “about” “provide[s] flexibility to a numerical range endpoint by providing that a given value may be ‘a little above’ or ‘a little below’ the endpoint.” EX1001, 8:29-32.

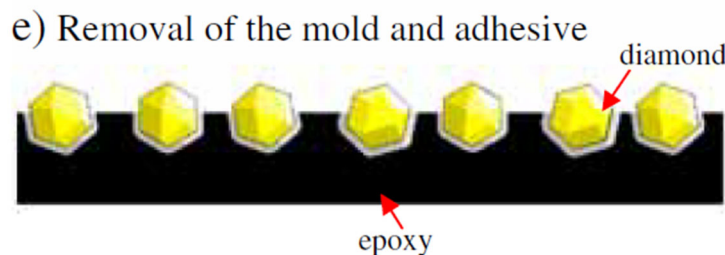
116. As I already discussed in Paragraph 98, “particle” means “a particulate form of superabrasive particle.” EX1001, 4:33-35.

117. Tsai’s diamond grits are superabrasive particles. Diamond has a Mohs hardness of 10, which meets the ’802 Patent’s definition of “superabrasive.” EX1007, 3; EX1001, 4:13-16. Additionally, the ’802 Patent lists diamond as an example of a superabrasive material. EX1001, 4:19-25.

118. Tsai uses “diamond grit” and “diamond particle” interchangeably, as is common in the art. For example, Tsai uses “diamond grits” and “diamond

particles” to describe superabrasive particles (in a particulate form) on first-generation CMP pad dressers. EX1004, 5:5-11 (“The first-generation diamond pad conditioners contained randomly distributed *diamond grits* that were typically buried in an electroplated nickel layer. The electroplated metal held the diamonds in place only mechanically, and hence, diamonds inevitably displaced from the matrix. The loss of *diamond particles* during the CMP process affected the wafer performance.”). Therefore, a “diamond grit” is a “diamond particle.”

119. Tsai describes a monolayer of diamond grits coupled to the epoxy support substrate, shown in Figure 2e below. *See also* EX1004, 5:23-6:5 (“First, the diamond grits are leveled on the surface of a mold for their regular distribution, ... each diamond grit is buried at a depth of more than twice the height of the exposed part of the grit. Then, the mold is reversed. Finally, the mold and the adhesive are removed and polymer-bonded diamond grits are obtained.”). As I noted in Paragraph 29, I understand that a claim may be anticipated by an image or drawing if the claimed structure is clearly shown.



EX1004, Fig. 2e.

120. In the reverse casting method, as I explained above in Paragraph 112 and is shown below in Figure 2, each diamond particle is coupled to and protrudes from the epoxy support substrate. The mold and adhesive are later removed, and only polymer-bonded grits remain on the epoxy support. EX1004, 5:23-6:5.

Therefore, any diamond particle not embedded in the epoxy support is removed with the adhesive and the mold, resulting in the depicted monolayer of diamond particles. EX1004, 6:1-6 (“In addition, to increase the adherence strength, each diamond grit is buried at a depth of more than twice the height of the exposed part of the grit...the mold and the adhesive are removed and polymer-bonded diamond grits are obtained.”).

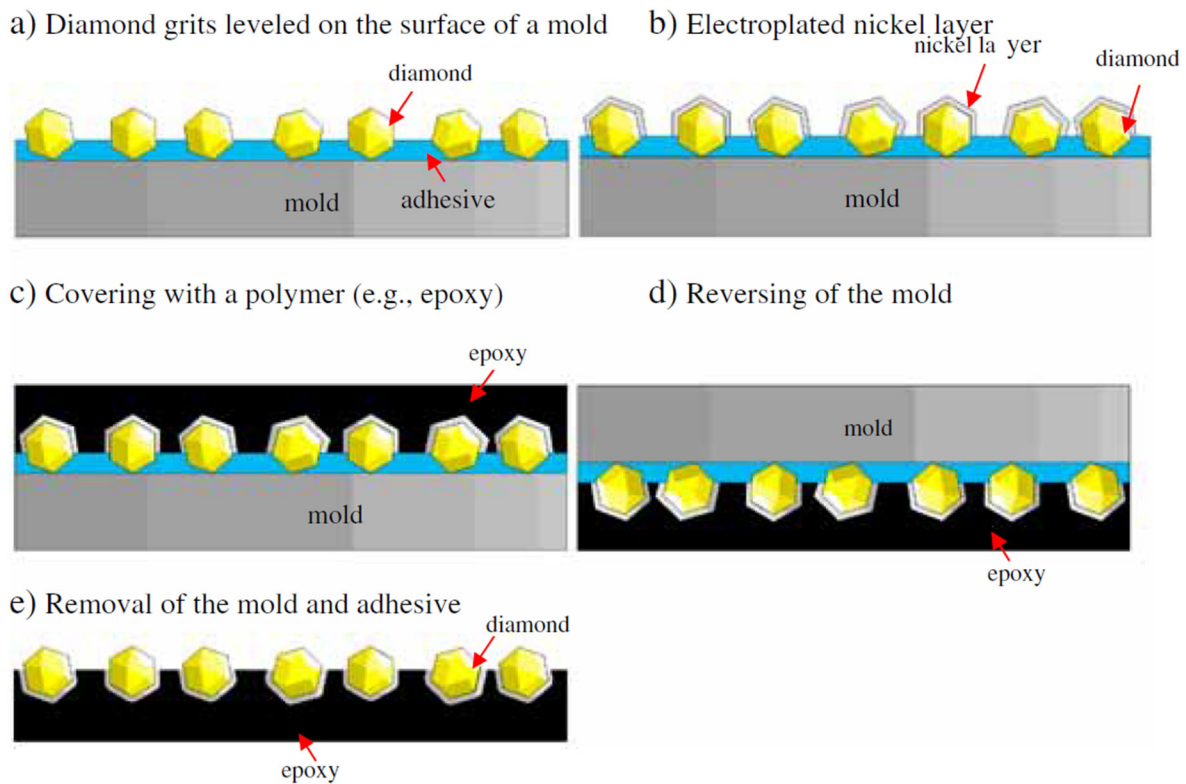


Fig. 2. Steps for manufacturing organic diamond disk.

EX1004, Fig. 2.

121. Additionally, Figures 3 and 8 show SEM images of the surface of the ODD. In these SEM images, it is clear that there is a monolayer of superabrasive particles on the surface of the ODD.

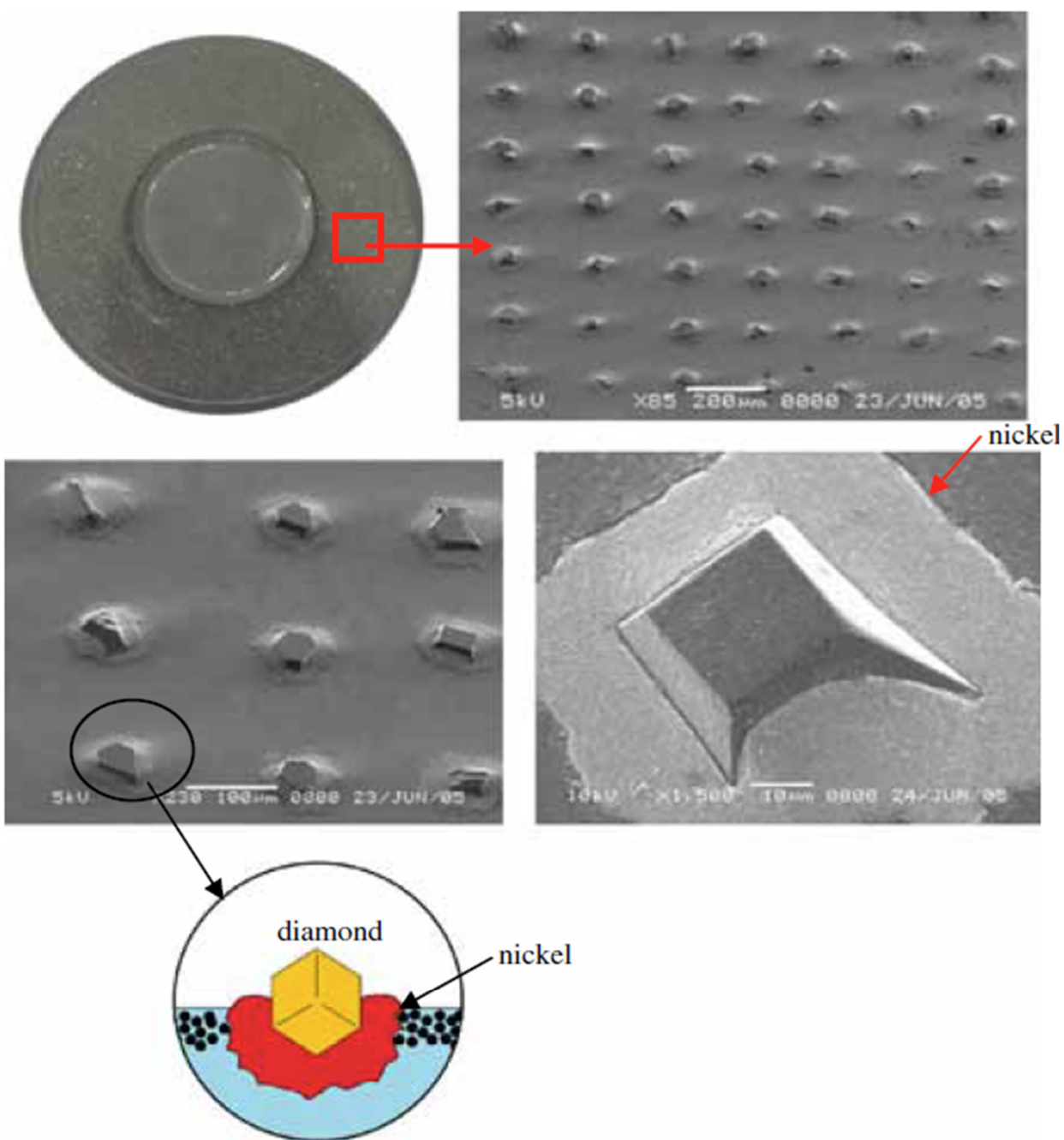


Fig. 3. Outer appearance of the organic diamond disk. Note that each diamond is covered with nickel.

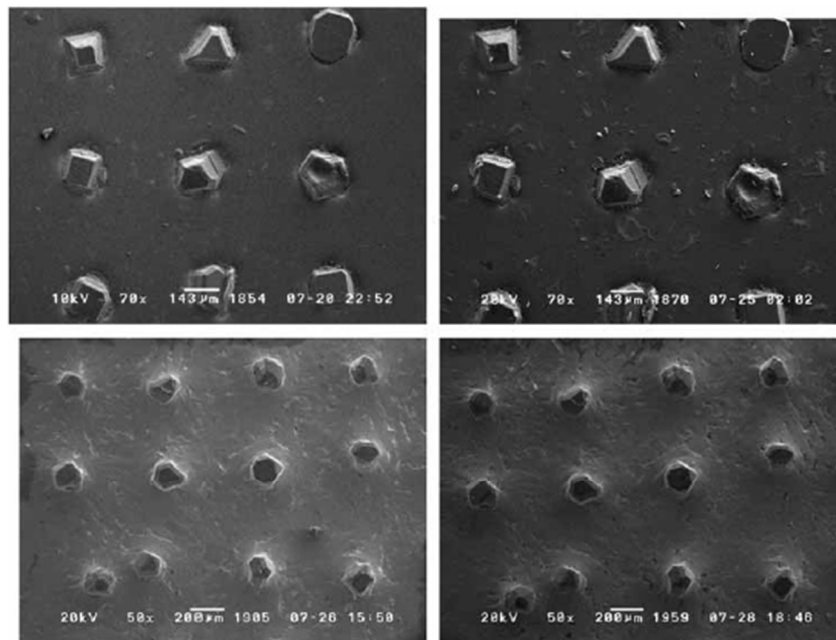


**Fig. 8.** SEM observation of the surface topography of the BDD after (a) 1 h and (b) 40 h and that of the surface topography of the ODD after (c) 1 h and (d) 40 h in the oxide-slurry solution.

EX1004, Figs. 3 and 8.

122. Furthermore, Figure 5 shows a contour map of the surface of the ODD. In Fig. 5, dark green represents a protrusion distance of about 0 µm, and red represents a protrusion distance of about 20 µm. It is clear that there is a single layer of diamond particles (shown in red) coupled to the rigid epoxy support (shown in green).

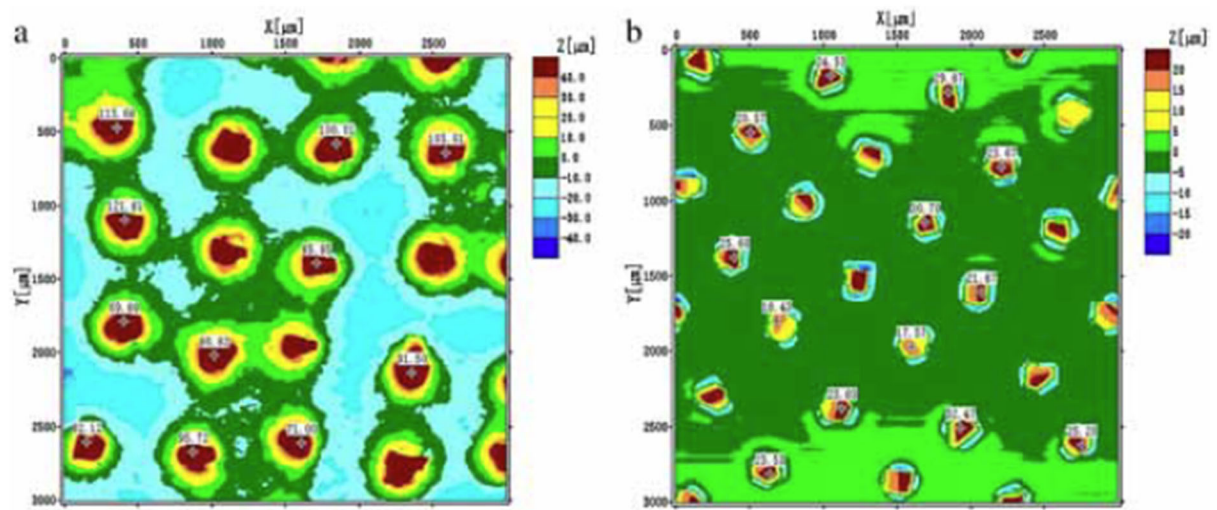


Fig. 5. Comparison of the cutting tips of (a) brazed diamond disk (b) organic diamond disk.

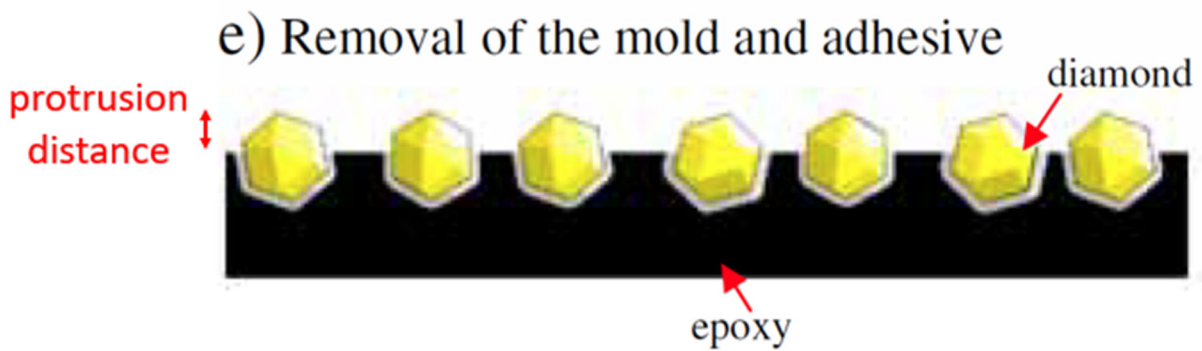
EX1004, Fig. 5.

iv. **[1C] wherein each superabrasive particle in the monolayer extends away from the support substrate to a protrusion distance,**

123. Tsai discloses [1C].

124. As I already discussed in Paragraph 103, “‘protrusion’ refers to the height of a particle relative to some reference point.” EX1001, 16:24-26.

Tsai clearly shows each diamond particle extending to some height, away from the epoxy resin, in Figure 2e. I have annotated the protrusion distance in Figure 2e (below). Tsai states that the protrusion distance is about 30 microns. EX1004, 8:14-16 (“In addition, the protrusion height (approximately 30  $\mu\text{m}$ ) of the diamonds for the ODD is smaller than that (approximately 80  $\mu\text{m}$ ) for the BDD.”).



EX1004, Fig. 2e (annotated).

125. Additionally, Figures 3 and 8 clearly show that each diamond particle on the surface of the CMP pad dresser protrudes from the epoxy resin layer.

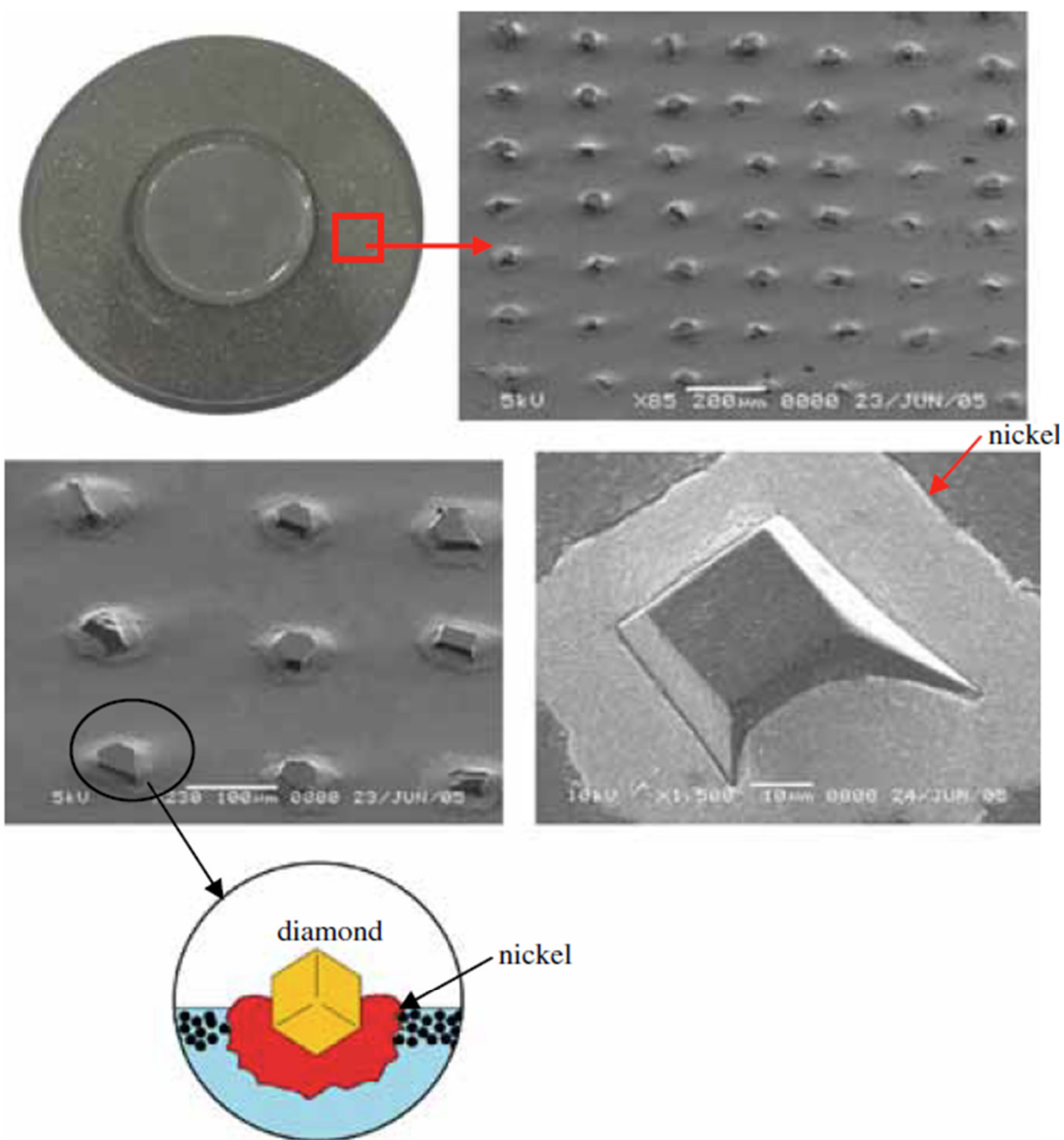


Fig. 3. Outer appearance of the organic diamond disk. Note that each diamond is covered with nickel.

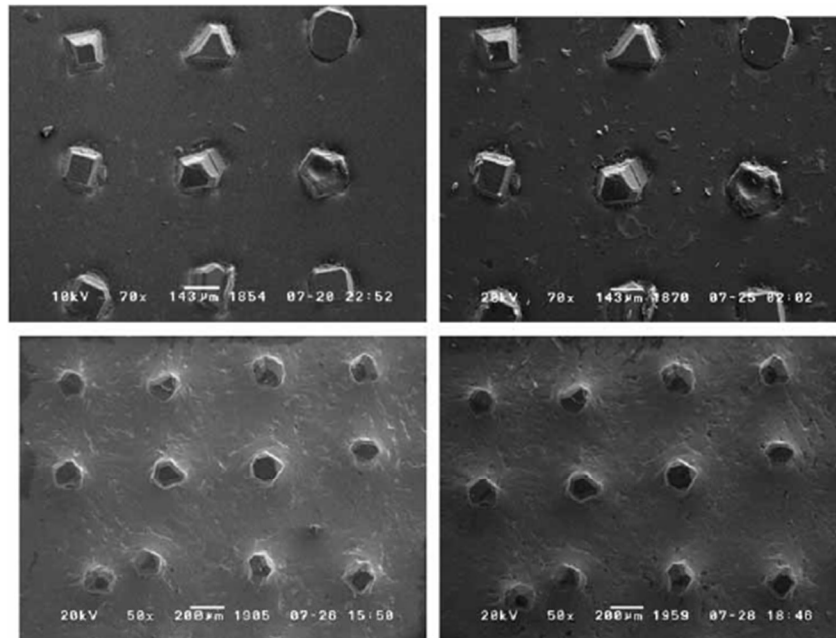


Fig. 8. SEM observation of the surface topography of the BDD after (a) 1 h and (b) 40 h and that of the surface topography of the ODD after (c) 1 h and (d) 40 h in the oxide-slurry solution.

EX1004, Figs. 3 and 8.

126. Furthermore, as explained above in Paragraph 122, Figure 5b shows a contour map of the surface of the ODD. Each diamond particle (red) shown has a protrusion distance of about 20  $\mu\text{m}$  from the rigid epoxy support (green).

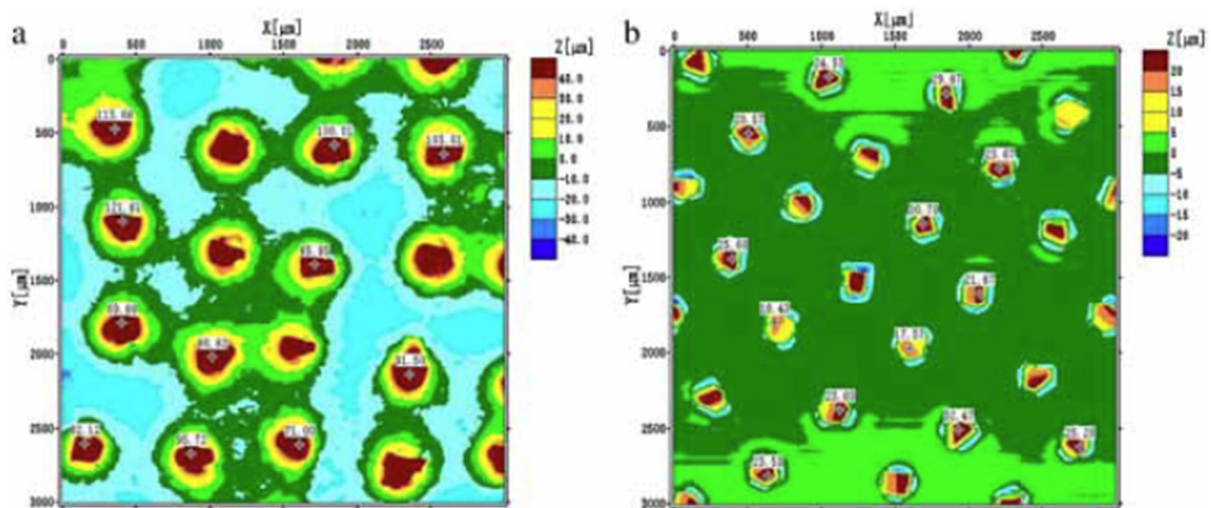


Fig. 5. Comparison of the cutting tips of (a) brazen diamond disk (b) organic diamond disk.

EX1004, Fig. 5.

- v. **[1D] wherein a tip of each of the plurality of superabrasive particles aligns along a designated profile with a tip variation of from about 5 microns to about 100 microns,**

127. Tsai discloses and/or renders obvious limitation [1D].

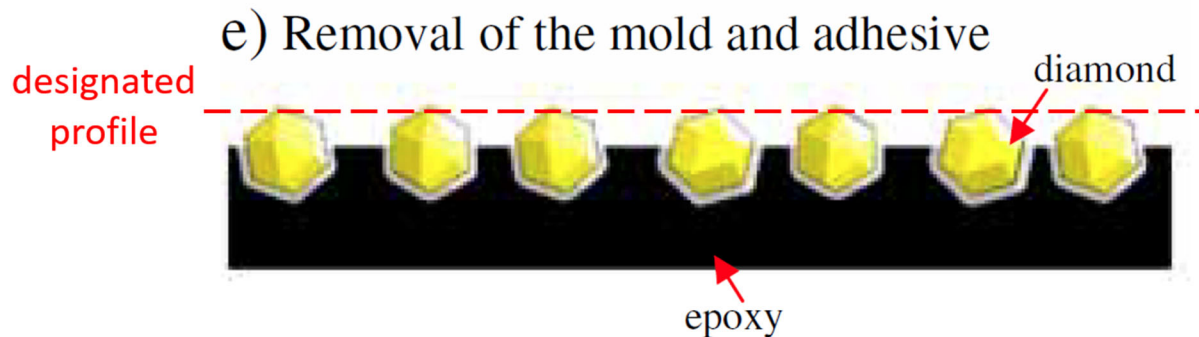
128. As I have already discussed in Paragraph 102, a “cutting ‘tip’ refers to a portion of a cutting element or particle that protrudes the greatest distance from the support substrate, e.g., that is the first portion of the cutting element that contacts a CMP pad when in use.” EX1001, 5:9-12.

129. As I have already discussed in Paragraph 100, “‘profile’ ... refer[s] to a predetermined contour above a support substrate to which a plurality of superabrasive particles or other cutting elements are intended to align.” EX1001, 6:21-25.

130. As I have already discussed in Paragraph 104, “‘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, 8:29-32.

131. Tsai describes “compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.” EX1004, 6:8-10. Controlling superabrasive tip height variation in this way designates a flat profile above the

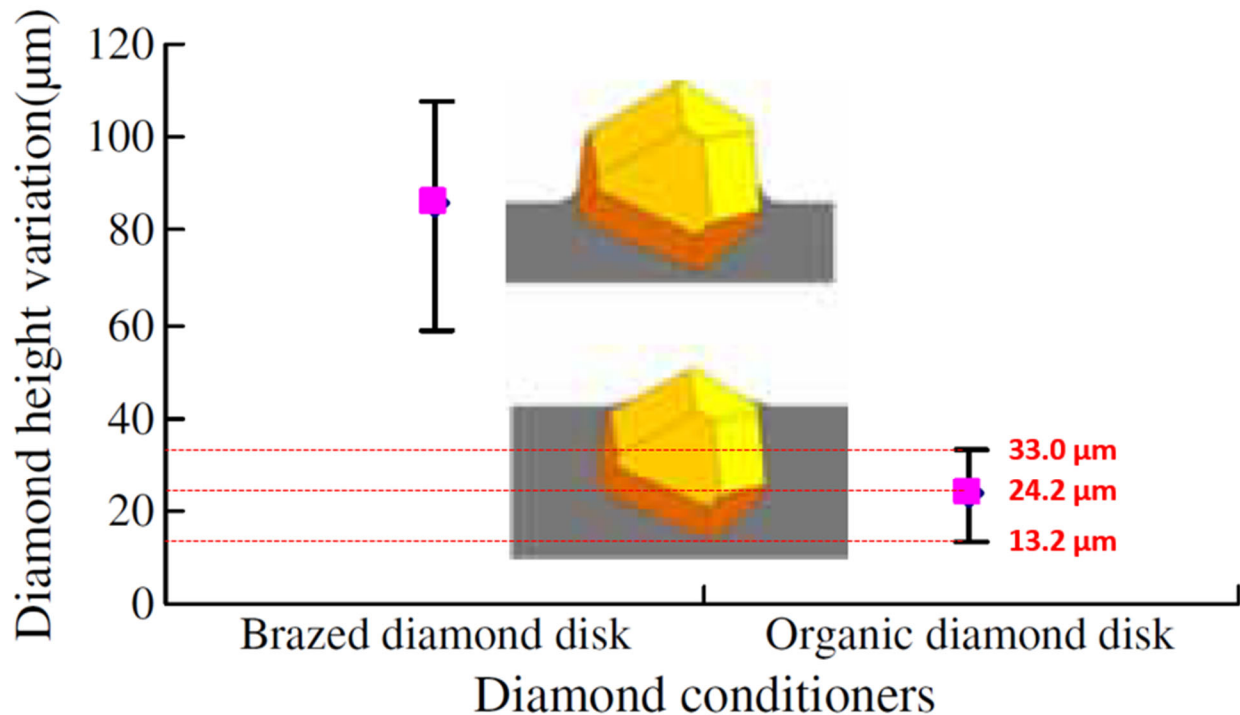
epoxy resin (represented as a red dotted line) to which each of the tips of the superabrasive particles should align, shown below in Figure 2e.



EX1004, Fig. 2e (annotated).

132. Some tips may protrude above or below (*i.e.*, vary from) the designated profile. However, Tsai discloses substantial tip-to-tip leveling to within 19.8 microns, as shown below in Fig. 6 (range in protrusion height from about 13.2 microns to about 33.0 microns). EX1004, 6:8-10 (“In this case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.”), 5:23-24 (“First, the diamond grits are leveled on the surface of a mold for their regular distribution...”), 8:22-24 (“...as shown in Fig. 6, in the case of the ODD, the diamond tips of the ODD can be leveled to less than 15  $\mu\text{m}$  because the diamond tips are already leveled.”), Fig. 6. Additionally, Tsai describes that the superabrasive particles protrude from the epoxy support substrate to approximately 30 microns. EX1004, 8:14-16 (“In addition, the

protrusion height (approximately 30  $\mu\text{m}$ ) of the diamonds for the ODD is smaller than that (approximately 80  $\mu\text{m}$ ) for the BDD.”).



EX1004, Fig. 6 (annotated).

133. Using the average protrusion height (*i.e.*, 24.2 microns) as the designated profile, the tip-to-designated profile variation disclosed by Tsai is approximately 8.8 microns (33.0 microns - 24.2 microns) or 11 microns (24.2 microns - 13.2 microns). Therefore, whether the claimed “tip variation” requires a tip-to-tip variation or a tip-to-designated profile variation, the ODD in Figure 6 discloses this limitation.

134. As I noted in Paragraph 28, I understand that a claimed range can be anticipated if one value in the range is in the prior art. Therefore, Tsai’s tip-to-

designated profile and tip-to-tip variations of about 8.8 or 11 microns and about 19.8 microns, respectively, disclose the range of from about 5 microns to about 100 microns claimed in [1D].

135. Additionally, Tsai discloses that the tips of the superabrasive particles can be leveled to less than 15 microns, which is even more substantial leveling than that shown in Figure 6. EX1004, 8:22-24. A tip variation of less than 15 microns also discloses or at a minimum renders obvious the claimed range of from about 5 microns to about 100 microns claimed in [1D]. Although a tip variation of less than 15 microns overlaps the claimed range of about 5 microns to about 100 microns, I see nothing in the '802 Patent that discusses the criticality of the particular range between 5-100 microns. Nor do I see anything in the '802 Patent that indicates that this claimed range between 5-100 microns provide some unexpected results that exceed what was already known in the art or that Tsai teaches away from the claimed range. Hence, I understand that Tsai's separate teaching of less than 15 microns of tip variation also teaches the range claimed in [1D].

136. Even if the Patent Owner argues that Tsai does not disclose limitation [1D], a POSITA, based on the teachings of Tsai, would have found a tip variation of from about 5 microns to about 100 microns obvious. A POSITA's routine efforts to optimize diamond particle tip leveling would have resulted in the claimed

ranges. It was known in the art that there were many disadvantages to having unveled tips on a CMP pad dresser. For example, Tsai mentions that in conventional disks where the tips of the superabrasive particles are not leveled, “less than 10% of the diamond grits are engaged in cutting the polishing pad. The rest of the grits remain unused on the disk.” EX1004, 2:14-17. This results in uneven wear of the CMP pad dresser. Tsai also explains that if any grits protrude to a significantly higher protrusion height than the rest of the superabrasive particles, they will cut “50% of the pad consumed during dressing”, causing uneven wearing of the CMP pad. This shortens the CMP pad’s lifespan and increases the costs associated with CMP. EX1004, 2:19-22 (“Moreover, the few tall diamond grits can cut 50% of the pad consumed during dressing; this shortens the pad lifespan and increases the running costs.”).

137. A POSITA would have been able to obtain different tip-to-tip or tip-to-designated profile variations. One way to do this would have been to modify a step in Tsai’s reverse casting process, which is recognized by the ’802 Patent as a suitable embodiment. EX1001, 25:14-22. For example, Tsai discloses that the superabrasive particles are first leveled on a mold. EX1004, 5:23-24. A POSITA would know that changing the degree of leveling of the superabrasive particles on the mold would affect the tip-to-tip or tip-to-designated profile variations.

138. As another example, a POSITA would have been able to change the compression of the flat plate used to reduce the variation in the tip heights.

EX1004, 6:8-10 (“In this case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.”).

Changing the compression taught by Tsai would have allowed a POSITA to obtain the tip height variation claimed in [1D].

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

**[1F] the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles are within about 80 microns or less.**

**[13] The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles align along the designated profile with a tip variation of from about 10 microns to about 50 microns.**

**[15] The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles align along the designated profile with a tip variation of less than about 20 microns.**

139. Tsai discloses [1E], [1F], [13], and [15].

140. As I explained above in Paragraphs 131-134, Tsai discloses a tip-to-tip variation of about 19.8 microns in Figure 6 and discloses that the variation can be less than 15 microns for all superabrasive particles. EX1004, 6:8-10 (“In this

case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.”), 5:23-24 (“First, the diamond grits are leveled on the surface of a mold for their regular distribution...”), 8:22-24 (“...the diamond tips of the ODD can be leveled to less than 15  $\mu\text{m}$  because the diamond tips are already leveled.”), 8:14-16 (“In addition, the protrusion height (approximately 30  $\mu\text{m}$ ) of the diamonds for the ODD is smaller than that (approximately 80  $\mu\text{m}$ ) for the BDD.”), Fig. 6. As I noted in Paragraph 28, I understand that a claimed range can be anticipated if one value in the range is in the prior art. Therefore, Tsai’s tip-to-tip variation of about 15 microns anticipates the claimed tip-to-tip variations.

141. With respect to limitation [1E], Tsai’s tip-to-tip variation for all superabrasive particles on the CMP pad dresser is about 19.8 microns in the example shown in Figure 6, and can be less than about 15 microns. Therefore, the difference in protrusion distance between the highest and second highest protruding tips must also be about 19.8 microns (or less than 15 microns), which is within the claimed range in [1E] of less than or equal to about 50 microns.

142. With respect to limitation [1F], since Tsai’s tip-to-tip variation for all superabrasive particles on the CMP pad dresser is about 19.8 microns in the example shown in Figure 6, and can be less than about 15 microns, the difference in protrusion distance between the highest 1% of protruding tips must also be about

19.8 microns (or less than 15 microns), which is within the claimed range in [1F] of about 80 microns or less.

143. With respect to limitation [13], since Tsai's tip-to-tip variation for all superabrasive particles on the CMP pad dresser is about 19.8 microns in the example shown in Figure 6, and can be less than about 15 microns, each of the highest protruding tips aligns along the designated profile with a tip-to-tip variation of about 19.8 microns (or less than about 15 microns). Assuming [13] is directed to a tip-to-tip variation, this is within the claimed range in [13] of about 10 microns to about 50 microns.

144. With respect to limitation [15], because Tsai's tip-to-tip variation for all superabrasive particles on the CMP pad dresser about 19.8 microns in the example shown in Figure 6, and can be less than about 15 microns, each of the highest protruding tips aligns along the designated profile with a tip-to-tip variation of about 19.8 microns (or less than about 15 microns), which is within the claimed range in [15] of less than about 20 microns.

145. Even if the Patent Owner argues that [15] is directed to a tip-to-designated profile variation instead of a tip-to-tip variation, Tsai teaches a tip-to-designated profile variation of about 8.8 microns or 11 microns for all tips, and a tip-to-designated profile variation that can be less than 7.5 microns. Therefore, the highest tip of each of the plurality of superabrasive particles will also have a tip-to-

designated profile variation of about 8.8 microns or about 11 microns (or less than about 7.5 microns), which is within the claimed less than about 20 microns. Even if the designated profile is not intended to be the average distribution of tip heights, the maximum tip-to-designated profile on a CMP pad dresser with a tip-to-tip variation of 15 microns is 15 microns, which is still within the claimed less than about 20 microns.

146. Even if the Patent Owner argues that Tsai does not disclose the limitations [1E], [1F], [13], and [15] because Tsai does not use the specific words recited in the claim limitations, a POSITA would have found the ranges claimed in [1E], [1F], [13], and [15] obvious. Tsai's teaching of "less than 15 microns" of tip variation overlaps the ranges that are claimed in [1E], [1F], [13], and [15]. A POSITA could have obtained any of these claimed ranges by optimizing the reverse casting method taught by Tsai to obtain substantially leveled tips, as I explained in Paragraphs 137-138, because of the disadvantages of having unleveled tips that I explained in Paragraph 136. And I see nothing in the '802 Patent that would suggest that the ranges claimed in [1E], [1F], [13], and [15] are critical to the claims or that they produce some unexpected results that exceed what was already known in the art or that Tsai teaches away from the claimed range.

**2. Dependent Claims 2 and 3**

- i. **[2] The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns.**

**[3] The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than about 10 microns.**

147. Tsai renders obvious [2] and [3].

148. As I explained above in Paragraphs 131-134, Tsai discloses a tip-to-tip variation of about 15 microns for all superabrasive particles. EX1004, 6:8-10 (“In this case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.”), 5:23-24 (“First, the diamond grits are leveled on the surface of a mold for their regular distribution...”), 8:22-24 (“...the diamond tips of the ODD can be leveled to less than 15  $\mu\text{m}$  because the diamond tips are already leveled.”), 8:14-16 (“In addition, the protrusion height (approximately 30  $\mu\text{m}$ ) of the diamonds for the ODD is smaller than that (approximately 80  $\mu\text{m}$ ) for the BDD.”).

149. As I noted in Paragraph 31, I understand that a range in the prior art that encompasses a slightly narrower claimed range may render obvious the narrower range. Tsai does not teach away from the claimed range nor does the '802 Patent describe any unexpectedly superior results over this disclosed range.

150. Therefore, Tsai's disclosure of a tip-to-tip variation of less than 15 microns across all tips renders obvious the tip-to-tip variations of less than or equal to 10 microns claimed in [2] and less than 10 microns claimed in [3].

### **3. Dependent Claims 4 and 5**

i. **[4] The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the 10<sup>th</sup> highest protruding tip is less than or equal to about 20 microns.**

**[5] The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the 100<sup>th</sup> highest protruding tip is less than or equal to about 40 microns.**

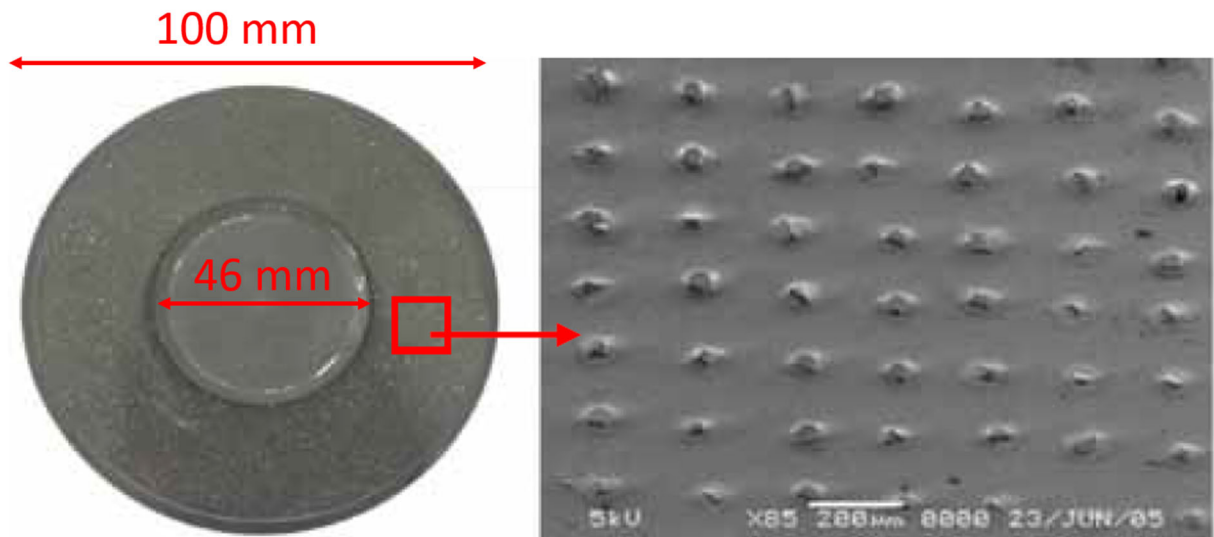
151. Tsai discloses [4] and [5].

152. As I explained above in Paragraphs 131-134, Tsai discloses a tip-to-tip variation and tip-to-designated profile variation for all superabrasive particles in the ODD of Figure 6 of 19.8 microns and 8.8 microns or 11 microns, respectively. Tsai also discloses a tip-to-tip variation of less than 15 microns for all superabrasive particles, which results in a tip-to-designated profile variation of about 7.5 microns. EX1004, 6:8-10 ("In this case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips."), 5:23-24 ("First, the diamond grits are leveled on the surface of a mold for their regular distribution..."), 8:22-24 ("...the diamond tips of the ODD can be leveled to less than 15  $\mu$ m because the diamond tips are already leveled."),

8:14-16 (“In addition, the protrusion height (approximately 30  $\mu\text{m}$ ) of the diamonds for the ODD is smaller than that (approximately 80  $\mu\text{m}$ ) for the BDD.”), Fig. 6. As I explain below, Tsai’s CMP pad dressers contain more than the claimed 10 and 100 tips. As I noted in Paragraph 28, I understand that a claimed range can be anticipated if one value in the range is in the prior art. Therefore, Tsai’s tip-to-tip variation of about 15 microns anticipates the claimed tip-to-tip variations.

153. Tsai discloses an ODD CMP pad dresser with a diameter of 100 mm. EX1004, 6:19-20 (“The diameter and thickness of the ODD are 100 mm and 5 mm, respectively.”), 7:10-11 (“The diameters of both the BDD and the ODD were 100 mm.”). Tsai’s CMP pad dresser does not have superabrasive particles in the center, as shown in Figure 3 below. The center portion of the dresser has a measured diameter of 46 mm, based on the outer diameter being 100 mm.

154. The area of the CMP pad dresser can be calculated using the formula for the area of a circle,  $A = \pi r^2$  (where “A” is the area of the circle and “r” is the radius of the circle, *i.e.*,  $\frac{1}{2}$  the diameter). The total area of the CMP pad dresser is about 7,854  $\text{mm}^2$ , and the area of the center portion of the CMP pad dresser (with no superabrasive particles) is approximately 1,662  $\text{mm}^2$ . Therefore, the area of the CMP pad dresser that contains superabrasive particles is about 6,193  $\text{mm}^2$ .



EX1004, Fig. 3 (annotated).

155. The superabrasive particles are shown in the SEM image above to be arranged in a grid with an inter-diamond spacing of about 200 microns. EX1004, 3:10-4:1 (“The ODD is manufactured by reverse casting polymers. Instead of using a flat substrate as the backing for attaching diamond grits, the substrate is prepared after the diamond grits are leveled on the surface of a mold.”), Fig. 3. If the superabrasive particles are arranged in a grid with an inter-diamond spacing of 200 microns, there is about 1 superabrasive particle per  $0.04 \text{ mm}^2$  of the surface of the CMP pad dresser. Therefore, as shown in the calculation below, Tsai’s CMP pad dresser has about 154,800 superabrasive particles.

$$A_{outer} = \pi r^2 = \pi \left( \frac{100}{2} \text{ mm} \right)^2 = 7,854 \text{ mm}^2$$

$$A_{inner} = \pi r^2 = \pi \left( \frac{46}{2} \text{ mm} \right)^2 = 1,662 \text{ mm}^2$$

$$\frac{1 \text{ particle}}{(\text{particle spacing})^2} \times (A_{outer} - A_{inner}) =$$

$$\frac{1 \text{ particle}}{0.2 \text{ mm} \times 0.2 \text{ mm}} (7,854 \text{ mm}^2 - 1,662 \text{ mm}^2) =$$

$$\underline{\underline{154,800 \text{ particles}}}$$

156. A similar calculation can be performed for the CMP pad dresser shown in Figure 5. In Figure 5, the inter-diamond spacing is about 500 microns, and the superabrasive particles are again arranged in a grid. Assuming the same configuration of superabrasive particles shown in Figure 3 (*i.e.*, no particles on the center of the disk), the CMP pad dresser has about 24,768 superabrasive particles.

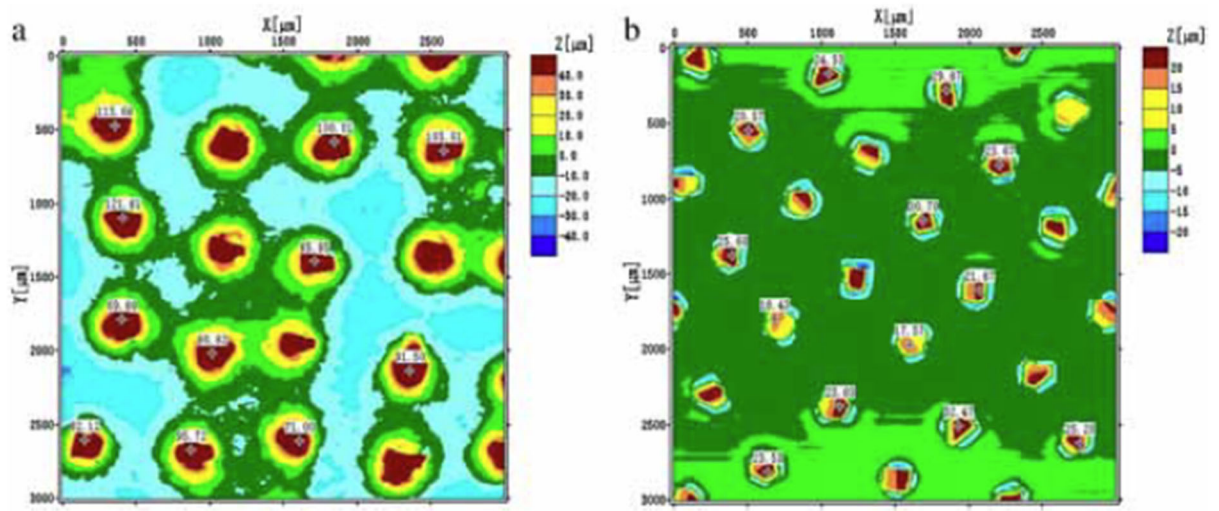


Fig. 5. Comparison of the cutting tips of (a) brazed diamond disk (b) organic diamond disk.

EX1004, Fig. 5.

$$A_{outer} = \pi r^2 = \pi \left( \frac{100}{2} \text{ mm} \right)^2 = 7,854 \text{ mm}^2$$

$$A_{inner} = \pi r^2 = \pi \left( \frac{46}{2} \text{ mm} \right)^2 = 1,662 \text{ mm}^2$$

$$\frac{1 \text{ particle}}{(\text{particle spacing})^2} \times (A_{outer} - A_{inner}) =$$

$$\frac{1 \text{ particle}}{0.5 \text{ mm} \times 0.5 \text{ mm}} (7,854 \text{ mm}^2 - 1,662 \text{ mm}^2) =$$

$$\underline{\underline{24,768 \text{ particles}}}$$

157. A similar calculation can again be performed for the CMP pad dresser shown in Figure 8. Again, an inter-diamond spacing of about 500 microns is shown and the superabrasive particles are arranged in a grid. Assuming the same configuration of superabrasive particles shown in Figure 3 (*i.e.*, no particles on the center of the disk), the CMP pad dresser has about 24,768 superabrasive particles.

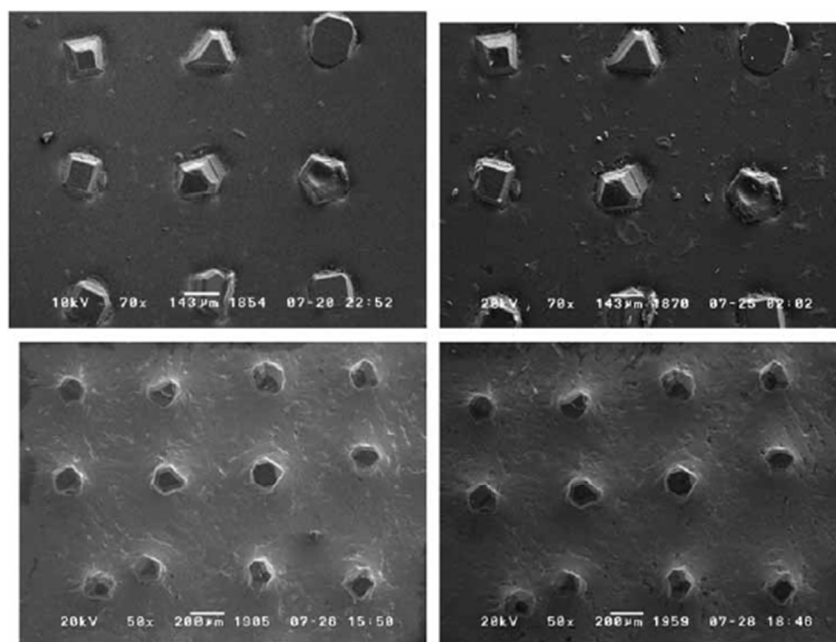


**Fig. 8.** SEM observation of the surface topography of the BDD after (a) 1 h and (b) 40 h and that of the surface topography of the ODD after (c) 1 h and (d) 40 h in the oxide-slurry solution.

EX1004, Fig. 8.

$$A_{outer} = \pi r^2 = \pi \left( \frac{100}{2} \text{ mm} \right)^2 = 7,854 \text{ mm}^2$$

$$A_{inner} = \pi r^2 = \pi \left( \frac{46}{2} \text{ mm} \right)^2 = 1662 \text{ mm}^2$$

$$\frac{1 \text{ particle}}{(\text{particle spacing})^2} \times (A_{outer} - A_{inner}) =$$

$$\frac{1 \text{ particle}}{0.5 \text{ mm} \times 0.5 \text{ mm}} (7,854 \text{ mm}^2 - 1662 \text{ mm}^2) =$$

$$\underline{\underline{24,768 \text{ particles}}}$$

158. Any of the CMP pad dressers disclosed by Tsai have significantly more superabrasive particles than the claimed 10 and 100. As I noted in Paragraph 28, I understand that a claimed range can be anticipated if one value in the range is in the prior art.

159. With respect to limitation [4], Tsai's tip-to-tip variation for all superabrasive particles on the CMP pad dresser is about 19.8 microns in Figure 6, or generally can be less than about 15 microns. Therefore, the difference in protrusion distance between the highest and 10<sup>th</sup> protruding tips must also be about

19.8 microns (or less than 15 microns), which is within the claimed range in [4] of less than or equal to about 20 microns.

160. With respect to limitation [5], Tsai's tip-to-tip variation for all superabrasive particles on the CMP pad dresser is about 19.8 microns in Figure 6, or generally can be less than about 15 microns. Therefore, the difference in protrusion distance between the highest and 100<sup>th</sup> protruding tips must also be about 19.8 microns (or less than 15 microns), which is within the claimed range in [5] of less than or equal to about 40 microns.

161. Even if the Patent Owner argues that Tsai does not explicitly disclose [4] and [5], a POSITA would have found the ranges claimed in [4] and [5] obvious. A POSITA could have obtained these claimed ranges by optimizing the reverse casting method taught by Tsai to obtain substantially leveled tips, as I explained in Paragraphs 137-138, because of the disadvantages to having unlevelled tips that I explained in Paragraph 136. Therefore, the claimed ranges are not inventive because they would have resulted from routine optimization.

#### **4. Dependent Claims 19-21**

- i. [19] The dresser of claim 1, wherein the designated profile includes a configuration selected from the group consisting of a plane, a slope, a curved shape, a dome shape, and combinations thereof.**

162. Tsai discloses [19].

163. As I explained in Paragraph 131, Tsai describes a flat profile above the epoxy resin, which meets the claimed “plane” configuration of the designated profile. EX1004, 6:8-10 (“In this case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.”), Fig. 2e.

ii. **[20] The dresser of claim 1, wherein the plurality of superabrasive particles is arranged across the support substrate in a predetermined pattern.**

**[21] The dresser of claim 20, wherein the predetermined pattern includes an even distribution of the plurality of superabrasive particles spaced at a distance of from about 100 microns to about 800 microns.**

164. Tsai discloses [20] and [21].

165. The first step in Tsai’s reverse casting method is to level the diamond particles “on the surface of a mold for their regular distribution.” EX1004, 5:20-6:5. This results in a predetermined pattern (*e.g.*, a grid) across the epoxy resin support substrate on the finished CMP pad dresser. EX1004, Figs. 2, 3, 5, and 8, 3:10-4:1 (“The ODD is manufactured by reverse casting polymers. Instead of using a flat substrate as the backing for attaching diamond grits, the substrate is prepared after the diamond grits are leveled on the surface of a mold.”).

166. As shown in Figs. 3, 5, and 8 below and as I described above in Paragraphs 155-157, the superabrasive particles on Tsai’s CMP pad dressers are

arranged in a grid with even inter-diamond spacing. This arrangement discloses [20].

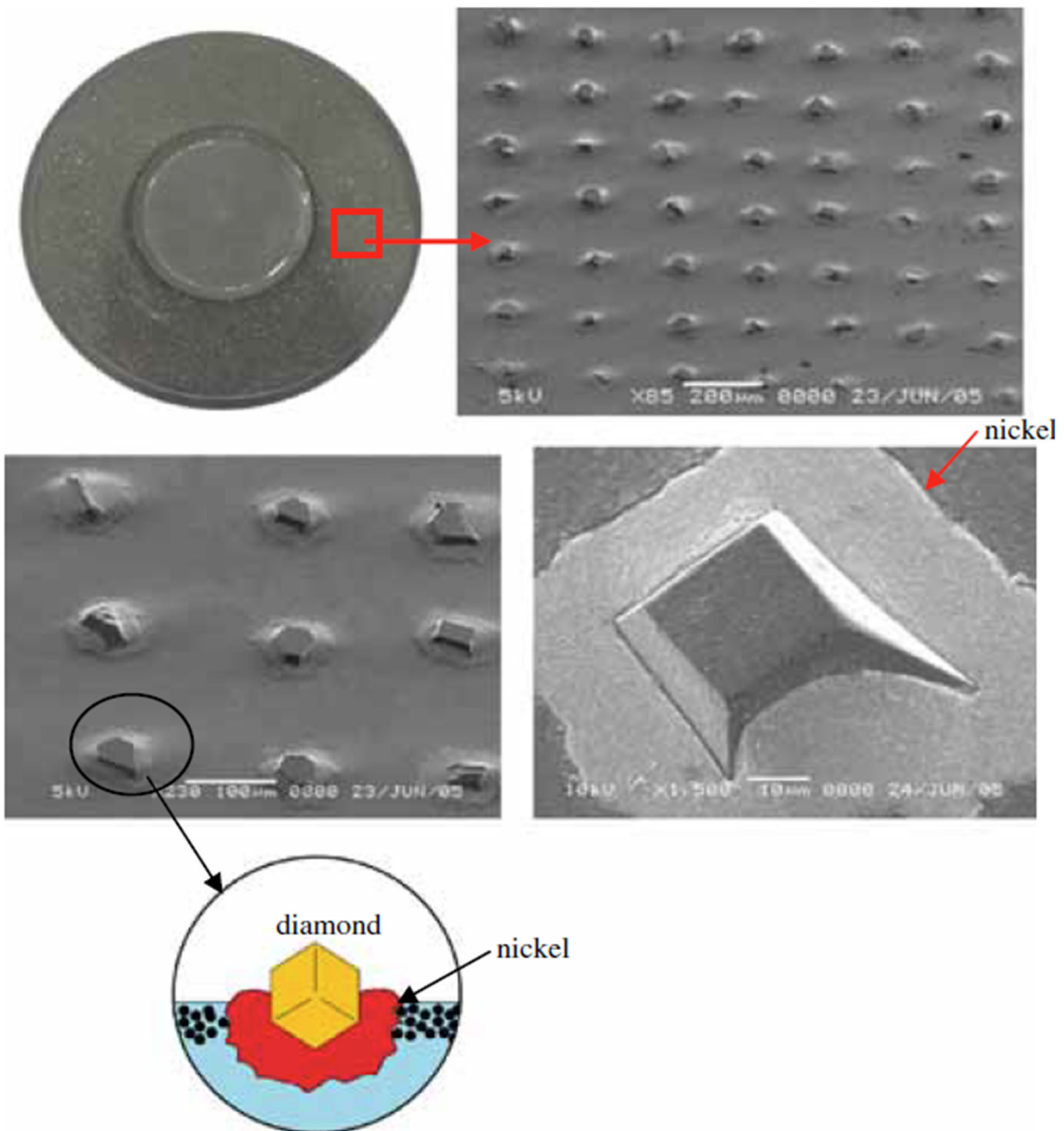


Fig. 3. Outer appearance of the organic diamond disk. Note that each diamond is covered with nickel.

EX1004, Fig. 3.

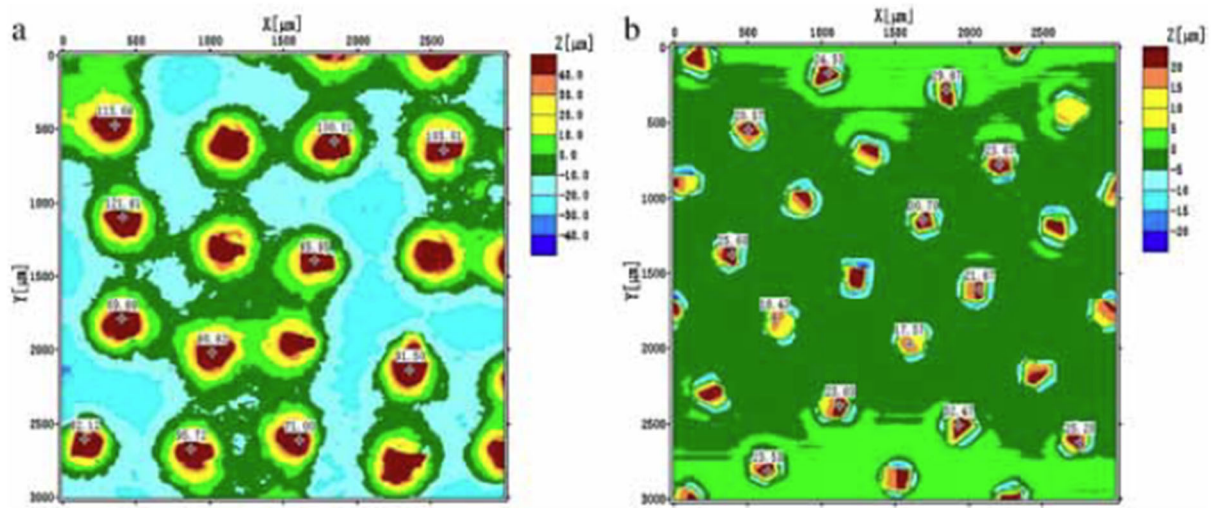


Fig. 5. Comparison of the cutting tips of (a) brazed diamond disk (b) organic diamond disk.

EX1004, Fig. 5.

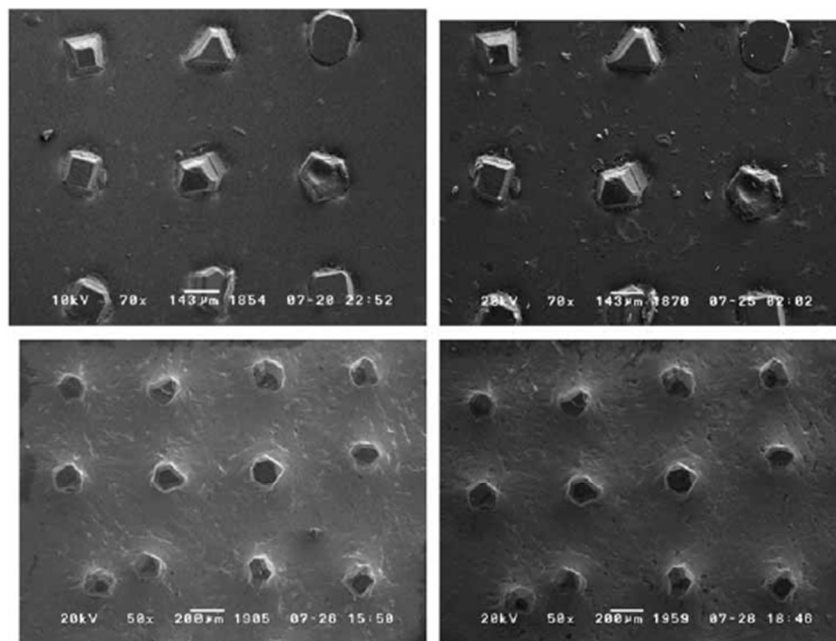


Fig. 8. SEM observation of the surface topography of the BDD after (a) 1 h and (b) 40 h and that of the surface topography of the ODD after (c) 1 h and (d) 40 h in the oxide-slurry solution.

EX1004, Fig. 8.

167. In Fig. 3 above, there is an inter-diamond spacing of about 200 microns. In Figs. 5 and 8 above, there is an inter-diamond spacing of about 500 microns. As I noted in Paragraph 28, I understand that a claimed range can be anticipated if one value in the range is in the prior art. Each of the CMP pad dressers disclosed by Tsai anticipates the claimed range of superabrasive particle spacing in [21] of about 100 microns to about 800 microns.

**B. Ground II: Tsai in Combination with Sung'026 Renders Obvious Claims 1-3, 6-14, and 16-18**

**1. Independent Claim 1**

- i. [1D] wherein a tip of each of the plurality of superabrasive particles aligns along a designated profile with a tip variation of from about 5 microns to about 100 microns,**

168. As I explained in paragraphs 107-146, Tsai anticipates or at a minimum renders obvious all of the limitations of claim 1. Alternatively, Sung'026 also teaches [1D].

169. Specifically, Sung'026 discloses that the tips of the superabrasive particles vary from the designated profile by from about 5 microns to about 100 microns. EX1005, [0053] ("It 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."), [0011] ("As such, the superabrasive particles may protrude to a predetermined height that is along a

designated profile...to less than about 40 microns above the organic material matrix...to less than about 30 microns above the organic material matrix...to less than about 20 microns above the organic material matrix. Thus the designated profile defines the extent to which a plurality of superabrasive particles protrude from the solidified organic material layer.”), [0056] (“In another aspect, the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by from about 5 microns to about 100 microns.”).

## **2. Dependent Claims 2 and 3**

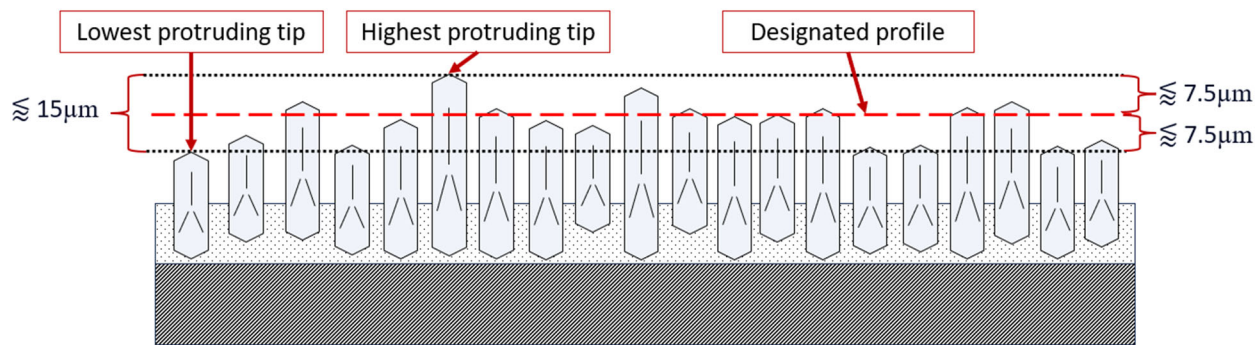
- i. [2] The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns.**

**[3] The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than about 10 microns.**

170. Tsai and Sung’026 render obvious [2] and [3]. As I noted in Paragraph 28, I understand that a claimed range can be anticipated if one value in the range is in the prior art.

171. As I explained above in Paragraphs 131-134, Tsai teaches a tip-to-tip variation of about 15 microns for all superabrasive particles. EX1004, 6:8-10 (“In this case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.”), 5:23-24 (“First, the

diamond grits are leveled on the surface of a mold for their regular distribution...”), 8:22-24 (“...the diamond tips of the ODD can be leveled to less than 15  $\mu\text{m}$  because the diamond tips are already leveled.”), 8:14-16 (“In addition, the protrusion height (approximately 30  $\mu\text{m}$ ) of the diamonds for the ODD is smaller than that (approximately 80  $\mu\text{m}$ ) for the BDD.”).



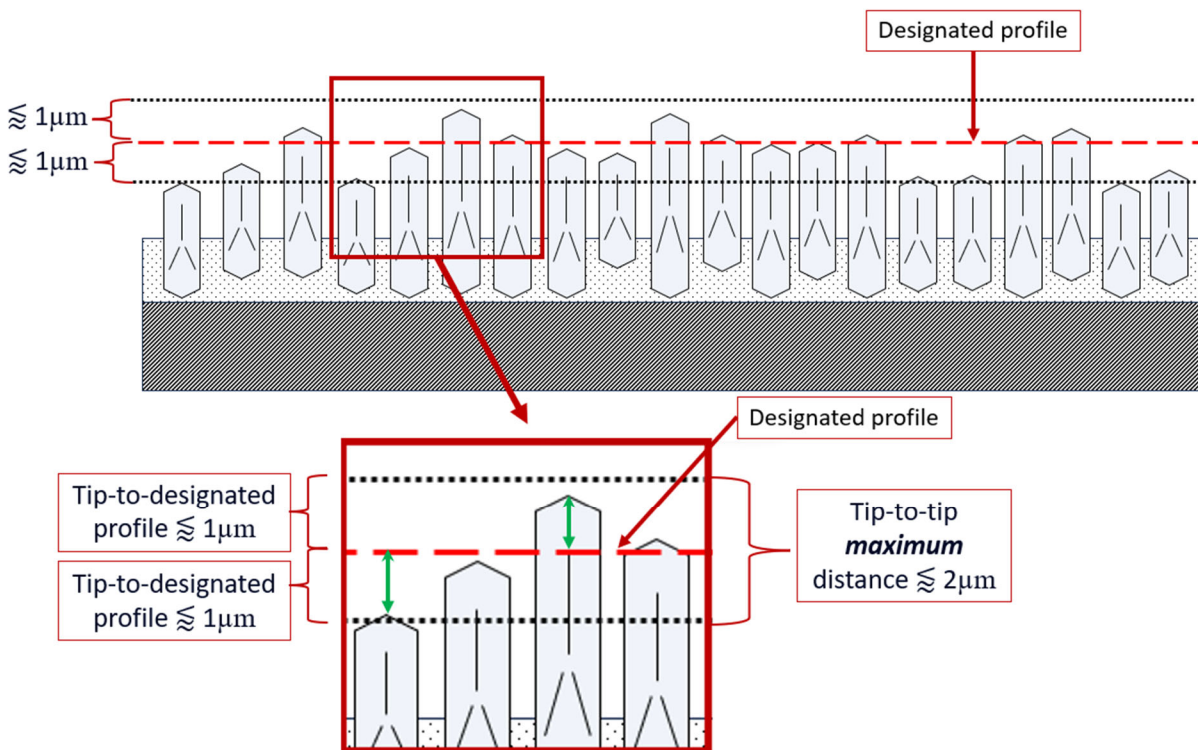
172. Tsai does not expressly disclose a tip-to-tip variation of less than or equal to about 10 microns. However, a POSITA would have found it obvious to obtain a tip-to-tip variation of less than or equal to about 10 microns using the reverse casting method taught by Tsai, for at least the same reasons I explained in Paragraph 136-138. A POSITA would have been motivated to make a CMP pad dresser with a smaller tip-to-tip variation because it was known in the art that there were many disadvantages to having unlevelled tips on a CMP pad dresser. Indeed, Tsai mentions that in conventional disks where the tips of the superabrasive particles are not leveled, “less than 10% of the diamond grits are engaged in cutting the polishing pad. The rest of the grits remain unused on the disk.”

EX1004, 2:14-17. This results in uneven wear of the CMP pad dresser. Tsai also explains that if any grits protrude to a significantly higher protrusion height than the rest of the superabrasive particles, they will cut “50% of the pad consumed during dressing”, causing uneven wearing of the CMP pad. This shortens the CMP pad’s lifespan and increases the costs associated with CMP. EX1004, 2:20-22.

173. Further, there is nothing inventive about the claimed ranges, because they would have resulted from routine optimization of Tsai’s reverse casting method.

174. In fact, a tip-to-tip variation of less than or equal to about 10 microns was well-known in the art. For example, Sung’026 uses the same reverse casting method disclosed by Tsai to obtain a CMP pad dresser where “each of the plurality of superabrasive particles may protrude to predetermined height above the solidified organic material layer.” EX1005, [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.”), [0083] (“Various reverse casting methods may be utilized to manufacture the CMP pad dresser...”). Sung’026 discloses a tip-to-designated profile variation of less than about 1 micron, among other tip height variations. EX1005, [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 micron[.]”), [0052] (“Various

configurations or arrangements are contemplated for minimizing the mechanical stress impinging on the superabrasive particles held in the abrading tool. One potentially useful parameter may include the height that the superabrasive particles protrude above the organic material layer.”), [0010] (“Various methods are contemplated for minimizing the mechanical stress impinging on the superabrasive particles held in the abrading tool. One example may include superabrasive particle arrangement according to protrusion height.”), claims 33-35 (“...variation from the predetermined height is from about 1 micron to about 20 microns...from about 5 microns to about 20 microns...from about 10 microns to about 20 microns.”), 37 (“...wherein the designated profile is a plane”). Because the tip-to-designated profile variation is less than about 1 micron, Sung’026 discloses a tip-to-tip variation of less than about 2 microns, as illustrated below.



175. As I explained in Paragraph 28, I understand that a broadly claimed aspect of an invention is anticipated if a description of a single embodiment is described.

176. With respect to limitation [2], Sung'026 discloses a tip-to-tip variation of less than about 2 microns for all superabrasive particles on the CMP pad dresser. Therefore, the tip-to-tip variation between the highest and second highest protruding tip is also less than about 2 microns, which is within the less than or equal to about 10 microns claimed in [2].

177. With respect to limitation [3], Sung'026 discloses a tip-to-tip variation of less than about 2 microns for all superabrasive particles on the CMP pad dresser.

Therefore, the tip-to-tip variation between the highest and second highest protruding tip is also less than about 2 microns, which is within the less than about 10 microns claimed in [3].

### **3. Dependent Claims 6, 7, and 16-18**

#### **i. [6A] The dresser of claim 1, wherein the plurality of superabrasive particles includes a plurality of working superabrasive particles,**

178. Tsai teaches [6A].

179. As I already discussed in Paragraph 99, “‘working superabrasive particles’ are superabrasive particles that cut or otherwise deform a CMP pad during a dressing or conditioning procedure.” EX1001, 4:46-48.

180. Tsai’s ODDs have superabrasive particles that share an equal dressing load while conditioning the CMP pad. EX1004, 8:13-14 (“[T]he ODD has regular diamond cutters.”), 8:24-26 (“The better-leveled ODD has more cutters that can dress the pad, and thus, they share an equal dressing load.”). This is an improvement over traditional CMP pad dressers, which have over 10,000 superabrasive particles, but only around 10% of the superabrasive particles cut the CMP pad. EX1004, 2:14-17 (“A typical diamond disk contains over 10,000 grits; however, less than 10% of the diamond grits are engaged in cutting the polishing pad. The rest of the grits remain unused on the disk.”). The cutting tips are shown below in Figure 5b. Tsai’s cutting tips within the monolayer of superabrasive

particles on the CMP pad dresser disclose the claimed working superabrasive particles because the cutting tips condition the CMP pad.

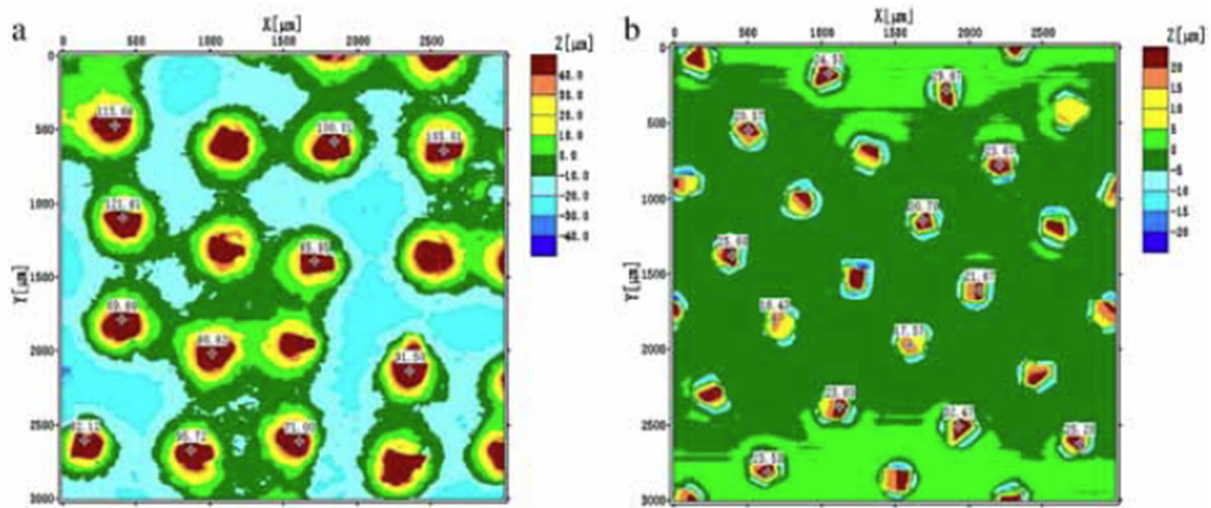


Fig. 5. Comparison of the cutting tips of (a) brazed diamond disk (b) organic diamond disk.

EX1004, Fig. 5.

- ii. **[6B] such that rotating the dresser against a CMP pad cuts asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns.**

**[7] The dresser of claim 6, wherein the cutting depth is from about 10 microns to about 50 microns.**

**[16] The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad.**

**[17] The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of from about 1 micron to about 20 microns when used to abrade a CMP pad.**

**[18] The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.**

181. Tsai and Sung'026 render obvious [6B], [7], [16], [17], and [18].

182. As described by Tsai, the CMP process involves mounting a CMP pad on a rotating table disk. The CMP pad dresser is attached to a rotating element, and the CMP pad dresser is rotated against the CMP pad. EX1004, 6:22-7:2 ("Dressing experiments were performed using a polishing pad mounted on a commercially modified polishing machine with variable speed control. The diamond pad conditioner was attached via a connecting holder to a rotating head spinning at 10 rpm. A polyurethane pad was mounted on a table disk that rotated at a speed of 40

rpm. The oscillation speed of the conditioner was set at approximately 5 mm/s, and the applied load was fixed at approximately 3 kg.”).

183. As the CMP pad dresser conditions the CMP pad, the superabrasive particles on the CMP pad dresser cut asperities into the CMP pad. EX1004, 2:4-9 (“For the CMP process to continue and to regenerate the asperity structure of the pad...”), 8:13-14 (“[T]he ODD has regular diamond cutters.”), 8:24-26 (“The better-leveled ODD has more cutters that can dress the pad, and thus, they share an equal dressing load.”), Fig. 5b.

184. Tsai does not specify the cutting depths that can be obtained by using the disclosed CMP pad dresser. However, Sung’026 discloses various cutting depth ranges. For example, Sung’026 discloses cutting depth ranges from about 1 to about 20 microns, less than about 20 microns, and from about 10 microns to about 20 microns. EX1005, claims 4-6 (“...wherein the predetermined height produces a cutting depth of less than about 20 microns...of from about 1 micron to about 20 microns...of from about 10 micron[s] to about 20 microns when used to abrade a work piece.”), [0010] (“...the predetermined height may produce a cutting depth of from about 1 micron to about 20 microns...of from about 10 micron[s] to about 20 microns when used to abrade a work piece.”), [0052] (“...the predetermined height may produce a cutting depth of less than about 20

microns...of from about 1 micron to about 20 microns...of from about 10 micron[s] to about 20 microns when used to abrade a work piece.”).

185. As I noted in Paragraph 28, I understand that a claimed range can be anticipated if one value in the range is in the prior art. Therefore, the disclosed ranges in Sung’026 teach [7], [16], [17], and [18].

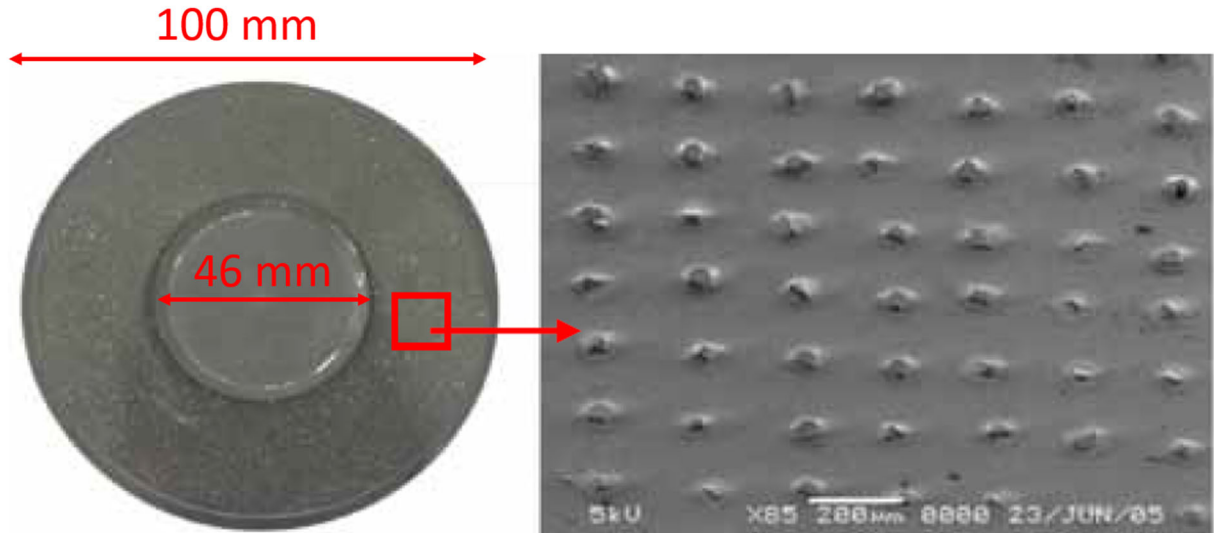
#### 4. Dependent Claims 8-12

i. **[8] The dresser of claim 6, wherein the plurality of working superabrasive particles includes at least 100 working superabrasive particles.**

**[9] The dresser of claim 6, wherein the plurality of working superabrasive particles includes at least 1000 working superabrasive particles.**

186. Tsai teaches, or Tsai and Sung’026 render obvious the limitations [8] and [9].

187. For example, as I described in Paragraphs 153-155, Tsai discloses a CMP pad dresser with approximately 154,800 superabrasive particles based on the 200 micron inter-diamond spacing shown in Fig. 3.



EX1004, Fig. 3 (annotated).

$$A_{outer} = \pi r^2 = \pi \left( \frac{100}{2} \text{ mm} \right)^2 = 7,854 \text{ mm}^2$$

$$A_{inner} = \pi r^2 = \pi \left( \frac{46}{2} \text{ mm} \right)^2 = 1,662 \text{ mm}^2$$

$$\frac{1 \text{ particle}}{(\text{particle spacing})^2} \times (A_{outer} - A_{inner}) =$$

$$\frac{1 \text{ particle}}{0.2 \text{ mm} \times 0.2 \text{ mm}} (7,854 \text{ mm}^2 - 1,662 \text{ mm}^2) =$$

$$\underline{\underline{154,800 \text{ particles}}}$$

188. As I described in Paragraphs 156-157, Tsai also discloses a CMP pad dresser with approximately 24,768 superabrasive particles, based on the 500 micron inter-diamond spacing shown in Figs. 5 and 8.

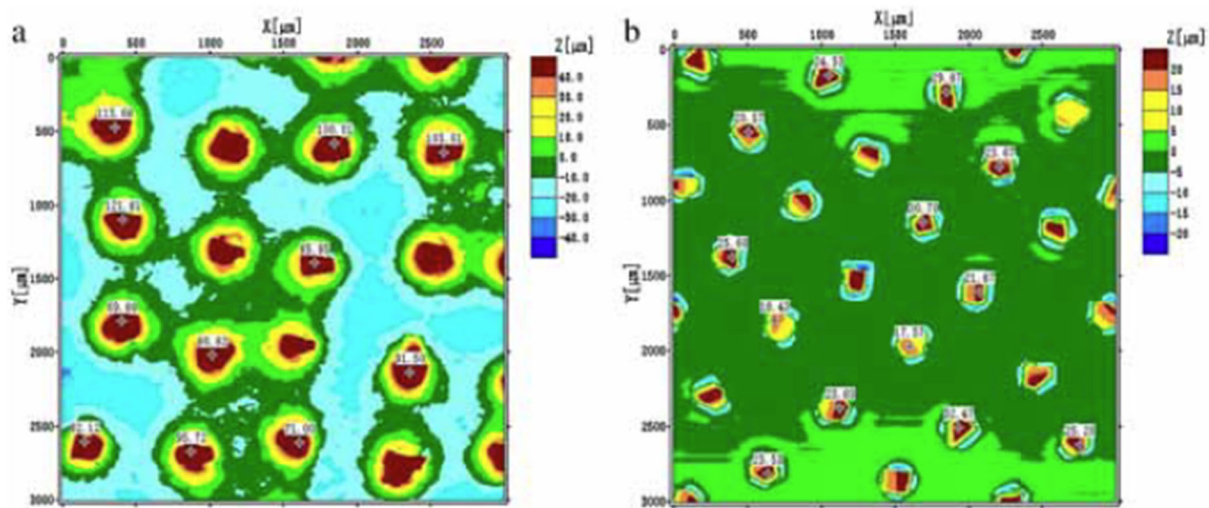


Fig. 5. Comparison of the cutting tips of (a) brazed diamond disk (b) organic diamond disk.

EX1004, Fig. 5.

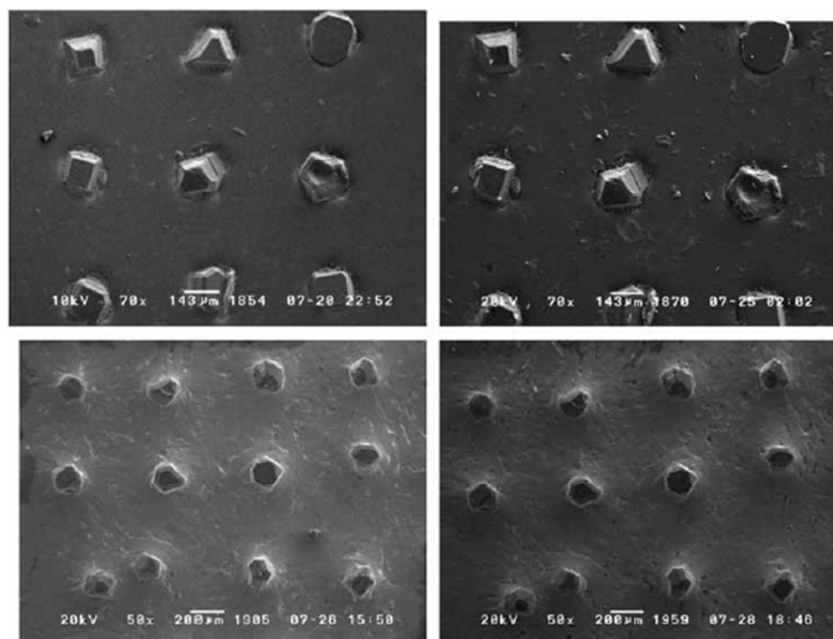


Fig. 8. SEM observation of the surface topography of the BDD after (a) 1 h and (b) 40 h and that of the surface topography of the ODD after (c) 1 h and (d) 40 h in the oxide-slurry solution.

EX1004, Fig. 8.

$$\begin{aligned} A_{outer} &= \pi r^2 = \pi \left( \frac{100}{2} \text{ mm} \right)^2 = 7,854 \text{ mm}^2 \\ A_{inner} &= \pi r^2 = \pi \left( \frac{46}{2} \text{ mm} \right)^2 = 1,662 \text{ mm}^2 \\ \frac{1 \text{ particle}}{(\text{particle spacing})^2} \times (A_{outer} - A_{inner}) &= \\ \frac{1 \text{ particle}}{0.5 \text{ mm} \times 0.5 \text{ mm}} (7,854 \text{ mm}^2 - 1,662 \text{ mm}^2) &= \\ \mathbf{\underline{24,768 \text{ particles}}} \end{aligned}$$

189. As I explained in Paragraph 180, Tsai discloses that all the diamond particles on the CMP pad dressers are cutters and share an equal dressing load when conditioning CMP pads. EX1004, 8:13-14 (“[T]he ODD has regular diamond cutters.”), 8:24-26 (“The better-leveled ODD has more cutters that can dress the pad, and thus, they share an equal dressing load.”), Fig. 5b. Therefore, Tsai’s CMP pad dressers teach the claimed “at least 100 working superabrasive particles” of [8] and “at least 1000 working superabrasive particles” of [9].

190. Alternatively, Tsai and Sung'026 render obvious [8] and [9].

191. Sung'026 discloses that, during CMP pad conditioning, frictional forces are distributed equally across each superabrasive particle. This minimizes the stress placed on individual particles and prevents them from displacing from the organic material layer. EX1005, [0051] (“...the plurality of superabrasive particles may be configured to uniformly distribute frictional forces across substantially each superabrasive particle. Such a uniform distribution of frictional force prevents any individual superabrasive particle from being overstressed and pulling out of the solidified organic material layer.”), [0075] (“Such an arrangement may increase the retention of the superabrasive particles 12 in the organic material layer 14 due to a substantially even distribution of frictional forces across all the superabrasive particles in the tool.”), claim 2 (“...the plurality of superabrasive particles is configured to uniformly distribute drag forces across substantially each superabrasive particle.”). If each superabrasive particle is experiencing the same force when conditioning a CMP pad, each superabrasive particle is itself cutting asperities in the CMP pad and is a working superabrasive particle.

192. Additionally, Sung'026 discloses that a “majority” of the superabrasive particles protrude to a predetermined height above the rigid epoxy support layer. EX1005 [0052], claims 3-6. The protruding superabrasive particles

produce cutting depths “that [are] essentially the distance[s] of protrusion.”

EX1005, [0076], [0052], claims 3-6. Therefore, at least the majority of the superabrasive particles on the disclosed CMP pad dressers are working superabrasive particles.

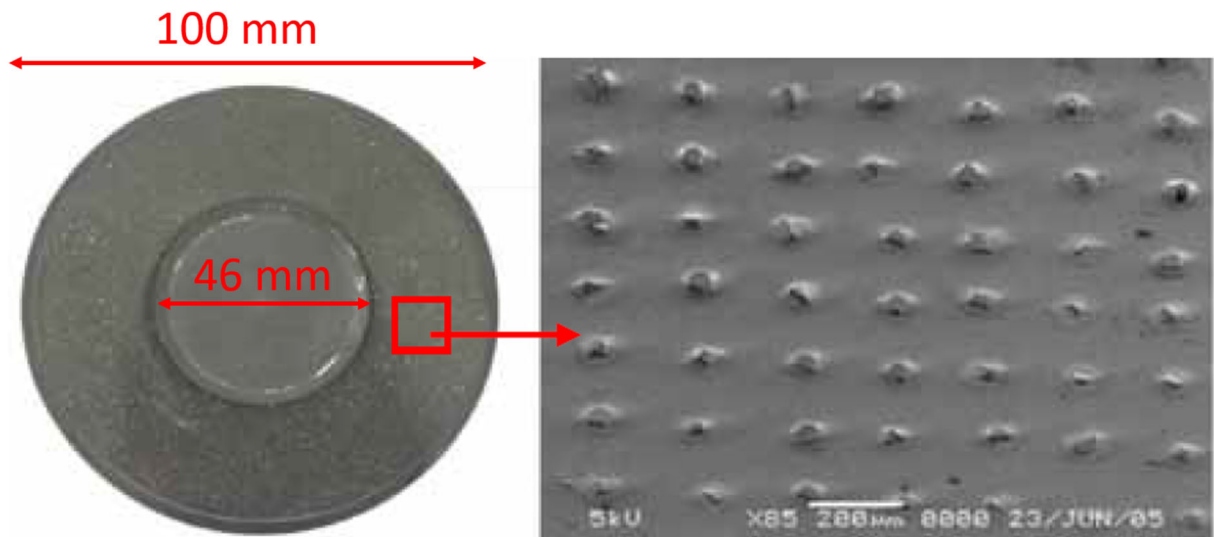
193. More than half (*i.e.*, the majority) of the superabrasive particles disclosed (*e.g.*, at least 77,400 or 12,384 superabrasive particles) are orders of magnitude larger than the claimed “at least 100 working superabrasive particles” of [8] and “at least 1000 working superabrasive particles” of [9].

ii. **[10] The dresser of claim 6, wherein the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles.**

**[11] The dresser of claim 6, wherein the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles.**

194. Tsai and Sung’026 render obvious [10] and [11]. It would have been obvious to a POSITA to try to make different CMP pad conditioners with the claimed number of particles based on the ranges disclosed by Tsai and Sung’026.

195. As I have already explained in Paragraphs 153-158, Tsai discloses a CMP pad dresser with a diameter of 100 mm. The diamond particles are located on the periphery, and the inner diameter can be measured to be about 46 mm. This configuration resulted in tens of thousands of superabrasive particles on the CMP pad dresser.



EX1004, Fig. 3 (annotated).

196. Sung’026 explains that superabrasive particles of any size are within the scope of the invention and discloses a superabrasive particle size range of from about 30 microns to about 250 microns. EX1005, [0012] (“Any superabrasive particle size that would provide benefit to the methods and tools of the present invention are considered to be within the present claim scope. In one specific aspect, the plurality of superabrasive particle[s] may be from about 30 microns to about 250 microns in size.”).

197. Additionally, Sung’026 discloses various arrangements of superabrasive particles on the CMP pad dresser. For example, Sung’026 explains that the superabrasive particles may be evenly spaced (*e.g.*, in a grid) at an inter-diamond distance “from about 3 times to about 5 times the average size of the

superabrasive particles” to “minimiz[e] the mechanical stress impinging on the superabrasive particles.” EX1005, [0014], [0052].

198. It would have been obvious to a POSITA to use the ranges disclosed by Sung’026 to manufacture a CMP pad dresser. For example, a POSITA may have used the endpoints disclosed by Sung’026 (*e.g.*, 250-micron superabrasive particles, with spacing five times the size of the superabrasive particles, *e.g.*, 1250 microns).

199. If an inter-diamond spacing of 1250 microns were used on a CMP pad dresser with the same proportions as those disclosed by Tsai (*i.e.*, an outer diameter of 100 mm and a center portion devoid of superabrasive particles with a diameter of 46 mm), a POSITA would have manufactured a CMP pad dresser with approximately 3,963 superabrasive particles. This is within the claimed ranges of “from about 1000 to about 6000” in [10] and “from about 2000 to about 5000” in [11].

$$A_{outer} = \pi r^2 = \pi \left( \frac{100}{2} \text{ mm} \right)^2 = 7,854 \text{ mm}^2$$

$$A_{inner} = \pi r^2 = \pi \left( \frac{46}{2} \text{ mm} \right)^2 = 1,662 \text{ mm}^2$$

$$\frac{1 \text{ particle}}{(\text{particle spacing})^2} \times (A_{outer} - A_{inner}) =$$

$$\frac{1 \text{ particle}}{1.25 \text{ mm} \times 1.25 \text{ mm}} (7,854 \text{ mm}^2 - 1,662 \text{ mm}^2) =$$

**3,963 particles**

200. Therefore, the ranges of working superabrasive particles claimed in [10] and [11] would have been achievable by a POSITA by simple changes to the arrangement of superabrasive particles on the CMP pad dresser and size of the superabrasive particles used, and there is nothing inventive about the claimed ranges of working superabrasive particles.

- iii. [12] The dresser of claim 6, wherein the plurality of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.**

201. Tsai teaches [12].

202. As I explained in Paragraphs 187-192, Tsai discloses, or Tsai and Sung'026 render obvious, that the plurality of superabrasive particles includes at least about 1000 working superabrasive particles.

203. Additionally, as I explained in Paragraphs 124-126 and 131-138, Tsai discloses or renders obvious that all superabrasive particles on the CMP pad dresser protrude from the rigid support to distances within 15 microns of each other. As I noted in Paragraph 28, I understand that a claimed range can be anticipated if one value in the range is in the prior art. Therefore, Tsai's disclosure that all superabrasive particles are working superabrasive particles, that there are 154,800 (or that there are 24,768) working superabrasive particles on the dresser, and that all superabrasive particles protrude to distances within 15 microns of each other anticipates [12].

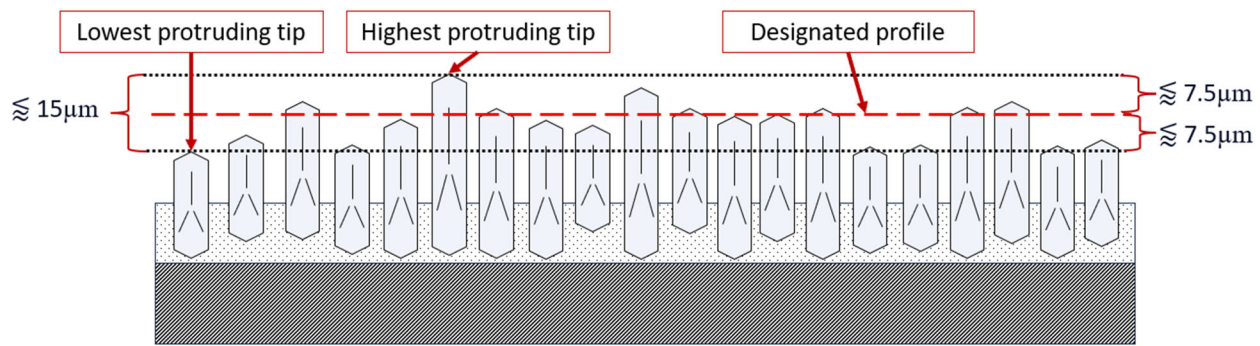
**5. Dependent Claims 13 and 14**

- i. **[13] The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles align along the designated profile with a tip variation of from about 10 microns to about 50 microns.**

**[14] The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles align along the designated profile with a tip variation of from about 20 microns to about 40 microns.**

204. Tsai and Sung'026 render obvious [13] and [14].

205. As I explained in Paragraphs 131-138, Tsai teaches a tip-to-tip variation of less than about 15 microns, and therefore discloses a tip-to-designated profile variation of less than about 7.5 microns. EX1004, 6:8-10 (“In this case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.”), 5:23-24 (“First, the diamond grits are leveled on the surface of a mold for their regular distribution...”), 8:22-24 (“...the diamond tips of the ODD can be leveled to less than 15  $\mu\text{m}$  because the diamond tips are already leveled.”), 8:14-16 (“In addition, the protrusion height (approximately 30  $\mu\text{m}$ ) of the diamonds for the ODD is smaller than that (approximately 80  $\mu\text{m}$ ) for the BDD.”).



206. A POSITA would have found it obvious to obtain the claimed tip-to-designated profile variations using the reverse casting method taught by Tsai, for the same reasons I explained in Paragraphs 136-138. There is nothing inventive about the claimed ranges, because they would have resulted from routine optimization.

207. Assuming [13] is directed to the tip-to-designated profile variations, the range claimed in [13] was well-known in the art. For example, Sung'026 uses the same reverse casting method disclosed by Tsai to obtain a CMP pad dresser where “each of the plurality of superabrasive particles may protrude to predetermined height above the solidified organic material layer.” EX1005, [0073], [0083]. Sung'026 discloses a tip-to-designated profile variation of less than about 1 micron, among other tip height variations. EX1005, [0056], [0052], [0010], claims 33-35.

208. In fact, Sung'026 discloses the claimed tip variations of “from about 10 microns to about 50 microns” in [13] and “from about 20 microns to about 40

microns” in [14]. EX1005, [0056] (“In yet another aspect, the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by from *about 10 microns to about 50 microns*. ... In another aspect, the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by from *about 20 microns to about 40 microns*.”) (emphasis added). Because each of the superabrasive particles varies from the designated profile by from about 10 microns to about 50 microns or from about 20 microns to about 40 microns, the highest protruding tip of each of the plurality of superabrasive particles must also align along the designated profile by from about 10 microns to about 50 microns or from about 20 microns to about 40 microns.

209. In addition to the reasons I explained in Paragraphs 136-138, a POSITA would have found it obvious to change the tip variations by a few microns.

210. For example, allowing for a slightly wider tip variation would allow for relaxed tolerance requirements and may make fabrication easier and more streamlined. A POSITA would have been able to achieve different degrees of tip variation by changing the compression of the flat plate taught by Tsai. EX1004, 6:8-10 (“In this case, the diamond tips can be leveled by compressing the disk with a flat plate to reduce the variation in the heights of the diamond tips.”).

211. From the tip-to-designated profile variations disclosed by Sung'026, a POSITA would have been able to manufacture a CMP pad dresser with substantially leveled tips with a reasonable expectation of success. The modifications I described above are only simple substitutions using different tip leveling (*i.e.* tip-to-designated profile variations of 7.5 microns from Tsai vs. 20-40 microns from Sung'026 vs. the claimed 10-50 microns). A POSITA would have been able to obtain different degrees of tip leveling on the surface of the mold, which is described as the first step of the reverse casting process. EX1004, 5:23-24; EX1005, [0083]-[0084]; EX1001, 25:16-18.

212. Minimally, it would have been obvious to a POSITA to try the different tip-to-designated profile variations (*e.g.*, from about 10 microns to about 50 microns, from about 20 microns to about 40 microns, less than about 1 micron) taught by Sung'026 to produce a suitable CMP pad dresser with a reasonable expectation of success. EX1005, [0056].

**ii. Reasons to Combine Tsai with Sung'026**

213. It would have been obvious to combine Tsai with Sung'026 for at least the following reasons.

214. First, Tsai and Sung'026 are both directed to CMP pad dressers and are analogous to the claims of the '802 Patent. EX1004, Title ("Organic diamond disk versus brazed diamond disk for dressing a chemical-mechanical polishing

pad”); EX1005, [0009] (“Accordingly, the present invention provides superabrasive tools and methods that are, without limitation, suitable to groom the CMP pads used for the delicate polishing applications.”); EX1001, claim 1 (“A CMP pad dresser...”).

215. Second, Tsai and Sung’026 both manufacture CMP pad dressers by reverse casting processes. EX1004, 3:10 (“The ODD is manufactured by reverse casting polymers.”), 5:20-21 (“We propose a novel design of a diamond disk by reversing the process of attaching diamonds using an organic matrix (e.g. epoxy.”); EX1005, [0083] (“Various reverse casting methods may be utilized to manufacture the CMP pad dresser of the present invention.”), [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.”). This reverse casting process is the same reverse casting process discussed by the ’802 Patent as a suitable embodiment of the invention. EX1001, 25:14-22 (“Additionally, so-called ‘reverse casting’ methods can be used to accurately orient and attach the dressing segments to the support substrate.”). A POSITA would have understood that applying the features taught in Sung’026 to Tsai’s CMP pad dresser would have been a simple modification and vice versa. For example, Sung’026’s equal distribution of frictional forces across all superabrasive particles of the CMP pad dresser

(EX1005, [0051]) would be easily applied to Tsai's 100 mm diameter CMP pad dresser with superabrasive particles on the peripheral region.

216. Third, Tsai and Sung'026 both disclose that the performance of the CMP pad dressers is better if the superabrasive particles are substantially leveled. Tsai and Sung'026 both explain that CMP pad dressers can uniformly condition CMP pads when their tips are level. EX1004, 8:22-26; EX1005, [0006]. With the teachings of Tsai and Sung'026, a POSITA would have been motivated to make CMP pad dressers with various tip-to-tip and tip-to-designated profile variations.

217. For example, a POSITA would have thought to try different tip variations to reduce manufacturing costs and simplify the manufacturing process. EX1004, 3:08-10. A POSITA would have found it obvious to choose from the tip-to-designated profile variations disclosed in Sung'026 (*e.g.*, from about 1 micron to about 150 microns, from about 10 microns to about 50 microns, and from about 20 microns to about 40 microns) to optimize manufacturing conditions of a CMP pad dresser. EX1005, [0056]. Additionally, a POSITA would have found it obvious to make CMP pad dressers with very small tip-to-tip variations, such as those disclosed by Tsai (*e.g.*, less than about 15 microns) and Sung'026 (*e.g.*, less than about 2 microns), because CMP pad dressers perform better with leveled tips. EX1004, 8:22-26; EX1005, [0056], [0011], [0006].

218. Because Tsai and Sung'026 both disclose CMP pad dressers that can be used on polyurethane CMP pads, a POSITA would have recognized that the cutting depth ranges disclosed by Sung'026 (*e.g.*, less than about 20 microns) would be achieved with a simple modification to the CMP pad dresser disclosed in Tsai. EX1005, [0010], [0052], claim 4. Sung'026 explains that the superabrasive particles protruding from the epoxy support layer cut the CMP pad to a depth essentially equal to the protrusion distance. EX1005, [0076]. A POSITA would have modified the protrusion distance of the superabrasive particles on the CMP pad dresser disclosed by Tsai to obtain the cutting depths disclosed by Sung'026.

219. Fourth, a POSITA would have had a reasonable expectation of success when combining the teachings of Tsai and Sung'026 to manufacture CMP pad dressers with level superabrasive particles. Tsai and Sung'026 describe the same reverse casting process to manufacture CMP pad dressers, and a POSITA would have slightly modified the process to obtain different degrees of tip leveling.

220. A POSITA would have achieved different degrees of leveling by, for example, changing the compression of the flat plate used to reduce variation in tip heights described by Tsai. EX1004, 6:8-10. As another example, a POSITA would have made changes to the distribution on the mold in the first step of the reverse casting process to achieve a different tip variation. EX1004, 5:23-24.

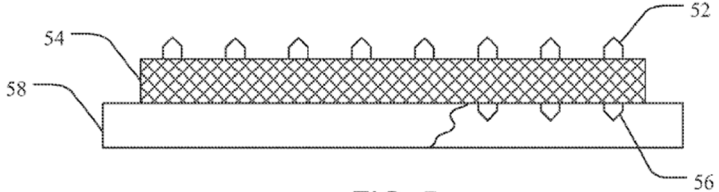
**C. Ground III: Sung’146 in Combination with Sung’026 Renders Obvious Claims 1-7 and 13-21**

221. As I explained in Paragraphs 70-77, the earliest priority date of the ’802 Patent is October 3, 2014.

222. I have been informed by counsel that the applications that the ’802 Patent claims priority to qualify as prior art if they were published more than one year before the priority date of the ’802 Patent (October 3, 2014).

223. Accordingly, I have prepared the following claim chart to identify the portions of Sung’146 and Sung’026 that render obvious claims 1-7 and 13-21 of the ’802.

| <b>’802 Patent Claims</b>                                                                                             | <b>Sung’146 (EX1029) and Sung’026 (EX1005)</b>                                                                                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. A CMP pad dresser, comprising:                                                                                     | Claim 1 “A CMP pad dresser, comprising: ...” (EX1029, claim 1)<br><br>Claim 65 “...wherein the tool is a CMP pad dresser.” (EX1005, claim 65)                                                                                                                |
| a rigid support substrate;<br>and<br><br>a monolayer of a plurality of superabrasive particles coupled to the support | “In one specific aspect, a rigid support is coupled to the matrix layer.” (EX1029, [0003])<br><br>“In yet another aspect, as is shown in FIG. 5, a CMP pad dresser can include a <i>first monolayer of superabrasive particles 52</i> and a second monolayer |

|                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>substrate,</p>                                                                                                                                                             | <p>of superabrasive particles 56 <i>coupled to a metal support layer 54</i>. The superabrasive particles can be coupled to the metal support layer directly or via a bonding material.” (EX1029, [0069])</p>  <p style="text-align: center;">FIG. 5</p> |
| <p>wherein each superabrasive particle in the monolayer extends away from the support substrate to a protrusion distance,</p>                                                 | <p>“wherein each superabrasive particle in the monolayer protrudes from the matrix layer” (EX1029, claim 1)</p>                                                                                                                                                                                                                           |
| <p>wherein a tip of each of the plurality of superabrasive particles aligns along a designated profile with a tip variation of from about 5 microns to about 100 microns,</p> | <p>“In another aspect, the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by from about 5 microns to about 100 microns.” (EX1005, [0056])</p>                                                                                                                                    |
| <p>and wherein the difference in protrusion distance between the highest protruding tip and the</p>                                                                           | <p>“and 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</p>                                                                                                                             |

|                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns, and the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles are within about 80 microns or less.</p>    | <p>50 microns and the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles are within about 80 microns or less.” (EX1029, claim 1)</p> |
| <p>2. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns.</p> <p>3. The dresser of claim 1, wherein the difference in protrusion distance between the highest</p> | <p>“In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns.” (EX1029, [0004])</p>        |

|                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| protruding tip and the second highest protruding tip is less than about 10 microns.                                                                                                         |                                                                                                                                                                                                                                                                                                       |
| 4. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns.  | “The dresser of claim 2, wherein the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns.” (EX1029, claim 3)                                                                                           |
| 5. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns. | “The dresser of claim 3, wherein the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.” (EX1029, claim 4)                                                                                          |
| 6. The dresser of claim 1, wherein the plurality of superabrasive particles includes a plurality of working superabrasive particles, such that rotating                                     | “Though any predetermined height that would be useful in an abrading tool would be considered to be within the presently claimed scope, in one specific aspect the predetermined height may produce a cutting depth of less than about 20 microns when used to abrade a work piece.” (EX1005, [0052]) |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| the dresser against a CMP pad cuts asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns.                                                                                                                                                                                                                                                                                                                             | “The protruding superabrasive particles 12 can cut into the CMP pad to a depth that is essentially the distance of the protrusion.” (EX1005, [0076])                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <p>7. The dresser of claim 6, wherein the cutting depth is from about 10 microns to about 50 microns.</p> <p>16. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad.</p> <p>17. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of from about 1 micron to</p> | <p>“[I]n one specific aspect the predetermined height may produce a cutting depth of less than about 20 microns when used to abrade a work piece. In another specific aspect, the predetermined height may produce a cutting depth of from about 1 micron to about 20 microns when used to abrade a work piece. In yet another specific aspect, the predetermined height may produce a cutting depth of from about 10 micron to about 20 microns when used to abrade a work piece.” (EX1005, [0052])</p> <p>“The protruding superabrasive particles 12 can cut into the CMP pad to a depth that is essentially the distance of the protrusion.” (EX1005, [0076])</p> |

|                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>about 20 microns when used to abrade a CMP pad.</p> <p>18. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.</p>                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <p>13. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles align along the designated profile with a tip variation of from about 10 microns to about 50 microns.</p> <p>14. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles</p> | <p>“In a further aspect, the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by from about 10 microns to about 50 microns. ... In another aspect, the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by from about 20 microns to about 40 microns. Additionally, in one aspect, the plurality of superabrasive particles are arranged such that their tips vary from the designated profile by less than about 20 microns.”</p> <p>(EX1005, [0056])</p> |

|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| align along the designated profile with a tip variation of from about 20 microns to about 40 microns.                                                                                                     |                                                                                                                                                                                                                                                                                |
| 15. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles align along the designated profile with a tip variation of less than about 20 microns. |                                                                                                                                                                                                                                                                                |
| 19. The dresser of claim 1, wherein the designated profile includes a configuration selected from the group consisting of a plane, a slope, a curved shape, a dome shape, and combinations thereof.       | “In one aspect, the designated profile may be a plane. In another aspect, the designated profile may have a slope. In yet another aspect, the designated profile may have a curved shape. In a further aspect, the designated profile may have a dome shape.” (EX1005, [0011]) |
| 20. The dresser of claim 1, wherein the plurality of superabrasive particles is                                                                                                                           | “In one aspect, the superabrasive particles can be arranged into a predetermined pattern.” (EX1029, [0058])                                                                                                                                                                    |

|                                                                                                                                                                                                               |                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| arranged across the support substrate in a predetermined pattern.                                                                                                                                             |                                                                                                                                                                       |
| 21. The dresser of claim 20, wherein the predetermined pattern includes an even distribution of the plurality of superabrasive particles spaced at a distance of from about 100 microns to about 800 microns. | “In yet another aspect, the plurality of superabrasive particles may be evenly space at a distance of from about 100 microns to about 800 microns.” (EX1005, [0060]). |

224. It would have been obvious to combine Sung’146 with Sung’026 for at least the following reasons.

225. First, Sung’146 and Sung’026 are both directed to CMP pad dressers and are analogous to the claims of the ’802 Patent. EX1029, claim 1 (“A CMP pad dresser...”); EX1005, claim 65 (“The tool of claim 30, wherein the tool is a CMP pad dresser.”); EX1001, claim 1 (“A CMP pad dresser...”).

226. Second, Sung’146 and Sung’026 both manufacture CMP pad dressers by reverse casting processes. EX1029, [0073] (“Additionally, so-called ‘reverse casting’ methods can be used....”); EX1005, [0083] (“Various *reverse casting* methods may be utilized....”), [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.”); EX1001, 25:14-22 (“Additionally, so-called ‘reverse casting’ methods can be used ....”). A POSITA would have understood that applying the features taught in Sung’026 to Sung’146’s CMP pad dresser would have been a simple modification and vice versa.

227. Third, a POSITA would have had a reasonable expectation of success when combining the teachings of Sung’146 and Sung’026 to manufacture CMP pad dressers with level superabrasive particles. Sung’ and Sung’026 describe the same reverse casting process to manufacture CMP pad dressers, and a POSITA would have slightly modified the process to obtain different degrees of tip leveling.

#### **X. Availability for Cross-Examination**

228. 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.

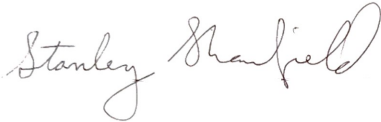
#### **XI. Right to Supplement**

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

**XII. Jurat**

230. 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<sub>0.24</sub>GaAs/In<sub>0.16</sub>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

**Contact information for Stanley Shanfield****STANLEY SHANFIELD**

342 Otis Street  
Newton, MA 02465

**Phone:**

617-969-9574 (home)  
617-258-3392 (office)  
617-699-7262 (mobile)

**Email:** shanfield@alum.mit.edu