

EXHIBIT 4

Analysis of Infringement of U.S. Patent No. 9,138,862

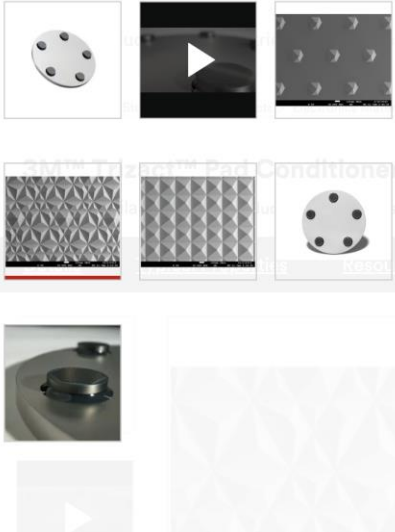
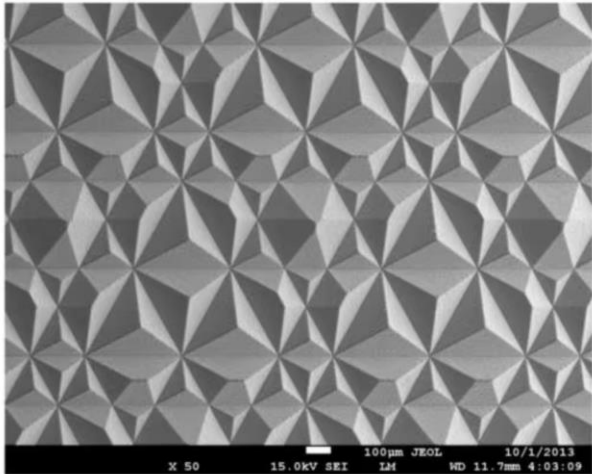
Chien-Min Sung, Ph.D. (“Dr. Sung”) provides this preliminary and exemplary infringement analysis with respect to infringement of claim 1 of U.S. Patent No. 9,138,862 entitled “CMP Pad Dresser Having Leveled Tips and Associated Methods” (hereinafter “the ’862 patent”). The following chart illustrates an exemplary analysis regarding infringement by Defendant by making, using, selling, and/or offering to sell in the United States, or imported into the United States, Accused Products that are/were manufactured or fabricated using CMP pad dressers with the claimed structural characteristics, including at least one of CMP pad conditioners from 3M (e.g., Trizact or Diamond) (collectively, the “’862 Accused Instrumentalities”).

The analysis set forth below is based only upon information from publicly available resources regarding the Accused Instrumentalities, as Defendant has not yet provided any non-public information.

Unless otherwise noted, Dr. Sung contends that Defendant directly infringes the ’862 patent in violation of 35 U.S.C. § 271(a) by selling, offering to sell, making, using, and/or importing the Accused Products that are/were manufactured using the ’862 Accused Instrumentalities. Dr. Sung also contends that Defendant directly infringes the ’862 patent in violation of 35 U.S.C. § 271(g) by selling, and/or offering to sell in the United States, and/or importing into the United States, the Accused Products made by the claimed methods of the ’862 patent. The following exemplary analysis demonstrates that infringement. Unless otherwise noted, Dr. Sung further contends that the evidence below supports a finding of indirect infringement under 35 U.S.C. § 271(b), in conjunction with other evidence of liability under one or more of those subsections.

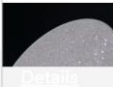
Unless otherwise noted, Dr. Sung believes and contends that each element of each claim asserted herein is literally met through Defendant’s use of the Accused Instrumentalities. However, to the extent that Defendant attempts to allege that any asserted claim element is not literally met, Dr. Sung believes and contends that such elements are met under the doctrine of equivalents. More specifically, in its investigation and analysis of the Accused Instrumentalities, Dr. Sung did not identify any substantial differences between the elements of the patent claims and the corresponding features of the Accused Instrumentalities, as set forth herein. In each instance, the Accused Instrumentalities are used to perform at least substantially the same function in substantially the same way to achieve substantially the same result as the corresponding claim element.

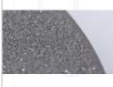
Dr. Sung notes that the present claim chart and analysis are necessarily preliminary in that Dr. Sung has not obtained substantial discovery from Defendant nor has Defendant disclosed any detailed analysis for its non-infringement position, if any. Further, Dr. Sung does not have the benefit of claim construction or expert discovery. Dr. Sung reserves the right to supplement and/or amend the positions taken in this preliminary and exemplary infringement analysis, including with respect to literal infringement and infringement under the doctrine of equivalents, if and when warranted by further information obtained by Dr. Sung, including but not limited to information adduced through information exchanges between the parties, fact discovery, claim construction, expert discovery, and/or further analysis.

U.S. Patent No. 9,138,862	Infringement by the '862 Accused Instrumentalities
1. A method of conditioning a CMP pad, comprising:	To the extent the preamble is found to be a limitation, as discussed below, Defendant performs a method of conditioning a CMP pad using the '862 Accused Instrumentalities. For example, Defendant uses 3M's Trizact and Diamond CMP pad dressers for conditioning a CMP pad, as reproduced below: 3M™ Trizact™ Pad Conditioner   Click or tap image to zoom in See https://www.3m.com/3M/en_US/p/d/b5005049057/; see also:

3M™ Diamond Pad Conditioner









Click or tap image to zoom in

View more details

See https://www.3m.com/3M/en_US/p/d/b5005035338/; see also:

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	For the purpose of this contention, Trizact is used as a representative product because it provides the claimed structural characteristics as the remaining '862 Accused Instrumentalities.
pressing a CMP pad dresser against a CMP pad,	Defendant performs the method of pressing a CMP pad dresser against a CMP pad. For example, Defendant uses Applied Materials' Mirra CMP system to perform the method of pressing the Trizact pad conditioner against a CMP pad. As an example, Defendant discloses: "Slurry B was third generation copper slurry that had low abrasives and is chemical in nature, unlike any other slurry on the market at that time. This slurry was also selective to the Ta/Nitride but demonstrated low dishing

	and erosion with high copper removal rates using low process parameters. The one problem with this slurry had to do with the premature pad balding. (see figure 3). This was overcome by multi-DOE runs looking at process parameters offsets. The final outcome was to reduce the conditioner down-force and time, with such a low abrasive amount in the slurry it was not wearing the conditioner diamonds and degrading the cut rate of the pad.” <i>See Brannon et al.</i>, “Reduced Cost of Ownership Copper CMP Process using Third Generation Low Abrasive Selective Slurry,” at 4, available at https://nccavs-usergroups.avs.org/wp-content/uploads/CMPUG2011/cmp2011_5brannon-1.pdf; <i>see also</i>: “Using a Mirra-Desica™ Cu Polishing process for benchmarking, the team succeeded in demonstrating a lower cost of ownership and equivalent yield with a new low abrasive, high rate, high selectivity and low dishing copper slurry.” <i>See id.</i> at 1. <i>See also</i> Insights for Electronics Manufacturing, Solid State Technology (Jun. 2015), at 18, available at https://www.semiconductor-digest.com/wp-content/uploads/2020/02/SST-Jun-2015.pdf (“For initial qualification and benchmarking, TI installed and setup the best known method (BKM) Cu polishing process on an Applied Materials Mirra-Desica™.”)
the dresser including a monolayer of a plurality of superabrasive particles protruding from a matrix layer,	The ’862 Accused Instrumentalities, including Trizact pad conditioners, include a monolayer of a plurality of superabrasive particles protruding from a matrix layer. For example, as shown below, the Trizact pad conditioners include a monolayer of diamond grits protruding from a matrix layer:

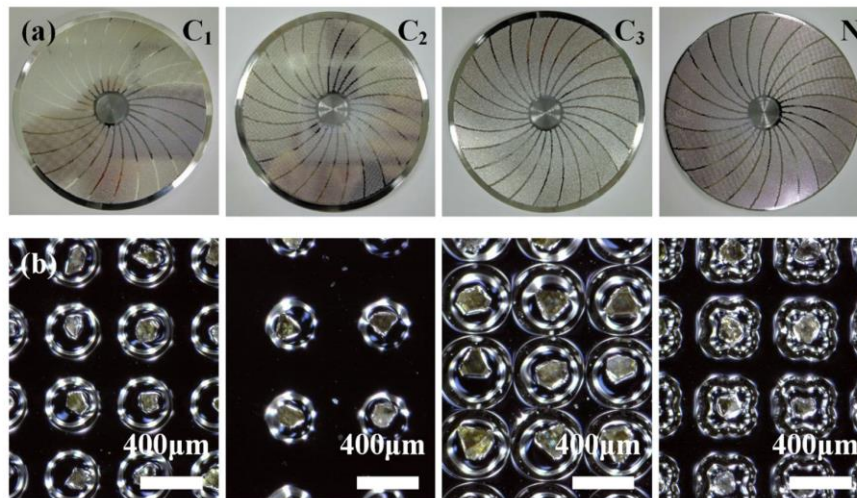
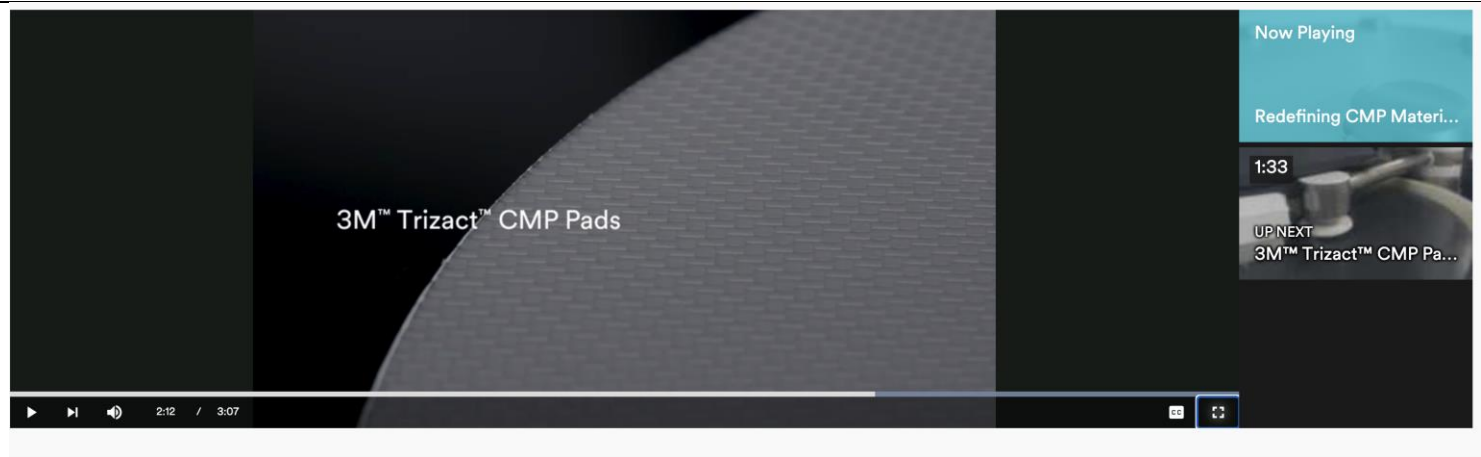


Fig. 1 Details for conventional diamond conditioners (C₁, C₂, C₃ type) and novel diamond conditioner (N type). **a** Actual photographs and **b** magnified optical microscope images

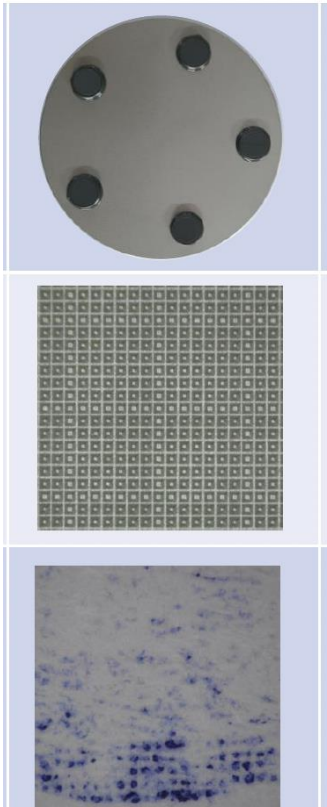
See Shin, C., Kulkarni, A., Kim, K. *et al.* Diamond structure-dependent pad and wafer polishing performance during chemical mechanical polishing. *Int J Adv Manuf Technol* **97**, 563–571 (2018).
<https://doi.org/10.1007/s00170-018-1956-3> (photos and microscope images of 3M CMP Pad Conditioners); see also:



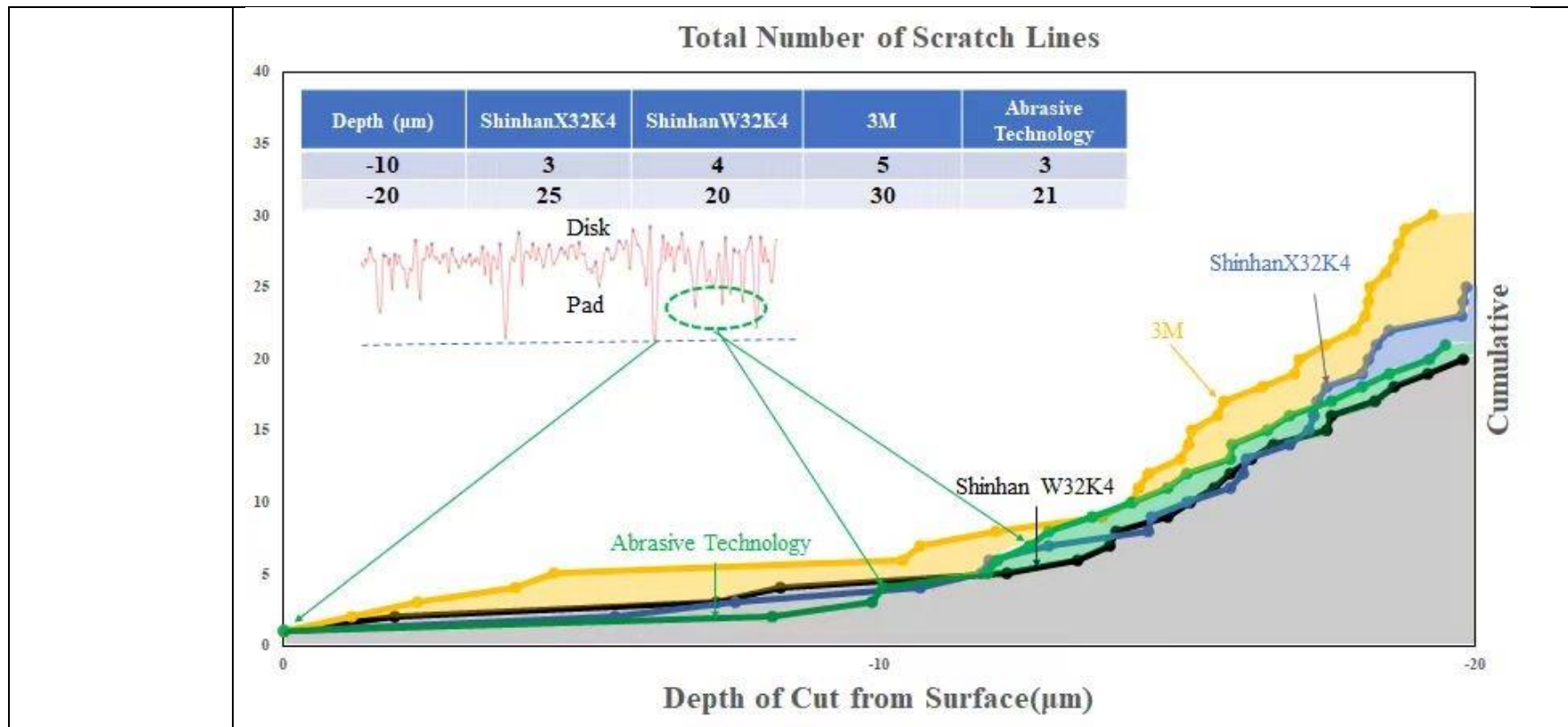
See https://www.3m.com/3M/en_US/p/d/b5005049057/; see also *id.* at:

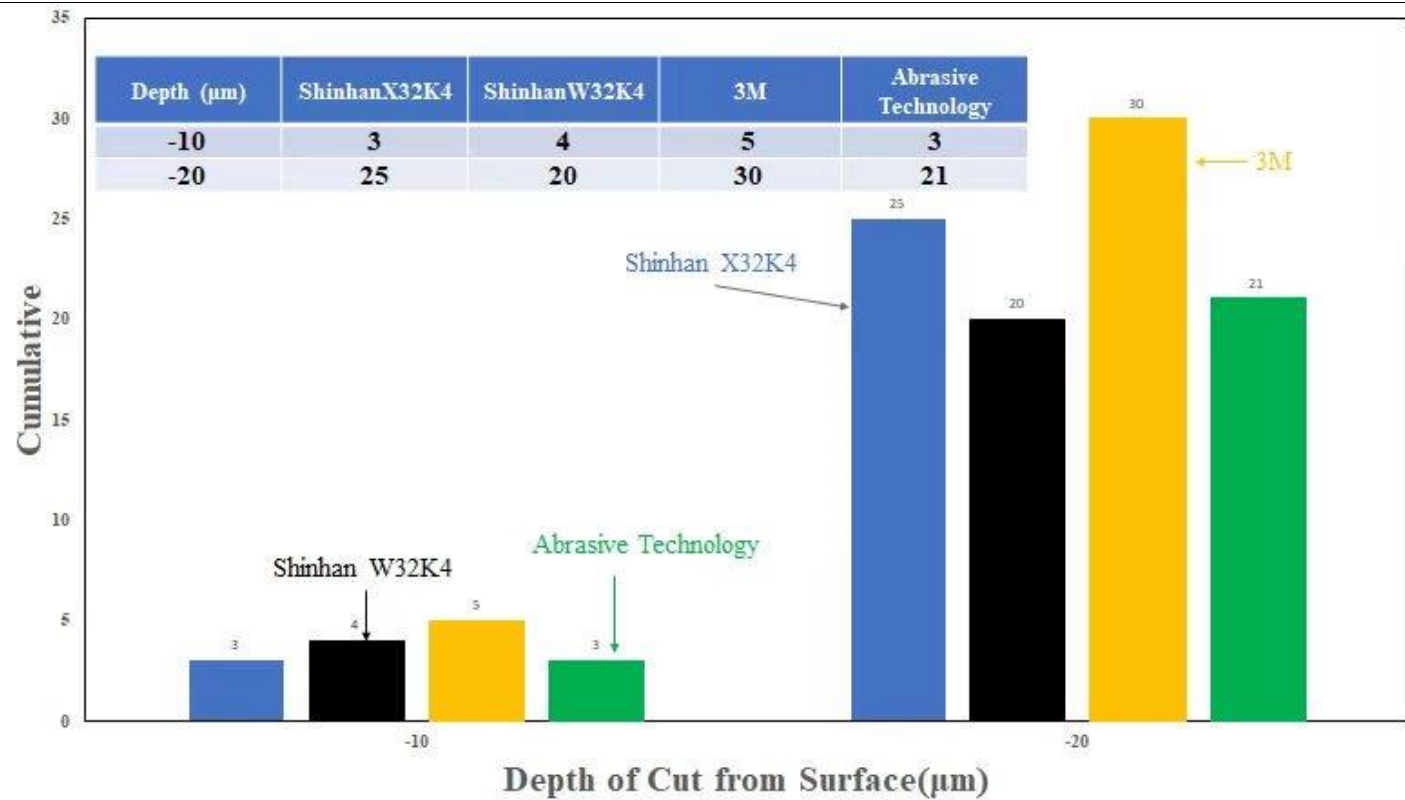


See also:

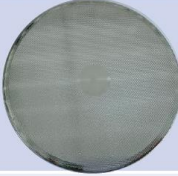
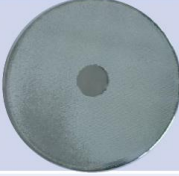
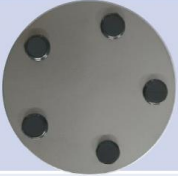
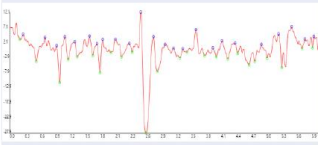
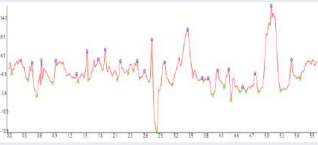
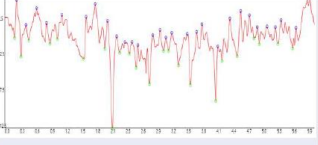
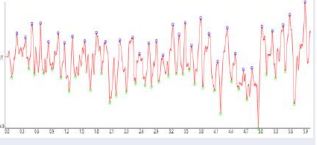
	3M 
wherein the difference in protrusion distance between the highest protruding tip	In the '862 Accused Instrumentalities, including Trizact pad conditioners, the difference in protrusion distance between the highest and second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 10 microns.

and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 10 microns and	For example, the difference in protrusion distance between the highest and second highest protruding tip of the monolayer of superabrasive particles in the Trizact pad conditioners is less than or equal to about 10 microns, as shown below:
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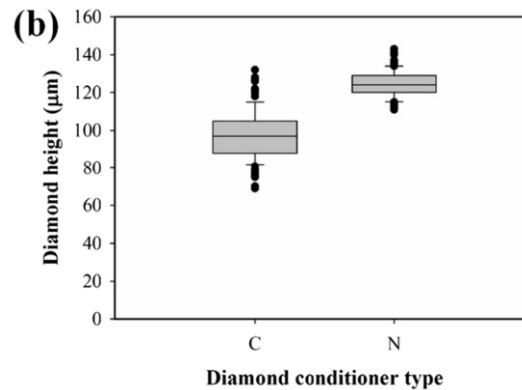




See also:

项目/ 样品	Saesol An1j62	Shinhan X32K4	Shinhan W32K4	3M Trizact
宏观				
划痕				

See also:



See Shin, C., Kulkarni, A., Kim, K. *et al.* Diamond structure-dependent pad and wafer polishing performance during chemical mechanical polishing. *Int J Adv Manuf Technol* 97, 563–571 (2018).

<https://doi.org/10.1007/s00170-018-1956-3> (chart showing diamond height distribution in 3M CMP Pad Conditioners).

See also Pysher et al., “Design, Characteristics and Performance of Diakond Pad Conditioners,” at 4, available at <https://multimedia.3m.com/mws/media/6678240/design-characteristics-performance-of-diamond-pad-conditioners.pdf?fn=DesignCharDiaPadCond.pdf> (“Figure 4 compares two dimensional surface profiles of the

current and new fine-finish conditioners and illustrates the improvements in flatness and diamond height distribution”):

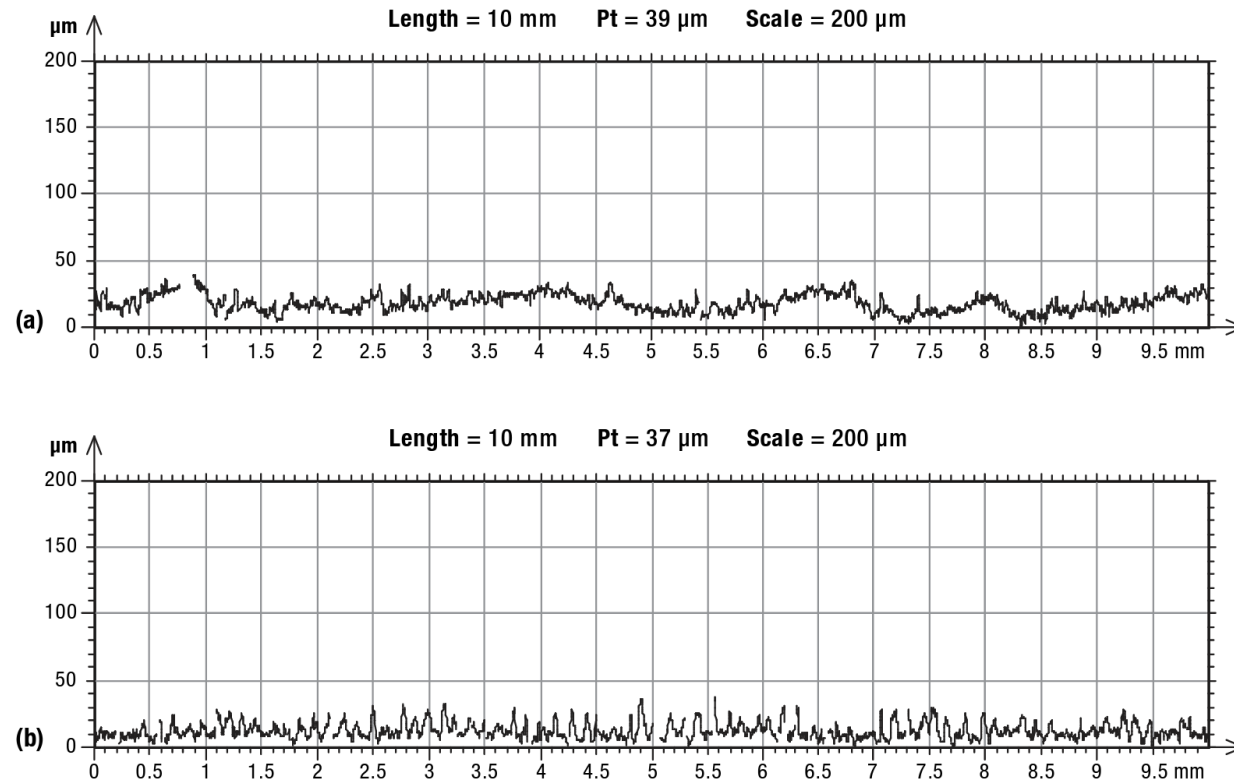


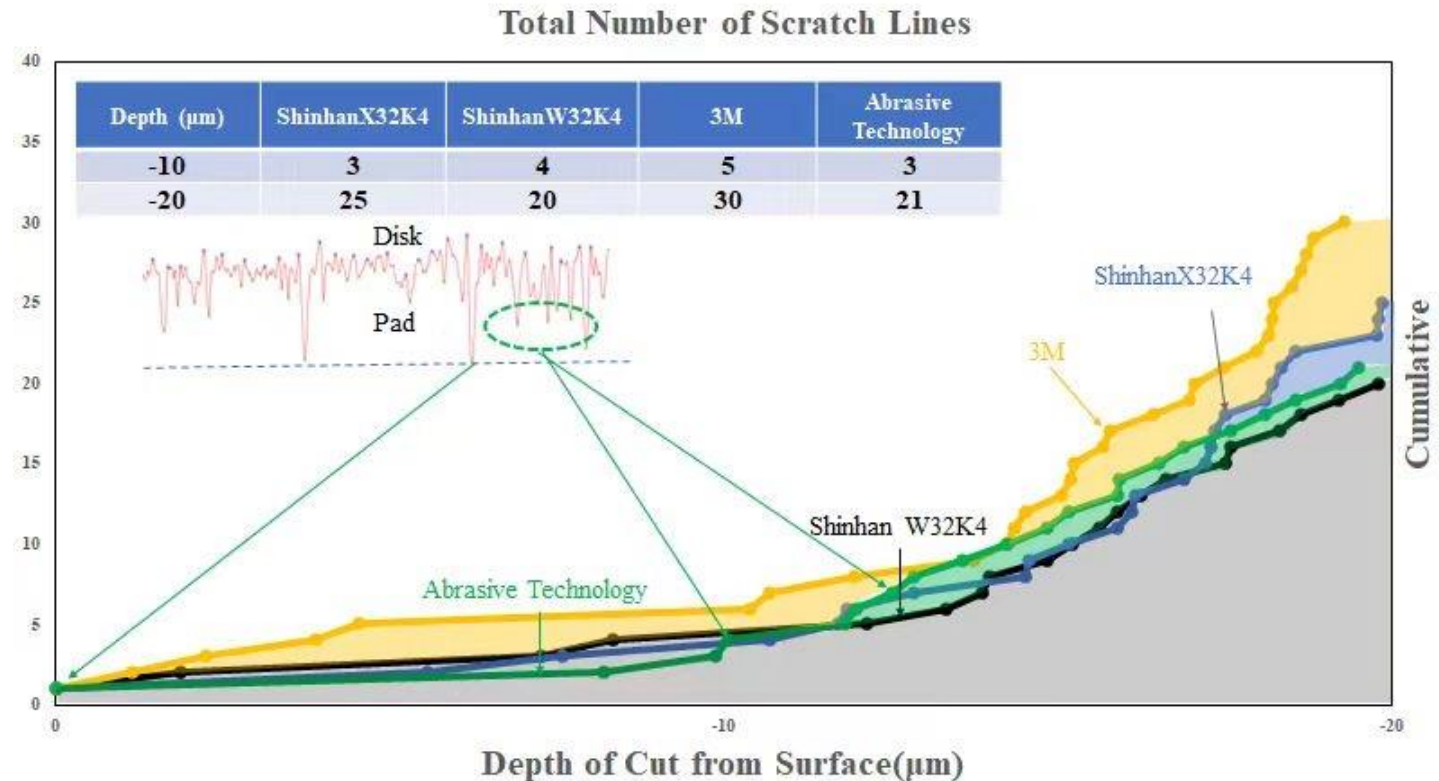
Figure 4. Surface profiles showing flatness of a) current and b) improved fine-finish disk designs

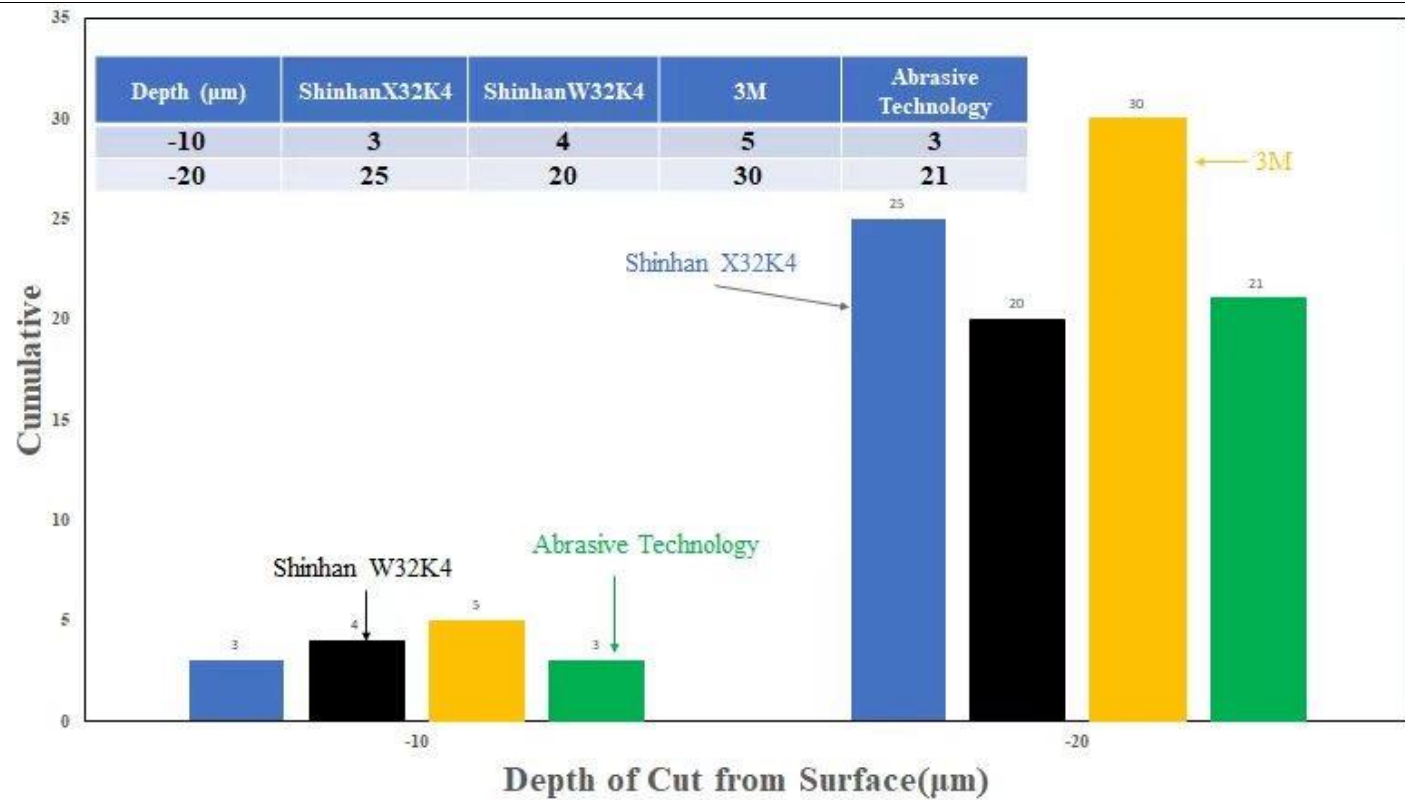
the difference in protrusion distance between the highest 10 protruding tips of the monolayer

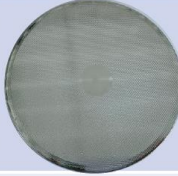
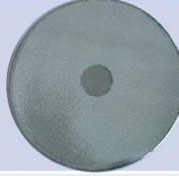
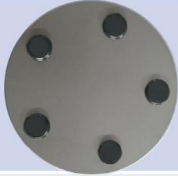
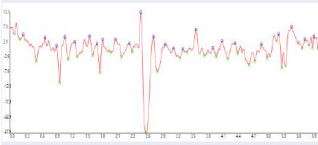
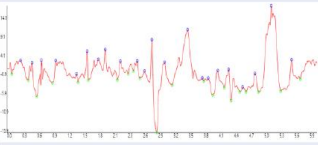
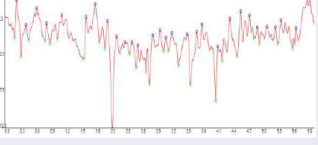
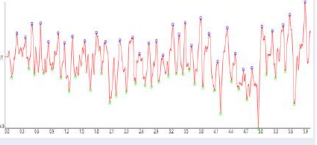
In the '862 Accused Instrumentalities, including Trizact pad conditioners, the difference in protrusion distance between the highest 10 protruding tips of the monolayer of superabrasive particles are within about 20 microns or less.

For example, the difference in protrusion distance between the highest 10 protruding tips of the monolayer of superabrasive particles in the Trizact pad conditioners are within about 20 microns or less, as shown below:

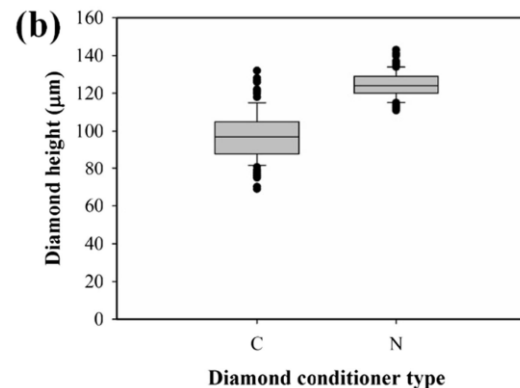
of superabrasive particles are within about 20 microns or less; and





项目/ 样品	Saesol An1j62	Shinhan X32K4	Shinhan W32K4	3M Trizact
宏观				
划痕				

See also:



See Shin, C., Kulkarni, A., Kim, K. *et al.* Diamond structure-dependent pad and wafer polishing performance during chemical mechanical polishing. *Int J Adv Manuf Technol* **97**, 563–571 (2018).

<https://doi.org/10.1007/s00170-018-1956-3> (chart showing diamond height distribution in 3M CMP Pad Conditioners).

See also Pysher et al., “Design, Characteristics and Performance of Diakond Pad Conditioners,” at 4, available at <https://multimedia.3m.com/mws/media/667824O/design-characteristics-performance-of-diamond-pad->

[conditioners.pdf?fn=DesignCharDiaPadCond.pdf](#) (“Figure 4 compares two dimensional surface profiles of the current and new fine-finish conditioners and illustrates the improvements in flatness and diamond height distribution”):

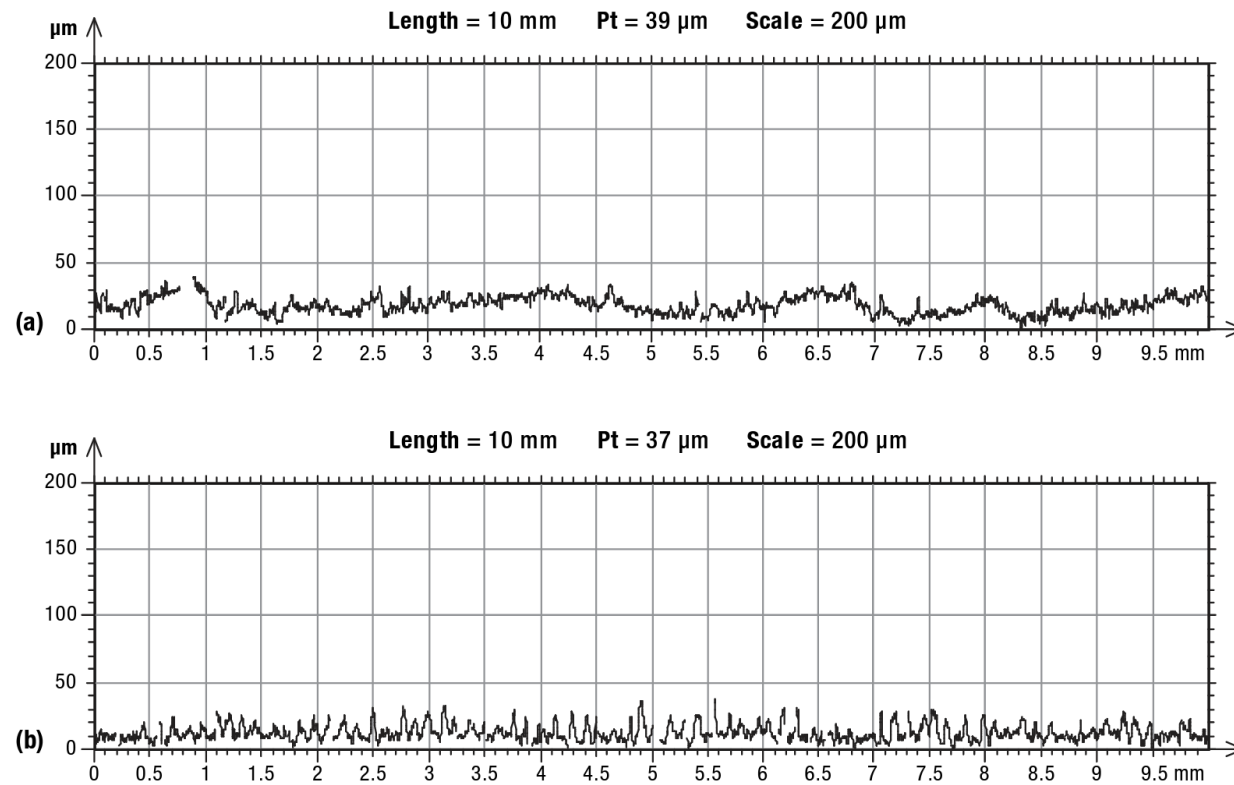


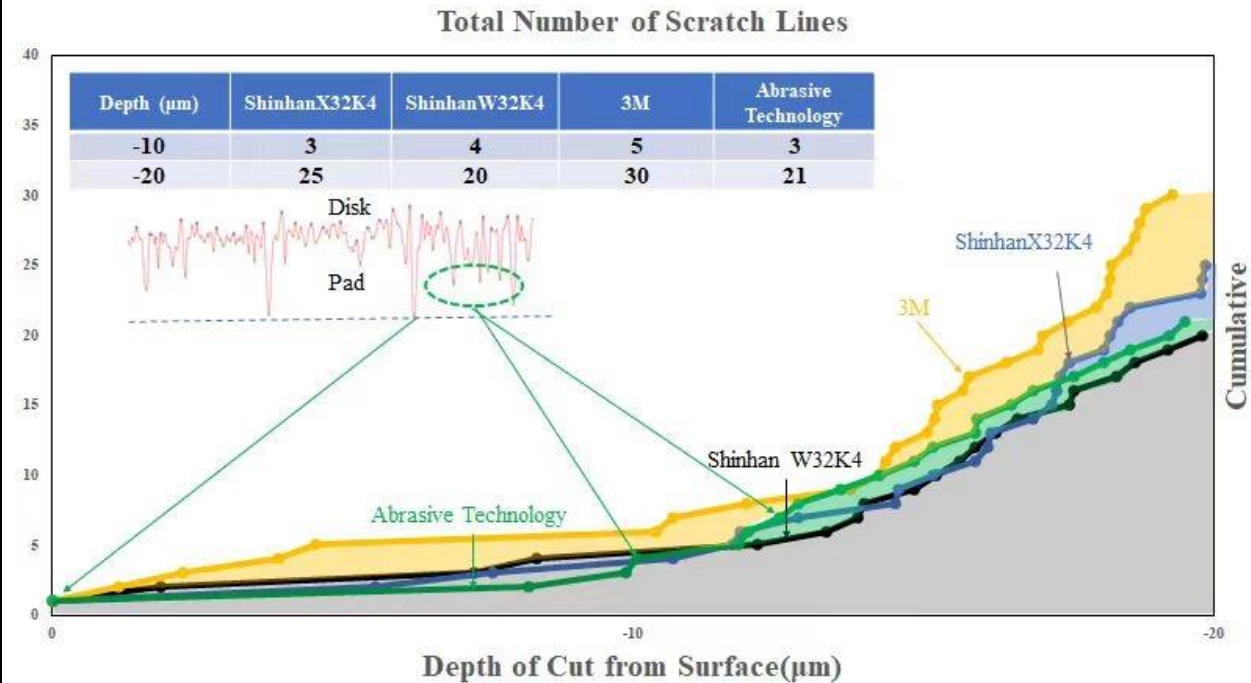
Figure 4. Surface profiles showing flatness of a) current and b) improved fine-finish disk designs

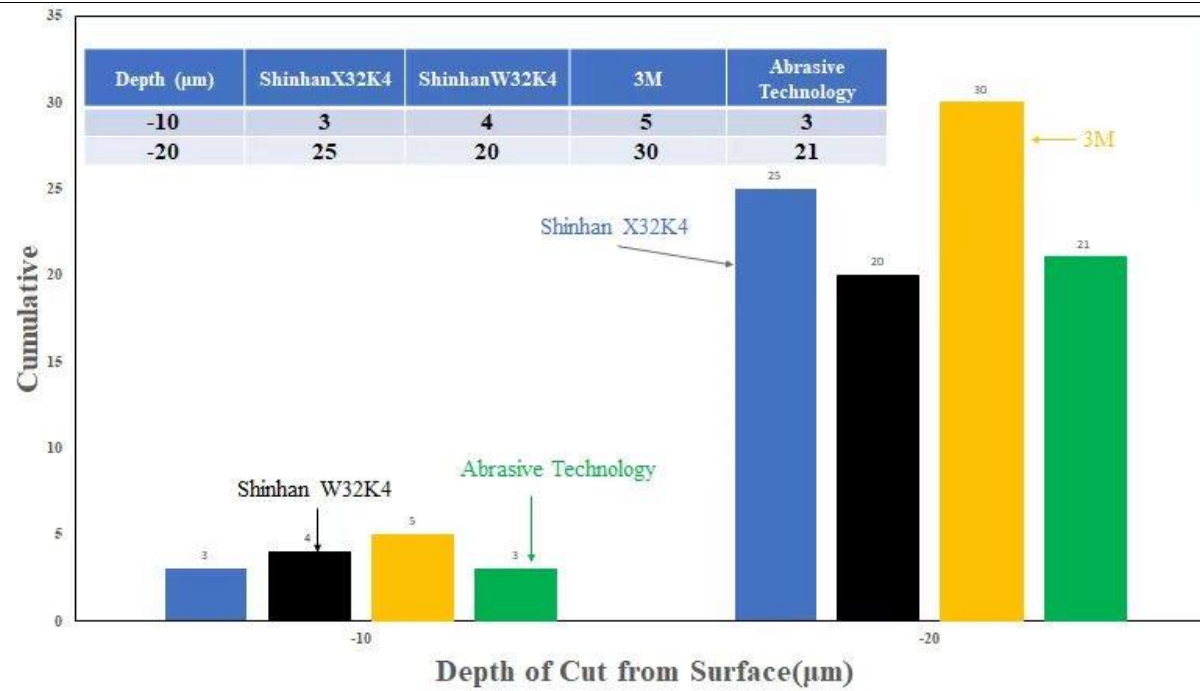
rotating the dresser against the CMP pad such that asperities are cut

Defendant rotates the dresser against the CMP pad such that asperities are cut into the CMP pad having a maximum cutting depth of about 60 microns.

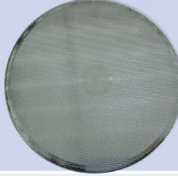
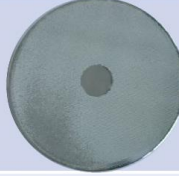
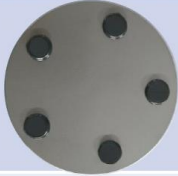
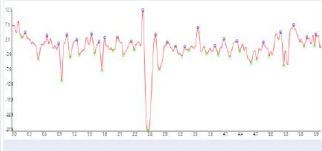
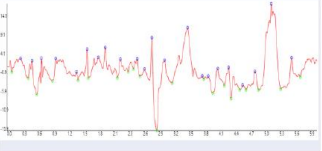
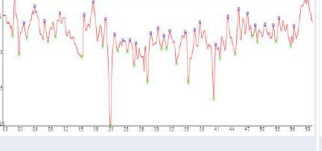
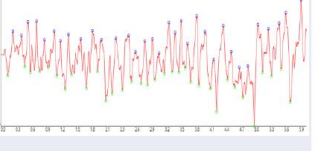
into the CMP pad having a maximum cutting depth of about 60 microns.

For example, Defendant uses the Mirra CMP system to rotate the Trizact pad dresser/conditioner against a CMP pad such that asperities are cut into the CMP pad having a maximum cutting depth of about 60 microns, as shown below:





See also:

项目/ 样品	Saesol An1j62	Shinhan X32K4	Shinhan W32K4	3M Trizact
宏观				
划痕				

See also <https://patents.google.com/patent/US6386963B1/en> (a patent assigned to Applied Materials showing the rotation of a conditioning device 182 of the Mirra system that comprises a dresser 201; see Figs. 1 and 2).