

Diamond Pad Conditioner Design and Performance in Copper CMP

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Abstract

Polishing tests to evaluate and characterize the performance of conditioning disks in copper CMP were conducted on the AMAT Reflexion polishing tool. Break-in and extended marathon testing were used to generate copper removal rates and within wafer non-uniformities. 3D pad profile measurements were also conducted to evaluate the pad and conditioner wear throughout the polish.

Disks with the highest aggressiveness had the largest and most stable removal rate with the standard IC1010™ pad. 3D pad profile measurements showed a correlation between pad wear, surface roughness and removal rate. For next generation pads however, the relationship was more complicated. Disks with lower aggressiveness and pad wear performed as well on these pads and their performance could be modulated by changing the pad and slurry used in the process.

Introduction

The importance of conditioning in CMP processes has been discussed extensively in the literature.¹ The design, characteristics and performance of diamond pad conditioners in CMP processes have also been reviewed and discussed elsewhere.²

Current devices utilize multiple layers of copper metallization with complicated integration schemes resulting in a variety of pads being deployed to meet the user's manufacturing requirements. To match the pad evolution, different types of conditioners with different level of aggressiveness and surface finish have to be fabricated. For bulk copper removal, pads with a large degree of hardness have been traditionally used and for these pads, very aggressive conditioning disks are needed to texturize

the pad and maintain surface morphology.³ However, for improved defectivity, next generation pads with lower hardness are being considered.⁴ Also, next generation slurries are targeting lower concentrations and smaller abrasive particle sizes compared to traditional copper slurries.⁴ Less aggressive disks to maintain the original pad asperities, minimize pad wear and erosion and reduce defectivity are being deployed to match next generation pads and slurries.

In this paper, we highlight the performance of four commercial conditioner designs that are currently being used and qualified in high volume manufacturing. We correlate the data generated with the conditioner design and surface characteristics.

Experimental

Table 1 shows the properties of the 3M commercial disk designs employed in this study. To evaluate the performance of these disks, break-in and marathon testing on a 300 mm platen/200 mm Titan 2 head AMAT Reflexion polishing platform were conducted. 3D pad profile in-situ measurements were also conducted on the tool⁵ to generate pad profiles and measure pad wear. The profiles were generated by subtracting the scan of the pad after completing the conditioning and polishing with the disk from the scan of the pad before starting to condition and polish with the disk. We also conducted ex-situ laser pad profile measurements to measure pad surface roughness after polish.

All the polishing and conditioning was conducted at 100% in-situ at 5 lbs down force. The initial baseline pad used for the evaluation was the Dow Chemical IC1010 pad. We also evaluated next generation pads B, C and D which had varying degrees of hardness and porosity. We employed two high volume manufacturing copper slurries, Y and Z to conduct the tests.

Table I. Conditioning Disk Properties

	H2	S126	B9	A165
Diamond Size (microns)	63	150	180	250
Diamond Type	Blocky	Semi Blocky	Sharp	Semi Sharp
Aggressiveness	1 to 3	9 to 11	25 to 35	15 to 19
Surface Finish (microns)	1.65-1.77	1.73-2.42	3.12-3.67	2.95-5.0

Discussion

Figure 1 shows results of copper marathon testing with an IC1010™ pad with copper slurry Y for all the four disks. The figure shows that removal rate values were highest and more stable for the most aggressive disks compared to the less aggressive disks.

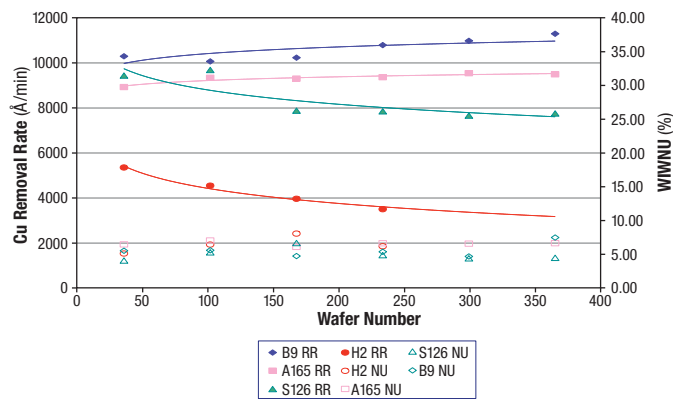


Figure 1. Marathon Copper Polish Testing on IC1010™ Pad With Cu Slurry Y showing that removal rates were highest and more stable for the most aggressive disks.

Figure 2 shows typical 3D pad wear profiles generated during this marathon test with the IC1010 pad. This figure shows the pad profiles generated with the S126 and B9 disks. In the figure, it is shown that the range of pad wear was 3 to 4 times larger for the more aggressive disk which was consistent with the differences in the aggressiveness values measured between the two disks.

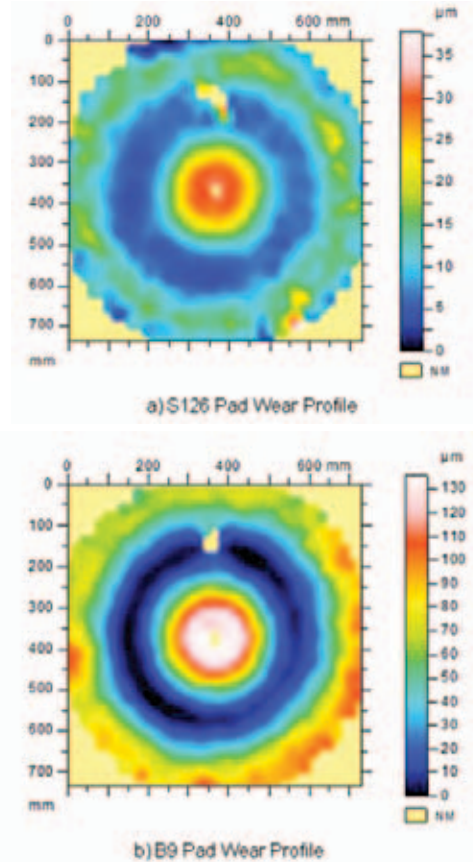


Figure 2. Pad Wear Profile Topography after Marathon Testing on IC1010 Pad showing that the range of pad wear was 3 to 4 times larger for the more aggressive disk.

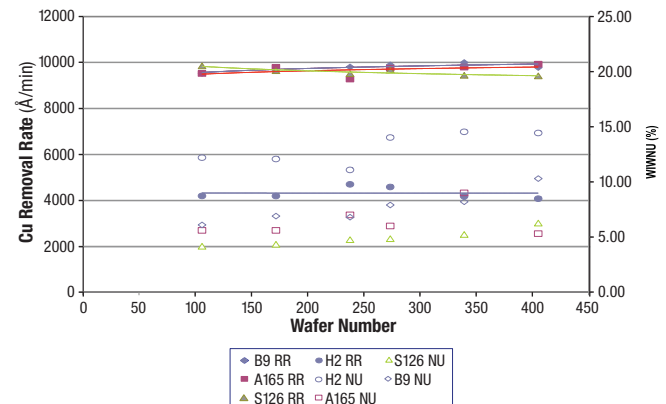


Figure 3. Marathon Testing on Pad B with Cu Slurry Y, showing the Cu RR for the less aggressive S126 disk was similar to the Cu RR of the aggressive disks.

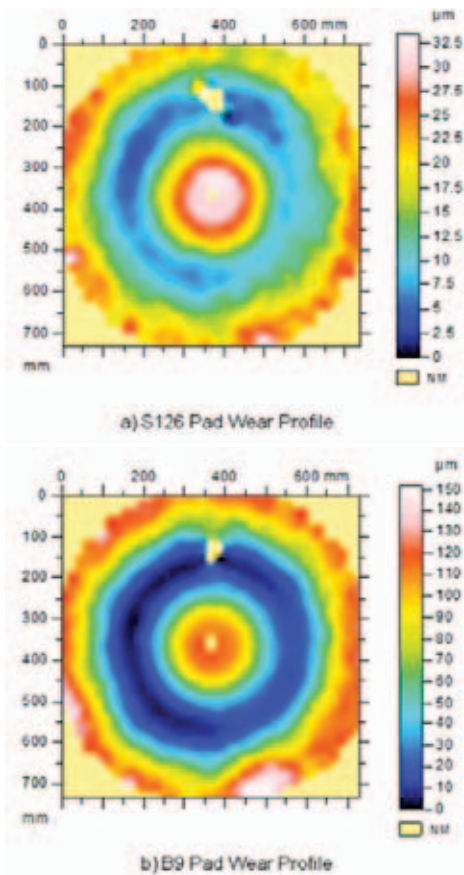


Figure 4. Pad Wear Profile after Marathon Testing on Pad B with Cu Slurry Y showing the pad wear rate for the more aggressive B9 disk was still 3 to 4 times greater than the pad wear rate for the less aggressive S126 disk although both disks had similar Cu RR on this pad B.

We also conducted a similar test with copper slurry Y with the next generation pad B. Figure 3 shows the removal rates for all four disks. The removal rate for S126 was similar to the removal rates observed with the more aggressive disks on this pad. This result was significant for S126 and contrasted sharply with the results observed with IC1010 pad where the removal rate degraded more significantly with the less aggressive disks. The differences in pad wear rate between the S126 and B9 disks is shown in Figure 4.

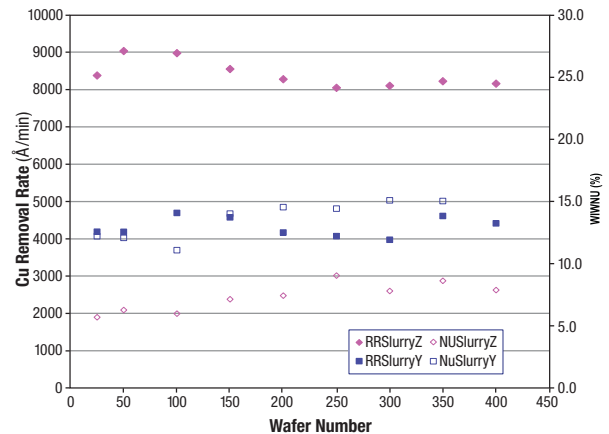


Figure 5. Copper Polish Testing on Pad B With H2 Disk with Cu Slurries Y and Z showing that the removal rate with the less aggressive H2 disk could be increased with copper slurry Z.

In Figure 5, it is shown that with this pad B, the removal rate of one of the other less aggressive disks, (H2) could also be modulated by switching to another copper slurry Z. The removal rate was more stable (over 8000 Å/min) with copper slurry Z compared to less than 4500 Å/min with copper slurry Y. This difference could be explained by physical differences between the slurries and more work is in progress to understand these differences.

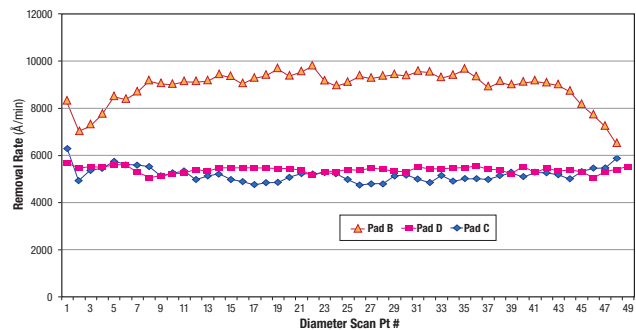


Figure 6. Copper Removal Rate and Non-uniformity with H2 disk with Cu slurry Z on Pads B, C and D showing relatively high copper removal rates (above 5000 Å/min) with pads B, C and D.

In Figure 6 in addition to pad B, with the H2 disk, we evaluated the disk performance with other pads with copper slurry Z. We obtained relatively high copper removal rates (above 5000 Å/min) with pads C and D compared to values obtained with copper slurry Y for this disk. Both pads C and D- like pad B-, are next generation pads and are softer and more porous than the standard IC1010 pad.

Conclusions

In conclusion, for copper CMP with the standard IC1010 pad, we have shown in this work that conditioner aggressiveness strongly influences the effectiveness of the conditioner. In contrast, for next generation pads, the interaction between pad and conditioner is more complicated and nuanced. The choice of a conditioner will be more greatly influenced by the type of pad and slurry used in the process. This work has not taken into account the influence of the conditioner on planarity and defectivity, which are quite significant and it is planned to continue to conduct this work and further explore this significance.

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