

CMP Pad Surface Conditioning Solution for Consistent CMP

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I. Introduction

In the CMP process, CMP pad conditioners are used to enable stable, consistent CMP performance by adjusting the CMP pad surface texture and removing chemical reaction agents from the pad surface. In this paper, we will propose a method for achieving consistent pad conditioning performance by reducing metal leaching during the CMP process that will be required for advanced node CMP.

II. Background

In the CMP process for advanced node semiconductor device manufacturing, CMP performance improvements such as higher throughput, dishing/erosion and defectivity improvements are required. To address these requirements, 3M™ Diamond Pad Conditioner, which features consistent conditioning performance, is used to achieve a consistent CMP performance. Especially for metal film CMP processes such as W and Cu, as well as emerging substrates such as SiC, which is used as a power device substrate, acidic CMP slurry and higher oxidizing slurry are often used to meet these needs.

These chemical properties of the CMP slurry can potentially damage the pad conditioner surface. Diamonds are attached to the pad conditioner surface by using metal matrices such as electroplated Ni or Ni-based alloys. There are concerns about metal leaching into the CMP slurry, which can potentially cause metal contamination on the wafer. In addition, metal matrix layer damage can potentially cause the diamonds to fall off, which leads to scratch and defect issues.

III. Experimental Methods

To address the metal leaching technical trend, we are proposing a new platform for 3M™ Diamond Pad Conditioner with coatings, with the first launched coating featuring hydrophobic properties. This hydrophobic coating fully covers the front side of the CMP pad conditioner surface including the diamonds. The contact angle of the hydrophobic coating layer is around a hundred degrees. To confirm the hydrophobic coating layer's water protection performance, DI water was dropped from 20cm above the pad conditioner surface. Fig. 1 shows the result: the hydrophobic layer prevents water from contacting the metal matrix layer on the pad conditioner.



Fig. 1 Coating effectiveness at water protection on pad conditioners
(1) Uncoated 3M diamond pad conditioner
(2) 3M diamond pad conditioner with a hydrophobic coating

To confirm metal leaching prevention performance, we prepared 3 pad conditioner samples, (1) Uncoated pad conditioner, (2) pad conditioner with a hydrophobic coating, (3) pad conditioner with a hydrophobic coating, after a 250 wafer Oxide CMP test. To analyze metal leaching, the samples were fully immersed in 2000ppm of Citric Acid for 24 hours at room temperature. The amount of Ni that dissolved into the Citric Acid was analyzed by ICP. Fig. 2 shows the metal leaching test result, demonstrating that a CMP pad conditioner with 3M’s hydrophobic coating can substantially reduce metal leaching for both new and post CMP. The result indicated the metal leaching prevention performance of hydrophobic coating layer is maintained even during the CMP process.

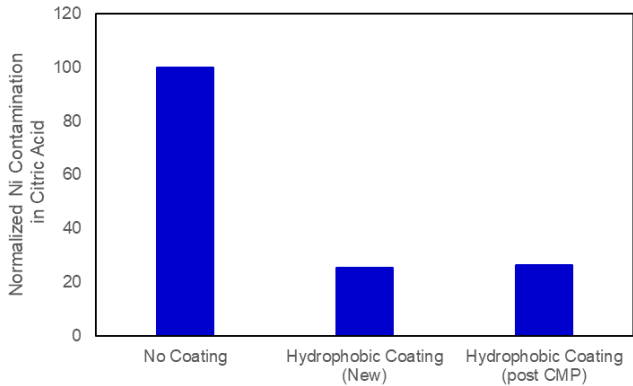


Fig. 2 Metal leaching prevention performance result

To confirm whether the hydrophobic coating affects CMP performance, the oxide removal rate and removal rate profile were evaluated under the CMP conditions described in Table 1. The test result was shown in Fig. 3. No difference in removal rate and removal rate

profile were observed between the uncoated and hydrophobic coated pad conditioners.

Table 1 CMP performance test conditions

Tool	FREX300X
Slurry	Ceria Slurry
Pad	IC pad
Wafer	TEOS
Polish Pressure	1.5 psi
Slurry Flow Rate	300 mL/min
TT Rotation	82 rpm
Wafer Rotation	78 rpm
DR Downforce	18 N
DR Rotation Speed	89 rpm
Conditioning Type	Full in-situ
CMP Duration	1 minute

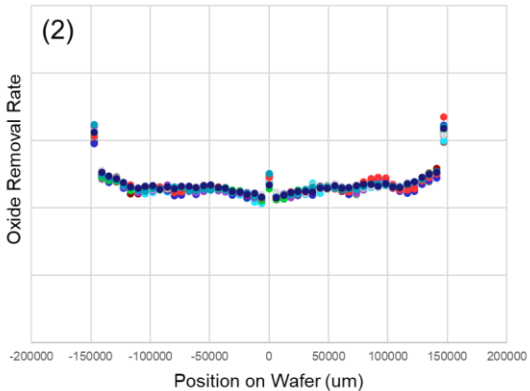
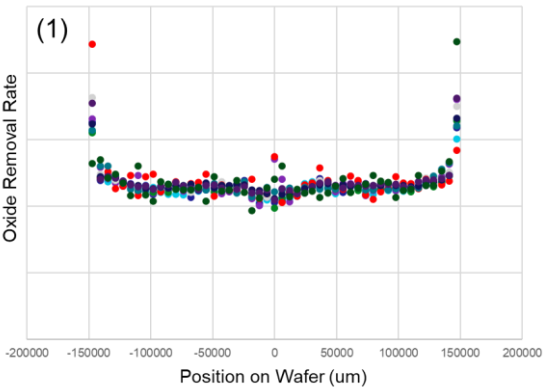


Fig. 3 Oxide Removal Rate profile

- (1) Conditioning with uncoated conditioner (250 wafers run)
- (2) Conditioning with hydrophobic coated conditioner (250 wafers run)

IV. Discussion

3M™ pad conditioners with a 3M hydrophobic coating substantially reduced metal leaching from the pad conditioner surface during CMP without a negative impact on CMP performance.

Studies have found that if diamond protrusion is changed significantly, pad conditioning performance such as pad wear rate and pad surface texture after conditioning was changed [1]. For this 3M hydrophobic coated pad conditioner, the thickness of the hydrophobic coating layer is a few microns, which is much less than diamond protrusion.

We checked both pad wear rate and pad surface roughness under the same pad conditioning condition (Fig. 4). No significant difference was shown in pad conditioning performance between non coating and hydrophobic coating. This indicates that the pad conditioning performance was not changed by the thin hydrophobic coating layer, so both TEOS removal rate and removal rate profile are expected to be as shown in Fig. 3.

This result demonstrates that the 3M hydrophobic coating can provide a solution for CMP processes with strong chemical properties such as W CMP or permanganate slurry for SiC polishing.

References

- [1] Zan Liu, et al., Advanced CMP Pad Surface Texture Characterization and Its Impact on Polishing, CMPUG Spring 2016

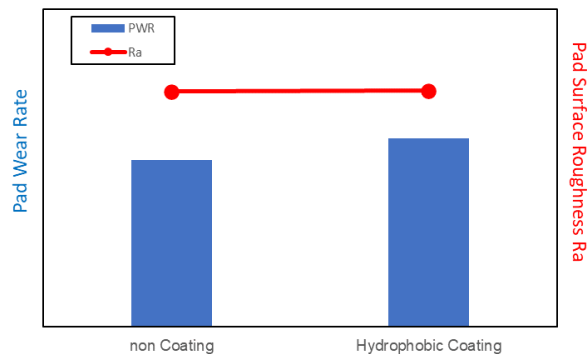


Fig. 4 Pad wear rate and pad surface roughness comparison

V. Conclusions

We proposed a hydrophobic coated diamond pad conditioner to achieve a consistent pad conditioning performance, with a particular focus on minimizing metal leaching. Testing demonstrated that this hydrophobic coating can reduce metal leaching without negatively impacting Oxide CMP process performance, because the hydrophobic coating can provide similar pad conditioning performance to an uncoated conditioner.

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