Wafer Planarization: A Front Side Approach

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INTRODUCTION

CMP operation needs to accommodate variety of incoming film profiles, wafer bows and wafer edge profiles, while producing flat outputs. Current main-stream CMP use wafer back side zonal pressure control[1] (**Fig.1**) to achieve such planarized surfaces with limited success. Backside control inherently restricted by wafer stiffness, spreading the applied force (backside pressure) over a wide range in wafer front side instead of narrow regions (**Fig. 2**).

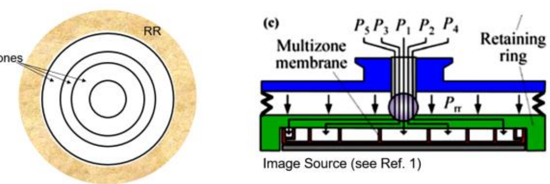


Fig.1 Pressure zones of a typical polishing head[1]

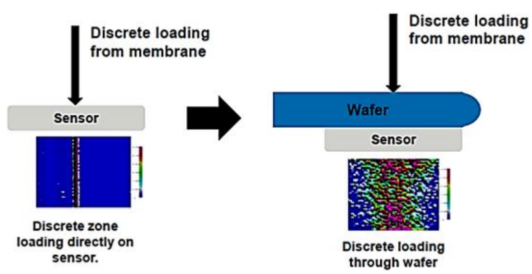


Fig.2 Backside point load (1mm) leads to +/- 15 mm frontside distribution

This work describes an exploratory front side planarization approach to overcome some of the shortcomings stated above. Here, the material removal is accomplished by a "roller polisher" (a polishing pad affixed to a cylindrical roller) translating the applied pressure directly to the front surface rather than through backside. This allows increased removal resolution and broader profile control.

EXPERIMENTAL

The polishing action is achieved by bringing the roller into contact with the front face of wafer at a desired radial position. Using combined actions of wafer rotation and roller rotation, a relative velocity between wafer surface and pad is achieved. Hence the removal. Abrasive slurry and rinse chemistries are introduced to the roller pad via multiple dispense lines. A typical removal cross-section at a single radial position is shown in **Fig 3a**. By moving the roller to different radial locations and applying variable downward pressure allows desirable removal depths at given locations. Removal rate can be further tuned by resident times, wafer rotation speed and roller rotation speed. For example, **Fig 3b** shows a removal profile in 125-140mm region. Scanning the roller along all radial positions allows full wafer polishing (excluding wafer center and near center region)

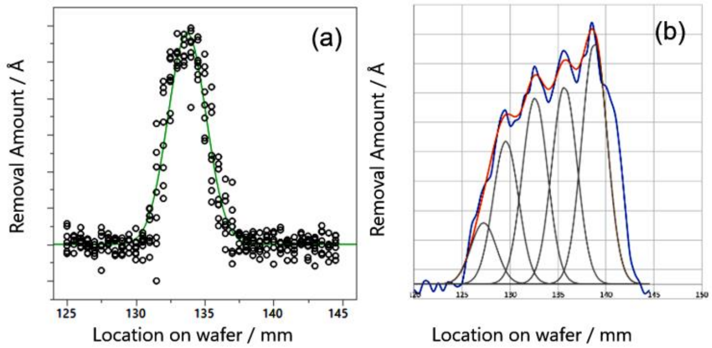
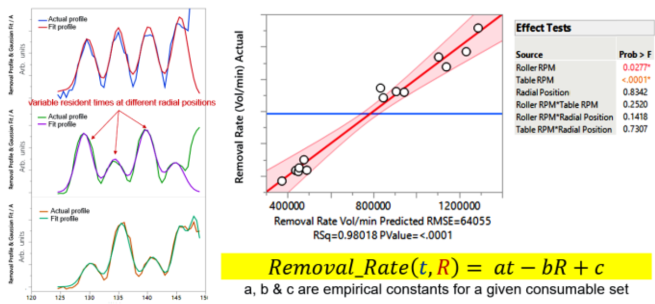


Fig.3 (a) Removal profile at single radial location. **(b)** an overlapping series of removal profiles fitted with Gaussians

REMOVAL MODEL



A relationship between Removal_Rate(t,R), resident time (t) and radial position (R), established based on empirical data. Accuracy and repeatability of the model validate by repeating a selected removal profile on multiple wafers.

RESULTS

A typical removal cross-section is shown in **Fig. 4**. A smooth removal profile can be produced by performing a series of overlapping removal bands determined by the model

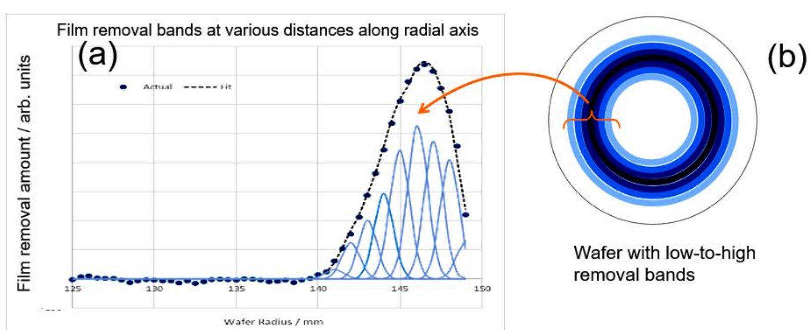


Fig.4 (a) Removal profile at single radial location. **(b)** an overlapping series of removal profiles fitted with Gaussians.

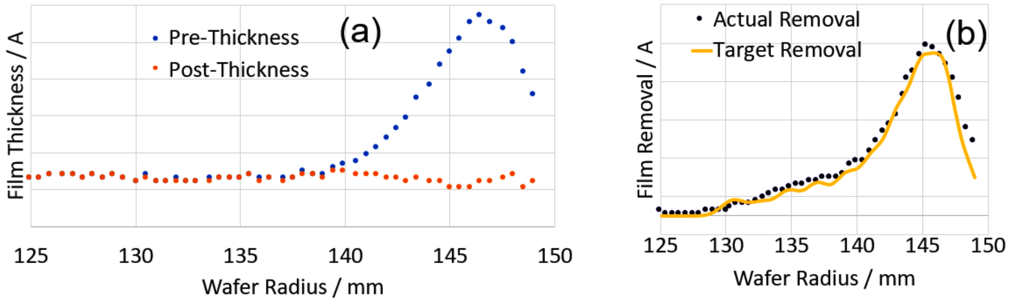


Fig.5 (a) film thickness difference before and after film removal. **(b)** Comparison between target (model) and actual film removal

DISCUSSION

With proper pad maintenance (conditioning), consistent and reproducible removal profiles generated with fine agreement with the model. In addition, removal rate drifts due pad/condition variabilities can be offset by scaling resident time(s) at each radial position. Post-polished wafer roughness, particle adders (film defects) from front side polishing shown to be comparable to conventional CMP methods.

CONCLUSIONS

Higher removal precision, greater profile control and reproducibility has been highlights of this experimental work. However, high removal resolution (narrow removal bands) negatively impacts on throughput. In addition, removal resolution rapidly degrades at smaller wafer radius (<40mm) regions (exact region determined by roller-wafer contact length).

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