Model-Based Profile Control for 200mm CMP: Easier than 300mm CMP or Not?

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Motivation

The last 3 years have seen an increased demand for analog, MEMS and RF chips, which has led to a shortage in both 200mm fab capacity as well as equipment. This has sparked a new interest among equipment makers to refurbish used 200mm tools, develop entirely new tools, or integrate 300mm technology into 200mm equipment. An example of this latter category is Applied Materials' 200mm Mirra® CMP system. For well over 15 years, Applied Materials' 300mm CMP has successfully used Real-Time Profile Control (RTPC™) to control polishing uniformity of metal layers based on measuring its thickness in real-time using a magnetic sensor, see Figure 1. The increased interest in 200mm, as well as new applications like thick Cu and the ability to run one recipe for multiple applications under varying process conditions, have motivated the integration of RTPC™ into 200mm CMP. Historically, 300mm control problems have been more difficult than 200mm control problems because of the larger wafer size. Interestingly, in this presentation we will show that 200mm CMP has its own unique challenges that defy the historical perception that 200mm is 'easier to control' than 300mm.

Approach

To enable Cu CMP process on multiple wafer types and incoming Cu profiles, Applied Materials' production-proven RTPC™ in-situ profile control from the 300mm CMP tool set was scaled and implemented on 200mm tools. The downscaling from 300mm to 200mm, while maintaining the same number of control zones, showed some unique challenges for 200mm that were resolved by comparing DOE data with SC Solutions physics-based model. A new application specific to 200mm is the polishing of very thick Cu films, up to 6µm. To accommodate this, two types of sensors were installed, one for very thick Cu films from 2µm up to 6µm, and one for Cu films of 2µm and below.

Results

The polishing of very thick Cu films posed additional challenges for control. We will demonstrate the capability and flexibility of RTPC™ to compensate for varying wafer thicknesses and incoming Cu profiles and by doing so, enable both rapid process development and consistent, sustainable performance. Data will be shown that shows how RTPC™ closed-loop control can be effectively used to adjust for a variety of scenarios including thick Cu polish for extended polishing times and automatic edge profile control, see Figure 2.

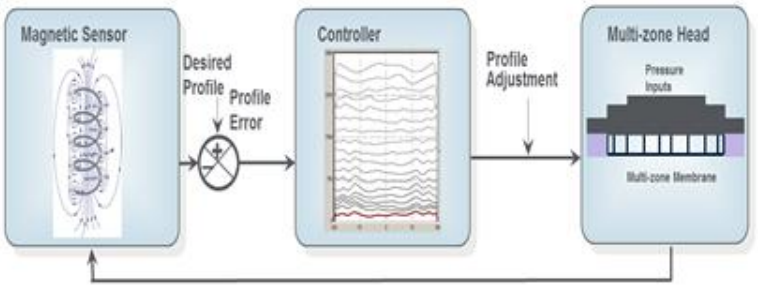
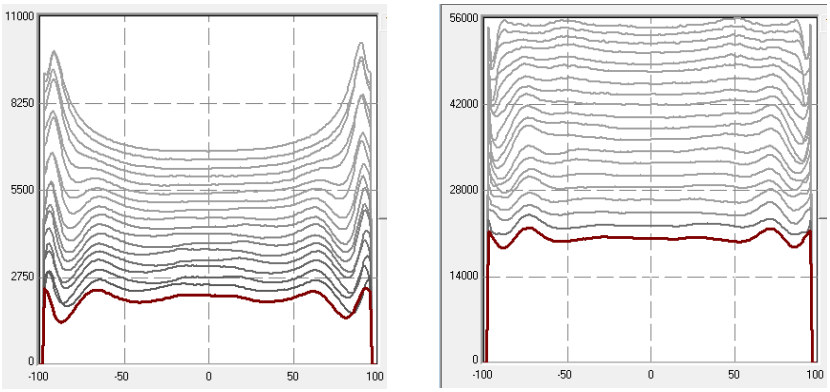


Figure 1: Schematic of RTPC Closed-Loop Profile Control.



Initial Edge thick overburden flattened by RTPC

Dynamic profile control through 4um (thick) Cu removal

Figure 2: Wafer thickness profile evolution during polishing with RTPC™ closed-loop control.