

Advanced Planarization Technology

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Benchmark modeling work has been conducted in the Boning Group investigating one of the most critical and costly processes in silicon integrated circuit (IC) fabrication process, chemical mechanical polishing or planarization (CMP). However, challenging device dimensions, novel materials, and advanced toolsets call for a deeper level of physical understanding and more empirically sensitive models. Therefore, two transformative approaches to better understanding and modeling of CMP have been undertaken.

First, die-level modeling of STI CMP using novel slurries, like Ceria are currently being explored. However, in performing experiments using traditional Silica slurries, more effective ways of modeling have been discovered. There has been an evolution of pattern density models in the Boning Group; however none of these models have explored the evolution of pattern density itself. Current work is seeking to model the change in pattern density and deposition profiles as a response to step height reduction over time in order to enhance the model specificity and consequently, accuracy. We believe that pattern density will increase parabolically as the step height decreases (i.e.-time increases), and have been able to prove this experimentally as shown in Figure 1.

Secondly, a reassessment of previous assumptions that the CMP pad surface has the same Young's modulus as the bulk was done. After comparing the most current CMP model with the direct measurement of a JSR pad, it was shown that the model's extracted bulk modulus proved to be on the order of five times higher than the actual measured result. In order to attribute this discrepancy to either a high surface modulus or a high bulk Poisson's ratio, a preliminary experimental study was performed using nanoindentation measurement techniques as shown in Figure 2. Current work is exploring the statistical confidence of the technique and its incorporation of the proper modulus towards a more physically accurate die-level CMP model.

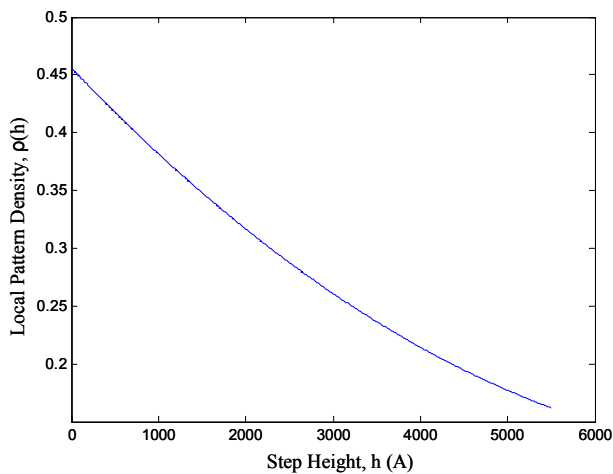


Figure 1: Local pattern density, ρ , as a function of step height, h , observed a decrease of almost 40% over the course of the STI CMP process in areas with structures $<10\mu\text{m}$ in length.

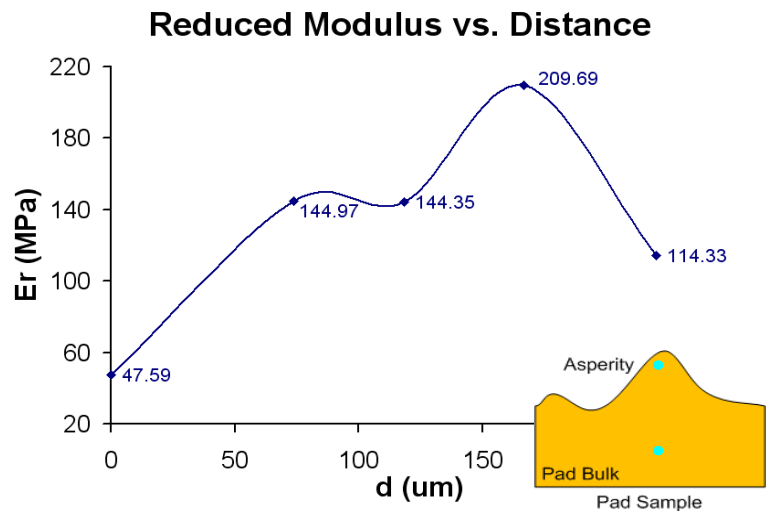


Figure 2: First successful scan of nanoindentation on a JSR pad follows hypothesized trend of pad asperity effective modulus being significantly less than that of the pad bulk effective modulus.

References

- [1] X. Xie, "Physical Understanding and Modeling of Chemical Mechanical Planarization in Dielectric Materials," PhD Dissertation, Massachusetts Institute of Technology, Cambridge, MA, 2007.