Superconformal Film Growth: Challenges and Opportunities

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State of the art manufacturing of semiconductor devices involves electrodeposition of copper for device wiring and more recently for through-silicon-vias (TSVs). The process depends on the use of electrolyte additives that affect the local deposition rate thereby resulting in superconformal, or bottom–up “superfilling” of trenches and vias. In the case of Damascene processing of submicron features the deposition process is explained by the recently developed curvature enhanced accelerator coverage (CEAC) mechanism. The model stipulates that 1.) the growth velocity is proportional to the local accelerator, or catalyst, surface coverage and 2.) the catalyst remains segregated at the metal/electrolyte interface during copper deposition. For growth on non-planar geometries this leads to enrichment of the catalyst on advancing concave surfaces and dilution on advancing convex sections; thereby giving rise to bottom-up superfilling of recessed surface features such as trenches and vias. In the case of larger features other avenues for feature filling become available that will be outlined in some detail. Despite the success of these superconformal growth processes much remains to be known concerning the detailed molecular nature of the competitive co-adsorption processes involved in both the suppression and acceleration of the metal deposition reaction. The application of in situ surface science tools such as in situ STM and SEIRAS towards a better understanding of the additive interaction will also be detailed. Finally, the talk will conclude with an overview of the current understanding of additive adsorption, consumption and/or deactivation dynamics relevant to superfilling and microstructural evolution in both Damascene and TSV Cu processing.