Influence of Bath Lifetimes and Electroplating Performance

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With shrinking metal lines and increased stacking of layers, BEOL processes today show higher dominance in affecting device performance. To maintain high process margin with low cost-of-ownership, a robust Cu process module is essential to any high volume manufacturing environment. Electroplating techniques with sophisticated current & voltage application methodologies are commonly used in the presence of electrolytes with widely varying conductivities to produce uniform Cu films. Well known also are the importance of organic additives to plating baths and their influence on the "bottom-up" or "super-filling" of Cu in damascened interconnect structures.

Copper films used in semiconductor applications are sensitive to bath chemistries, their age and possible byproducts in that they can affect the microstructure, gap-filling ability and reliability performance. Today auto-replenish and monitoring of organic and inorganic components help establish a closed loop control of the plating bath. As the bath ages, a performance shift can cause detrimental wafer-level effects and bath instability.

Key factors influencing plating bath performance with emphasis on wafer level effects were the focus of this study. Rigorous aging of the bath with simultaneous changes to organic additive concentrations helped drive the bath test conditions to an extreme. 200mm electrically testable wafers were plated at pre-determined intervals of time to gauge the wafer-level influence. A comparison of large and narrow dense as well as isolated lines showed differences in cu resistance variation on aged bath. Our work delves into identifying causes for this variation and its impact on reliability.

Presence of large concentration of organic by-products confirmed by spectroscopy is shown to both affect plated film purity and defects. Elements such as C, F, S & Cl exhibit larger variations than H, N and O. Stressed baths have shown to lead to defects both at the microscopic and macroscopic levels. These results along with the impact of the bath age on plated Cu film reliability will be discussed. Innovative ways to extend the bath life time with minimal impact on process cost will be also be shared.

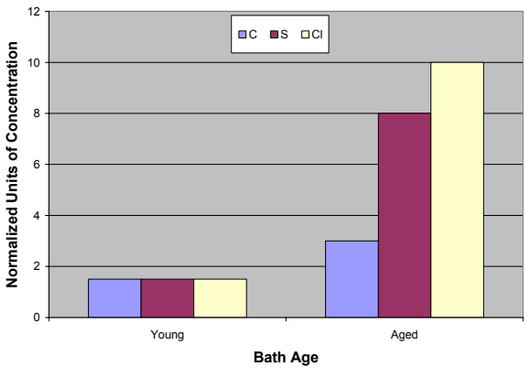

Fig. 1. Cu Film Impurity Concentration Variation with Bath Age

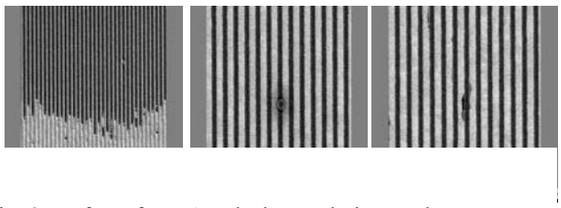

Fig. 2. Defects from Aged Electroplating Baths

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