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Conformal Electroless Deposition on monolayers for TSV applications

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Recent progresses in Integrated Circuits technology, constantly responding to the demand for “faster, cheaper, smaller”, require the development of new, controllable yet cost-effective processes, specially engineered to built on-chip features with acceptable properties at a nanoscale level of precision. Modern TSV’s features may reach dimensions as small as a few microns, requiring therefore high aspect ratio metallization treatments on a nanometer scale[1,2]. A method of electroless plating both the barrier and the seed layer, meeting the aforementioned requirements, is hence proposed.

Nickel-Boron and Nickel-Phosphorous barrier layers were deposited onto 5x50µm TSV samples using homemade solutions. Formation of a thin metal barrier layer of NiP and NiB was possible using a Palladium-based activator, which is densely adsorbed on the SiO_2 sidewalls of the TSV. A silane coupling agent of 3-aminopropyl-triethoxysilane is effective for enhancement of the adsorption density of Pd. Deposition parameters such as concentration of the bath, temperature, and pH were optimized based on the characterization data acquired from the obtained coatings. Studies on the deposits revealed the formation of a thin, conformal barrier layer with thicknesses ranging between 60nm and 500nm for NiP and NiB metal layers, respectively (Figure 1).

A conformal electroless Cu layer was deposited on the barrier layer using a Palladium-based catalyst to activate the reaction. Troubleshooting this solution required a deep study over the effects of coupling the barrier and the Cu seed layer together with an understanding of the influence of various parameters like temperature, pH, concentration, etc. on the quality of the coatings. Experiments produced highly conformal deposits with thicknesses ranging between 10nm and 40nm (Figure 1).

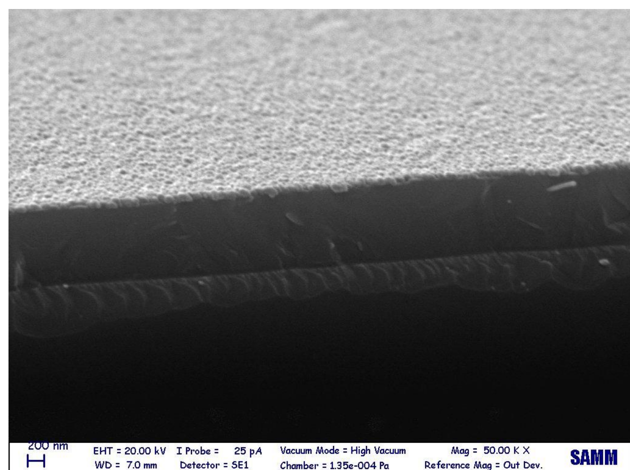

Figure 1: Cross-section SEM image of the electroless deposited Cu seed layer onto the NiB barrier layer.

Morphological, structural and electrochemical analysis were pursued to fully characterize the coatings. Deposition rate of the various solutions was 15 µm/h for NiB, 3.6 µm/h for NiP and 4.8µm/h for Cu. Table 1 summarizes the properties of the deposited layer.

Table 1. Maximum thicknesses, sheet resistance and conformality for the various deposits.

	Max. Thick	Sheet Resistance	Conformality
NiP	120 nm	$0,75 \cdot 10^2$ Ω/sq	50 %
NiB	800 nm	0,06 Ω/sq	50 %
Cu	60 nm	0.4 Ω/sq	25 %

The results strongly suggest that an all-wet process for the formation of Cu-filled TSV with a high aspect ratio is possible.

References

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