**Selective electroless copper deposition at a high rate using Dimethylamine Borane as a reducing agent**

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The use of copper for on-chip metallisation of semiconductor integrated circuits (IC's), has now been implemented by a number of manufacturers for high performance advanced devices. Among the advantages of copper over aluminium metallisation are the inherently lower resistance and lower susceptibility to electro-migration. A further departure in this new technology is that electrochemical techniques may be used to deposit the copper. The copper damascene or dual-damascene process requires a conductive copper seed layer (deposited by vapour deposition techniques) for subsequent electrolytic copper deposition. Electroless copper is being investigated for seed layer repair in high aspect ratio features, as a low cost method of seed layer deposition [1] and as an alternative to electrolytic copper in the interconnect line and via deposition [2,3]

Traditionally, electroless copper baths have used formaldehyde as the reducing agent and high pH regimes. Alkali metal ions are introduced into the bath in the form of hydroxides to bring the bath to its operating pH (>12). Minimisation of such mobile ion content is desirable to ensure device reliability. It is also desirable to decrease the operating pH of the bath as organic compounds which may be unstable in strongly alkaline solution are increasingly being investigated as future low-k dielectrics for microelectronic devices are.[4]

A number of workers have investigated the electroless deposition of copper using DMAB as the reducing agent. DMAB has a number of advantages over formaldehyde-based plating baths. It does not produce toxic fumes and it can be run at a lower pH. DMAB has been used to deposit copper on to electroless nickel, palladium activated plastic, copper substrates[5] and tin/palladium activated epoxy[6], with deposition rates of approximately 2.3μm/hr and 4 μm/hr, respectively.

This paper will introduce a formaldehyde-free electroless copper bath for selective deposition at a high rate on polyimide patterned substrates. Dimethylamine borane (DMAB) is the reducing agent in the bath that has a near neutral and stable pH for compatibility with organic dielectrics such as polyimide. Furthermore, the bath does not contain any mobile ions such as sodium which may be critical contaminants for CMOS devices. Deposition rates up to 19 μm/hr have been verified using surface profilometry, scanning electron microscopy (SEM) (Figure 1 and 2) and SEM of microsectioned samples (Figure 3).

A Royce Universal bond test system 552 was used to determine the adhesion of the deposited copper on the copper substrates. A shear strength of 41.2g was obtained for 30 x 30 μm square pads. This equates to a shear force of 45.8 kg/mm$^2$. To verify the good contact between the plated copper and the underlying seed layer electrical resistance measurements, using a 4-point probe instrument, were obtained. The pad to pad resistance found was 12.4 mΩ, giving an average contact resistance of each interface of 6.2mΩ.

**Acknowledgements.**
This work was partly funded by Intel Ireland and Enterprise Ireland under the Applied Research Grants Scheme project number HE-00-365.

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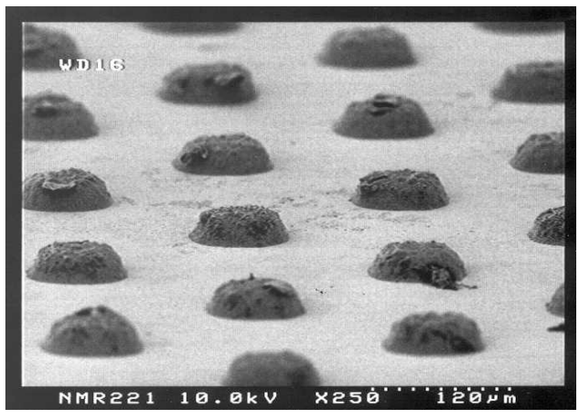


Figure.1 Selective copper deposition at a high rate on polyimide patterned copper substrate. Deposition rate 19 μm/hr.

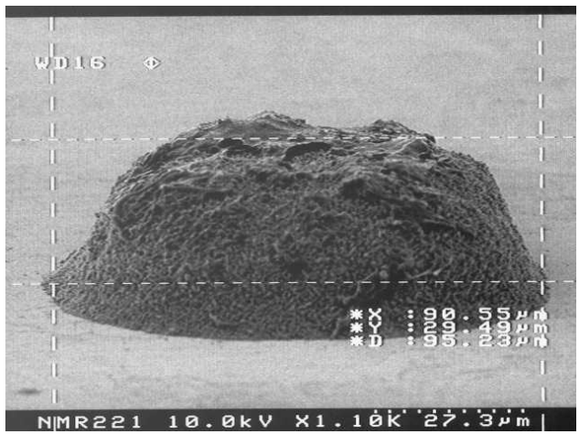


Figure.2 Individual copper bump 29.5 μm high deposited at 19 μm/hr.

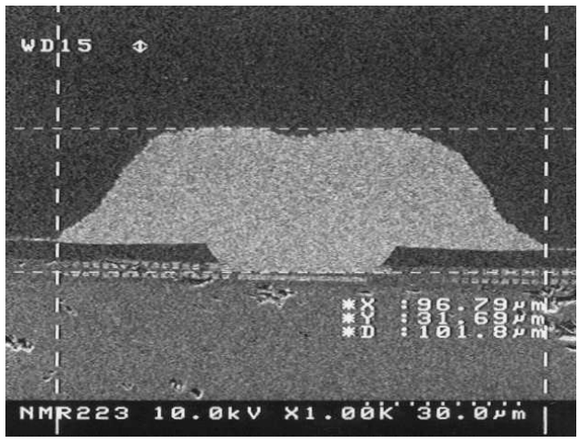


Figure 3. Cross section of plated deposit showing total deposition of 31.69 μm in 100 minute deposition..