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Study on fundamental aspects of seedless copper electrodeposition on diffusion barriers in an additive-free electrolyte for silicon-based integrated devices

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Electrochemical deposition (ECD) has become the most promising technology for copper filling on integrated circuits since 1997. Copper dual damascene technology has allowed for chip wiring to replace aluminum occupying the dominant position in the on-chip metallization. Copper ECD was carried out to fill high-aspect-ratio dual damascene features of copper ICs. However, it has become more difficult to obtain conformal deposition of a diffusion barrier layer and a copper seed layer as the feature size gets decreased continuously. Therefore, seedless copper ECD directly onto diffusion barrier layer is desired to avoid creation of voids inside trenches during copper filling in the dual damascene structure. However, the absence of a copper seed layer gives rise to an unusual condition for copper deposition. Diffusion barrier layers provide considerably different platforms for copper nucleation and growth compared to systems, in which the copper seed layer acts as an adherent base and an excellent electrical conductor for subsequent copper ECD.

We here study nucleation characteristics of copper directly electrodeposited on diffusion barriers fundamentally, including the theoretical nucleation mode, area density, and size distribution of copper nuclei according to diffusion barrier material. Diffusion barriers considered here are metallic (W, Ta, Ru) and non-metallic (TiN, TaN) materials. We also present the quantitative test result measuring the adhesion strength between electrodeposited copper and diffusion barrier. The adhesion degree of copper film on diffusion barriers can be increased by selecting a specific electrolyte chemistry, which is good for producing more copper complex ions that promote adhesion and for suppressing the formation of unwanted copper complex ions that are disadvantageous to adhesion. It is additive-free so that byproduct problems originating in additive addition could be reduced.

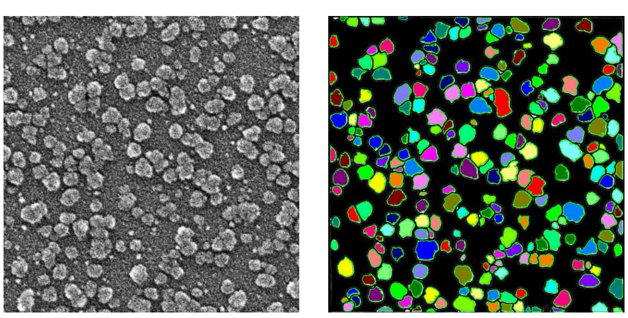

Fig. 1. Images of copper electrodeposited directly on ALD-Ru diffusion barrier in an additive-free electrolyte, showing the morphology (left) and size distribution (right) of copper clusters in the early stage of copper film formation.

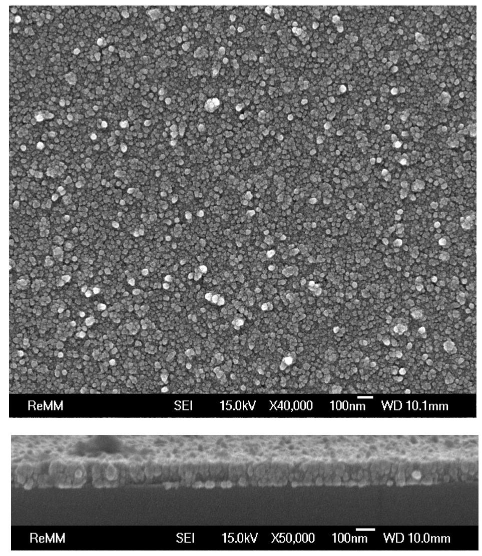

Fig. 2. Complete formation of a dense and smooth copper film directly on ALD-Ru diffusion barrier in an additive-free electrolyte.

References

[1] J. Reid, S. Mayer, E. Broadbent, E. Klawuhn, and K. Ashtiani, *Solid State Technol.*, 43, 85 (2000).
[2] L. Graham, C. Steinbruchel, and D. J. Duquette, *J. Electrochem. Soc.*, 149, C390 (2002).
[3] T. P. Moffat, D. Wheeler, S.-K. Kim, D. Josell, *Electrochimica Acta*, 53, 145 (2007).
[4] K. Kondo, N. Yamakawa, Z. Tanaka, K. Hayashi, *Journal of Electroanalytical Chemistry*, 559, 137 (2003).
[5] M. A. Pasquale, L. M. Gassa, A. J. Arvia, *Electrochimica Acta*, 53, 5891 (2008).