Abs. 944, 206th Meeting, © 2004 The Electrochemical Society, Inc.

Transient Behavior in Copper Electrofilling

J. Flake[1*], J.P. Jacqueman[2], M. Hartig[1], E. Sicurani[3], P. Vannier[4]
[1]Freescale Semiconductor, [2]Philips, [3]CEA-Leti, [4]ST Microelectronics
Crolles2 Alliance, 870 rue Jean Monnet 38926 Crolles, Cedex FRANCE

Experimental results show damascene features undergo an initial conformal deposition followed by steady state superconformal filling. As interconnect dimensions continue to decrease beyond the 90nm technology node, the effects of this (mostly conformal) transient period become more apparent and can lead to seams or voids. Fill behavior was investigated on 300mm substrates using various interconnect structures at the 90nm and 65nm technology nodes. As seen in the progression of FIB/SEM cross sections in Figure 1, some dual damascene structures show conformal fill profiles (approximately 50nm thick) up to total charges equal to 40C. Other structures show faster transitions from conformal to superconformal filling depending on density and dimensions.

Fill profile evolution is shown to be dependent on both barrier / seed profiles and electrodeposition processes. Conventional PVD barrier / seed processes produce structures with relatively thicker overhangs and bottom coverage with relatively thin sidewall coverage. Ionized PVD processes or resputtering of the barrier / seed layer have been shown to improve step coverage; however, completely conformal barrier/seed films are difficult to achieve. The resulting barrier/seed profiles affect the effective resistance to current flow and the ensuing electrodeposited profile. Experimental data is considered for conventional PVD and advanced barrier/seed deposition processes.

In the electrodeposition process, the wafer may be immersed into the electrolyte with an applied potential (hot-entry). The charge must initially satisfy the nonfaradaic capacitance before any deposition is realized. Experimental results show that the cell time constant (nonfaradaic capacitance x uncompensated resistance) can be significant (on the order of seconds) owing to the large area 300mm electrodes.

Cell transients are further affected by additive adsorption, hydrodynamics, and diffusion transients. Experiments were done under various process conditions and the effects on fill behavior and interconnect functionality are considered. Results demonstrate a large fraction of interconnect structures are filled during this initial transient period at the 90 and 65nm nodes.

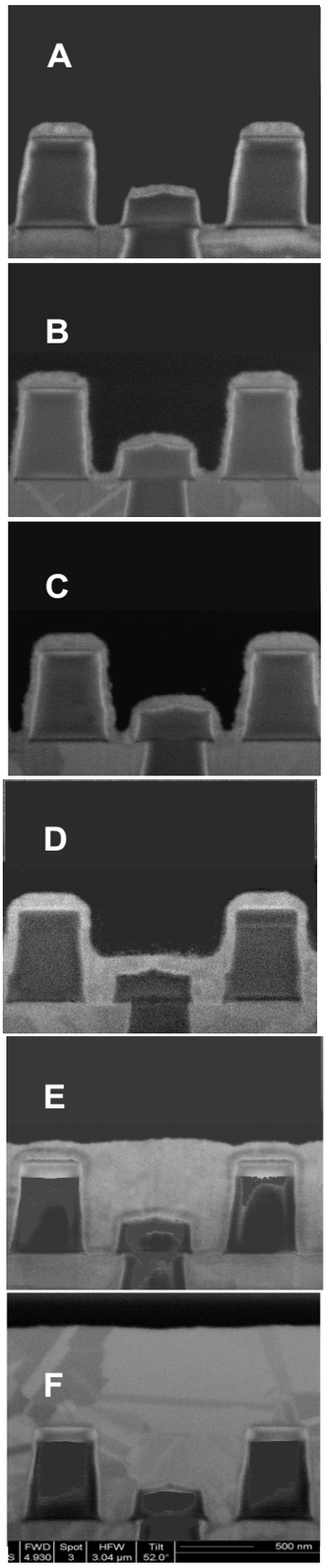

Figure 1: Cross section FIB/SEM images of dual damascene interconnect structures, images A-F show fill progression: (A) Barrier/Seed, (B) 20C, (C) 40C, (D) 60 C (E) 160C (F) 1400C.