EFFECTS OF DEPOSITION CONDITIONS ON THE FEATURE-SCALE GROWTHS OF THROUGH-MASK DEPOSITED METALS

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The current distribution and its impact on the growth shapes of electrodeposited metals has been investigated with numerical simulations,[1-2] but comparative experimental research is very limited.[3] We examined the effects of deposition conditions on the growth shape of copper and near-eutectic SnPb bumps.

EXPERIMENTAL

200mm-diam. wafers, which were plated with Semitool's conventional or CFD-type reactors, had a structure of Si(substrate)/SiO_2/Ta, Ti, or TiW/Cu/resist-patterns (with AZ4620 or BPR100 photoresist). We used Intervia 8540 additives for copper deposition and Solderon BP chemistries for SnPb deposition, which are from Rohm and Haas Electronic Materials. We utilized a focused ion beam (FIB, FEI Dual Beam 820) and a surface metrology tool (Veeco, Dektak 300-Si) to examine growth shape and thickness profile.

RESULTS AND DISCUSSION

Most deposition conditions influenced (to some extent) the growth shape of Cu and SnPb bumps. These include (*i*) bath type and composition, (*ii*) process conditions such as the fraction of limiting current density (%LCD), current waveform, deposit thickness, rotation speed, and flow rate, (*iii*) pattern parameters such as cavity thickness, diameter, and pitch, and (*iv*) surface treatment conditions of the mask. Depending upon these conditions, three types of growth were observed (Fig. 1).

SnPb bump deposition: We tested the effects of mask surface properties, bath composition, current density, waveform, and mass transfer conditions with a fixed cavity dimension. To see the impact of mask surface properties, we examined the effect of wafer aging (after plasma ashing). With an aged wafer, the overall growth is more affected by mass-transfer-related factors such as flow rate, rotation speed and direction. With increasing acid concentration, the shape ratio (= t_{edge}/t_{center}) increases. The concentration of organic components slightly influences the overall growth shape. With increasing current density (but not close to LCD) or decreasing duty cycle, the shape ratio increases due to the increased influence of primary current distribution.

Copper bump deposition: We investigated the effects of bath composition, surface treatment conditions (plasma ashing and chemical prewet), and pattern parameters as well as varying the average deposition rate. Each organic component significantly impacts the overall growth shape. Several problems are observed without mask surface treatments, which include nonuniform shape distribution, pore formation, and no deposition in small cavities. The strength of surface treatment conditions slightly influences the growth shape. When %LCD is low, the growth shape is not significantly influenced by cavity dimension and mass transfer conditions. At high %LCD, (*i*) asymmetric surface profiles are observed along flow direction, (*ii*) the growth shape varies with cavity size and pitch, and (*iii*) the growth shape also changes with deposit thickness. With a thicker mask, the dependency of growth shape on cavity size becomes more severe due to an increase in diffusion length scale (Fig. 2).

SUMMARY

Many factors influenced the current distribution and growth shape within the cavities. Dominant factors vary with %LCD, bath type, and surface treatment conditions. Full details of experimental results will be presented at the conference.

REFERENCES

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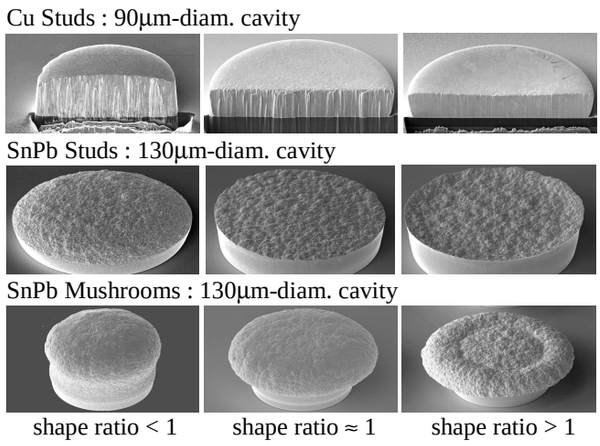

Figure 1. Shape ratio of features obtained at different deposition conditions, where shape ratio = t_{edge}/t_{center}.

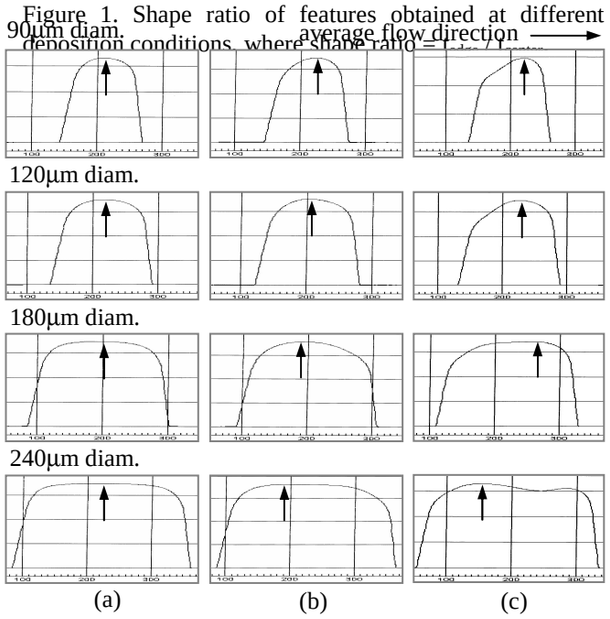

Figure 2. Effects of current density and resist thickness on the growth shape of copper bumps with various diameters, where the arrow indicates the location of peak thickness; 30-35μm deposits: (a) 100mA/cm^2 (~2μm/min) with 50μm resist; symmetric profiles, (b) 200mA/cm^2 (~4μm/min) with 50μm resist; slightly asymmetric profiles, and (c) 200mA/cm^2 with 100μm resist; very asymmetric profiles.