OBSERVATION OF THE BEHAVIOR OF ADDITIVES IN COPPER ELECTROPLATING USING A MICROFLUIDIC DEVICE

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Nowadays, high performance of integrated circuits is owing its interconnections and packaging technologies, and copper electroplating is widely used for the fabrication of wirings since 1997, so called "The IBM shock". IBM announced chips with copper interconnects in 1997. The copper wirings were made by filling copper into vias in an insulating layer. Surprisingly, wet electroplating in acid copper sulfate was employed for the copper filling because preferential deposition from via bottoms, i.e. superfilling, was available by addition of several organic additives into the copper sulfate bath. However, at that time, the mechanism of superfilling was not clarified. Then, CEAC (Curvature Enhanced Accelerator Coverage) mechanism was proposed by Moffat et al. and the accelerator based theory is widely recognized as the principle of the superfilling for the sub-micron scale vias.

Recently, there are also many challenges in much larger scale copper wiring, such as TSV (Through Silicon Via). TSVs have the holes with quite high aspect ratio whose diameter is around 10μm and the deep holes are filled with copper by electroplating. Though the bottom-up superfilling is obtained, filling mechanism is not understood yet. Different form sub-micron scale filling, suppression behavior of additive is considered as an essential factor for the bottom-up filling as shown in figure 1. But critical suppression behavior is not well observed by conventional electrochemical measurements. Desorption of suppressing additive from plating surface seems to have important role, because Xis most limited. In this study, we made a microfluidic device to realize precise mass transport and quick switching of plating solutions, and in-situ observation of plating surface was performed.

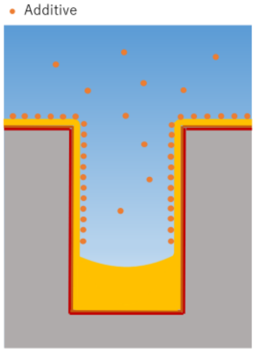

Figure 1- Additive inhibits deposition from top.

Figure 2 shows a result with a commercial leveler. Initially, VMS (virgin make-up solution) with no additive was supplied into the micro channel, and copper plating was performed on Pt working electrode with 100 μm in diameter. Then, the solution containing an additive was supplied. Finally, the solution was switched to VMS again and additive deactivation was monitored. With small overpotential (-550 mV vs. MSE), plating surface was covered by the additive and strong suppression was observed. After the plating solution was switched to VMS with no additives, localized depositions were observed all over the plating surface. While with large overpotential (-600 mV vs. MSE), strong suppression was observed only on up-stream region of the plating surface where bright smooth surface was kept during the leveler supply. After the solution change, suppression breakdown with localized depositions were observed gradually from the lower-stream region. Identical experimental procedure was applied to several additives and the behaviors were compared.

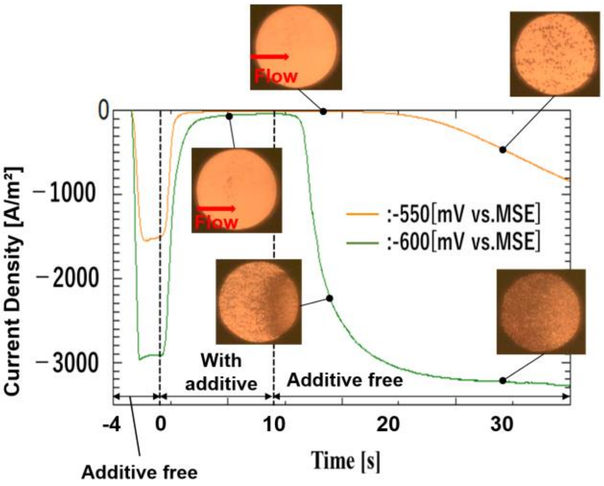

Figure 2- Additive supply was interrupted and in-situ observation of plating surface was carried out.