

## Via-Filling Using Electro Copper Plating for Build-up PCBs

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Recently, the build-up process has become a key technology of the printed circuit boards (PCBs) along with the miniaturization and high efficiency electronic devices. In this technology, the via-holes are used to connect the each conductive layer. After the interlayer connection by electro copper plating, the via-holes are filled with a conductive paste so far. However, the voids are generated in the via-holes. Therefore, a filling of via-holes by copper plating has become an effective method.

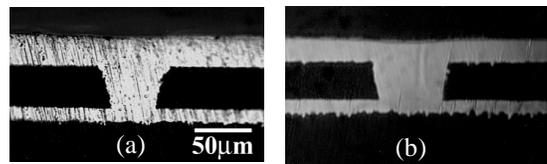
In the previous research, we confirmed that via-filling can be achieved using the periodical reverse (PR) current and electroless plating. Moreover, via-filling by direct current electrolytic method with a high and low copper concentration bath were achieved by the selection and combination of the additives as shown in Fig.1<sup>1-4)</sup>. In this research, we investigated the via-filling by the electro copper plating with direct electro current (DC), and the influence of the additives on the physical properties of copper deposits were examined.

Electro copper was deposited about 20  $\mu\text{m}$  to fill the via-holes. High copper concentration bath and low copper concentration bath were used as the electroplating bath. The additives used to electro plating were polyethylene glycol (PEG), bis (3-sulfopropyl) disulfidedisodium (SPS), Janus Green B (JGB) and thiourea (TU). Vickers hardness was measured as an evaluation of the copper deposits physical properties. Glow discharge optical emission spectroscopy (GDOES) was used for the evaluation of electric current density dependency of additives inclusion of copper deposits.

Fig.2 shows the Vickers hardness of the copper deposits in the high and low copper concentration bath with and without additives. The Vickers hardness was measured under the load of 10 gf. From these results, it was suggested that the additives influence the copper deposits hardness in the both bath. The hardness of the copper deposits in the additive-free bath were harder than that of the bath with additives. In addition, it was considered that hydrogen also influenced the hardness because hardness values from low copper concentration bath were harder than that of the high copper concentration bath.

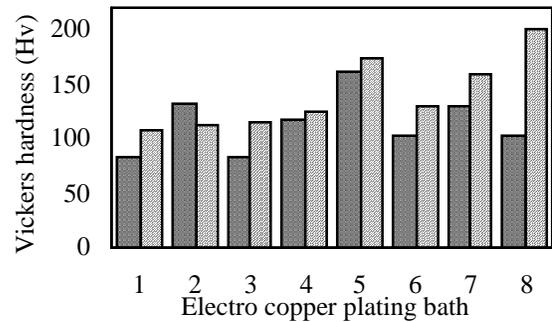
As mentioned above, it was considered that additives influenced the hardness of the copper deposits. Then, to examine the state of the inclusion of the additives element on the copper deposits, the element of depth direction of the deposits was analyzed by GDOES. The GDOES analysis of the copper deposits in each current density part using a high copper concentration bath were shown in Fig.3(a), (b), respectively. The elements of additives were detected only on the upper layer part of deposited copper. From these results, the additives were considered to form the adsorption layer additives on the copper surface, and copper deposition reaction is progressed by through this layer.

The electrochemical analyses (quartz crystal microbalance and cathode polarization measurement) for electro copper deposition were also measured in order to investigate the copper deposition reaction mechanism.



**Fig.1** Cross sectional view of plated via-holes by electro copper plating with additives.

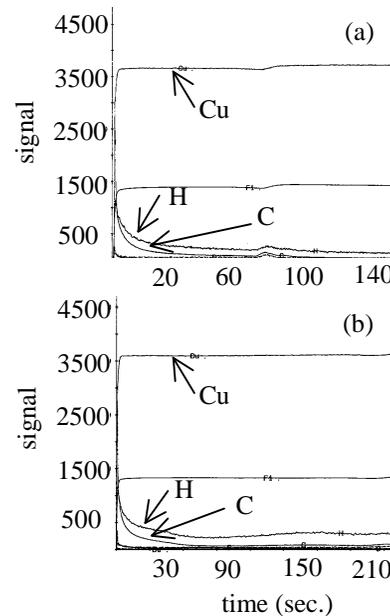
(a) High copper concentration bath  
(b) Low copper concentration bath



**Fig.2** Vickers hardness of the copper deposits using high and low copper concentration bath with and without additives.

1 additive-free, 2 SPS+JGB+PEG, 3 SPS, 4 JGB, 5 PEG, 6 SPS+PEG, 7 PEG+JGB, 8 SPS+JGB

■ High copper concentration bath  
▨ Low copper concentration bath



**Fig.3** GDOES depth profiles of the electro copper deposits using high copper concentration bath with additives.

(a) 1.0 mA/dm<sup>2</sup>, (b) 3.0 mA/dm<sup>2</sup>

### References

- 1) S. Abe, T. Fujinami, T. Aono, H. Honma, *J. Surf. Fin. Soc. Jpn.*, **48**, 433 (1997).
- 2) T. Fujinami, T. Kobayashi, M. Asao, H. Honma, *J. Surf. Fin. Soc. Jpn.*, **48**, 660 (1997).
- 3) T. Kobayashi, J. Kawasaki, J. Ishibashi, K. Tanaka, H. Honma, *J. Surf. Fin. Soc. Jpn.*, **49**, 1332 (1998).
- 4) T. Kobayashi, J. Kawasaki, K. Mihara, T. Yamashita, H. Honma, *J. Jpn. Institute Electronics Packaging*, **3**, 324 (2000).