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Improvement of adhesion strength of electroless barrier layer and its application to TSV process

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Recently, there has been much attention in development of 3-D LSI technology, which is considered to overcome various problems arising due to limit of miniaturization of LSIs. The 3-D LSIs can realize shorter signal transmission lines which brought about fast signal transfer and low power consumption as well as a higher packing density. Cu-filled TSV is important technology for 3-D LSI in order to obtain higher packing density, faster signal transmission, and lower power consumption. Cu filling process of TSV (through silicon via) is one of key issues for fabrication of TSVs. We reported the all-wet filling process using electroless plating of both barrier and seed layers, and succeeded in the filling of high aspect ratio TSV with Cu [1,2]. However, there was a problem of poor adhesion with an increase in the barrier layer thickness. In this study, we studied to improve adhesion property of the barrier layer by addition of organic additives in the plating bath.

Firstly, the SAM (self-assembled monolayer) was formed by silane coupling agent on SiO_2 film [3]. Then, catalyst adsorption treatment was performed by immersion a substrate in a Pd nanoparticle solution. Secondly, electroless plating of CoWB was carried out with DMAB (dimethylaminoboran) as a reducing agent. Cross-sectional views of CoWB films were observed by SEM, and evaluation of adhesion was carried out by a stud-pull test.

Fig. 1 shows the film thickness dependence of the adhesion strength of CoWB films. Adhesion strength in the cases of no additive showed a high value of 80 MPa, however, it decreased with an increase in film thickness. This is considered to be due to an increase of film stress with increasing film thickness. When saccharine was added to the plating bath, the tendency of decrease of adhesion strength with increasing thickness was much suppressed.

Adhesion strength of Co-W-B film (80 nm) as a function of saccharine concentration is shown in Fig.2. With addition of saccharine, adhesion strength increased until the concentration of 0.33mol/L, then it decreased slightly with further addition.

Fig. 3 shows the bath temperature dependence of coverage ratio of the CoWB film. The coverage ratio decreased with a temperature increase. Plating rate increases with temperature, and it seems that the Co ion diffusion flux is not sufficient at the TSV bottom because of consumption near the opening increased significantly at higher temperature.

We found that the addition of adequate amount of saccharine was very effective to improve adhesion strength of electroless plated CoWB film on SiO_2 substrate. We also found that addition of appropriate additives was effective to realize conformal deposition profile in high aspect ratio TSVs. These results strongly suggest that electroless plated barrier layer formed with appropriate additives would be practical solution to form high aspect ratio Cu-filled TSVs.

References

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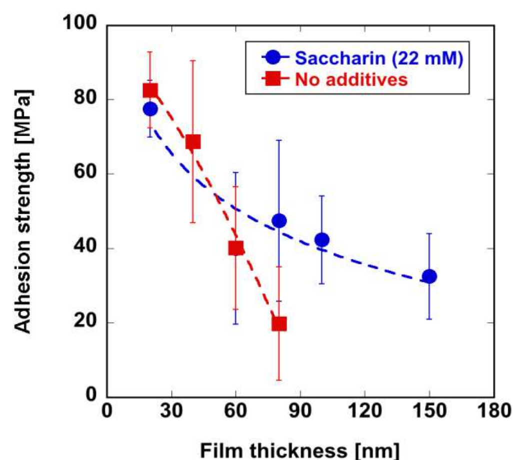

Fig. 1 Adhesion strength of CoWB

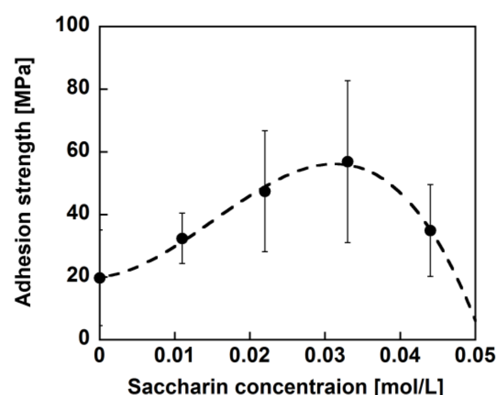

Fig. 2 Adhesion strength of Co-W-B film (80 nm) against additive concentration.

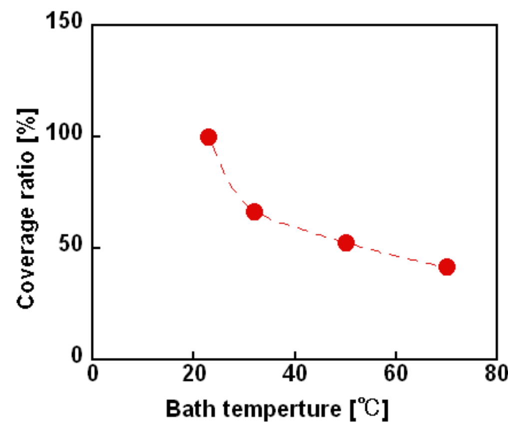

Fig. 3 Coverage ratio dependence of the CoWB film formation bath temperature