Characterization of Electroless NiB Film as a Diffusion Barrier Layer on Low-*k* Substrate

M.Yoshino [1)], T.Masuda [1)], J.Sasano [1)], T.Yokoshima [1)], I.Matsuda [1)], T.Osaka [1)], A.Hashimoto [2)], Y.Hagiwara [2)], I.Sato [2)]

[1)] *Department of Applied Chemistry; Advanced Research Institute for Science and Engineering, Waseda University,*
Okubo 3-4-1 Shinjuku-ku, Tokyo 169-8555, Japan
[2)] *TOKYO OHKA KOGYO CO., LTD.*
1590 Tabata, Samukawamachi,
Kouzagun, Kanagawa 253-0114, Japan

In the field of ULSI interconnect technologies, Cu wiring have been used, because this metal has the high electrical conductivity and electromigration resistance. However, it is known that the Cu atoms are easily diffusion into the SiO_2/Si substrate. In order to overcome this problem, a diffusion barrier layer should be formed on substrate. The diffusion barrier layers are generally formed using the dry processes, such as sputtering. On the other hand, the wet processes have a high advantage in terms of cost performance and mass production.[1-2] We proposed the formation process for the diffusion barrier layer by electroless deposition method. In this process, catalyst/adhesion layer is obtained by using Pd-activated Self-Assembled-Monolayer (SAM) on SiO_2/Si substrate (Fig.1). By using Pd activated SAM modified SiO_2/Si substrate, NiB film was successfully formed on the substrate and shows a good diffusion barrier property.[3] In this method, a diffusion barrier layer can be formed without sputtered seed layer. By the way, low-*k* materials for insulator are desired for high speed operating of high-integrated logic devices. Therefore, we also apply this wet process to the low-*k* material coated substrate. We have studied the formation of diffusion barrier layer by electroless deposition method on low-*k* substrate. In addition, the characteristic of the electroless NiB layer formed on low-*k* substrate was investigated.

Glass substrates coated with low-*k* materials were used. We used an inorganic and organic low-*k* material. Dielectric constant of the inorganic material is 2.9 and that of the organic material is 2.7. To form the SAM on low-*k* substrates, the surface was irradiation by UV light to generate OH groups, after this UV process, aminopropyltriethoxy silane (APTES) was formed.[3] $PdCl_2$ solution was used for the catalyzing process. Electroless deposition of NiB was carried out in a DMAB bath [2-4]. The sheet resistance of the electrolessly deposited NiB layer was measured from a four-point probe resistance meter. Thermal stability was evaluated by the variation in sheet resistance depending on the annealing temperature in vacuum ($<5\times10^{-5}$ Torr).

Adhesion between electroless NiB layer and low-*k* substrate was measured by peeling test using a tape. From the result, a good adhesion property was obtained.

Next, thermal stability of the electroless NiB layers was investigated in terms of sheet resistance. Fig. 2. Show the sheet resistance of Cu/NiB/SAM/low-*k* substrate after the annealing process. Cu layer with a thickness of 100 nm was deposited on NiB/SAM/low-*k* substrate by evaporation. Increase in the sheet resistance indicates that the interdiffusion between Cu and substrate took place. As seen in Fig. 2, the sheet resistances slightly rise up to 500°C. Therefore, it is indicated that the NiB layers prevent Cu atoms from diffusing into the low-*k* substrate.

The excellent diffusion barrier layer on low-*k* substrate is obtained by electroless deposition of NiB using Pd-activated SAM as a catalyst/adhesion layer. Another characterization for the NiB layer will be disused. This process is one of the candidates for the development of ULSI technology with smaller dimension and higher aspect ratio.

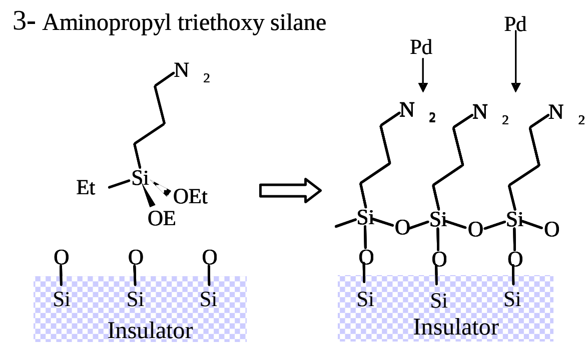

Figure 1. Scheme of SAM modification and catalyzation process.

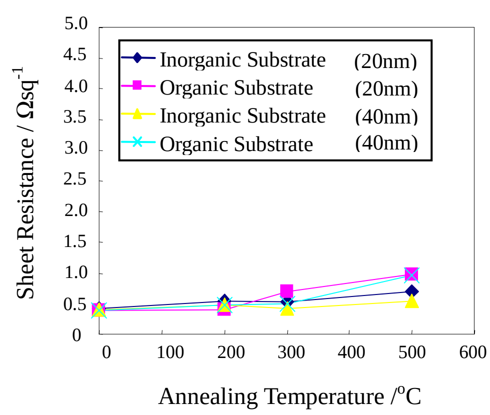

Figure 2. Sheet resistances of electroless NiB layers on a low-*k* substrate after annealing process.

Acknowledgements

This work is supported in part by a Grant-in-Aid for Center Of Excellence (COE) Research "Molecular Nano-Engineering", and the 21st Century COE Program "Practical Nano-Chemistry" from the Ministry of Education, Culture, Sports, Science and Technology.

References

1. Y.Shacham-Diamand, et al., *Microelectron. Eng.*, **37**, 77 (1997).
2. T.Osaka, N.Takano, T.Kurokawa, T.Kaneko, K.Ueno, *J.Electrochem Soc.*, **149**, C573 (2002).
3. T.Osaka, N.Takano, T.Kurokawa, T.Kaneko, K.Ueno, *Surf. Coatings Tech.*, **169,** 124 (2003).
4. M.Yoshino, T.Yokoshima, T.Osaka, *Electrochem Soc.*, **PV10-2003,** 137-145 (2003).