Chemical Mechanical Planarization of Ruthenium for Capacitor Bottom Electrode in DRAM Technology

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In the future DRAM technology, MIM (Metal-Insulator-Metal) structure capacitor is required because of the cell capacitance in shrinking cell size. [1-4] The novel metals such as platinum and ruthenium have been suggested as the bottom electrode materials in the fabrication of the capacitor. However, there are several issues in the application of these metals for MIM structure capacitor. One of them is the difficulty of planarizing the steps of cylinder capacitor to meet the requirement of the backend scalability. The maskless planarization technology or chemical mechanical planarization was introduced for the planarization of the metal layers after the capacitor process [5]. In this study, the chemical mechanical planarization process of ruthenium for the formation of bottom electrode in capacitor was investigated.

Ruthenium thin film was polished by HNO_3 and cerium ammonium nitrate based slurry. Because the ruthenium has very high resistance to chemical reaction at room temperature, it was difficult to find the chemistry that etch and polish the ruthenium surface. Strong oxidizers such as cerium ammonium nitrate (CAN), ammonium per-sulfate (APS), urea (H_2NCONH_2) and $KMnO_4$ were applied to etch the ruthenium surface with and without HNO_3. From etching experiment, it was found that only the CAN or chemical mixture of CAN and HNO_3 etched the ruthenium thin film slightly. The etch rate of ruthenium thin film was about 23Å/min in the CAN 5 wt% and 82Å/min in the CAN 5 wt% and HNO_3 6 wt%, after 5 min etching. However, the ruthenium thin film was not etched in the other applied chemicals.

CMP (Chemical Mechanical Planarization) experiments were carried out with Logitech PM5 polisher and Rodel IC 1400 pad. The carrier and platen speed was set at 30rpm. The down pressure of carrier was 6.5 psi and slurry flow rate was constant to 200ml/min during the polishing. Also, polishing time was 1 min. From the results of etching, slurry was maked with HNO_3 and CAN chemistry to polish the ruthenium. The removal rate of ruthenium was 854.67Å without abrasive particles. When Al_2O_3 particles were added into the slurry solution from 1 to 3 wt%, the removal rate increased over 1000Å and saturated as shown in Fig. 1. In the constant abrasive particle content, concentration of CAN was controlled. As the concentration of CAN increased, the removal rate of ruthenium was about 1000Å at HNO_3 6 wt% uniformly. However, the removal rate increased linearly in the slurry containing only CAN and abrasive particles. Figure 2 shows the change of removal rate. According to these results, the polishing behavior of ruthenium was dependent on the concentration of CAN when HNO_3 was not added to slurry.

References

[1] T. Aoyama, S. Yamazaki, J. Electrochem. Soc., pp.2961, (1998)
[2] W. D. Kim, et al., Symp. On VLSI Technical Dig. pp. 100, (2000)
[3] S. Kamiyama, J. M. Drynan, Y. Takaishi and K. Koyama, Symp. On VLSI Technical Dig., Pp.39, (1999)
[4] J. W. Kim, et al., IEDM Technical Dig., pp.793, (1999)
[5] Y. Fukuzumi, et. al., IEDM Technical Dig., pp.793, (2000)

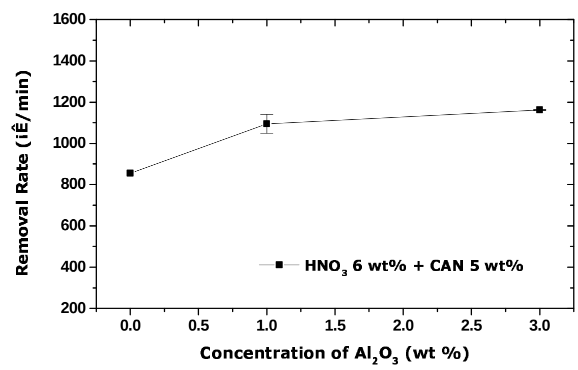

Fig.1. Removal rates of ruthenium in various concentration of abrasive particle at HNO_3 6 wt% and CAN 5 wt%

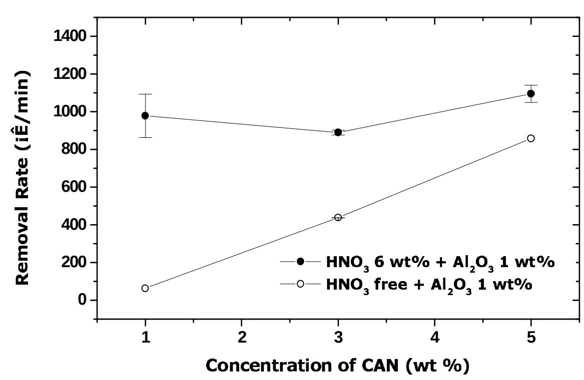

Fig.2. Removal rates of ruthenium with and without HNO_3