Plasma Technologies for Low-k Dry Etching

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1. INTRODUCTION

The need for reliable low-k/Cu interconnects technologies is increasing. Many kinds of low-k materials have been proposed and we need to etch various materials with various film densities and compositions. Therefore, the etching mechanisms of SiOCHs must be quantitatively clarified.

2. EXPERIMENT

Dual frequency RIE was used in this study. Plasma density, CF_x radical densities, and ions were measured using PAP, IRLAS, OES and QMS. SiOCH films of various compositions and densities were etched using $C4F_8/Ar/O_2$ (N_2) plasma. The etch rates, selectivity, and surface polymers were analyzed.

3. RESULTS AND DISCUSSIONS

The surface reaction of SiOCH depended both on the incident fluxes from the plasma and on outflux from the SiOCH (Fig.1). Changing the total number of incident CF_x fluxes by varying the C_4F_8 flow rates in $C_4F_8/Ar/O_2$ (or N_2) allowed us to classify etching reaction as:

- **I**: thin stable polymer,
- **II**: transition from **I** to **III** (or **IV**),
- **III**: thick steady state polymer, and
- (**IV**: deposition).

The etch rate changed significantly around "critical point (***Pc***, see Fig.2)", where the incident total C became equivalent to the thermal removal ability of O and N (see Fig.3). We can use etching condition **I** to solve problems with residue and etch stop. Porous material (p-SiOCH) is more sensitive to changes in the number of incident fluxes. Therefore, we must predict the ***Pc*** and control the incident fluxes precisely for each material that has different Si, O, C, and H compositions[1,2], film densities, and etched structures, such as the aspect ratios.

4. CONCLUSION

A model to predict the process window of SiOCH etching was proposed. The optimum flux condition (***Pc***) depended not only on the balance in the incident flux from the plasma (C, F, O, and N), but also on the density and composition of the SiOCH films. To ensure a reliable interconnects, we need to quantitatively control the uniform plasma.

[1] T. Tatsumi, et al., *Proc. on 23rd Dry Process Symp., Tokyo* (2002) 9.
[2] T. Tatsumi, et al., J. Vac. Sci. Technol. B18 (2000) 1897.

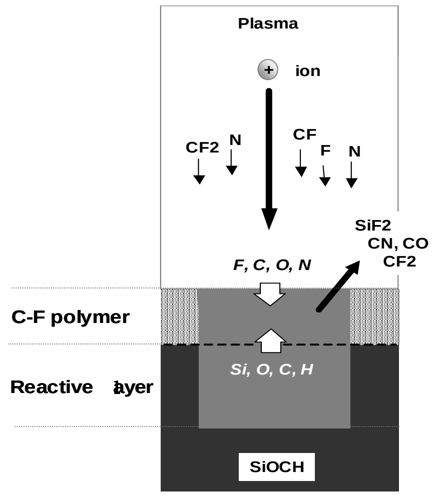

Fig. 1 Model for surface reaction

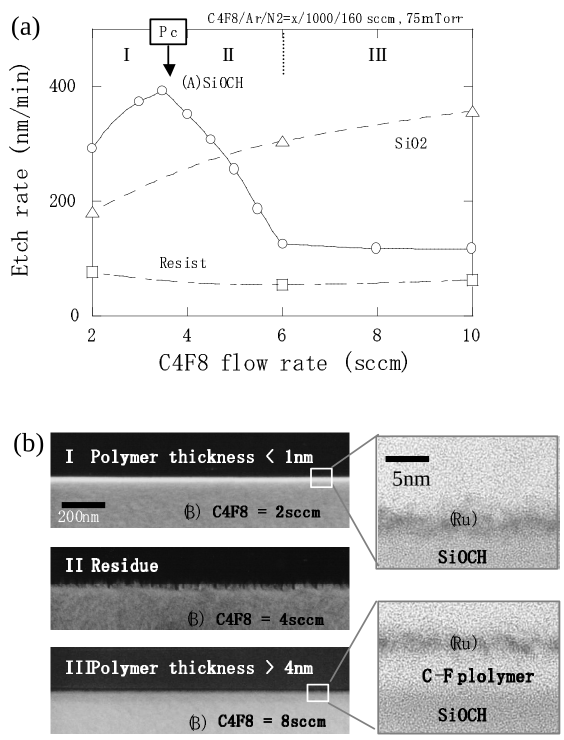

Fig. 2 (a) SiOCH etch rate and (b) surface polymer.

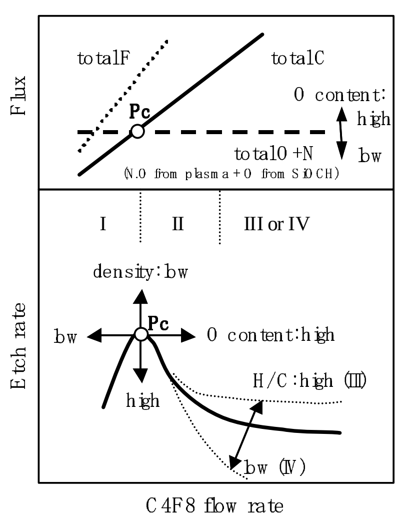

Fig. 3 Effect of film composition