Effect of CHF_3 addition on RIE process of aluminum using inductive coupled plasma.

Shuichi Saito, Kazuyuki Sugita, *Junichi Tonotani
Graduate School of Science and Technology,
Chiba University,
1-33 Yayoi-cho, Inage-ku, Chiba, Japan
*Corporate Manufacturing Engineering Center,
Toshiba Corporation,
33 Shin-isogo-cho, Isogo-ku, Yokohama, Japan

In the reactive ion etching (RIE) process for fabricating aluminum wiring, it is wellknown that etching characteristics are improved by the addition of N_2 or CHF_3 to BCl_3 and Cl_2 mixture. In the case of N_2 gas addition using parallel plate reactor, we already reported that ammonium salts were formed and they deposited on the pattern sidewall as the passivation layer[1]. In this paper, the role of CHF_3 gas addition in the inductive coupled plasma process was investigated.

Figure 1 shows the dependence of the aluminum wiring profile on CHF_3 flow rate. By the addition of CHF_3 gas, the aluminum pattern width increased, and the profile change to ordinary taper. Figure 2 shows the dependence of the etching rates of Al and the photoresist on CHF_3 flow rate. The etching rate ratio of the photoresist to Al was not changed. This data suggests that certain deposits were present on the sidewall when CHF_3 added even the amount from the photoresist decomposition was not so different.

Thermal desorption spectroscopy (TDS) was carried out to analyze the deposts. Figure 3 shows the TDS spectra of the aluminum wiring substrate before and after RIE under the condition as Figure 1. With CHF_3 addition, Al^+(M/e=27),F^+(M/e=19) and $C_2H_5^+$(M/e=29) were detected at about 350□Ž. The $C_2H_5^+$ fragment was generated by decomposition of the photoresist and Al and F had adhered to the photoresist. From this spectrum, F as well as Al was contained to the sidewall passivation layer.

To determine the chemical composition of the deposits on the sidewall, the next etching experiment was carried out with placing a small piece of Al_2O_3 was placed perpendicular to the wafer. The deposits on the small piece were analyzed by X-ray photoelectron spectroscopy (XPS) and fourier transform infrared spectroscopy (FT-IR). Since the Al_2O_3 piece and the electrode were insulated, and the stage of the Al_2O_3 piece had a floating electric potential, it was considered that low ions from the plasma bombarded the piece. On the other hand, the sidewall of aluminum pattern was also exposed to plasma, but there was less ion bombardment, because the direction of ion flux was parallel to the sidewall. Therefore, the deposits on the piece were considered to have a composition and structure similar to those on the sidewall of the Al wiring. Table 1 shows composition of the surface deposits on Al_2O_3 piece by XPS after aluminum etching with CHF_3. The Al content reduced, but Cl, F, and B were newly detected after RIE. From the XPS narrow scan spectra, neither fluoro- nor chloro- carbon polymer were detected. The fluorine was confirmed to combine with aluminum. In the FT-IR spectrum shown by Fig. 4, two peaks due to Al-F were observed at 1620cm^{-1} and 1350cm^{-1}.

Based on the above experiments, fluorine supplied in the form of CHF_3 was found to have reacted with aluminum byproduct, and formed AlF_3. The improvement of the etching profile was considered to be due to the deposition on the Al wiring sidewall.

1) S.Saito, et. al. Proc. of 197th Electrochem. Soc. Meeting (Toronto, May 2000), No. 286

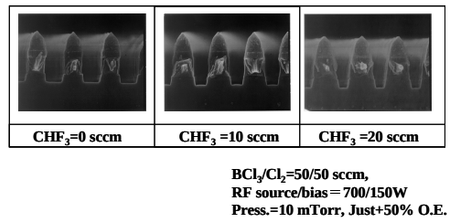

Fig.1 Effect of CHF_3 addition on the pattern profile.

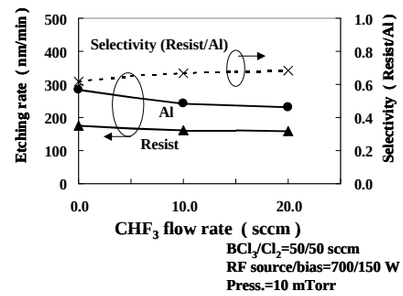

Fig.2 Effect of CHF3 addition on the etching rate.

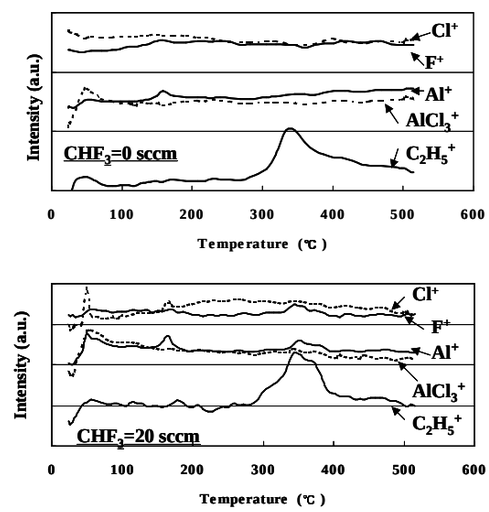

Fig.3 TDS spectra of the aluminum pattern substrate after RIE.

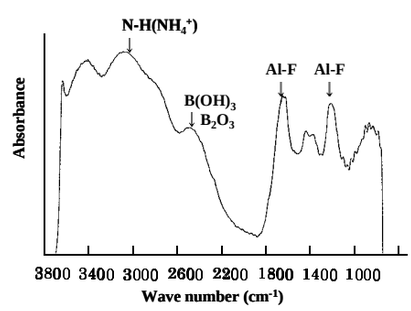

Fig.4 FT-IR spectrum of the deposits on Al_2O_3 piece.

Table 1 Composition of surface deposits on the Al_2O_3 piece.

	C	Al	Cl	F	N	B	O
Before RIE	29.2	32.6	-	-	1.6	-	36.6
After RIE	29.6	15.3	6.1	19.4	2.3	1.1	28.2