한국전기전자재료학회 2001년도 춘계학술대회 논문집

Employing of Metal Negative Ion in Halogen Plasmas

Young-Il Choi[1] Bong-Ju Lee[2], Kyung-Sub Lee[3]

[1]Dept. of Electronics & Information, Chosun College of Science & Technology
[2]Division of Physics and Chemistry, College of Nature Science, Chosun University
[3]Division of Electrical and Electronics Engineering, College of Engineering,Dong-Shin University

Abstract

The Al etching was studied employing negative ions generated in the downstream Cl_2 plasma. In order to etch the Al film practically on an insulator covered electrode coupled with RF power, reduction of the negative self bias voltage (Vdc) was examined using a magnetic filter which trapped electrons. Addition of SF_6 and H_2 to a Cl_2/BCl_3 mixture reduced significantly Vdc.

Key Words : Cl_2 plasma, self bias voltage, Al etching, oxygen radical, downstream

1. Introduction

To neutralize positive charge accumulated at bottom surfaces of high aspect ratio holes or gaps, generation of negative ions in downstream halogenous plasmas and alternate irradiation of positive and negative ions to an electrode coupled with RF field via a transformer have been studied [1,2]. In the previous work, the Si etching employing negative ions revealed the high etching reactivity which resulted from the fact that dominant negative species were formed by ions of atoms like F^- in SF^6 and Cl^- in Cl_2 plasmas[3]. However, when the substrate is placed on electrode covered by an insulator such as an electrostatic chucking, generation of the negative self bias voltage(Vdc) makes it hard to introduce negative ions to the substrate. This paper reports the possibility of reduction of Vdc using a magnetic filter and then discusses the Al etching employing Cl^- ions on the insulator covered electrode.

2. Experiments

Inductively coupled Cl_2 plasma was generated by 13.56 MHz RF power supplied to an one-turn antenna on a quartz window which was set on a 250 mm φ stainless-steel chamber. Cl^- ions were produced in the downstream region of 100-180 mm from the antenna. A wafer was placed on the water cooled stage The surface bias voltages supplied by (a) and (b) methods are expressed by Vpp and Vdc modes, respectively, where Vpp means peak-to-peak voltage. Vpp and Vdc were measured by reading off waveforms using an oscilloscope through a wire connected to a Si surface of wafer which was set on 70 mm thick polyimide film coated on the electrode. To improve the negative ion density ratio at the stage, a magnetic filter was equipped in upstream of the stage. The magnetic filter consists of two flattened coils, generating a field in (r,q) plane of the chamber and avoiding electrons to come to etching area. Saturation currents were measured by a plane probe of 1mm diameter.

3. Results and Discussion

The present sample consists of a 50nm Ti / 0.5mm Al-Si-Cu film / 0.11mm TiN. The etch rate of each layer in the Vpp mode was about two times higher than that in Vdc one. For the origin of the faster Al etch rates, negative ion of Cl atom is considered to enhance the metal etching reaction as demonstrated in the case of Si[3].

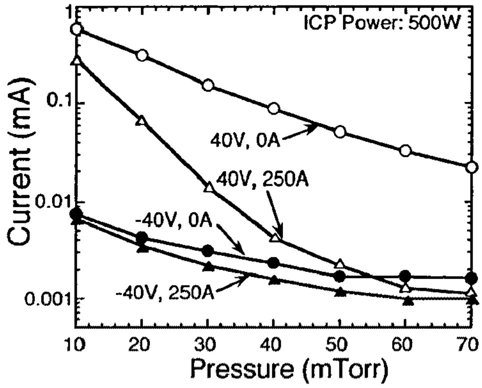

Fig. 1 Negatively and positively biased probe currents vs. Cl_2 pressure for magnetic coil current of 0 and 250 A (100 G).

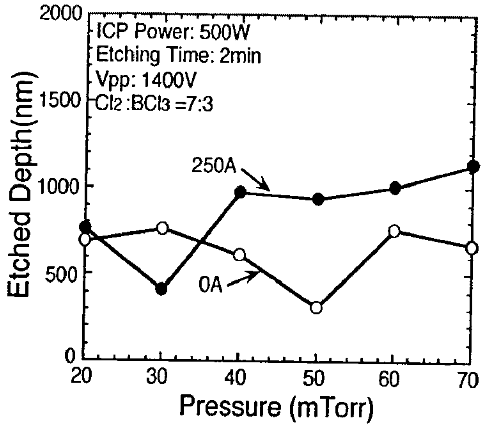

Fig. 2 Since 30% BCl_3 addition to Cl_2 reduced Vdc slightly as compared with Cl_2 alone, Al etch depth using Cl_2 / 30% BCl_3 vs. pressure. Etching time was 2 min.

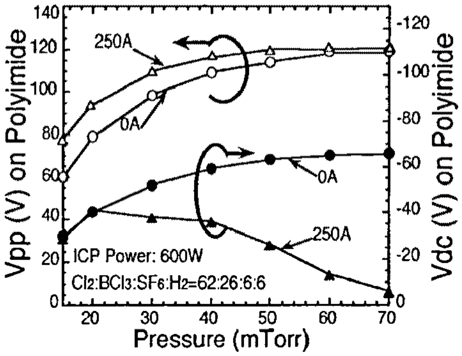

Fig.3 Vpp and Vdc vs. pressure employing 62% Cl_2 / 26% BCl_3 / 6% SF_6 / 6% mixture

Then, reduction of Vdc which is necessary to introduce negative ions was investigated, in prior to the Al etching experiment on the insulator covered electrode. In Fig. 1, negatively and positively biased probe currents are plotted against Cl2 pressure for magnetic coil current of 0 and 250 A (100G). Positively biased currents in the presence of the magnetic field decreased rapidly with increasing pressure and approached closely negatively biased currents over 50 mTorr. This indicates that considerable amount of electrons is trapped by the magnetic filter. Thus, Vpp and Vdc were measured for variation of pressures. However, Vdc appeared at about half of Vpp except slight decrease in Vdc over 50 mTorr. This is presumed to result from insufficient trapping of electrons. Then, SF_6 gas was added to Cl_2 to eliminate residual electrons in the Cl_2 plasma. Then the Al etching on the polyimide covered electrode in the Vpp mode was tried employing a Cl_2 / 6% SF_6 mixture at 50 mTorr. However, the etching ceased on the Al-Si-Cu layer immediately after removal of the upper Ti layer. This is attributed to the formation of fluorinated Al with the low volatility. Since 30% BCl_3 addition to Cl_2 reduced Vdc slightly as compared with Cl_2 alone, Al etch depths were measured as a function of pressure as shown in Fig. 2. Etching time was 2 min. Higher Al etch rates were observed at higher pressure more than

40 mTorr in the case of the magnetic filter, whereas severe undercutting occurred due to still low accelerating voltage of Cl^- ions. Finally, SF_6 and H_2 were added to Cl_2 / BCl_3, where H_2 was used to remove F atoms as HF against the fluorination of Al. As shown in Fig.3, Vdc decreased steeply with pressure. However, no etching occurred in spite of satisfactory accelerating voltage of Cl^- ions.

4. Conclusion

The Al etching on an insulator covered electrode was studied employing the alternative irradiation method of positive and negative ions in the Cl^2 downstream plasma. Reduction of Vdc, which was necessary to attract negative ions, was tried by electron trapping with a magnetic filter and addition of SF_6 and H2 to Cl_2/BCl_3

Reference

[1] H. Shindo, Y. Sawa and Y. Horiike: Jpn. J. Appl. Phys., 34 (1995) L925.

[2] T. Shibayama, et al. : Plasma Sources Sci. & Technol. 5 (1996) 24.

[3] Y. Horiike and H. Shindo: Proc. 3rd Int. Conf. Reactive Plasma, Nara, Japan, (1997) 515.

[4] H. Shindo and Y. Horiike: Jpn. J. Appl. Phys., 30 (1991)