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Study on the Residue Film Induced by Magnetically-Enhanced Reactive Ion Etching of Al(Si, Cu) Film Using the Mixture of BCl_3, Cl_2, and N_2 Gases

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In the present work, the residue film and the etching profile induced by the magnetically-enhanced reactive ion etching (MERIE) of Al(Si, Cu) film were studied using x-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM). The 8000 Å thick Al(Si, Cu) film was deposited on SiO_2 film by sputtering of Al(Si, Cu) target consisted of 98.5% Al, 1.0% Si, and 0.5% Cu. The mixture of BCl_3, Cl_2, and N_2 gases was used as the etch gas and the flow rates of BCl_3 and Cl_2 were 40 and 15 sccm, respectively.

The purpose of this work is to clarify the effect of N_2 gas on the etching behavior and the formation of residue film. The etch rate was decreased from approximately 2700 to 1900 Å/min as increasing N_2 flow rate from 10 to 90 sccm. The MERIE of patterned Al(Si, Cu) showed an undercut etch profile with N_2 flow rate lower than 50 sccm and the vertical etch profile of Al(Si, Cu) could be obtained with the N_2 flow rate ranging from 50 to 90 sccm. The vertical etch characteristics would be attributed to the residue film deposited on sidewall during etching.

After 1 min-etching of Al(Si, Cu) film with no pattern, the surface was *ex situ* characterized to determine the residue film using XPS. The result indirectly indicated that N_2 gas in the MERIE-plasma using BCl_3, Cl_2, and N_2 contributed to form a residue film protecting the sidewall of Al(Si, Cu) pattern. With N_2 flow rate of 10 sccm, only oxidized Al was detected from Al(Si, Cu) film exposed to air after etching. In contrast, the intensity of metallic Al 2p photoelectron peak was increased with increasing N_2 flow rate. The result means that thicker residue film was deposited with higher N_2 flow rate. The XPS studies also showed that the residue film was consisted of B, Cl, and N.

The effect of N_2 was also investigated on the etch behavior of Cu by analyzing the residue film of MERIE of Al(Si, Cu). After 1 min-MERIE of Al(Si, Cu) film using BCl_3, Cl_2, and N_2, Cu was shown to be accumulated on surface with N_2 of a flow rate lower than 30 sccm. Since Cu is generally known to be etched by sputtering rather than chemical etching during dry etching process, it can be inferred that the increase of N_2 enhances the physical sputtering etching mechanism under these experimental conditions.