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Fluorocarbon gas are used for contact hole etching process to achieve high aspect ratio profile. After dry etching process, etching residues are formed on the surface and inside patterns. These residues have a negative effect on the performance of semiconductor device. So, it is important to remove the etching residues effectively. In order to remove residues, generally, dry cleaning process is used. However, to improve the effectiveness of cleaning process, a detailed research on the characteristics of residues formed on the sidewalls of nano-scale pattern after the etching process needs to be preceded.

Therefore, in this study, the characteristics of etching residues formed on the sidewalls of silicon dioxide films after contact hole etching process using $C_4F_8+CH_2F_2+O_2+Ar$ gas plasma were investigated. After the contact hole etching process, scanning electron microscopy was used to observe etched profile. Furthermore, we analyzed the characteristics of etching residues formed on the silicon dioxide sidewalls by angle-resolved x-ray photoelectron spectroscopy (XPS). Through detailed research on the chemical components and bonding states of the etching residues, it was confirmed that the chemical composition of the etching residues formed on the sidewalls varied with the etched depth of the pattern.