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Etch characteristics of SiO2 by using Pulse-Time Modulation in the Dual-Frequency Capacitive Coupled Plasmas

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As the semiconductor devices have been abruptly scaled down for ultra-large scale integrated circuit, the dry etch process has been developed to very high frequency (VHF) source, lower process pressure and lower electron temperature in order to improve the etch selectivity, etch profile, aspect ratio. However, as increasing the aspect ratio or scaling down to nano size, plasma process induced damages occur during etching process. Therefore, to reduce the plasma process induced damages (P2IDs), the pulsed plasma have been studied extensively over the past a few decades. Pulsed plasma is generated by periodical tuning the rf power on and off state. At the rf power off state, the electron temperature decreased due to low electron energy and P2IDs reduced effectively in this period.
In this study, we used $Ar/C_4F_8/O_2$ gas mixture and low process pressure in the 60 MHz/2 MHz dual frequency capacitive coupled plasma (DF-CCP) and measured etch characteristics as various pulse parameters. As decreasing the duty ratio, etch rate of SiO_2 and ACL decreased but etch selectivity is increased due to abruptly decrease of electron temperature at rf power-off period and result in formation of thicker fluorocarbon polymer effectively. Therefore, etch profile and etch selectivity improved in pulsed plasma comparing to continuous wave plasma. In the varios pulse frequency condition, however, etch characteristics can not changed significantly owing to almost similar radical intensity of CF_2 as functions of pulse frequencies.

Keywords
pulse plasma
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VHF source
contact hole etching