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Etch Characteristics of SiO_2 by using Pulse-Time Modulation in the Dual-Frequency Capacitive Coupled Plasma

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The capacitive coupled plasma (CCP) has been extensively used in the semiconductor industry because it has not only good uniformity, but also low electron temperature. But CCP source has some problems, such as difficulty in varying the ion bombardment energy separately, low plasma density, and high processing pressure, etc. In this reason, dual frequency CCP has been investigated with a separate substrate biasing to control the plasma parameters and to obtain high etch rate with high etch selectivity. Especially, in this study, we studied on the etching of SiO_2 by using the pulse-time modulation in the dual-frequency CCP source composed of 60 MHz/ 2 MHz rf power. By using the combination of high /low rf powers, the differences in the gas dissociation, plasma density, and etch characteristics were investigated.

Also, as the size of the semiconductor device is decreased to nano-scale, the etching of contact hole which has nano-scale higher aspect ratio is required. For the nano-scale contact hole etching by using continuous plasma, several etch problems such as bowing, sidewall taper, twist, mask faceting, erosion, distortions etc. occurs. To resolve these problems, etching in low process pressure, more sidewall passivation by using fluorocarbon-based plasma with high carbon ratio, low temperature processing, charge effect breaking, power modulation are needed.

Therefore, in this study, to resolve these problems, we used the pulse-time modulated dual-frequency CCP system. Pulse plasma is generated by periodical turning the RF power On and Off state. We measured the etch rate, etch selectivity and etch profile by using a step profilometer and SEM. Also the X-ray photoelectron spectroscopic analysis on the surfaces etched by different duty ratio conditions correlate with the results above.

Keywords: contact hole etching, pulse plasma