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Etching characteristics of DLC-hard mask using dual frequency superimposed capacitively coupled plasmas (DFS-CCP)

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As the degree of device integration for the fabrication of Si semiconductor devices continuously increases, a shorter wavelength such as 193 nm ArF excimer laser is needed to increase the resolution of the photolithographic process. However, the photoresist (PR) becomes thinner due to a lower depth of focus at the shorter wavelength and softer because of no aromatic compound in the 193 nm ArF PR, which in turn limits the process capability of a dry etcher. Nano-scale plasma etching requires new schemes, such as multi-layer resist (MLR) in the etching mask structure, due to the difficulty in patterning the hard-mask layer with ArF PR below 50-nm technology node. Recently, MLR structure including amorphous carbon mask has attracted a lot of attention. Diamond-like carbon (DLC) may be also considered for a mask material because of its hardness and etch resistance to fluorine etch chemistry.

In this study, we investigated the etching characteristics of diamond-like carbon (DLC) layer with the SiO_2 hard-mask by varying the process parameters such as different high-frequency/low-frequency combination (f_{LF}/f_{HF}), HF/LF power ratio (P_{HF}/P_{LF}), O_2 flow and N_2 flow rate in $O_2/N_2/Ar$ plasmas. The results indicated an increased etch rate of DLC for the higher f_{LF}/f_{HF} combination and for the increased low-frequency power (P_{LF}). And the etch rate of DLC was decreased with increasing the N_2 flow rate in $O_2/N_2/Ar$ plasmas.