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Effect of high-frequency variation on ArF PR deformation and silicon nitride etching by dual frequency superimposed (DFS) rf capacitive coupled plasma

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As the critical dimension (CD) of advanced CMOS devices is scaled down below 100 nm, 193 nm ArF photoresist (PR) needs to be used as a mask for various etching processes including silicon nitride (Si3N4) hard-mask opening. Recently, dielectric etch process using ArF photoresist mask by dual frequency superimposed capacitive coupled plasma (DFS-CCP) etcher has attracted a lot of attention. High frequency (HF) power is used to enhance plasma density and low frequency (LF) power is used to control ion bombardment to the wafer. During dielectrics etch process using DFS-CCP, understanding of ArF photoresist deformation is very important. It has been found that the most serious problems of the hard-mask open process with ArF PR are striation, wiggling, and agglomeration of the PR. In this talk, deformation of unpatterned and patterned ArF photoresists by varying the process parameters such as HF(13.56, 27.12, and 60 MHz)/LF(2 MHz) power ratio, pressure and etch chemistry (CHF3/CF4/CH2F2/Ar/O2/N2) will be discussed. In particular, the effect of different HF/LF combinations on the deformation of patterned and unpatterned ArF PR will be highlighted. Characterization of surface chemical change was performed by X-ray photoelectron spectroscopy (XPS) and Fourier transform infrared spectroscopy (FT-IR). Surface morphological changes also investigated by scanning electron microscopy (SEM) and atomic force microscopy (AFM). Also, morphological changes of surface and line edges in ArF PR, Si3N4 etch rate, selectivity over PR during etching of ArF PR/BARC/Si3N4 structures will be discussed. The results indicated an enhanced deformation by increasing the low frequency power, CF4/CHF3 flow rate ratio, and O2 flow rate. Effects of process parameters on the etch results will be discussed.