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# Role of $N_2$ flow rate on etch characteristics and variation of line edge roughness during etching of silicon nitride with extreme ultra-violet resist pattern in dual-frequency $CH_2F_2/N_2/Ar$ capacitively coupled plasmas

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The process window for the etch selectivity of silicon nitride ($Si_3N_4$) layers to extreme ultra-violet (EUV) resist and variation of line edge roughness (LER) of EUV resist were investigated durin getching of $Si_3N_4$/EUV resist structure in a dual-frequency superimposed capacitive coupled plasma (DFS-CCP) etcher by varying the process parameters, such as the $CH_2F_2$ and $N_2$ gas flow rate in $CH_2F_2/N_2/Ar$ plasma. The $CH_2F_2$ and $N_2$ flow rate was found to play a critical role in determining the process window for infinite etch selectivity of $Si_3N_4$/EUV resist, due to disproportionate changes in the degree of polymerization on $Si_3N_4$ and EUV resist surfaces. The preferential chemical reaction between hydrogen and carbon in the hydrofluorocarbon ($CH_xF_y$) polymer layer and the nitrogen and oxygen on the $Si_3N_4$, presumably leading to the formation of HCN, CO, and $CO_2$ etch by-products, results in a smaller steady-state hydrofluorocarbon thickness on $Si_3N_4$ and, in turn, in continuous $Si_3N_4$ etching due to enhanced $SiF_4$ formation, while the $CH_xF_y$ layer is deposited on the EUV resist surface. Also critical dimension (and line edge roughness) tend to decrease with increasing $N_2$ flow rate due to decreased degree of polymerization.