Mechanism of infinite Si_3N_4/ArF PR etch selectivity during $CH_2F_2/H_2/Ar$ dual frequency capacitively coupled plasma etching of Si3N4 layers

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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 hard-mask opening. However, ArF PR has poor resistance to the conventional fluorocarbon etching plasmas resulting in a low etch selectivity of silicon nitride (SiN) layers to the ArF PR.

In this work, we investigated the role of the H_2 flow during the etch process with infinite Si_3N_4/ArF PR selectivity, in order to determine the Si_3N_4 etch conditions with no loss of the ArF PR in the $CH_2F_2/H_2/Ar$ dual-frequency superimposed capacitively coupled plasma (DFS-CCP). The etch rates of ArF PR and Si_3N_4 layers were slightly increased with the H_2 flow rate increased at the fixed CH_2F_2 flow rate. And, the ArF PR and Si_3N_4 etch rates were gradually increased with increasing the P_{LF} and in turn the etch selectivity was decreased. Also, the mechanism underlying the infinite Si_3N_4/ArF PR etch selectivity was investigated by analyzing the hydro-fluorocarbon deposition on the Si_3N_4 surface, the radicals in the plasma, and the effluents of the etch by-products in the exhaust.