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Plasma Systems for Dielectric Etch

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Plasma systems used to etch oxides on silicon wafers impose a complex set of simultaneous requirements on the plasma to meet performance specifications for etching present (70nm) and next-generation features (45-32 nm). Dielectric etch systems usually comprise an rf plasma source and an rf plasma bias. The function of the bias is to create a DC sheath by the rectification of the rf power that then accelerates ions into the wafer. Typically, a weakly ionized plasma in $Ar/O/C_xF_y$ chemistries is used in the millitorr pressure range. Because of the pressure range, the neutral/plasma collisions can substantially alter the power deposition between that needed for the sheath and the remainder that creates the plasma. Allocation of power for the ion energy distribution must also be considered in addition to the power division between bulk plasma and dc sheath. Ion energy distributions are tailored to meet etch requirements (which depend on the material etched) by using two rf frequencies in the bias system to accelerate ions. These two frequencies adjust energy from mono-energetic (when the ion sheath transit time is long compared to an rf period) to very broad (when the transit time is short relative to a period). To acquire higher etch rates and a wider dynamic range of plasma densities, a third rf frequency is used as a plasma density source. It is more advantageous to use a very low voltage rf capacitive source to generate sufficient density for the least power. We discuss the interrelated requirements, their impact on the wafer, the manner in which they are achieved, and limitations imposed by the physics of each frequency/power/pressure range.