380e Ion-Enhanced Plasma Etching of Metal Oxides in Chlorine Based Plasmas

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The development of plasma etching chemistries is necessary to pattern new gate dielectric materials, such as hafnium based oxides, for sub-65nm complementary metal oxide semiconductor (CMOS) devices. An electron cyclotron resonance high density plasma reactor is used in this work to study the etching of metal oxides and their corresponding metals in chlorine based chemistries. The plasma density, electron temperature, and gas phase species are characterized by a Langmuir probe, an optical emission spectrometer, and a quadrupole mass spectrometer. The etching of Al_2O_3, SiO_2, and HfO_2 was first studied in Cl_2 and BCl_3 plasmas, to allow for studies of the etching of hafnium aluminate, $Hf_{1-x-y}Al_xO_y$, and hafnium silicate, $Hf_{1-x-y}Si_xO_y$, with well controlled and varying compositions of Al and Si in HfO_2. The dominant etch products of Al and Hf metals in Cl_2 and BCl_3 plasmas were metal chlorides and metal boron-oxy-chlorides, respectively. These results enabled the assessment of the effect of metal-oxygen bond strength on the surface etching reactions, as well as the oxygen removal mechanism in the etching of metal oxides. The etch rates of hafnium aluminates were found to increase with the square root of ion energy, and the surface chlorination was enhanced with increasing ion energy, demonstrating that the etching reaction is limited by the momentum transfer from the ions to the film surface. The etching selectivity of $Hf_{1-x-y}Al_xO_y$ and $Hf_{1-x-y}Si_xO_y$ to Si in Cl_2 and BCl_3 plasmas will be presented, with a focus on the effect of increasing concentrations of Al and Si, and how the etch rates compare to the etching of Al_2O_3, SiO_2, and HfO_2 individually. Finally, the application of a generalized model, developed for the etching of ZrO_2 and HfO_2, to the etching of $Hf_{1-x-y}Al_xO_y$ and $Hf_{1-x-y}Si_xO_y$ in chlorine based plasmas will be discussed.