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The in-situ study of growth rate on silicon oxidations via ambient pressure XPS

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In many years, the silicon oxidation process has been throughly investigated with various surface science analytical tools, focusing on chemical and structural information on SiO2/Si interface, electronic structures, and the detailed kinetics of oxidation processes. Especially, with x-ray photoelectron spectroscopy (XPS), important knowledge on the oxidatoin process are desclosed, such as the different chemical oxidation states, the loca atomic structures, and the unique growth modes at the interfaces.

However, due to the short inelastic attenuation lengths photoelectrons, as well as the requirement of high vacuum in the electron spectrometer, only the model study of oxidation process has been carried out, i.e. ultrahigh-to-high vacuum conditions (10-10 to 10-6 torr) and/or after oxidation treatment in a preparation chamber.

In an attempt to close this pressure gap, we have used a newly developed ambient pressure(AP) XPS endstation at the Advanced Light Source (ALS) [D.F. Ogletree, Rev. Sci. Inst. 73, 3872 (2002)] to study the growth rates of silicon oxide and the nature of the chemical bonding at the interface between the silicon and the oxide at ambient pressures of oxygen and water up to 1 torr in real time. The measured growth rates of silicon oxidation at various substrate temperatures and gas pressure indicate that the growth rate of oxide is very rapid up to the thickness of a few monolayer, after which the reactions slows considerably. In addition, it is found that there exist a clear difference of growth rate between the dry and wet oxidations process in the early stage of growth. The observed growth rate shows a clear deviation from Deal-Grove model.