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Imaging of electronic defect states in SiO2 and HfSiOx films with sub-nanometer spatial resolution by two-way Single Electron Tunneling Force Mircroscopy J.P. JOHNSON, N. ZHENG, C.C. WILLIAMS, University of Utah — Electronic defects in dielectric materials are currently in sharp focus, for nano-technology and quantum information processing. A novel technique has been developed for imaging these states with sub-nanometer spatial resolution. It can be applied to completely non-conducting dielectric films, in contrast to the STM. The method is based on force detected single electron tunneling events to and from the defect states [1-3]. The exponential dependence of the tunneling rate on tip-sample gap provides the same spatial resolution as STM. An oscillating AFM tip is scanned at constant height above the sample surface. A voltage waveform, synchronous with the tip motion is applied. When the tip is above an accessible state, individual electrons shuttle between tip and state with the applied voltage (300 Hz). The two-way tunneling causes a detectable change in tip resonance. Images of SiO2 and HfSiOx films show a repeatable, random array of individual "point-like" defect states, some with sub-nanometer width. Spectroscopic measurements of the defect energy are also performed by this approach. The new method and an analysis of the defects in SiO2 and HfSiOx will be presented. [1] E Bussman et al., Appl. Phys. Lett. 85, 2538 (2004) [2] E Bussman and CC Williams, Appl. Phys. Lett. 88, 263108 (2006) [3] E Bussman et al., Nano Lett. 6, 2577 (2006)

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