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The Electronic Properties of AlN Tunnel Barriers and the Effect of Oxygen Impurities YUN LI, JOHN READ, PINSHANE HUANG, HSIN-WEI TSENG, ROBERT BUHRMAN, CORNELL UNIVERSITY TEAM — The use of ultra-thin aluminum nitride (AlN) barrier layers can result in Josephson Junctions (JJ's) with both very high critical current densities and low sub-gap leakage [1-4], demonstrating that AlN is a superior JJ tunnel barrier material in the ultra-thin barrier limit. We have utilized scanning tunneling spectroscopy (STS) and analytical scanning transmission electron microscopy (STEM) with electron energy-loss spectroscopy (EELS) to investigate thin AlN layers formed on Nb/Al bilayers by treating the Al surface with an atomic nitrogen beam. Under optimum nitridation conditions the resultant $\sim$1nm AlN barrier layers have small, $\sim$ 1 eV, but well defined band gaps and stable surfaces in UHV, with the absence of band-tail states extending close to the Fermi energy, which is in sharp contrast to the case for AlO_xlayers formed by thermal oxidation [5]. The AlN barrier layers are however quite sensitive to even low levels of background oxygen (O) exposure, either during or after the nitridation process, which reacts O into the barrier layer and results in the formation of low energy band-tail states and an unstable surface. [1] Zijlstra et al., APL 91, 233102 (2007); [2] Wang et al., APL 64, 2034 (1994); [3] Kleinsasser et al., IEEE TAS 5, 2318 (1995); [4] Kaul et al., JMRS 20, 3047 (2005); [5] Mather et al., APL 86, 242504 (2005)

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