Colloquium

Department of Physics, Temple University

Direct Measurement of Band Edge Profiles at Epitaxial Oxide/Semiconductor Heterojunctions

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Crystalline oxides on Group IV semiconductors have been of interest in the past primarily for their potential utility as high-*k* gate dielectrics. In this context, insulating oxides have been the focus, and band alignments with large offsets at both the valence and conduction band edges have been sought in order to minimize gate leakage. However, the ease with which $SrTiO_3$ can be *n*-doped with V_O, La_{Sr}, or Nb_{Ti} creates new possibilities for novel interface physics and device concepts. We have been investigating both perpendicular and lateral transport in heterojunctions consisting of *n*-$SrTiO_3$ (STO) on *p*-Ge and solid solutions of *n*-$SrNb_xTi_{1-x}O_3$ (SNTO) on intrinsic (*i*-) Si. Our interest in interfaces with *p*-Ge stems from the desirable properties of Ge for visible light harvesting and driving the hydrogen reduction step of the water splitting reaction. Heterojunctions employing *i*-Si may exhibit novel two-dimensional conductivity stemming from unusual electronic structures that form at the interface. Indeed, *n*-STO/*p*-Ge(001) exhibits visible-light-activated hydrogen evolution activity with an incident-photon-to-current efficiency of ~14 %. Likewise, *n*-SNTO/*i*-Si(001) generates a hole gas for certain Nb concentrations, with sheet carrier concentrations of 10^{11} to 10^{12} cm^{-2} and hole mobilities of 500 to 600 cm^2-V^{-1}-sec^{-1} at temperatures above 300K. Both of these sets of results beg for direct, accurate measurements of band edge profiles as a function of depth. In order to generate such profiles, we have employed hard x-ray photoemission spectroscopy (HAXPES) and have developed a new method of data reduction whereby the depth dependences of the valence band maxima and conduction band minima in both the oxide and the Group IV semiconductor can be extracted from core-level spectra. In this talk, I will present results for these investigations which have revealed completely unexpected interface physics, yet generate potential profiles that explain the observed photoelectrochemical and lateral transport data quite satisfactorily.

Monday, October 29, 2018, at 3:00 pm
SERC, Room 116
Refreshments served at 2:45 pm