

Surface and Interface in Nanoscale Electronic Materials: From Understanding to Engineering

Surfaces and interfaces play a critical role in determining properties and functions of nanomaterials, in many cases simply dominating bulk properties, owing to the large surface- and interface-to-volume ratio. One can further engineer and improve the performance of nanoscale devices through the control of surface and interface chemistry. Using Si nanomembrane as a model system, we have investigated how surfaces and interfaces influence electrical transport properties at the nanoscale by means of scanning tunneling microscopy (STM) and four-probe measurements. We show that electronic conduction in Si nanomembrane is not determined by bulk dopants but by the interplay of surface and interface electronic structures with the “bulk” band structure of the thin Si membrane, in the manner of “surface transfer doping”. Additionally, we characterize self-assembled alkanethiolate monolayers (SAMs) on Au{111} with embedded static dipole groups in the adsorbate molecules using Kelvin probe force microscopy (KPFM), X-ray photoelectron spectroscopy (XPS) and quantitative infrared vibrational spectroscopy (IR) techniques. We have modulated the metal work function by adjusting the orientation of the embedded dipole and the geometric structures of the SAMs, which will find applications in charge injections in organic electronic devices. These studies demonstrate that a thorough physical understanding of the emerging phenomena at the nano- or molecular scale can advance technologies ranging from nanoelectronics to photovoltaics.