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Scanning-tunneling microscopy and spectroscopy of oxide deposition on III-V semiconductor surfaces

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The correlation between the atomic bonding structure and the electronic structure at oxide-semiconductor interfaces is critical to understanding how atomic scale changes in electronic structure can cause localization of electrons or holes at these interfaces. All logic devices function by having an electric field perturb the electronic structure of a semiconductor to change its resistance thereby activating the device. The key material in this process is the interface between the gate oxide and the semiconductor. Any fixed charge or defects which trap electrons or holes destroy the device operation because the electric field will be terminated by interface charges instead of being transmitted into the semiconductor where the electrons or holes are conducted. We have used atomically resolved scanning tunneling microscopy (STM) images and scanning tunneling spectra (STS) to determine the atomic and electronic structure at the gate-oxide semiconductor interface. Our research focuses upon the group III-V semiconductors (GaAs, InGaAs, InAs) since they offer electron speeds up to 30x greater than silicon as well as germanium since it offers 3x higher hole speeds than silicon. In general, electronically passive interfaces are formed when oxide deposition does not disrupt the semiconductor lattice but instead restores the semiconductor surface atoms back to more bulk-like electronic structure. Even in the absence of a lattice disruption, oxide deposition can create new states in the bandgap thereby pinning the Fermi level by two mechanisms: direct (the adsorbate induced states in the bandgap region) and/or indirect (generation of undimerized surface atoms).