Oxides – Semiconductor Heterostructures for Smart Devices

Jasprit Singh
Department of Electrical Engineering and Computer Science,
University of Michigan, Ann Arbor, MI 48109-2122

Heterostructures between oxides and semiconductors have been exploited primarily for providing gate insulation or for passivation layers. For gate insulation only the Si/SiO_2 system has been able to fully exploit the benefits of semiconductor-oxide heterostructures. Recently GaAs-oxide based MOSFETs have been demonstrated. Additionally new work has been showing that it is possible to grow *reasonable* quality oxide-semiconductor interfaces. It is well known that in addition to large bandgaps, oxides also provide polar charge, tailorable polarization, tailorable dielectric response etc. Can we exploit these unusual properties to design new semiconductor devices?

There are oxides that have ferroelectric, pyroelectric and piezoelectric properties where polar charges as high as 1 electron per surface atom can be present. Such structures, if successfully integrated with semiconductors can yield novel physical properties with far reaching impact on technology. For these structures to make an impact we need to understand: (i) band lineup; (ii) polarization vs. thickness; (iii) dielectric response vs. thickness; (iv) and most importantly defect structures. Polarization differences at interfaces can be used to create very large band bending which in turn can be used to induce electron (hole) gas, create tunnel junctions, cause lateral as well as vertical band engineering. Most interestingly these structures can result in multi-function FETs which have high transconductance and respond not only to gate bias but to pressure, temperature variations, etc.