Wide Bandgap Heterojunctions on Crystalline Silicon Metal-Oxide and Organic Semiconductors

Prof. James C. Sturm
Dep't. of Electrical Engineering
Princeton Institute for the Science and Technology of Materials (PRISM)
Princeton University, Princeton, NJ 08540, USA
Tel: 609-258-5619, Fax: 609-258-1177, E-mail: sturm@princeton.edu

The development of the crystalline Si/$Si_{1-x}Ge_x$ heteroepitaxial material system some ~30+ years ago was a major milestone in the semiconductor field, as it marked the introduction of heterojunctions into mainstream silicon technology. This material system was commercialized for both bipolar and MOS devices, and is widely explored for both optical and quantum devices. However, the bandgap offsets are typically limited to a few 100 meV, and a band offset in the conduction band requires a "substrate" lattice constant different from that of bulk silicon.

We describe progress in wide bandgap heterojunctions on crystalline silicon, with bandgaps of materials ranging up to 4 eV. Because the lattice constant differences between Si and crystalline wide-gap column-IV materials, such as diamond or β-SiC, are too large for high-quality hetero-interfaces, we focus on amorphous organic and metal-oxide inorganic semiconductors. These materials have the advantage that they can be deposited at low-temperatures (typically ~200 °C or less) and without the constraints of lattice matching, but the non-epitaxial nature of the heterojunction means one must be concerned with interface states on the silicon surface. Specific topics in the talk include fundamental electronic properties of the heterojunctions (band offsets, electron-blocking vs. hole-blocking properties), materials aspects of the interfaces (such as interface bonding and passivation), and finally device applications (double-heterojunction solar cells and HBT's).