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Wide Bandgap Heterojunctions on Crystalline Silicon

James C. Sturm[*], Sushobhan Avasthi[*], Ken Nagamatsu[*], Janam Jhaveri[*], William E. McClain[t], Gabriel Man[*], Jeffrey Schwartz[t] and Antoine Kahn[*]

Princeton Institute for the Science and Technology of Materials
[*]Department of Electrical Engineering
[t]Chemistry Department
Princeton University
Princeton, NJ 08540

For 30 years there has been extensive research on pseudomorphic strained Si_{1-x} Ge_x semiconducting layers grown on the (100) surface of crystalline silicon. This technology provides a narrow bandgap compared to silicon, and has long been established in industrial production to make heterojunction bipolar transistors. On the other hand, despite the great wishes of the designers of silicon-based devices, there has been little progress to date on wide-bandgap heterojunctions on silicon. In this talk we present the development of both electron-blocking (large conduction band offset, small valence band offset) and hole-blocking (large valence band offset, small conduction band offset) heterojunctions on silicon.

Our work is based on organic semiconductors and inorganic metal oxide semiconductors, which can have bandgaps of 3-5 eV. Thus very large blocking barriers are possible, and are confirmed by electronic structure measurements of the widegap semiconductor/silicon interface. The material phases we use are amorphous, and hence the lattice-mismatch problem is avoided. However, great care must be taken to passivate the surface silicon atoms to reduce interface defects, in some cases using “hybrid” semiconducting molecules as a structural and electronic “bridge” between the different semiconductor systems. Finally, we demonstrate the application of these wide-bandgap heterojunctions on silicon in photovoltaic devices, MISFET’s, and in heterojunction bipolar transistors.

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