Approaching Molecular Nanodevices using Engineered Nanowire Templates

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A bottom-up approach, where functional electronic structures are assembled from chemically synthesized, well-defined nanoscale building-blocks, has the potential to go far beyond of the limits of top-down technology by defining key nanometer scale metrics through chemical synthesis and subsequent assembly. This approach can generate conceptually new device architectures and fundamentally different fabrication strategies, and provide unparalleled speed, storage and size reductions. Nanowires (NWs) have attracted increasing interest in the past decade because they represent the smallest dimension for efficient transport of electrical carriers and have great potential as efficient interconnects for next generation of nanoelectronics.

In this presentation I will talk about our recent efforts in generating silicide-silicon-silicide heterostructures in individual synthetic Si NWs through solid state reaction. The structure and electrical properties of the NW heterostructures were studied. Atomically sharp interfaces between Si and silicides were observed. It was also found that polycrystalline and single-crystalline silicide NWs are obtained at different conditions. Formation mechanism of poly vs single crystalline silicide structures will be discussed. Lastly, we will demonstrate nanoscale devices utilizing the Si/Silicide nanostructures. In specific, by choosing high work function PtSi as the contact, we have fabricated high performance nanoscale field-effect transistors from intrinsic silicon nanowires, in which the source and drain contacts are defined by the metallic PtSi nanowire regions, and the gate length is defined by the Si nanowire region. Electrical measurements show nearly perfect p-channel enhancement mode transistor behavior and the best-performed intrinsic Si NW transistor to date. This work has demonstrated the potential of using silicide/Si NW heterostructure for nanometer regime device engineering. Notebly, the Si region in the NW heterostructure may be controlled down to sub-5 nm, well beyond the limit of current lithography technique. At the end of the talk, I will talk about the potential of using NW heterostructures for studying material properties in the deep nanometer region, as well as the potential of using the NW heterostructures as a means to organize molecular scale devices.