Nanowire Photovoltaics

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Our research is developing semiconductor nanowires for low cost and high efficiency photovoltaics. Semiconductor nanowires are one-dimensional rods with lengths of several microns and diameters ~10 to 100 nm. Our nanowires are grown using metal seed particles in a physical vapor deposition process which allows precise control of nanowire geometry.

Our nanowires consist of coaxial core-shell structures; for example, p-doped cores surrounded by n-doped shells. In this structure, charge carriers can be collected efficiently across the diameter of the wires before recombination can occur. This leads to higher collection efficiency compared to conventional thin film geometries. Reflection at the front surface of a solar cell also represents a significant loss of light and reduction in efficiency of solar cells. Nanowires demonstrate natural light trapping properties with superior performance compared to conventional anti-reflection coatings.

The implementation of p-n junctions and III-V compound semiconductor heterostructures in the nanowires, essential for high efficiency photovoltaics, are accomplished by gas phase switching during growth. A number of nanowire heterostructures for photovoltaics will be reported, including GaAs/InAlP, GaAs/GaP, GaAs/AlGaAs, and GaAs/InGaP. Due to the small contact area between a nanowire and its substrate, lattice mismatch strain may be accommodated by elastic distortion of the nanowire without detrimental misfit dislocations, which gives a greater degree of bandgap engineering in nanowire cells as compared to thin film cells.

The high cost of III-V substrates has limited multijunction solar cells to space-based applications. For terrestrial applications, this problem can be addressed by concentrator technology that reduces the amount of solar cell area required. On the other hand, nanowires can be grown directly on Si substrates thereby avoiding more costly Ge or III-V substrates. Our research group has already demonstrated the growth of III-V nanowire heterostructures on Si substrates, on carbon nanotube fabrics, and on stainless steel. We have already fabricated prototype cells and will report some of the major issues for developing nanowire technology into high efficiency photovoltaic devices.

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