Nanowire Photovoltaic Devices

For ultrahigh-efficiency, radiation-tolerant space solar cells

Firefly Technologies, in collaboration with the Rochester Institute of Technology and the University of Wisconsin–Madison, developed synthesis methods for highly strained nanowires. Two synthesis routes resulted in successful nanowire epitaxy: direct nucleation and growth on the substrate and a novel selective-epitaxy route based on nanolithography using diblock copolymers. The indium-arsenide (InAs) nanowires are implemented *in situ* within the epitaxy environment—a significant innovation relative to conventional semiconductor nanowire generation using *ex situ* gold nanoparticles. The introduction of these nanoscale features may enable an intermediate band solar cell while simultaneously increasing the effective absorption volume that can otherwise limit short-circuit current generated by thin quantized layers. The use of nanowires for photovoltaics decouples the absorption process from the current extraction process by virtue of the high aspect ratio.

While no functional solar cells resulted from this effort, considerable fundamental understanding of the nanowire epitaxy kinetics and nanopatterning process was developed. This approach could, in principle, be an enabling technology for heterointegration of dissimilar materials. The technology also is applicable to virtual substrates. Incorporating nanowires onto a recrystallized germanium/metal foil substrate would potentially solve the problem of grain boundary shunting of generated carriers by restricting the cross-sectional area of the nanowire (tens of nanometers in diameter) to sizes smaller than the recrystallized grains (0.5 to 1 μm^2).

Applications

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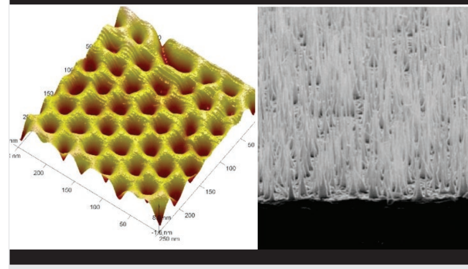
- Space-based applications
- Virtual substrates

Commercial

- Space-based power generation
- Photovoltaics:
    - Integration of III-V nanostructures on low-cost silicon substrates



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Phase II Objectives

- Demonstrate controllable gallium-arsenide (GaAS)-embedded InAs nanowire growth and characterization
- Demonstrate improved cell performance from nanowire-infused cells compared to standard GaAs cells

Benefits

- Offers solar cell efficiency of more than 40 percent
- Reduces costs in terms of photovoltaic array size, array weight, and launch costs
- Enables more optimal bandgap and material combinations for novel devices

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