Heterojunction Solar Cell Fabricated with Single-Crystalline GaN Nanorod Array

Arrays of one-dimensional nanostructures have important potential as building blocks for a variety of optoelectronic devices. They may be particularly useful in solar cells, because of their ability to carry photogenerated charges away from a junction region, thus minimizing recombination rates and improving conversion efficiencies. Now a team of researchers led by C.S. Lee and S.T. Lee at the City University of Hong Kong, H.T. Cong at the Chinese Academy of Sciences, and their collaborators have demonstrated a heterojunction solar cell based on an array of *p*-type GaN nanorods on an *n*-type Si substrate, with promising photovoltaic properties. They reported their findings in the December 10, 2008 issue of *Nano Letters* (DOI: 10.1021/nl801728d; p. 4191).

Gallium nitride is appealing for use in nanodevices because of its wide, direct bandgap, high-carrier mobility, good thermal and chemical stability, and its ability to be *p*- or *n*-doped. GaN nanorods are relatively easily grown on Si substrates with an oriented morphology and a large bandgap difference, making this an attractive potential combination for photovoltaic applications. Motivated by this logic, the Hong Kong group synthesized Mg-doped GaN nanorod arrays by thermally evaporating a powder mixture of $GaCl_3$ and $MgCl_2$ (molar ratio 30:1) for one hour at 850°C in a flow of high-purity ammonia and hydrogen onto a Si substrate that had been seeded with gold nanoparticles. The resulting nanorods had a uniform size distribution of approximately 100 nm in diameter and 1.0 μm in length, and were confirmed by high-resolution transmission electron microscope images to have a single-crystal wurtzite structure with no observable defects or amorphous shells. Energy-dispersive x-ray spectroscopy revealed that the Mg was uniformly distributed in each nanorod, in concentrations varying from 1.1 to 2.4 at.%.

The researchers next fabricated a solar cell using one of the arrays, by filling the spaces between the nanorods with insulating photoresist (PMMA) and then electron-beam evaporating a Ni/Au (30/50 nm thicknesses) electrode onto the nanorods and a Ti/Al (30/50 nm thicknesses) electrode onto the backside of the Si substrate. This *p*-GaN nanorod/*n*-Si heterojunction device, measuring 0.5×0.5 cm^2, was exposed to AM1.5G solar illumination with an intensity of 100 mW/cm^2, and was found to have a rectification ratio of better than 10^4 at ± 0.5 V, a fill factor of 0.38, and a power conversion efficiency of 2.73%. Additionally, the nanorod array displayed a relatively low reflection coefficient, as was expected from its one-dimensional array form, thus functioning as an antireflection coating for the device.

The researchers said that these "aligned GaN nanorods can be directly incorporated into the device structure without a complicated fabrication process." These results suggest that one-dimensional nanostructure arrays of GaN are promising components in heterojunction solar cells, and may one day lead to a technology impact rivaling that of GaN in light-emitting diodes.

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Urease-Functionalized Silica Enables Self-Mineralization

Hydroxylapatite (HAp) is found in teeth and bones, and is commonly used as a filler or surface coating in bone repair. Typically, coating deposition requires energetic, physically driven processes, such as plasma spraying and magnetron sputtering. Even solution-based processes require hydrothermal conditions that make unviable incorporation of labile bioactive compounds. Alternative, soft chemistry techniques require long time periods for HAp-like film formation. Biologically driven mineralization processes, however, have inspired biomimetic approaches for the preparation of biocomposites under mild conditions. Recently,