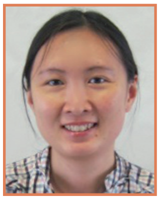

Nanowire Innovative Solar Cells

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In the quest for next generation photovoltaic technology, nanowire solar cells attract wide interest for two reasons. First, the enhanced light absorption of nanowire arrays, based on their anti-reflecting properties, light trapping and resonant waveguiding effects, allows for an order of magnitude reduction in the amount of materials, needed for an efficient solar cell. Second, due to their large surface/volume ratio, nanowires exhibit relaxed lattice-mismatch requirements allowing for high quality nanowire growth on less costly substrates (e.g. GaAs nanowires on Si). Recently, a conversion efficiency of 15.3% has been demonstrated using GaAs nanowires, underlining their potential to compete with other solar cell technologies.

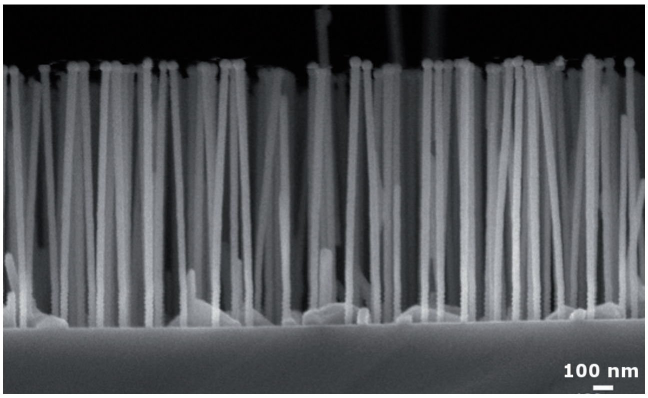

Fig. 1: SEM image of highly uniform GaAs nanowires grown on Si(111) substrates covered with chemical oxide.

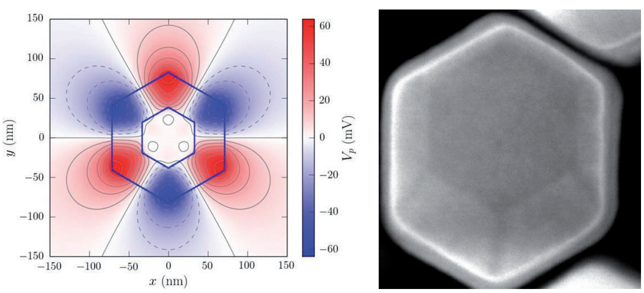

Fig. 2: (Left) Piezoelectric potential profile across a GaAs/In0.05Ga0.95As core-shell nanowire. (Right) Cross-section TEM picture of a GaAs/InGaAs core-shell nanowire.

A critical parameter in fabricating a nanowire solar cell is the uniformity of the nanowire array. This issue is typically addressed by pre-patterning the substrate in order to trigger simultaneous nucleation of the nanowires. This pre-patterning step, however, adds to the complexity and cost of fabrication of the nanowire arrays. In this project, we have devised a new method producing highly uniform GaAs nanowire arrays on unpatterned Si substrates. The method consists of a controlled chemical oxidation process to replace the native oxide on Si(111) substrate with a reproducible chemical oxide. As a result, a high yield (over 90%) of vertical GaAs nanowires is achieved with excellent uniformity on chemical oxide-covered substrate, as shown in Fig. 1. In addition, the structural quality of the nanowires is significantly improved and pure zinc blende crystal structure is achieved with minimal defects.

The above method was successfully extended to the case of GaAs/InGaAs core-shell nanowire arrays, with In content between 10-50%. In these nanowires, the piezoelectric potential profile shown in Fig. 2 is expected to reduce carrier recombination losses and improve the conversion efficiency. First solar cell devices have been fabricated in the context of this project, but have shown significant shunt resistance paths which need to be addressed.

OUTCOMES

Publications:

[1] Highly Uniform Zinc Blende GaAs Nanowires on Si(111) Using a Controlled Chemical Oxide Template, Nanotechnology 28, 255602 (2017).

[2] Strained GaAs/InGaAs core-shell nanowires for photovoltaic applications, Nanoscale Res. Lett. 11, 176 (2016).

[3] Ultra-low threshold polariton lasing at room temperature in a GaN membrane microcavity with a zero-dimensional trap, Sci. Rep. 7, 5542 (2017).

Oral presentations:

E-MRS, Warsaw, 2016

ISCS, Toyama, 2016.

Poster presentations:

J2N, Grenoble, 2017

MBE, Montpellier, 2016

NGW, Barcelona, 2015.

Collaboration:

Th. Kehagias, Aristotelean University of Thessaloniki, Greece.