SORINS
SELF-ORGANIZED RADIAL INP NANOPILLAR SOLAR CELLS

KTH · Srinivasan Anand
Aalto University · Harri Lipsanen

Motivation

Thermodynamic limit has been the main guideline to assess the performance limit of solar cells for decades. The driving force in the recent years in solar photovoltaics (PV) research has been the reduction of active cell thickness for cost benefit and at the same time maintaining high efficiency. Nanostructured devices in the form of nanowire (NW) or nanopillars (NP) are possible means for achieving the ultimate goal of making cheaper and more efficient solar cells.

Solar cells based on NPs can benefit both from the light trapping due to the pillars geometry, and the effective carrier collection due to the enhanced surface to volume ratio at the junction area (radial junctions). The continuous grading of refractive index obtained with conical pillars means no requirement for antireflection coating in solar cells and consequently results in higher short circuit current and higher efficiency. Among semiconductors, InP with a direct band-gap offers the advantage of efficient light absorption in very thin layers. Moreover, InP has a very high electron mobility and also its bandgap (1.34 eV) has a very good overlap with the maximum intensity of solar spectrum. InP also has a low surface recombination velocity (~ 103 cm/s) which makes it less affected by surface recombination which is ideal to realize efficient solar cells. Therefore, NW solar cells based on InP have a very good potential to reach the aforementioned goals.

Both growth techniques and top-down approaches have been used for fabrication of InP NWs. In the last few years tremendous efforts have been made in growth of NWs and progress in NW solar cells research has pushed the efficiency limit for InP NW solar cells with axial junction geometry to 14%. However, improvement in structural morphology with precise control over their composition and dopant concentration is still required. In this regard, realizing NW solar cells with radial junctions is advantageous, where relatively lower carrier diffusion lengths of NWs can be compensated without affecting the cell performance.

For large-scale fabrication, cost effectiveness is a very important issue. Here we propose a unique low-cost method to fabricate InP NPs with high optical quality at wafer scale without any requirement for patterning.

Results

Suitable processes for fabricating InP nanopillars were investigated. Ion beam etching of InP was developed to obtain nanopillars with wafer scale coverage. By controlling the etch parameters the height and shape of the nanopillars could be varied. The realization of radial p-n junction for carrier collection is achieved by a Metalorganic vapor phase epitaxy (MOVPE) overgrowth step on the fabricated pillars. The overgrowth is optimized for controlled lateral growth and doping levels. The results indicate the feasibility of this technology and optical data show that broad-band suppression of reflectivity can be obtained, a property useful for solar cells. The fabricated overgrown NPs with top down approach can also serve as a bench mark for bottom-up grown epitaxial wires in terms of materials quality and solar cell performance.