Extended Abstracts of the 2016 International Conference on Solid State Devices and Materials, Tsukuba, 2016, pp501-502

K-5-03(Invited)

Nanowire Based Photovoltaics

Enrique Barrigón

Division of Solid State Physics / Nanolund, Lund University, Box 118, SE-221 00 Lund, Sweden
Phone: +46 (0)46 222 3850 E-mail: enrique.barrigon@ftf-lth.se

Abstract

Nanowire (NW) solar cells are an innovative and promising way to further reduce the cost of photovoltaic electricity for terrestrial applications, due to their efficient light absorption and significant cost reduction. I will present an overview of the state-of-the-art and future development of NW solar cell technology, where we focus on InP and GaAs-based single and multijunction solar cell approaches.

1. Introduction

Deployment of III-V based solar cells for one sun applications has been hindered due to the high costs associated to their industrialization in comparison to Si-based photovoltaics technology. On the contrary, III-V nanowire (NW) solar cells have the potential to reduce the cost of photovoltaic (PV) electricity by means of reduced material consumption, production cost and relatively high efficiencies [1,2].

Material consumption can be reduced because of efficient light absorption in sub-200-nm-diameter III-V based NW arrays due to resonant light trapping. This enables typical NWs length of about 2 µm to absorb all incoming light with energy above the band gap [3]. Regarding cost production, Lund University and Sol Voltaics AB are developing a continuous growth system based on vapor–liquid–solid (VLS) growth called Aerotaxy, that employs no substrate and yields very high growth rates in comparison to MOVPE standard NW growth [4].

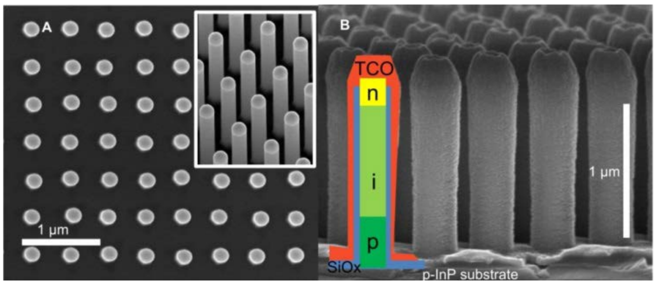

Fig. 1 (A) 0° and 30° (inset) tilt scanning electron microscopy (SEM) images of as-grown 180 nm diameter InP NWs in an array with 470 nm pitch. (B) Cross-sectional SEM image of processed InP NWs; the superimposed schematics illustrate the silicon oxide (SiOx, blue), transparent conducting oxide (TCO, red) and the p-i-n doping layers in the NW [5].

On the other hand, reported NW-based solar cell efficiencies have been increasing in recent years, outperforming several other next-generation PV architectures. In 2013 Lund University reported an InP NW solar cell array with a conversion efficiency of 13.8% at one sun (see SEM images of that device in Fig.1) [5]. Two years later, Sol Voltaics in collaboration with Lund University reported a new world record efficiency; an efficiency of 15.3% obtained with a GaAs-based NW solar cell array (see a picture of the solar cell in Fig.2) [6]. In both cases, NWs only covered around 13% of the cell area.

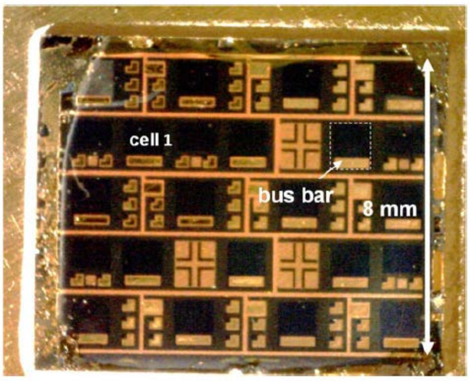

Fig. 2 Picture of a GaAs NW-based solar cell. The outline and busbar of one of the cells have been marked for clarity [6].

Still, there are new challenges and ways to further increase the efficiency of NW-based photovoltaic devices. In this work, an overview of NW solar cell development at Lund University will be presented, with special attention to the new challenges that are being faced. In particular, topics such as nano-imprint lithography, shell material assessment for passivation of GaAs NWs, GaAsP NW growth and doping using Aerotaxy and current development of GaInP/InP dual junction solar cell will be addressed.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 641023 and under the Marie Sklodowska-Curie grant agreement No 656208. Financial support of the Swedish Research Council and the Swedish Research Energy is also acknowledged.

References

[1] Borgström, M. T. et al. IEEE J. Sel. Top. Quantum Electron. **17**, (2011) 1050–1061.
[2] LaPierre, R. R. et al. Phys. Status Solidi RRL – Rapid Res. Lett. **7**, (2013) 815–830.
[3] Anttu, N. et al. Nano Res. **7**, (2014) 816–823.
[4] Heurlin, M. et al. Nature **492**, (2012) 90–94.

[5] Wallentin, J. et al. Science **339**, (2013) 1057–1060.
[6] Aberg, I. et al.IEEE J. Photovolt. **6**, (2015) 185–190.