Couplage des modélisations électriques/optiques pour l'étude de cellules à base de nanofils a-Si:H

A. Levtchenko[1], R. Lachaume[1,2], J. Michallon[1,2,3], S. Collin[3], J. Alvarez[1], S. Le Gall[1], Z. Djebbour[1*], J-.P. Kleider[1]

[1]Laboratoire de Génie Electrique et Electronique de Paris, UMR-CNRS 8507, Centralesupelec, Univ. Paris-Sud, UPMC, 11 rue Joliot Curie, 91192 Gif-sur-Yvette, France

* Département des Sciences Physiques, UVSQ, 45 avenue des Etats-Unis, 78035 Versailles, France

[2] Institut Photovoltaïque d'Ile-de-France, 8 rue de la Renaissance, 92160 Antony, France

[3] Centre de Nanosciences et de Nanotechnologies, CNRS, Univ. Paris-Sud, C2N – Marcoussis, 91460 Marcoussis, France

Recently, many researches have been focused on the development of nanowire (NW) arrays for microelectronic and photovoltaic applications. Significant improvements of nanowire growth and properties have been reported. In the context of photovoltaics, optical modeling has been used to demonstrate light absorption enhancement in NW arrays as compared with planar layers [1-3]. It is now mandatory to couple optical models to electrical simulations to assess the efficiency of carrier collection and properly evaluate the energy conversion efficiency in NW solar cells. In this work, coupled optical/electrical simulations are performed on solar cells consisting of arrays of nanowires on c-Si substrates, conformally coated with hydrogenated amorphous silicon (a-Si:H) yielding radial nanowire p-i-n heterojunctions and planar heterojunctions between them (Figure 1(a)). For this purpose we first perform 3D optical calculations based on Rigorous Coupled Wave Analysis (RCWA), and then we couple them to a semiconductor device simulator based on the finite volume method that exploits the radial symmetry of the NWs (Figure 1(b)). We show that, depending on the back contact work function, the planar heterojunction, in between the nanowires, can degrade the open circuit voltage of the whole system (Figure 2(a)) due to the increase of the dark current in this part (Figure 2(b)) [4].

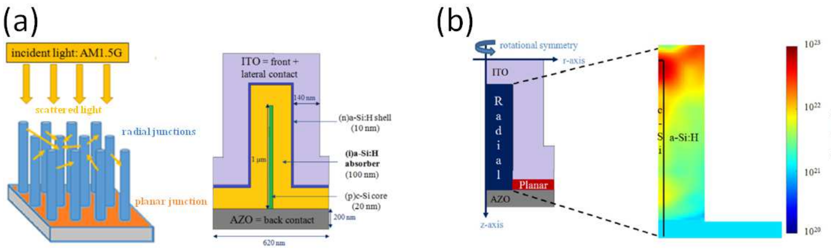

Figure 1 (a) Geometry of the simulated nanowire array and detailed structure of a single nanowire with the planar cell interspacing that has been modelled.
(b) Sketch of the radial symmetry of nanowires with the surrounding planar part and corresponding photogeneration rate distribution calculated by RCWA.

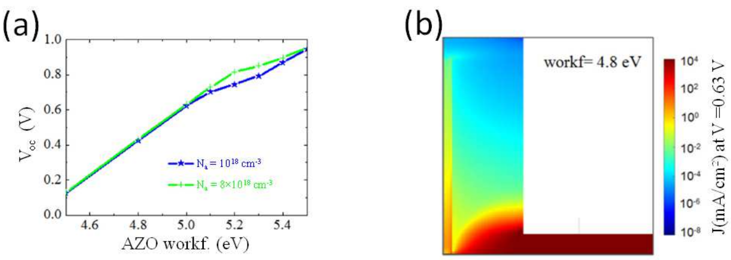

Figure 2 (a) Open-circuit voltage (Voc) as a function of AZO work function for two doping concentration values.
(b) Distribution of the dark current in the entire structure at a fixed bias, for a low back contact workfunction value.

[1] Yu Linwei *et al*. *Sci. Rep.* **4**, 4357 (2014)
[2] M. Foldyna *et al*. *Sol. Energy Mater. Sol. Cells* **117**,645 (2013)
[3] J. Michallon *et al*. *Opt. Express* **22**, A1174-A1189 (2014)
[4] A. Levtchenko *et al*. *Phys. Status Solidi C,* 1700181 (2017). doi:10.1002/pssc.201700181