

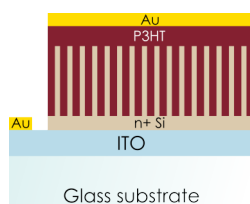
# Nano-hybrid solar cells based on thin film silicon and P3HT

Pierre-Jean Alet <sup>(1,2)</sup>, Serge Palacin <sup>(1)</sup>, Rémi de Bettignies <sup>(3)</sup>, Stéphane Guillerez <sup>(3)</sup>, Yassine Djeridane <sup>(2)</sup>, Linwei Yu <sup>(2)</sup>, Pere Roca i Cabarrocas <sup>(2)</sup>

<sup>(1)</sup> CEA Saclay, Laboratory of Chemistry of Surfaces and Interfaces, DSM/IRAMIS/SPCSI/LCSI, Bât. 462 - P.C. 53, 91191 Gif-sur-Yvette cedex, France

<sup>(2)</sup> Laboratory of Physics of Interfaces and Thin Films (LPICM), CNRS/Ecole Polytechnique, 91128 Palaiseau cedex, France

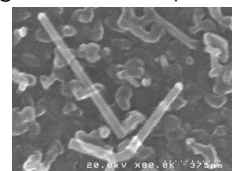
<sup>(3)</sup> CEA INES RDI, Laboratory of Solar Components, 50 avenue du Lac Léman, 73370 Le Bourget du Lac, France



**Fig. 1:** Ideal side-view of the device.

**Abstract:** This project started in 2005 and aims at investigating the feasibility and potential of solar cells based on a brush of silicon nanowires covered with P3HT. The goal of this structure is to reduce the distance from any point of the polymer to its interface with the electron acceptor (here, silicon) and ideally to make it lower than the diffusion length of excitons. In addition, the nano-structured silicon provides a continuous electric path from the interface to the electrode and it can contribute to the absorption of solar light. The collaboration between the three laboratories is realized through a PhD thesis.

**Current status and main results:** The first step of this work has been to investigate the interface between silicon and P3HT, especially through devices with flat layers, which efficiency has reached 1.6%. Both materials can contribute to the photocurrent [1]. Then, methods have been developed to grow silicon layers with increasing surface to volume ratios: hydrogenated amorphous silicon, "conventional" and high-roughness micro-crystalline silicon and silicon nanowires. The latter typically grow through the Vapor-Solid-Liquid mechanism, which involves metal catalyst aggregates (Au or Cu) controlling both the size and the density of the final structures. By annealing evaporated thin gold layers, such droplets can be obtained at temperatures as low as 200°C on TCO, which opens the way to low-temperature growth of silicon nano-structures [2]. Finally, nano-structured layers are currently incorporated in devices. The effects of the design and the nature of the metal electrodes have also been investigated.



**Fig. 2:** Silicon nano-wires grown on ZnO [2]

**Conclusions:** The combination of nano-structured silicon thin films with P3HT in photovoltaic devices is promising. It can be further enhanced through the chemical control of the interface and thermal treatments. How these treatments affect the electrical behavior of the device and the infiltration of the silicon layer by the polymer is currently under investigation.

**About us:** The Laboratory of Chemistry of Surfaces and Interfaces (LCSI) works on the chemical modification of surfaces, mainly through electrochemistry. The applications of these techniques range from water treatment to organic electronics. It has also developed an expertise in the characterization of chemical species and bonds on surfaces by techniques such as X-ray photoelectron spectroscopy (XPS). Contact: Serge Palacin (serge.palacin@cea.fr); web site: [www-drecom.cea.fr/spcsi](http://www-drecom.cea.fr/spcsi)

The Laboratory of Physics of Interfaces and Thin Films (LPICM) works on plasma enhanced CVD of inorganic semi-conductors, especially silicon, with applications to large area electronics and solar cells, on carbon nanotubes and on polarimetry. A new group recently started activities on OLEDs. The work presented here is mainly done in the group "Nanostructured Semiconductors and Thin Films" lead by Pere Roca i Cabarrocas (pere.roca@polytechnique.edu). Web site: [www.lpicm.polytechnique.fr](http://www.lpicm.polytechnique.fr)

The Laboratory of Solar Components (LCS) is specialized in organic solar cells, with a strong expertise in characterization. It is now part of the French National Institute of Solar Energy (INES). Its activities are detailed elsewhere. Contact: Stéphane Guillerez (stephane.guillerez@cea.fr).



Pierre-Jean Alet (pierre-jean.alet@cea.fr) started his PhD in November 2005. He was originally trained as an engineer with an emphasis on modeling but his work is now mainly experimental. His contribution to the project covers investigations on the deposition of the silicon thin films and their characterization, fabrication and characterization of devices as well as developments on some experimental setups.

[1] P.-J. Alet, S. Palacin, P. Roca i Cabarrocas, B. Kalache, M. Firon and R. de Bettignies, "Hybrid Solar Cells Based on Thin-Film Silicon and P3HT", *Eur. Phys. J. B – Appl. Phys.*, **2006**, *36*, 231

[2] P.-J. Alet, L. Eude, S. Palacin and P. Roca i Cabarrocas, "Transition from thin gold layers to nano-islands on TCO for catalyzing the growth of one-dimensional nanostructures", *Phys. Stat. Solidi A*. (accepted)