SOLAMON Final Report: Executive Summary

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Executive Summary

Within the FP7 programme, the SOLAMON[1] project, launched in February 2009, targets the conversion efficiency enhancement of thin-film solar cells through optical plasmonic effects. The research consortium, coordinated by CEA-Liten, gathers 5 partners among the major European thin film solar cells players together with the Australian pioneer in the field of improvement of solar cell performances through nanomaterials. SOLAMON activities address various thin film solar cells like a-Si-H, organic and Dye sensitized cells.

The quantitative objective of SOLAMON is an increase of 20% in the short circuit current density of the solar cells. For that purpose, the concept of Plasmon Generating Nanocomposite Materials (PGNM) has been introduced, consisting in metallic nanoparticles (NP) of well controlled characteristics embedded in a matrix. This nanocomposite associated with the active layer is expected to boost the absorption of sun light and lead to a more efficient electrical carrier generation (fig. 1).

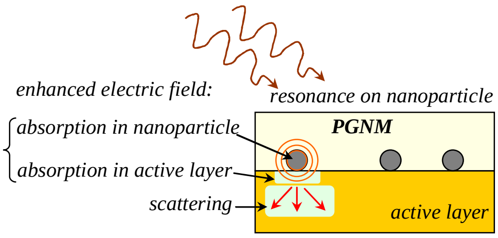

Fig.1: PGNM promotes absorption and scattering in active laver

PGNM synthesis

The deposition of well controlled small Ag NPs (ϕ<10nm) inside various matrices was demonstrated. The deposition of larger NPs (ϕ=10~50nm) promoting far field Plasmon resonance scattering was also made possible on the basis of a new source design (patent pending). Despite a broader size distribution, good process control and reproducibility were achieved. Furthermore, going beyond the scope of SOLAMON, preliminary experiments demonstrated the feasibility of Ag/Al_20_3 core shell NPs that could be advantageously used in PGNM-based solar cells for electrical management purpose.

PGNMs based solar cell design

The building blocks required for a complete modelling of PGNM-based solar, namely the MMP simulation code for the determination of PGNM optical properties, the optical Sunshine simulator and electrical ASPIN code have been integrated successfully. The EQE and I/V curves of the different cells integrating or not PGNMs were simulated and some of them experimentally validated. At the present state of progress and taking into account only the far field Plasmon resonance effect, we already get first evidence of the potential interest of PGNMs into Dye sensitized cells. In return, for organic and a-Si:H solar cells, no noticeable improvement was foreseen with sub-30nm Ag NPs very near or directly inside the active layer. However, preliminary modelling refinements taking better into consideration the near field Plasmon effect should improve these predictions.

PGNMs integration in solar cells

The PGNMs layers were successfully integrated in the different cell technological chains (a-Si;H, OSC and DSSC) since most PGNMs based cells were found to correctly operate. Some of them like organic cells seem to exhibit some improvement (+5%) of their photocurrent and efficiency. However, the experimental results confirmed the modelling predictions that embedding Ag NPs can strongly impact the electrical chain of the solar cell; this was found obvious for the a-SiH cells, much less in the organic cells. For DSSC cells, an additional chemical compatibility issue between electrolyte and Ag NPs was evidenced. However, the new core-shell technological solutions could solve both, electrical and chemical issues.
A first assessment of the costs of the vacuum NP technology shows that, at the present level of technological maturity, the additional cost of PGNM based a-Si:H solar cell would be negligible.

Conclusion:

After 2 years of research, the basic tools necessary to the development of Plasmon-based solar cells have been successfully implemented, in particular a patented low temperature large NP deposition technology, an optical and electrical model dedicated to the simulation of PGNM-based solar cell structures and a complete technological chain now operational for NPs integration in thin film solar cells. The results obtained sofar showed that the main objective of SOLAMON could not been reached (+20% increase in photocurrent), mainly because of enhanced electrical recombination issues. That is why, on the basis of the SOLAMON foreground, new technological solutions are proposed to produce large passivated core-shell metallic NPs. Two technological patents have been filled for the production of this new kind of NPs.

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[1] http://www.solamon.eu/ ; Contact: Etienne.quesnel@cea.fr