FINAL PUBLISHABLE SUMMARY ALD4PV

Atomic layer deposition (ALD) is a vapour-phase deposition technique that can be used to tailor interface properties of devices by depositing high-quality thin films with precise growth control, very good uniformity over large areas and excellent coverage on irregular surfaces at relatively low temperatures. These unique features make ALD very attractive for many solar cell designs that require (ultra)thin layers. Photovoltaic applications of ALD include absorber films, buffer layers, interface layers, transparent front contacts, photoanodes, encapsulation layers and surface passivation films. From the manufacturing point of view, ALD is on the verge of being introduced in the PV industry and it is expected that it will be part of the standard solar cell manufacturing equipment in the near future.

The relevance and potential of ALD of different materials for different layers in crystalline silicon solar cells, thin film solar cells, and dye-sensitized solar cells (DSC) were explored during this fellowship. Collaborations with industrial and academic partners of the host group proved very beneficial and fruitful. A summary of the most significant results follows.

1. Passivation properties of ALD Al_2O_3 films and Al_2O_3/ZnO stacks for silicon solar cells. We have found that the stacks perform particularly good and the results were compiled in a fast-track communication published in the journal Semiconductor Science and Technology. This publication was highlighted in the Europhysics News. Some of the tests were conducted together with the company Hanwha Q-Cells (Germany). The use of ALD will enable the processing of passivation layers for new concepts of solar cells (*e.g.* 3D structured devices) with higher efficiencies, which is not possible using conventional deposition techniques.

2. ALD for dye sensitised solar cells (DSCs). The novel use of ALD-platinized counter electrodes for flexible DSCs was published in the journal Advanced Energy Materials. We also explored the feasibility of ALD to produce other parts of the DSSCs, namely barrier layer and compact layer, using different metal oxides. This research was conducted in close collaboration with the Centre for Hybrid and Organic Solar Energy (C.H.O.S.E.) of the Department of Electronic Engineering at the University Tor Vergata of Rome (Italy).

3. Use of alternative precursors to dope ALD ZnO and produce highly conductive and transparent TCOs (transparent conductive oxides) for various types of thin-film solar cells. Novel doping precursors were studied, and the promising results will be compiled in a publication. We expect that this work will be useful for different types of solar cells such as silicon and thin film solar cells (CIGS, a-Si, CdTe and DSCs), as they use TCOs for different layers.

In March 2014 shortly after concluding the project, a workshop was organised to highlight the potential of ALD for the various solar cell technologies investigated within the framework of the IEF project. The website of the workshop is: http://phys.tue.nl/PMP/Nanomanufacturing/