Organic and Printable Photovoltaics at CSEM

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The Printable PV activity at CSEM addresses disruptive, organic and inorganic printable materials and processing technologies that target applications with design added value and reduced environmental impact. The additive technologies developed are aimed at mass customizable manufacturing of PV products with high automation and reduced capital equipment cost. The objective is to provide Switzerland with know-how and technological options at the device design and process development level to support equipment developer, materials researchers and industrial suppliers as well as end users in the emerging field of printed PV.

Design and customizability of printable PV

The use of printing methods for the deposition of all layers required in an OPV stack allows direct patterning of all layers and thus printing of any desired shape of cell – and consequently module. The design feature of printed OPV is thus not only of aesthetic value but it allows the embedding of a module into an electrical device without limiting the design of the device. This opens up totally new market potential for printed OPV. In a design example below (Figure 1a), a module consisting of 9 interconnected cells in series were fabricated, by coating the photoactive layers on a flexible substrates, which were patterned in a single post-patterning step, followed by a screen printed top electrode.

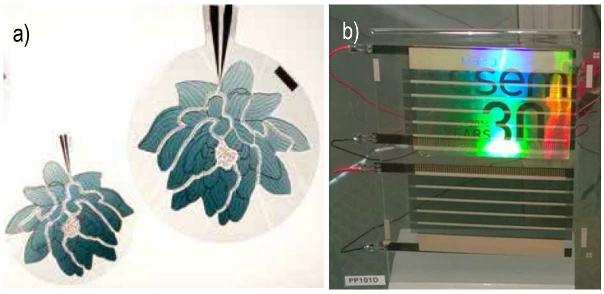

Figure 1: a) Free-shape modules; b) Module with integrated logo.

From small labscale cells to demonstrators

During the past years, CSEM has developed their printing and device fabrication capability from lab-scale single cells made by spin-coating in an inert gas on small 2.5x2.5cm glass substrates, through dr. blade coating in the ambient environment on increasingly larger substrates to complete modules printed on flexible substrates (Figure 2).

Figure 2: (left) 2.5x2.5cm spincoated cells on a glass substrate, (middle) 5x5cm blade coated cells on a glass substrate and on a flexible substrate, (right) a mini-module.

Recently, our first slot-die coated cells were fabricated with an efficiency of ~6% in a single junction using commercially available material, still on glass. Our current efforts focus on the transfer of the establish processes for glass substrates to flexible substrate. Part of this transfer is complete. Using screen printing or inkjet printing metal grids that can be used for the bottom or the top grid were demonstrated (Figure 3).

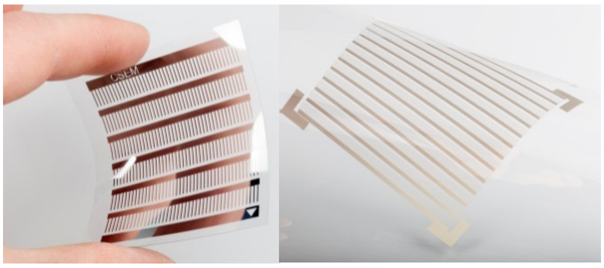

Figure 3: Example of (left) an inkjet printed silver grid, (right) a screen printed grid.

Module development

Such screen printed grid was integrated in one of our latest module demonstrators (Figure 1b). The module in the Figure 1b is fully printed on a flexible substrate, and encapsulated between flexible barriers. The performance of the device is 3-4% at the cell level. To generate an eye-catching effect, a foil with a nano-textured holographic logo (30 years CSEM) was integrated into the inside of the module, by lamination between the barrier foils.

Towards high efficiency printed tandem cells

To enable the next generation of OPV, a process was developed to fabricate tandem solar cells. Using the tandem architecture efficiencies well over 10% are expected to be feasible. Selected organic and inorganic materials were blade-coated on glass substrates from non-halogenated solvents at ambient conditions, and at temperature below 120°C. Nanometer control of the layer thicknesses (see Figure 2 for a TEM analysis of the stack) lead to an 8.5% tandem cell realized in our lab.

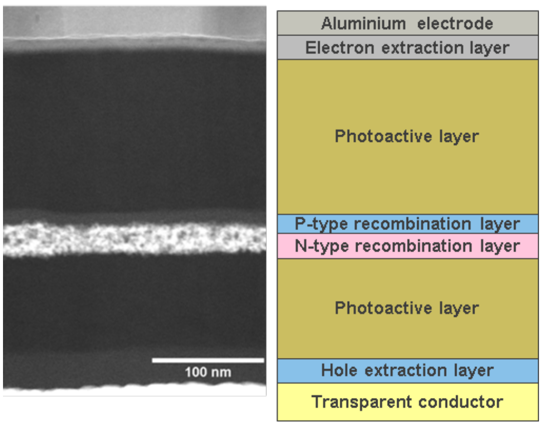

Figure 4: TEM cross-section and schematic representation of an 8.5% organic tandem cell.

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