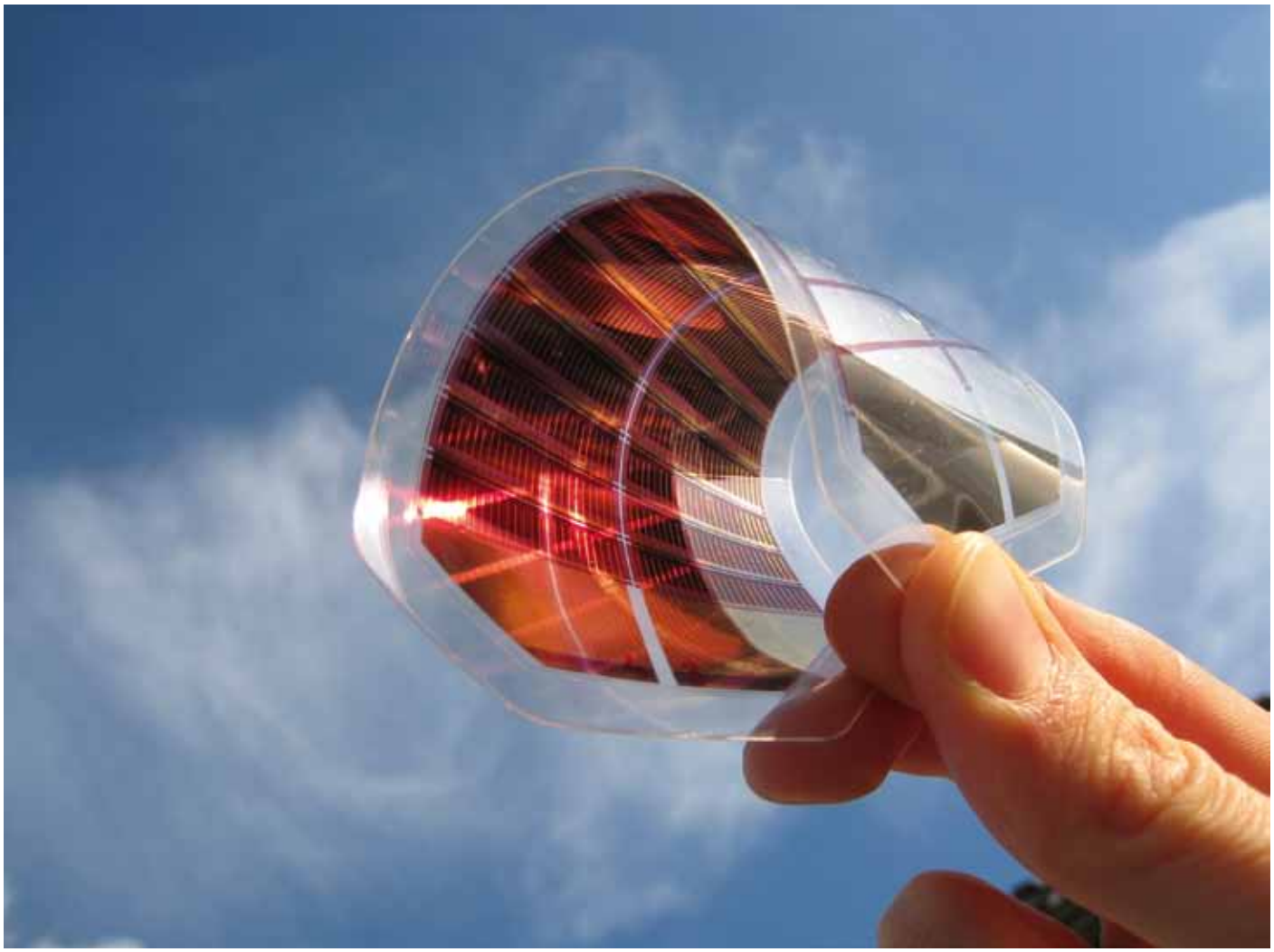

Photo: Fraunhofer ISE/Birger Zimmermann

ITO-free organic solar module.

Hot Topics in OPV Research

Fraunhofer ISE experts think that printed organic solar cells can soon reach mass markets. First, the optimal combination of the different materials and cell-components needs to be identified.

Organic solar cells are the natural choice when it comes to remotely powering printed organic electronic devices. Up until now, organic photovoltaic (OPV) technology has not been successful in a broad market because of an unbalanced mix of properties, even though it can provide lightweight, flexible and potentially cheap solar cells. “With respect to what organic solar cells can offer in terms of power output and lifetime, they are just too expensive to use them in mass market applications,” Dr. Birger Zimmermann from Fraunhofer ISE says. “This is why OPV research has put a lot of effort into replacing costly components like, for example, the transparent ITO-electrode”, adds Dr. Uli Würfel.

Varying approaches were taken, ranging from a combination of an organic transparent conductor in combination with printed silver grids, nanowires or graphene and carbon nanotubes.

One interesting and near- term technologically feasible alternative is a less than 10nm thin Ag layer sandwiched between two metal oxides, which can be used as a direct replacement for ITO since the electrical and optical properties are very similar. Besides lower costs, this electrode has superior mechanical properties. The thin silver layer does not crack upon bending like ITO does which allows maintenance of a low sheet resistance even after

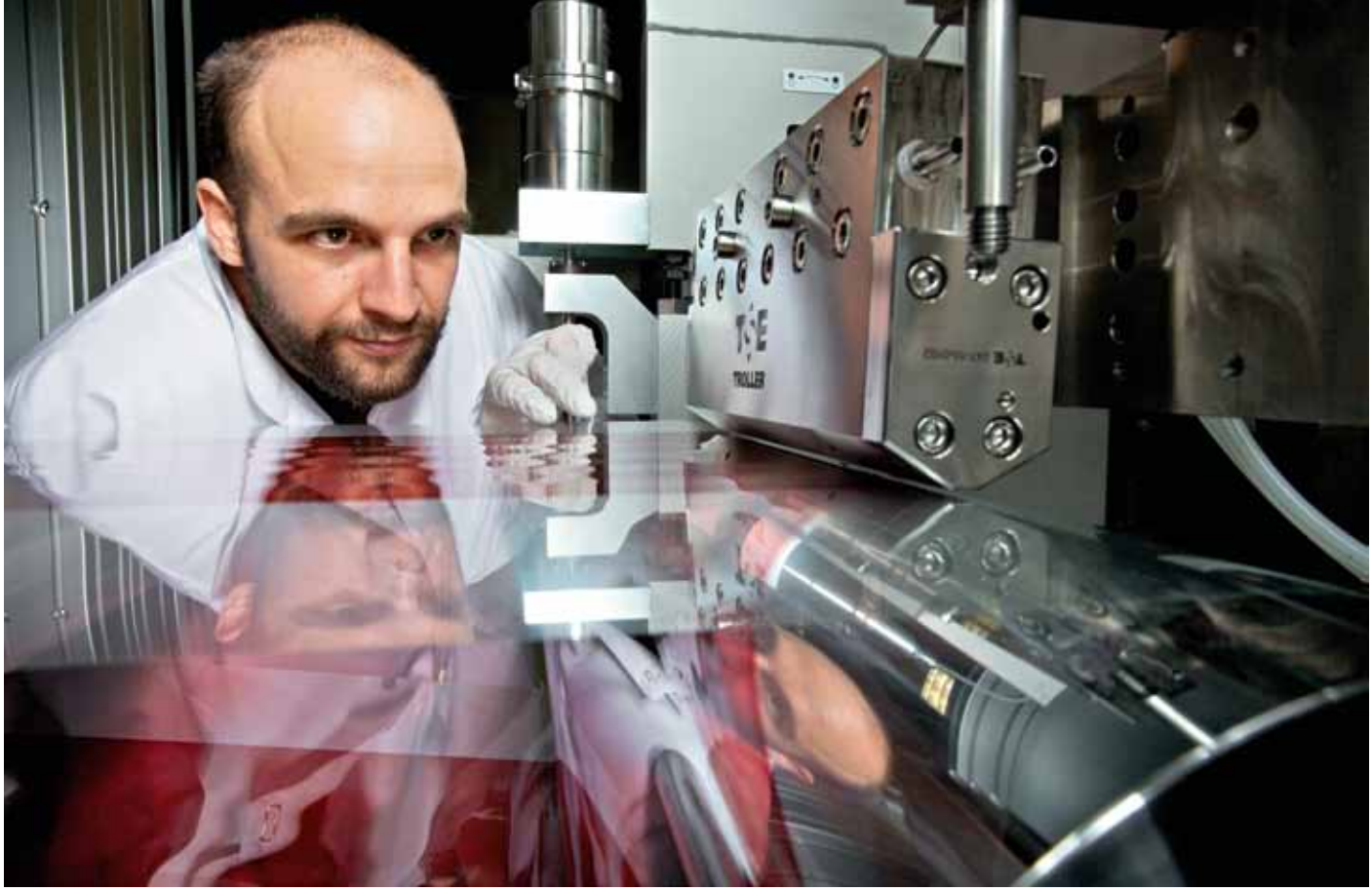

Photo: Fraunhofer ISE/Thomas Klink

Roll-to-Roll coating of the 220nm thin photoactive layer.

numerous bending cycles. “We reached more than 6% efficiency which is 90% of the efficiency of an ITO based reference device using the same photoactive materials”, Dr. Würfel reports.

For even lower costs, the researchers at Fraunhofer ISE are working on cell and module concepts based on opaque metallized PET-film similar to chips bags as the back electrode and an organic transparent front-electrode. Initial results on processing these solar cells with roll-to-roll slot die coating from non-halogenated solvents under atmospheric conditions are very encouraging as these devices can reach comparable efficiencies to cells that are processed under laboratory conditions.

With the so called “wrap through circuitry” concept based on this approach, in principle, one can even make modules with higher area utilization without using ITO or silver. “At lab scale this concept has shown very promising efficiencies but there are still some technical issues to be solved. For low-light applications one could use a simple stripe module using only the organic transparent electrode without additional current collecting scheme as a grid or wrap through circuitry”, explains Dr. Zimmermann from numerical modeling and characterization of the solar cells under indoor-lighting conditions. This offers a very low-cost approach for these niche applications, he says. The remaining dominant cost factor is the barrier film for encapsulation as organic solar cells need protection from oxygen and water vapor.

Although organic solar cells have been proven to be stable for thousands of hours during operation if encapsulated properly, researchers worldwide are still working on improving the stability on all scales; beginning with the basic organic semi-conductors and their morphology to the device stack with electrodes and interfacial layers to improved glues as well as better and more cost-efficient high-barrier films to decrease the cost for encapsulation. ”Advanced characterization methods help us to identify which component of the solar cell causes degradation, and imaging techniques can help reveal where the problems occur in the device”, Dr. Würfel explains.

Especially the interfacial layers have recently attracted a lot of attention as it turned out that they can simultaneously improve the efficiency and the stability of the devices. Furthermore, they are key components for multi-junction devices as the internal recombination contact can be constructed from these materials. Multi-junction solar cells are some of the most promising pathways to efficiencies in the range of 15% for organic solar cells which is one prerequisite for broad adoption of this technology in the power market. This is because the surrounding infrastructure of a PV power plant adds the so called balance-of-system costs which the solar modules have to cover with the electricity generated.

Dr. Würfel sees the need for significant progress if outdoor applications for electrical power generation are the goal, but he is very optimistic that there are applications for printed organic solar cells in the printed and organic electronics segment in near term. “The key is to find the optimal combination of the different components, device stack and module layout, and this optimal choice depends on the specific application you have in mind”, summarizes Dr. Zimmermann. \\

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