Karlsruhe Institute of Technology

Division III – Mechanical and Electrical Engineering

Light Technology Institute (LTI)

Material Research Center for Energy Systems (MZE)

Sustainable Solar Solutions

Rethinking Photovoltaics: Developing new areas for solar energy harvesting

The integration of solar modules into greenhouses warrants shading of the crop during times of strong insolation. The smart design of the solar cells allows the light used for photosynthesis to pass while harvesting the remaining solar energy to operate interior appliances.

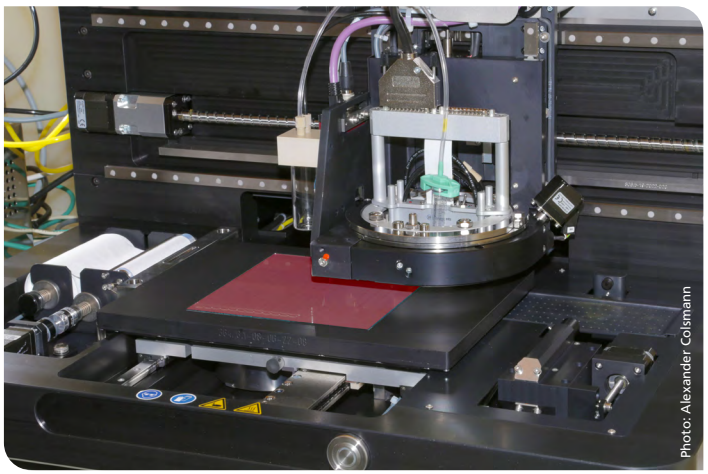
The growing demand for renewable energy lets us to rethink strategies for solar energy harvesting. The future belongs to the dual use of land: solar energy harvesting will be combined with agriculture, with building façades or with otherwise sealed surfaces. This development of new areas for photovoltaic installations also benefits the primary use of the area. The shading of crop with highly specialized solar modules in greenhouses or even on open fields provides sun-protection for the crop while selectively allowing the "good" part of the solar spectrum to reach the plants (agrivoltaics). Photovoltaic building facades or overhead glazing allow buildings to be customized or offices to be shaded. Lightweight solar modules on plastic foils can be retrofitted on factory buildings at reduced installation costs, where the delicate statics cannot support heavy solar energy harvesting installations. The integration of solar cells into everyday infrastructures and their large-scale production call for production processes with minimal environmental impact.

Lowest environmental impact: Organic solar cells

Among the emerging photovoltaic technologies, organic solar cells stand out with a projected fully eco-friendly cradle-to-grave life cycle, using abundant carbon-based raw materials while largely avoiding rare elements and toxic compounds. The minimal semiconductor demands of about 0.1 g/m^2 will leverage unsurpassed energy payback times of a few days, which are critical for a rapid ramp-up of solar cell production in the face of climate change.

Ctrl-P: Solar cell fabrication by printing

Device fabrication by printing and coating of the organic solar cells enables freedom of design in shape and color. Similar to the printing of daily newspapers, organic solar cells are projected to be produced on large roll-to-roll production lines, with a different layout every day if required. More importantly, printing processes entail one of the lowest carbon footprints in industrial production and are often considered to significantly reduce production costs. One day, solar cells may be printed at home on consumer inkjet printers.



High-precision inkjet printing of semiconductor layers enables the free-form design of organic solar cells. Typical layer thicknesses are on the order of 1/100 of the thickness of a human hair.

Photo: Alexander Colsmann

KIT has invented highly specialized and eco-friendly organic semiconductor inks for the fabrication of organic solar cells from water or alcohol instead of toxic aromatic solvents.

Eco-friendly solar cell production from water

Increased awareness of sustainability and legislation on the Restriction of Hazardous Substances (RoHS) has fostered many innovations in eco-friendly production processes in industry. Coating processes, in particular, have undergone major transformations from toxic and/or carcinogenic to less harmful media, examples of which include the development of water-based car finish or dispersant wall paints. Contrary to industry standards, as of today, organic solar cells are often deposited using aromatic or even chlorinated solvents, which not only pose health risks in large-scale industrial production but also entail solvent vapor capture techniques that would drive up production costs.

KIT has developed and patented a novel ink design, based on dispersions of organic semiconductors in water or alcohols. Highest performances are enabled by using a novel electrostatic stabilization concept instead of surfactants which would otherwise remain in the solar cells where they would impair the performance of the device.

Rapid semiconductor ink design

The eco-friendly solar inks consist of a complex and well-balanced composition of compounds, tailored to the requirements of the individual application. In order to maximize the development speed and reduce the development costs at the same time, KIT operates a high-throughput and automated robotic system, the Energy Materials Acceleration Platform (E-MAP). It is capable of ink synthesis, the deposition of functional layers thereof and their characterization.

Technology offer

KIT invites industrial partners to advance the cutting-edge, eco-friendly aqueous inks for the production of organic solar cells and other semiconductor applications. KIT seeks partnerships with industry to promote the integration of organic solar cells into novel applications, such as façade or window integration, agrivoltaics, internet of things (IoT) or mobile applications. KIT offers sampling of tailored organic solar cells, device fabrication in world-class research laboratories, and device characterization from fundamental understanding to real-world appliances.

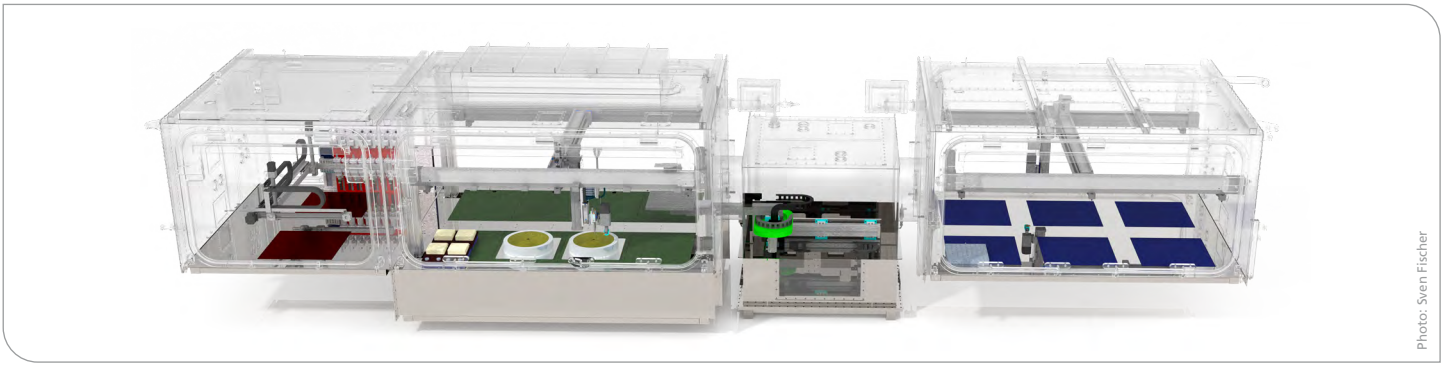


Photo: Sven Fischer

To accelerate the development of high-performance photovoltaic inks, KIT operates an automated research platform capable of ink synthesis, layer deposition and characterization (E-MAP).

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