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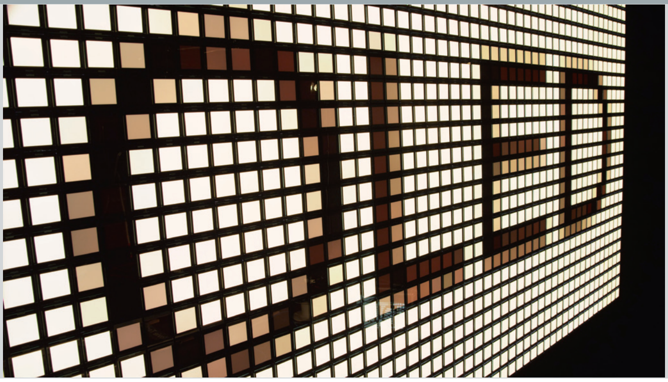

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SCATTERING LAYERS

TO IMPROVE THE EFFICIENCY OF SOLAR CELLS AND OLED LIGHTING

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Motivation

In order to increase the efficiency of thin film solar cells and OLED lighting, the management of light, loss modes and in-/outcoupling plays a key role. For OLED lighting, the outcoupling of light from the electroluminescent stack through the electrodes and the substrate is crucial. For thin film solar cells, it is demanded that the light path is prolonged within the absorber material. Fraunhofer ISC has developed scattering layers which support the light management for both OLED lighting and thin film solar cells.

The scattering layers are applied by wet chemical process and can be adapted to the desired property by adjusting ratio, size and chemical functionality of nanoparticles, inorganic networks and hybrid polymers. The selection of the respective combination of material concepts is determined by the temperature which is to be applied during the processing and by the thermal stability required in subsequent process steps. The respective layers are compatible to process steps used in the fabrication of OLEDs and thin film solar cells (vacuum stable, chemical inertness).

Scattering layers by Fraunhofer ISC

The scattering layers developed at the Fraunhofer ISC are based on sol-gel chemistry. The coating can be performed by dip-coating, spray coating or other application methods for wet chemicals. If necessary, solvent free solutions can be offered to create layers with comparably high thermal stability (up to 200 °C). If solvent based solutions are allowed, the thermal stability can be increased to values up to > 600 °C. The low-cost processing makes the materials superior to alternative etching or imprinting processes, not only regarding economic aspects but also in the way in

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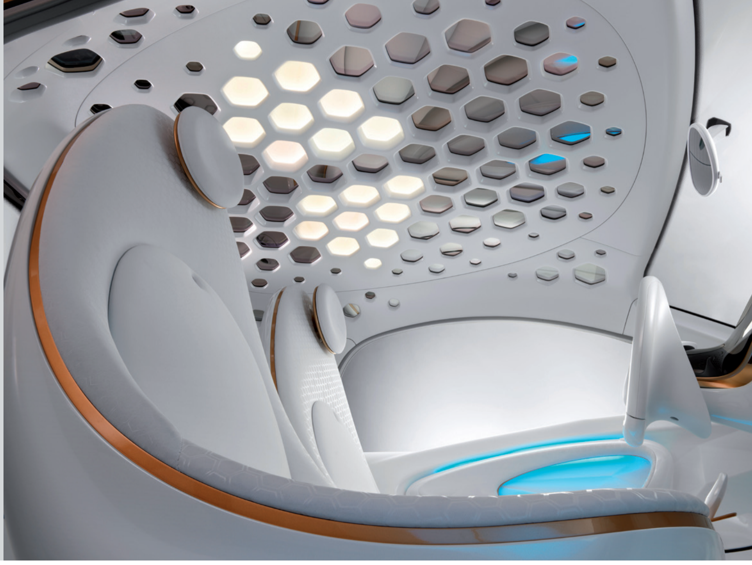

which the scattering properties can be adjusted. Just by varying the composition, the layers scatter predominantly at small or large angles. The material processing is chosen in a way as to provide the scattering layers with a high abrasion resistance.

Application 1 –
Thin film silicon solar cells

Thin-film silicon solar cells can be produced at very low cost and therefore have a short energy payback time. However, especially due to the low absorption in the longer wavelength range, they fall behind in overall efficiency. To compensate for that, the light path through the absorber material has to be prolonged. This can be achieved by inserting a scattering layer in the PV-device between the substrate and the front contact. These layers might replace any etching of front transparent conductive oxide (TCO). By scattering the light at the front contact the light path through the absorber is extended, which results in a higher efficiency of the solar cell. Besides, the TCO can be applied in a way as to improve the electrical performance as it eliminates any etching step of the front contact.

Application 2 – OLED lighting

One of the loss mechanisms in OLED lighting systems is the reflection on the interface between glass substrate and ITO electrodes. An internal light outcoupling (ILO) layer can be used to improve the incoupling from the ITO into the glass substrate. The external light outcoupling (ELO) layer, which might be realized by micropatterns, additionally supports the outcoupling. In such OLED stacks, the refractive index of the scattering layer should be as close as possible to the refractive index of the ITO in order to enable a light extraction from the ITO to the scattering layer. Similar to the scattering layers designed for thin film solar cells, the optical properties can be adjusted at a wide range (refractive index, haze): The roughness of the scattering layers is optimized in a way to realize a deposition of ITO with high conductivity.

2 LED design variety for lamps (© Philips Lumiblade)
3 Philips design study (© Philips Lumiblade)

Haze	0% - 99%	
Thermal stability	*solvent-free* 200 °C	*solvent-based* > 600 °C
	refractive index between 1.45 and 1.6 *thermal stability up to 200 °C*	*refractive index above 1.6* *thermal stability up to > 600 °C*
Process temperature	> 100 °C	> 500 °C
Surface roughness (rms)	< 10 nm	> 40 nm
Layer thickness	>500 nm	< 500 nm