PRESS RELEASE

Even thinner solar cells through use of nanoparticles?

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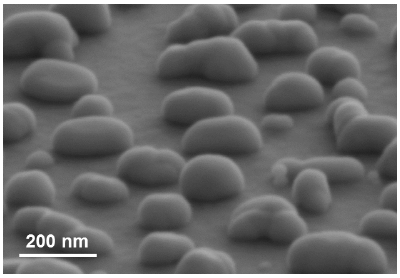
Nanostructures could enable more light to be directed into the active layer of solar cells, increasing their efficiency. Prof. Martina Schmid (HZB und Freie Univ. Berlin) has now measured how irregularly distributed silver particles influence the absorption of light. She demonstrated that nanoparticles interact with one another via their electromagnetic near-fields, so that local "hot spots" arise where light is concentrated especially strongly. The work has been classified by *Europhysics News*, the magazine of the European Physical Society, as a highlight and points the way for improved designs of these kinds of nanostructures.

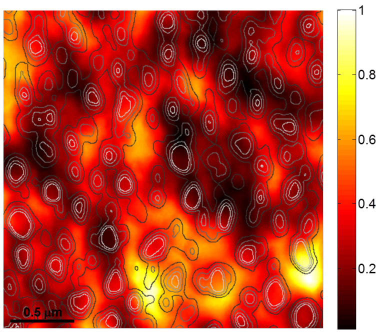
It is desirable even with thin-film solar cells to utilise less material and thereby save on fabrication costs. As an example, chalcopyrite cells (i.e. copper-indium-gallium-diselenide, or 'CIGS' cells) in part consist of rare-earth elements like indium and gallium. If the active layer is made too thin, however, it absorbs too little light and the efficiency level drops. Nanostructures on top of the active material might be able to capture the light and thus increase the efficiency. This idea is being pursued by Prof. Martina Schmid, who heads the NanooptiX group of junior scientists at HZB and holds a junior professorship at Freie University Berlin. "Our objective is to optimise nanostructures so they selectively direct certain wavelengths of the solar spectrum into the cells."



The silver nanoparticles are irregularly shaped and randomly distributed over the surface, as shown by the scanning electron microscope image.
Image: HZB

Irregularly distributed nanoparticles

One option to achieve this is to construct simple nanostructures from metallic particles that self-organise by heat-treatment of a thin metallic film. Martina Schmid initially coated a glass substrate with an extremely thin film of silver (20 nm), which she subsequently subjected to heat treatment. Irregular silver particles are formed in this way having diameters of around 100 nanometres.



The topography of the sample surface can be seen here (white lines around the nano-particles) as well as the local optical excitations. The image displays several "hot spots" (yellow) that arise through interactions of the nanoparticles with the light and also with one another.
Image: HZB/CalTech

Traversing the sample with the "light pick"

In collaboration with colleagues at the California Institute of Technology (CalTech), Schmid investigated how these types of randomly distributed nanoparticles influence the incidence of light on a cell below. They used a particularly sensitive method known as scanning near-field optical microscopy (SNOM). In this technique, an extremely tiny point scans the sample, determining the topography as with atomic force microscopy. However, it also simultaneously illuminates the sample through an even smaller aperture in the probe point to create optical excitations (plasmons) in the nanoparticles. These optical excitations can either couple the light into the solar cell as desired - or instead transform the light into heat, whereby it is lost to the solar cell.

It’s all about neighbourhood: interactions determine the light scattering
Measurements showed that there can be strong interactions between densely situated, irregularly distributed nanoparticles leading to local "hot spots". „Whereas the darker regions tend to absorb light and transform it into heat, the hot spots show where nanoparticles strongly interact via their electromagnetic near-fields. In these regions of enhanced fields, energy transformation in the solar cell could potentially be enhanced“, Martina Schmid explains.

In the end, areas of stronger fields but also of comparatively weaker ones arise. However, it is difficult to establish a clear relationship between the occurrence of these hot spots and specific nanoparticles. “The particles mutually affect one another through their electromagnetic near-fields, which are notably more complex than suspected until now. We need to ascertain how we can intentionally create the desired field distributions", explains Schmid. She will investigate these questions further at HZB and at the Freie Universität Berlin together with the research group headed by Prof. Paul Fumagalli.

Original publication: M. Schmid, J. Grandidier and H. A. Atwater, “Scanning near-field optical microscopy on dense random assemblies of metal nanoparticles“, *J. Opt.*, **15**, 125001 (2013)
The text can be retrieved free of charge here.

Afterword: Prof. Martina Schmid heads the ***Nano-Optical Concepts for Photovoltaics” (NanooptiX)” group of junior scientists.*** *She also holds a junior professorship at the Freie Universität Berlin. The experimental work was carried out during her postdoc period at the renowned California Institute of Technology (Caltech) in the group headed by Prof. Harry Atwater.*

The Photonics Europe conference of SPIE, the international society for optics and photonics, takes place in Brussels 14-17 April, where PhD-Student Patrick Andrae from the NanooptiX-group will give a talk on the topic.