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Nanooptical Concepts for Solar Cells

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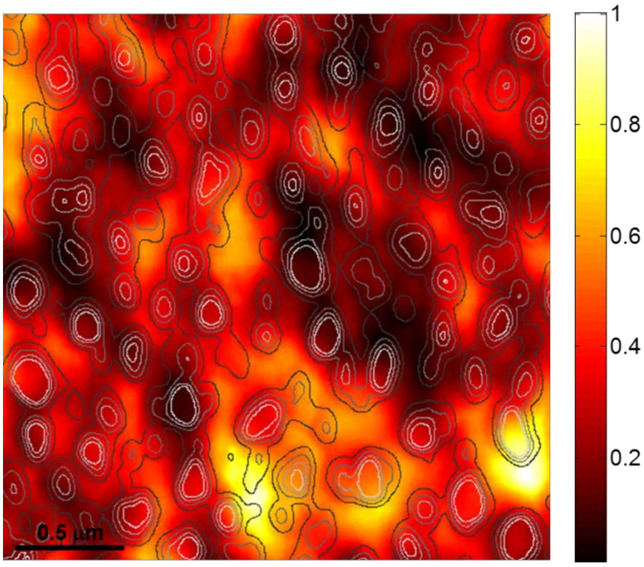
Solar cells made from thin films have brought an important step forward in terms of reduced material consumption while featuring efficiencies beyond 20%. To further make them competitive, concepts of light management on the micro- and nanometer-scale are applied. The absorbing layer may be physically thinned down by a factor of ten if it remains optically thick exploiting e.g. plasmonic and photonic scattering from nanoparticles. Solar cells of only a few tens of micrometer in size can give high efficiencies when operated under concentrated sun light.
Whereas microconcentrator solar cells are still in its infancy and first approaches focus on the general proof of concept, plasmonic absorption enhancement has already found application to various thin-film devices such as amorphous silicon solar cells. The implementation in Chalcopyrite solar cells is highly promising due to their good initial efficiency, yet the stability of the nanoparticles with high temperature fabrication processes is challenging. Besides the experimental realization of the ultra-thin devices including optically active nanoparticles, theoretical investigations of the light interaction with the nanoparticle assemblies and the solar cell play an important role to identify suitable configurations. Advanced optical analytics like scanning near-field optical microscopy provides insight into the local field distribution around nanoparticles at solar cell interfaces and based on this help to deduce the expected impact on the photogeneration.



Expected local optical generation rate for a solar cell with integrated random nanoparticle assemblies. The arrangement of the nanoparticles is visible from the overlapped AFM-topography, the optical generation rate is derived from SNOM-(scanning near-field optical microscopy) measurements.