NaLuWiLeS: LUMINESCENCE ENHANCING NANOSTRUCTURES FOR LEDS AND SOLAR CELLS WITH INCREASED EFFICIENCY

NaLuWiLeS will bring promising new theoretical concepts for increasing the efficiency of solar cells and LEDs in practical applications.

One of the main factors which presently limit the efficiency of silicon-based solar cells is the fact that not the whole solar spectrum can be converted into electricity: in particular, photons with low energies (i.e. lower than the bandgap of silicon) cannot be absorbed and are therefore lost. This limitation can be overcome by upconverting these photons into photons with higher energy, which then can be used by the solar cell. In order to increase the upconversion quantum yield, we are planning to use photonic nanostructures and downconverters that enlarge the utilizable spectral range. The role of the nanostructures will be to enhance the local irradiance as well as to favor the desired emission of photons with high energy. The optimization of these nanostructures will be performed on the basis of advanced theoretical models, in particular taking into account the effect of those structures on the relevant energy transfer processes. At the end of the project, the upconversion enhancement will be demonstrated in calibrated upconversion photoluminescence measurements as well as by the electrical characterization of solar cell upconverter devices.

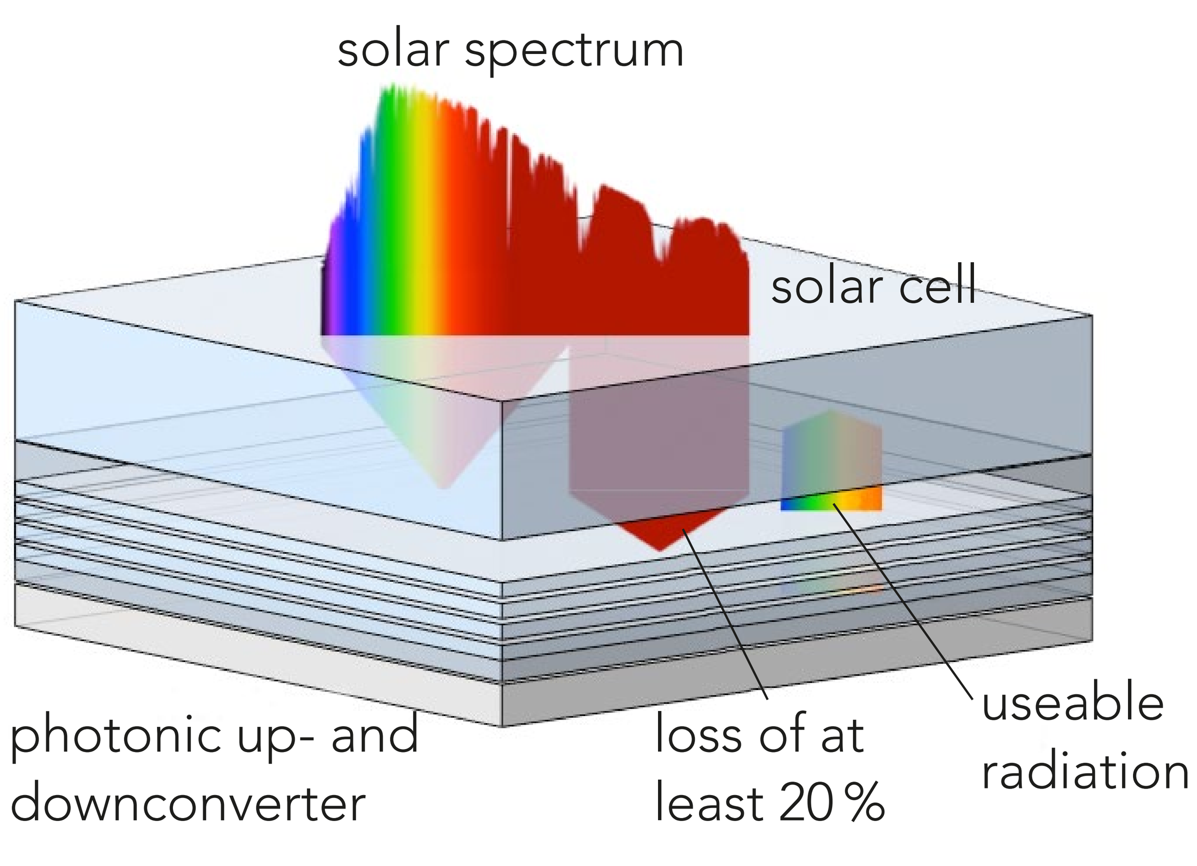

Figure 1: Light which cannot be directly absorbed by the solar cell will be converted into useful light by up- and downconverters in combination with optimized photonic nanostructures.

Similar challenges exist concerning the realization of efficient LEDs. The emitted light first has a definite color (determined by the bandgap of the respective semiconductor) and must then be converted into white light by fluorescent converters. Our aim is to provide the industry with suitable tools for the optimization of core-shell micro-rod LEDs (CSMR-LEDs). Most importantly, these will contain a simulation toolbox for conversion of light by nano-particles, taking into account their real three-dimensional structure. This model will be evaluated using a CSMR-LED with converters to be realized at the Department of Microsystems Engineering (IMTEK) in Freiburg. The development and application of the model requires a precise characterization of the internal quantum efficiency and the angularly and spectrally resolved emission chararacteristics of the CSMR-LED, taking into consideration the polarization of the emitted and scattered light.

On the basis of experimental results in combination with the simulation tools to be developed, we will, at the end of the project, devise detailed requirements for obtaining optimized structures. In particular, we will investigate the influence of geometrical quantities, such as the thickness of the converter layer or the dimension and arrangement of micro-rods, on the efficiency of the whole system.

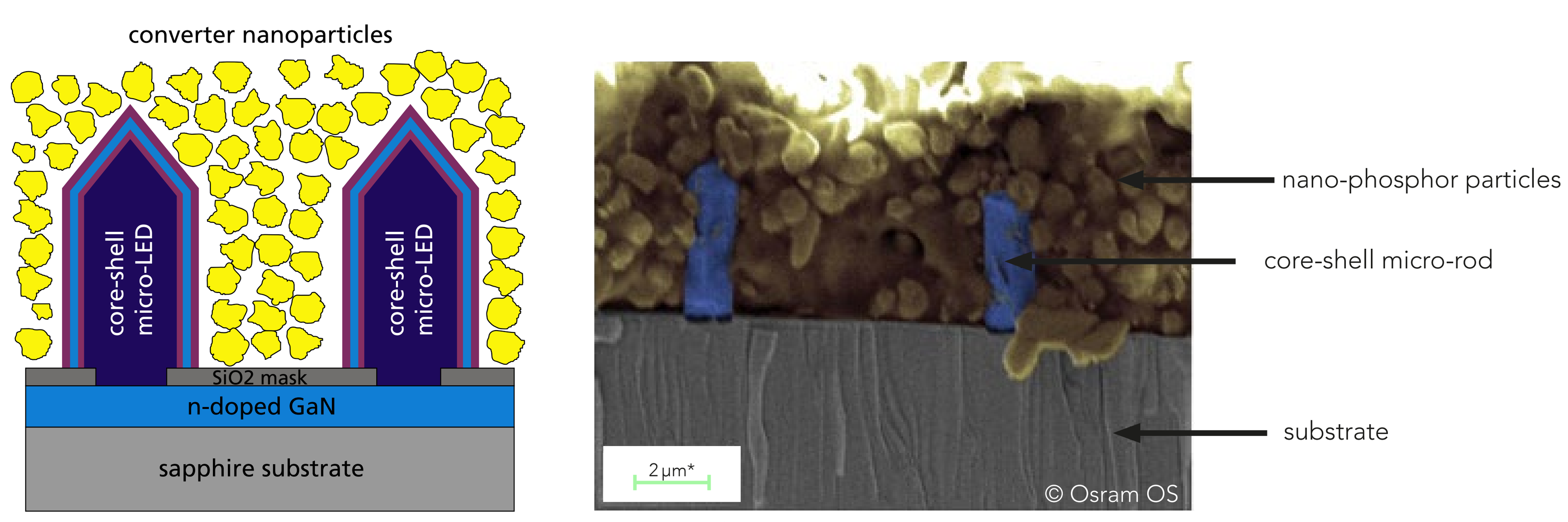

Figure 2: Core-shell micro-rod LED with downconverting phosphor nanoparticles in a schematic drawing (left) and in the scanning electron microscope (right, with kind permission of OSRAM OS). The picture taken by the scanning electron microscope is shown in false colors in order to highlight the micro-rods and the surrounding matrix of phosphor nanoparticles.

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Funded by:

Baden-Württemberg
MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST

Baden-Württemberg
MINISTERIUM FÜR FINANZEN UND WIRTSCHAFT

Fraunhofer

UNI FREIBURG