MULTIWIRE
LIGHT TRAPPING IN MULTI-JUNCTION NANOWIRE PV

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Project context and objectives

In this project, we have investigated the effects of resonant light trapping in nanowire mats for application in multi-junction photovoltaic cells. Emphasis was to exploit effects of the single-wire guided modes and collective multiple scattering to improve the light management. Our objectives included: theoretical modeling of nanowire guided modes, characterization of optimized nanowires using methods of statistical optics and nanophotonics, and the first measurements on pn-junction nanowire solar cells. In all of these objectives, progress was made demonstrating the feasibility of our approach.

Brief description of the main results

We have demonstrated new effects of strongly correlated transport in nanowire mats, convincingly showing that transport is governed by only a few open channels, in agreement with mesoscopic models. In collaboration with Twente University the first transmission matrix measurements on nanowire mats were performed, confirming the strongly correlated light trapping in these materials. Eindhoven have successfully fabricated their first pn-junction solar cells made from InP nanowires and already achieved efficiencies up to 10.2% with the first generation of devices. Currently the first experiments are in progress characterizing the photocurrent using broadband microscopy in Southampton.

Final results, potential impact and use

This 6-month project has provided new results showing that nanowires form one of the strongest light trapping materials available today. The presence of strongly correlated transport shows that traditional light diffusion models are no longer valid when describing photon transport and emission in strongly scattering nanowire mats, which is of importance for a wide range of applications. Since mesoscopic effects are reduced in the presence of strong absorption, they are less important for light harvesting when strongly absorbing layers are used. However mesoscopic effects may become relevant in parts of the spectrum where absorption is weak, which is where photon management strategies are particularly useful. Follow-on studies are planned in the coming months to address in detail how collective light trapping influences the photoconversion efficiency of the solar cells.