3D Photovoltaics Group

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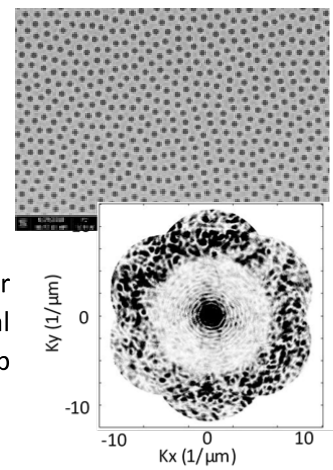
Research Theme: The ultimate goal of the group 3D Photovoltaics is to push the frontiers of nano-PV by aiming towards the achievement of low-cost semiconductor nanostructures as building blocks. We focus on the fundamental understanding of the potential benefits and/or limitations of semiconductor nano-structures when used for solar energy conversion. These include exploring non-traditional conversion principles enabled by the nano geometry or the fundamental development of cost-effective nanofabrication methods.

Project 1: Exploring photonic properties of hyperuniform arrangement of vertical nanowires for ultrathin tandem solar cells

Supervisors: Nasim Tavakoli and Esther Alarcon Llado

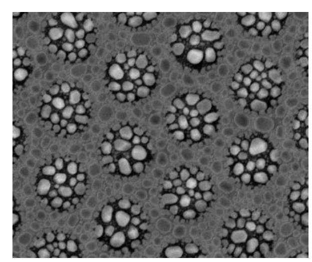
We have explored the photonic behavior of vertically standing array of nanowires (NW) with different geometries on Si ultrathin bottom cell. Optical coupling between the two cells gives dual functionality to the NW array: High absorption in the top cell and light trapping in the bottom cell. This theoretical project is designed to push the conversion efficiency of this system even further by optimizing light scattering in the k-space. We would like to explore even smarter arrangement of the NWs –hyperuniform- with different diameters/height. Optical FDTD simulation gives us the opportunity to build up this complicated system step by step to gain a thorough understanding of its unique photonic properties.



Project 2: Electrochemical mediated InGaAs growth for thermal photovoltaics

Supervisors: Marco Valenti and Esther Alarcon Llado

Thermal photovoltaics (TPV) exploits the thermal radiation emitted from hot materials to generate electricity in the same way as in PV, but with a short bandgap semiconductor. InGaAs has a composition-tunable short bandgap which is a promising light absorbing material for TPV. This ambitious project consists in making InGaAs with control over its size, morphology and composition dependent optoelectronic properties for its use in TPV. In our lab, we have demonstrated the growth of InAs by using an electrochemical set-up with in-situ optical monitoring. Beyond InAs bulk, nanostructures are being pursued by using Indium nanoparticles.



Project 3: Investigating Polarized Solid-Electrolyte Interfaces by Atomic Force Microscopy during electrochemical growth

Supervisors: Mark Aarts and Esther Alarcon Llado

Chemical reactions at the solid-liquid interface are widely used in industrial applications for material fabrication, and are also critical for the production of sustainable fuels such as hydrocarbons and hydrogen. While it has become apparent that the processes arising at the phase boundary are dependent on atomic-scale inhomogeneities such as kinks and defects, they are still poorly understood. We use an atomic force microscope to detect ionic forces at and near the surface, by using a nanometer-sized probe and collecting force-distance curves at high frequencies, within the framework of local electrochemical deposition. We will investigate fundamental questions regarding the makeup of this interface as a function of salt concentration, polarization, and topography.