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# Light-excited scanning tunneling spectroscopy of III-V semiconductors

© Dr. Michael Schnedler


## Dr. Michael Schnedler

**Forschungszentrum Jülich**


The efficiency of solar cell and optoelectronic devices is closely connected to the nanoscale distribution of charge carriers. For example, defects can give rise to non-radiative carrier recombination centers, reducing the charge-carrier concentration locally. Such effects are detrimental to both the electron-light and light-electron conversion efficiencies in optoelectronic and solar cell devices, respectively. In order to understand the physical processes involved at the atomic scale, the materials used in the device structures need to be investigated simultaneously under illumination and with atomic resolution.
Photoexcited scanning tunneling spectroscopy (STS) is ideally suited to probe the illumination-induced local surface photovoltage, band bending, carrier concentrations, and the electrostatic potential distribution. A quantitative understanding of photoexcited tunneling spectroscopy is unfortunately not at all straight forward. This is further aggravated by the fact that only for very few materials tunneling spectra can be intuitively understood, while for all other materials simulations of the tunnel current are a prerequisite for extracting the underlying physics, even without illumination. Therefore, we developed a theoretical modelling of photoexcited tunneling spectroscopy using simulations of the exact sample structure as “digital twin”. In this presentation, we will illustrate the methodology and apply it to III-V semiconductors to extract the local non-equilibrium charge-carrier concentration and redistribution. The same methodology is also applied to analyze tunneling spectra without photoexcitation and off-axis electron holography measurements in a transmission electron microscope to derive potential maps, electron affinity differences, mean inner potentials, polarization, band offsets, etc.