Photonic Materials group

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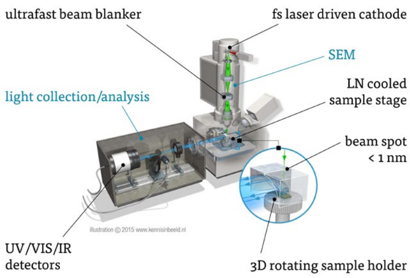
Research theme The *Photonic Materials* group studies the interactions between light, electrons, and matter at the nanoscale. We develop new materials and concepts for solar cells with improved efficiency, create optical metasurfaces that can perform mathematical operations (optical computing), and develop time-resolved cathodoluminescence spectroscopy to study ultrafast optical phenomena at the nanoscale. All these topics are strongly linked and we have a strong culture of collaboration within our group.

Project 1. Pump-probe cathodoluminescence spectroscopy of ultrafast phase transformations

Supervisors: Magda Sola Garcia, Kelly Mauser and Albert Polman

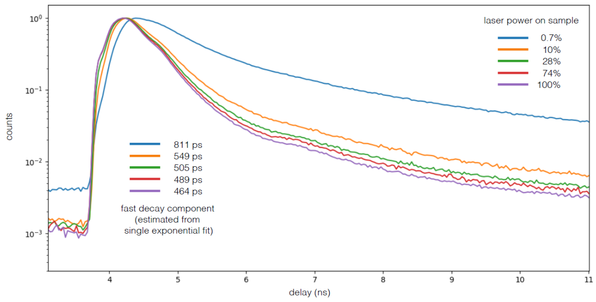
In this project you will use our group's newly developed ultrafast cathodoluminescence (CL) microscope. You will use 200-fs laser pulses (λ=345, 517 nm) to excite materials and probed them with 1-picosecond 5-30 keV electron pulses to generate CL with nanoscale spatial resolution. You will use the new technique to investigate ultrafast light-induced excitations in nanostructures and metasurfaces made of Si, indium-tin-oxide and InGaN. The pulsed laser creates phase transformations and carrier dynamics that reflect themselves in ultrafast changes in the resonant cathodoluminescence spectra. In this way you will obtain fundamental insight in light-electron-matter interactions at ultra-small and ultra-fast time scales.



Project 2. Ultrafast electron-induced carrier dynamics in photovoltaic semiconductors

Supervisors: Matthias Liebtrau and Albert Polman

In this project, you will reveal the generation and recombination dynamics of carriers in photovoltaic semiconductors generated by 5-30 keV electron pulses. You will use our time-resolved cathodoluminescence (CL) microscope to generate dense cascades of electrons and holes that recombine by emission of CL. From the CL decay dynamics you will probe the carrier recombination mechanisms and learn details of the electron cascade dynamics. By varying the energy, number of electrons per pulse and pulse duration you develop and test models to obtain fundamental insight in the mechanism of electron-induced carrier generation in semiconductors.



Project 3. Resonant metasurface spectral splitters for tandem solar cells

Supervisors: Tom Veeken, Andrea Cordaro, and Albert Polman

In this project, you will develop optical metasurfaces to control scattering of light in order to create solar cells with improved efficiency. We will develop spectrally selective surfaces composed of metallic and dielectric nanoantennas that serve as a spectrum splitter for a multi-junction solar cell in which the individual cells are arranged in parallel, rather than in series. We will use inverse-design algorithms and concepts of neuromorphic computing to develop light scattering architectures with optimized performance. The structures will be made using cleanroom nanofabrication and applied to create a Si/GaAs parallel tandem solar cell.