Photonic Materials group (AMOLF)

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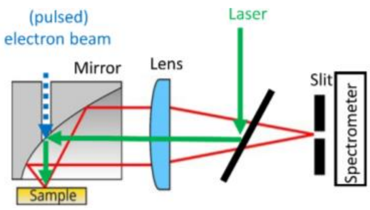
Research theme The *Photonic Materials* group studies the interactions between light, electrons, and matter at the nanoscale. We develop new materials and concepts for solar cells with improved efficiency, create optical metasurfaces that can perform mathematical operations (optical computing), and use 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.

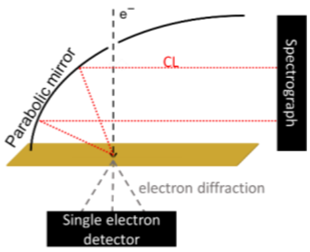
Project 1. Studying perovskite (in)stability using cathodoluminescence spectroscopy *Supervisors:* Saskia Fiedler and Albert Polman



Halide perovskites are promising solar cell materials, but in some cases they slowly degrades under illumination. Solving this problem is a key topic in PV research. In this project, you will investigate the optical properties of perovskite films in a scanning electron microscope (SEM) equipped with cathodoluminescence (CL) and light in-coupling capabilities. In CL, we scan a nanoscale electron beam over the sample surface and simultaneously collect the luminescence spectrum with a spatial resolution of 10s of nanometers. You will vary the scan pattern of the electron beam over perovskite films and study the effect on of optical and electron irradiation on the properties of organic and inorganic perovskite films. You will then develop ways to mitigate electron beam-induced degradation experimentally and develop a numerical model of spatially resolved electron beam induced structural transformations.

Project 2. Correlating electron diffraction and cathodoluminescence spectroscopy for energy materials analysis *Supervisors*: Evelijn Akerboom and Albert Polman

In this project, you will explore the use of free electrons in a SEM to correlate the optical and structural properties of materials relevant for the energy transition. Electron diffraction – the elastic scattering of the electron by the lattice – unveils the crystallinity and lattice orientation of the sample by studying the angular pattern of the scattered electrons. Simultaneously, CL contains information about how the structure interacts with light at the nanoscale. You will combine these two techniques to study the relation between grain orientation and CL emission in nanocrystalline perovskite films, and to determine structural and optical changes under laser excitation. You will develop the new measurement technique on the SEM, develop coding, and do data analysis.



Project 3. Light-driven reactions studied with novel ultrafast electron-driven spectroscopic tool *Supervisors:* Hollie Marks and Albert Polman

The Smith-Purcell (SP) effect is a free-electron radiation phenomena whereby an electron grazing a periodic structure (e.g. a grating) induces far-field optical emission with a broadband (0-30 eV) spectrum. In this project you will integrate such gratings onto the input facet of an optical fibre, and generate broadband light pulses for ultrafast optical spectroscopy. You will investigate how the SP fibre geometry can be used as a sensing platform for molecular species and plasmonic/catalytic nanoparticles that are placed on the fiber. As the electron-driven pulses have a duration of only a few femtoseconds this can open new ways to perform ultrafast spectroscopy of optically induced chemical reactions at the fiber surface. You will use optical simulations and nanofabrication techniques to design and prepare samples, and use cathodoluminescence spectroscopy to study the dynamics of light propagation within this system.