Time-resolved cathodoluminescence: measuring dynamics at the nanoscale

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Cathodoluminescence spectroscopy is an established technique that is used to obtain information on a material’s optical properties with a spatial resolution well below the optical diffraction limit of light. The electron beam acts as a broadband excitation source that can bring a material into an excited state. The subsequent relaxation of these excited states often follows complex relaxation pathways that can include both radiative and nonradiative recombination mechanisms. Understanding the dynamics of these processes aids the design and optimization of nanomaterials and devices.

Here we will describe different experimental realizations of time-resolved cathodoluminescence (TRCL) that can be used for lifetime mapping or $g^{(2)}$ imaging. In the former, a decay trace is measured after excitation by a pulsed electron beam from which the lifetime of the excited state can be derived. In the case of $g^{(2)}$ imaging, photon statistics are used to measure bunching and anti-bunching effects. From the bunching behavior observed in extended material systems the emission lifetime and excitation efficiency can be obtained. The main benefit of this approach is that a continuous electron beam can be used, so that no adaptions to the electron microscope are needed.

We will discuss the latest developments in TRCL, drawing examples from semiconductor research to underline the capabilities and value that TRCL can add as an advanced nanoscale characterization technique.