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Recent developments and future trends in time-resolved cathodoluminescence: measuring dynamics at the nanoscale

Dr Herman Duim[1]
[1]Delmic, Delft, The Netherlands

Background

Cathodoluminescence spectroscopy is a well-established technique utilized to extract detailed information about the optical properties of materials [1, 2] at spatial resolutions surpassing the diffraction limit of light. By employing an electron beam as a broadband excitation source, materials can be brought into an excited state. The subsequent relaxation of these excited states typically follows intricate pathways involving both radiative and nonradiative recombination mechanisms. Gaining a comprehensive understanding of these dynamic processes is essential for the design and optimization of nanomaterials and devices.

Results

We will explore various experimental implementations of time-resolved cathodoluminescence (TRCL) that are applicable for lifetime mapping or g(2) imaging. In the former, a decay trace is measured following excitation with a pulsed electron beam, enabling the determination of the excited state's lifetime [3]. In the case of g(2) imaging, photon statistics are instead utilized to observe bunching and anti-bunching effects [4, 5]. By analyzing the bunching behavior in extended material systems, it becomes possible to extract valuable information about emission lifetime and excitation efficiency. An important advantage of this approach is its compatibility with a continuous electron beam, eliminating the need for modifications to the electron microscope.

Conclusions

Here we describe the latest advancements in time-resolved cathodoluminescence and future directions, drawing examples from semiconductor research to highlight the remarkable capabilities and value that TRCL brings as an advanced nanoscale characterization technique.

Keywords:

Time-resolved cathodoluminescence, spectroscopy, dynamics, ultrafast

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