MONASH University

Monash Centre for Electron Microscopy

Monash Centre for Electron Microscopy Seminar

Single-photon time-resolved cathodoluminescence imaging spectroscopy

Monday 6 February, 2017

11.00am

Lecture Theatre S1
16 Rainforest Walk (Building 25)
Clayton Campus
Monash University

Presenter

Professor Albert Polman
Center for Nanophotonics, AMOLF, Amsterdam, The Netherlands

Abstract

We use a 30 keV time-resolved cathodoluminescence microscopy to create femtosecond plasmonic and photonic wave packets on metallic and dielectric metasurfaces and create strong photon bunching of quantum emitters.

A fast electron beam passing through the surface of a polarizable material generates a single-cycle electric field oscillation near the surface that couples strongly to the free or bound electrons in the material. The ultrafast field oscillation presents a spectrally broadband excitation from deep UV to near IR, and the nanoscale electron probe size results in deep-subwavelength optical excitation resolution. Indeed, electron beam excitation is one of the purest forms of optical excitation, directly addressing the quantum nature of optical matter.

We present a newly built time-resolved cathodoluminescence microscope in which the electron beam is pulsed and the emitted light is analyzed using single-photon detectors in a Hanbury-Brown-Twiss geometry. 500-ps pulses composed of a single electron on average are created using electrostatic blanking; picosecond pulses can be made using femtosecond UV laser-induced photoemission from the electron cathode which is under construction.

We investigate InGaN/GaN quantum wells and observe strong photon bunching, with the single-photon correlation $g^{(2)}(\tau)$ depending on the excitation conditions. The $g^{(2)}(\tau)$ data provide insight in the electron-induced carrier excitation processes and serve as a probe of carrier diffusion as well as the nanoscale spatially-resolved spontaneous emission lifetime.

We study the generation of femtosecond plasmonic and photonic wave packets on metallic and dielectric metasurfaces by the 30 keV electron beam. In angle-resolved mode, the azimuthal and zenithal CL emission distributions are measured, probing the angular radiation profile of optical nanoantennas and allowing for momentum spectroscopy to reconstruct the optical band structure. In polarization-resolved mode, the full polarization state of the emitted light is determined, allowing distinction between linearly and circularly polarized light in a spatially and angle-resolved way. In tomographic mode, 2D CL images are taken under multiple angles of incidence, and a 3D image of the local field distributions is obtained from a tomographic reconstruction.

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