Interference of light emission in cathodoluminescence STEM

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Nanoscale imaging of electric field in optical frequency is essential to analyze nanoscale photonic devices consisting of e.g. plasmonic nanostructures. There are different light field imaging techniques such as scanning nearfield optical microscopy (SNOM), photo electron emission microscopy (PEEM), electron energy loss spectroscopy (EELS), and cathodoluminescence (CL). Electron beam based methods, namely EELS and CL, are advantageous in terms of spatial resolution, when scanning transmission electron microscopy (STEM) is combined, as well as the available simultaneous spectroscopy. The optical information acquired by EELS or CL corresponds to the projected electromagnetic local density of state (EMLDOS) along the electron beam path with a certain optical frequency. Here we use CL techniques to take advantage of the possible manipulation of light without the uncertainty limit of incident electrons. Using an angularly resolved STEM-CL technique with polarized light detection, we have previously performed dispersion relation measurement of plasmonic waveguides [1] and selective imaging of degenerate modes [2]. In this work, we aim to take advantage of the interference of the radiated light to obtain more optical information.

The CL-STEM system used in this measurement is based on JEM 2100F (JEOL) with a Schottky type field emission gun, and aberration corrector. Acceleration voltage was set to 80 kV with a probe current of around 4 nA. The resultant probe size is 1 nm or below. The optical detection part consists of a parabolic mirror to collimate the emitted light, pinhole mask select the angle of the radiated light, and a polarizer to select the electric field direction. We prepared spherical silver nanoparticles on a dielectric/metal bilayer substrate to provide the interference. The particles were deposited by vapor deposition in argon atmosphere. By selecting a proper collection angle and polarization, it was possible image the interference of transition radiation and emission from the particle mediated by surface plasmon polariton (SPP) showing interference patterns.

References:
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