Observing quantum emitters and measuring their lifetime using fast electrons

Luiz H. G. Tizei[1]*, Sophie Meuret[1], Romain Bourellier[1], Alberto Zobelli[1], François Treussart[2], Huang Cheng Chang[3], Thomas Auzelle[4], Bruno Gayral[4], Bruno Daudin[4] and Mathieu Kociak[1]

[1]*Laboratoire de Physique des Solides, Université Paris Sud, UMR 8502, 91405 Orsay, France*
[2]*Laboratoire Aimé Cotton, CNRS, Université Paris Sud and ENS Cachan, Orsay 91405, France*
[3]*Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei 106, Taiwan*
[4]*CEA-CNRS Group Nanophysique et Semiconducteurs, Institut Néel/CNRS-Université J. Fourier and CEA Grenoble, INAC, SP2M, 17 rue des Martyrs, 38 054 Grenoble, France*

Electron microscopy techniques have been used to probe the optical properties of materials in the subwavelength scale. In particular, it has been shown that using cathodoluminesncence and by a propitious choice of electron beam energy and target material, resolution below 10 nm is attainable. However, typical cathodoluminescence experiments only probe the spectral information of the emitted light, being an analogue of photoluminesncence.

In this contribution, two types of experiments attempting to implement quantum optics techniques in the electron microscope will be presented. In these experiments a 1-nm-wide 60 keV electron beam was used to excite the sample. Fundamentally, we have measured the second order correlation function ($g^{(2)}(t)$) of the emitted light of different materials using a Hanbury-Brown and Twiss interferometer (an intensity interferometer).

With the first set of experiments we have shown that single photon emission from NV0 centers in diamond can be observed, showing high spatial resolution. In the second set of experiments, we have used the same interferometer to measure the $g^{(2)}(t)$ of nanodiamonds containing hundreds NV^0 emitters. Surprisingly, we have observed a large bunching effect in the nanosecond time scale. This bunching arises due to the simultaneous excitation of multiple centers by a single incoming electron and it gives information about the excitation mechanism behind light emission in cathodoluminescence, allowing the measurement of objects' lifetimes.