Characterization of single photon emitters with cathodoluminescence

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Single photon emitter (SPE) are emitters who emits only one photon at a time. Due to their possible applications in quantum information, they are intensively studied. A famous SPE is the NV centers in diamond. The usual way to characterize them is to perform an intensity interferometry experiment (Hanbury Brown and Twiss (HBT)). Such an experiment measures the autocorrelation function $g^{(2)}(\tau)$ of the emitters. The $g^{(2)}(\tau)$ function of a SPE presents a dip at short delay ($g^{(2)}(0) < 1$), a phenomenon called the anti-bunching. Here, we used a unique home-made cathodoluminescence (CL) set-up in a scanning transmission electron microscope (STEM) coupled to an HBT experiment allowing nanometer resolution [1,2]. The $g^{(2)}(\tau)$ obtained with our STEM-CL set-up is called hereafter $g^{(2)}_{CL}(\tau)$.

As a proof of principle, we will present results on *NV* centers in diamond. The $g^{(2)}_{CL}(\tau)$ acquired on a nanodiamond is shown in figure 1 and presented in details in [2]. We can clearly see a dip at short time delay, proving the possibility to study SPE with fast electrons (60 keV). We will then show how this technic can be used to detect new SPE, difficult to access with pure optical means.

In order to go further in the understanding of this new type of experiment, we will see that even if the interaction mechanisms of photoluminescence (PL) and CL-STEM are close enough to give the same emission spectra [3], they may lead to huge differences in their $g^{(2)}(\tau)$ function. Indeed we will see that if there is more than one SPE in the sample, due to electron excitation mechanism, the $g^{(2)}_{CL}(\tau)$ function will present a huge bunching effect ($g^{(2)}_{CL}(0) > 1$) in stark contrast to the expected $g^{(2)}_{PL}(\tau)$ function ($g^{(2)}_{PL}(0) \leq 1$) see figure 2.

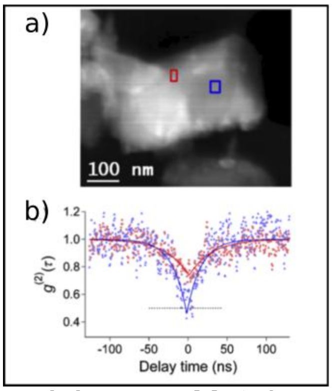

Fig1 : SPE studied in a STEM [2]. a) The ADF image of the studied diamond. b) Associated experimental $g^{(2)}_{CL}(\tau)$, showing single photon emission triggered by electrons.

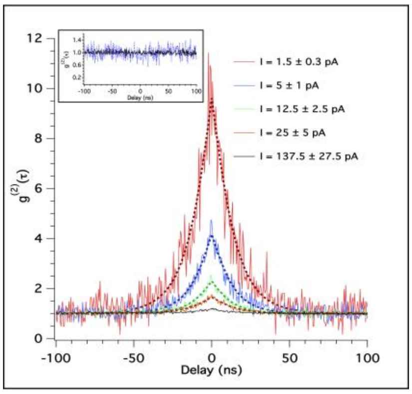

Fig 2 : The bunching effect. Continuous lines are the experimental results from $g^{(2)}_{CL}(\tau)$ of a nano-diamond (size ≈ 100 nm, containing a few hundreds of NV centers). The excitation current ranges from 1.6 pA to 137 pA. On the inset, $g^{(2)}_{PL}(\tau)$) with excitation on the same sample (but not the same diamond) for two different excitation powers.

Références

[1] Zagonel and al., Nano Letters 11, 568-73 (2011)
[2] Tizei and al., PRL 110, 153,604 (2013)
[3] Mahfoud and al., J. Phys. Chem. Lett., 4090-94 (2013)