# Time Resolved E-beam Experiments (TREE)

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In the frame of condensed matter physics, an electron beam is a very convenient source to excite and probe wide-bandgap semiconductors at the nanometer scale, by measuring the cathodoluminescence or the electron beam induced current. Internal electric fields can be mapped and the diffusion of charge carriers can be measured. This is particularly interesting for the improvement of new lighting and power devices.

Furthermore, the dynamical study of excited carriers brings additional information such as carrier lifetime and mobility, which are key parameters for the realization of state-of-the-art devices. One available solution to achieve this at the nanometer scale is the use of a dedicated, very expensive system consisting of a specific scanning electron microscope (SEM) with a photocathode excited by a pulsed laser. A 10 ps temporal resolution is reported, which is often much shorter than our characteristic times, to the detriment of the energy per pulse.

Our project consisted in the use of an add-on solution on a conventional field effect SEM (FESEM). In this case, an electrostatic beam blanker system (Fig. 1) is inserted in the FESEM column. Under operation, the detrimental spatial deflection of the electron beam is overcome by column realignment. The core of our equipment is an in-house add-on system for a FEI Inspect F50 FESEM. It is a fast beam-blanking system with 150 ps intrinsic response time thanks to an ultra-high-speed pulse generator. However, when the device under study is smaller than the deflection length of the electron beam, a 35 ps resolution can be achieved. Both optical and electrical time-resolved electron beam experiments are possible using fast detectors associated with time-correlated single photon counting system and high bandwidth oscilloscope with RF connection, respectively.

The usefulness of such dynamical studies at the nanometer scale has been proven by this installation and that of comparable setups in several French laboratories. Our setup is currently used by different groups to study the luminescent and electrical characteristics of GaN, AlN and ZnO nanowires (Fig. 2), and on hybrid perovskites for luminescent and photovoltaic applications. We started time-of-flight experiments on diamond-based and perovskite-based x-ray detectors. Industrial companies, such as OSRAM and ALEDIA (using our equipment), have also seen the advantage of this technique to probe the quality of their lighting devices made of semiconductor nanorods.

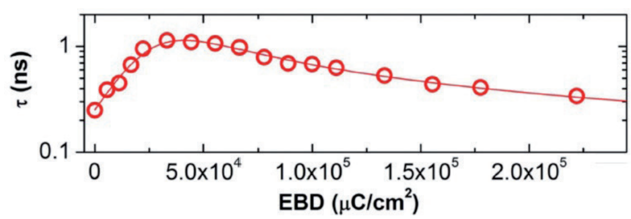


*Fig. 2: Exciton lifetime τ in a ZnO nanowire exposed to an electron beam dose (EBD)*

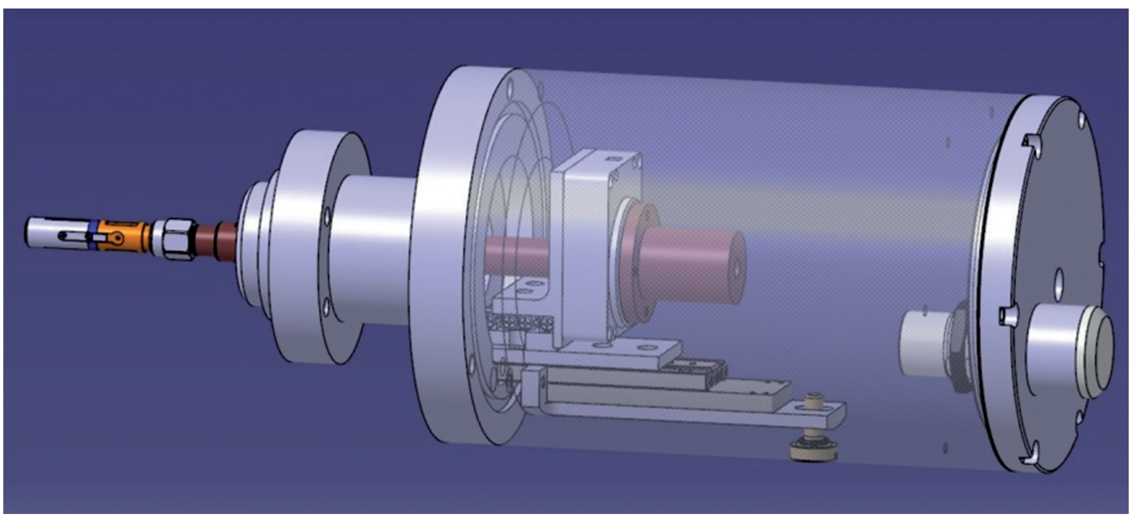

*Fig. 1: 3D technical drawing of the beam blanker*

## OUTCOMES

[1] Exciton diffusion coefficient measurement in ZnO nanowires under electron beam irradiation, Nanotechnology 29, 105703 (2018).

**Oral presentations:** TWCSN, Berlin, Germany, 2018; J2N, Grenoble, 2017.

**Main users :** Bruno Gayral, Bruno Daudin, Julien Pernot and Gwénolé Jacopin.

**Collaborations:**

Denis Dauvergne, LPSC, Grenoble, 2018.

Pierre Tchoulfian, ALEDIA start-up company in Grenoble and Timothée Lassiaz, ALEDIA/NEEL Cifre PhD fellowship 2018-2021.

Recruitment: Gwénolé Jacopin, CNRS 2018, NEEL.

**Leverage:** ANR project ROLLER 2018-2021.

EQUIPMENTS