Nanoscale optical analysis using cathodoluminescence combined with Transmission Electron Microscopy

A. Maigne[1*]. D.J. Stowe[1]
[1]Gatan Inc. 5794 W. Las Positas Blvd, Pleasanton, CA 94588, USA
*Corresponding author: Email amaigne@gatan.com

Cathodoluminescence is the type of luminescence emitted from an object excited by an electron beam. Here we will present a new system allowing the collection of such luminescence in situ in a TEM while scanning the beam over the sample in a nanoprobe. We could achieve spatial resolution of several nanometer and we will discuss in this paper about both the design

While cathodoluminescence is not a new technique, until now it was mainly used in Scanning Electron Microscope and not in Transmission Electron Microscope, limiting greatly the spatial resolution obtained and the type of sample used.
Here, we will present a new system allowing both collecting and inserting light inside a TEM.

The main challenges when performing cathodoluminescence in a TEM come from the small size of the polepiece and of the low intensity of the light emitted. To overcome this issues we designed two ellipsoidal mirrors that are attached to the sample holder and who can collect up to 60% of the light emitted. The light is then transmitted to a spectrometer through optic fibers. To avoid quenching, the sample is cooled down by LN_2 to -150ºC. A schematic of the area surrounding the sample is shown in Fig. 1.

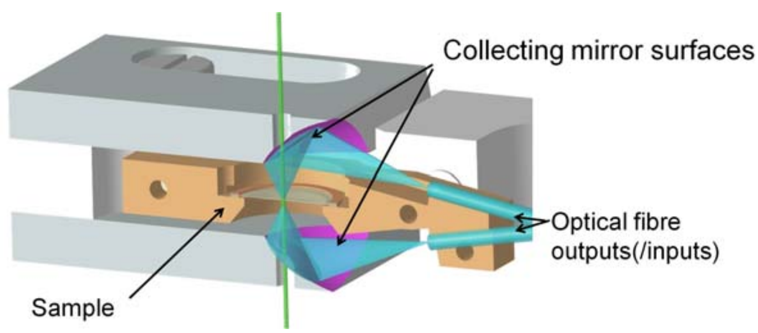

Fig. 1. The figure caption should be Arial 10pt and indented 0.5 cm.

In cathodoluminescence, the interaction volume is much larger than in Electron Energy Loss Spectroscopy (EELS) and is also harder to understand. The spatial resolution is therefore much lower than the probe size and will depends on the experiment. However details smaller than 2nm has been observed using nanorod of GaN/AlN heterostructure. A traditional Dark Field is showed in Fig.2a where we can identify each wells of GaN (2nm quantum discs). A cathodoluminescence spectrum-linescan acquired along the length of the nanorod (indicated by the green line in the DF image) has been acquired and the resulting data are shown in Fig. 2b. The black arrows indicated quantum wells with directly attributable luminescence spectra.

The Y axis represents the position along the nanorod and the X axis, the wavelength.

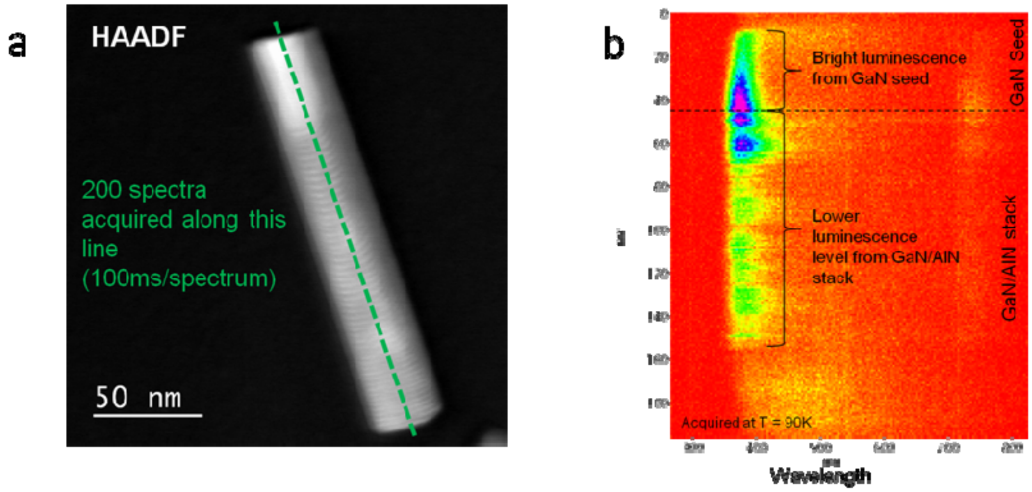

Fig. 2.CL-SI study of a nanorod of GaN/AlN heterostructure

In situ excitation: The newly design system can also be used to excite the sample by illuminating it through one of the mirror (Fig.3). The 2 ellipsoidal mirrors are connected to their own optic fiber, which allows them to be used independently.

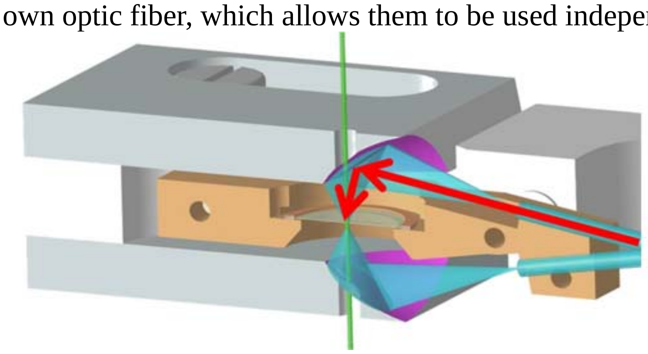

Fig. 3. Schematic of the light insertion process

Summary: Light-matter interaction is still a phenomenon very hard to fully understand and to observe. Our recent studies show that cathodoluminescence performed in a TEM can help us understand it.