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# Raman Imaging of a Single Gallium Nitride Nanowire : Pushing the limits of Confocal Microscopy

**François Lagugné-Labarthet and David Talaga**
**Institut des Sciences Moléculaires, CNRS-Université Bordeaux 1,**
**351 cours de la Libération, 33405 Talence cedex, France**

**One dimensional semiconductor-nanowires of the wide-bandgap gallium nitride (GaN) are prime candidates for nanoscale devices such as short wavelength emitter optoelectronic devices and high-power/high-temperature electronics. Subsequently, it is of importance to measure the homogeneity and the composition of such nanowires at the individual scale and to correlate them with the dimensions and optical properties of these strongly anisotropic materials. In the present work, we have conducted high resolution Raman measurements on a single GaN nanowire using a confocal microscope in conjunction with a high resolution piezoelectric stage for an accurate and reproducible positioning.**

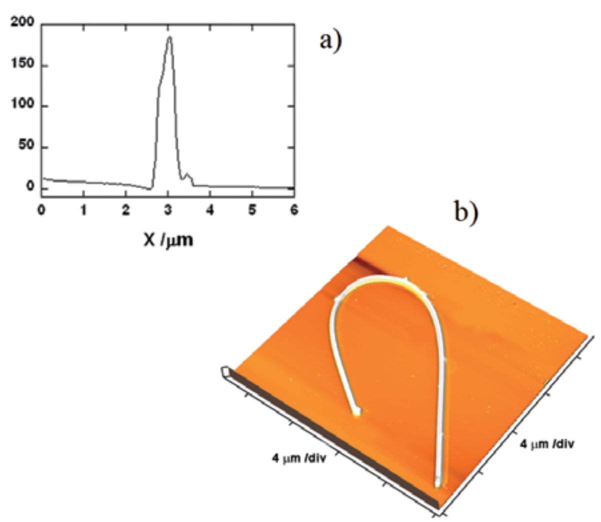


*Figure 1: Cross section (a) and atomic force microscopy topographical image (b) of the [001] GaN nanowire deposited on a glass substrate.*

A single [001] nanowire with a Wurtzite-like hexagonal cross section was first cut and positioned on a microscope glass slide. Atomic force microscopy (AFM) reveals a diameter of about 170 nm and a length of 41 µm (Fig.1). Our Raman instrument is based on an inverted microscope (Olympus IX 71) combined with a LabRAM (HORIBA Scientific) spectrometer (grating 600 grooves/mm, resolution 4 $cm^{-1}$). The sample was scanned with a piezoelectric stage with an intrinsic accuracy of about 1 nm in the lateral directions.

The light beam input excitation wavelength was fixed at $\lambda$=514.5 nm from an $Ar^{+}$ ion laser and the input polarization was selected with a half-waveplate. Focussing on the sample was done with a 100X objective (Olympus MPL 100X-NA=0.90) and an analyzer just in front of the entrance slit of the spectrometer to measure the $Y(ZZ)\bar{Y}$, $Y(XX)\bar{Y}$ and $Y(XZ)\bar{Y}$ polarized spectra. The detector was a liquid-nitrogen cooled CCD camera and acquisition time was fixed to 1s per spectrum in the imaging mode while an acquisition time of 20s per spectrum was used to record most spectra shown in the present work. For GaN single nanowire, four main signals are observed at 142, 530, 557 and 568 cm and they can be assigned to $E_2$(low), $A_1$(TO), $E_1$(TO) and $E_2$(high) symmetry type modes, respectively (Fig.2).

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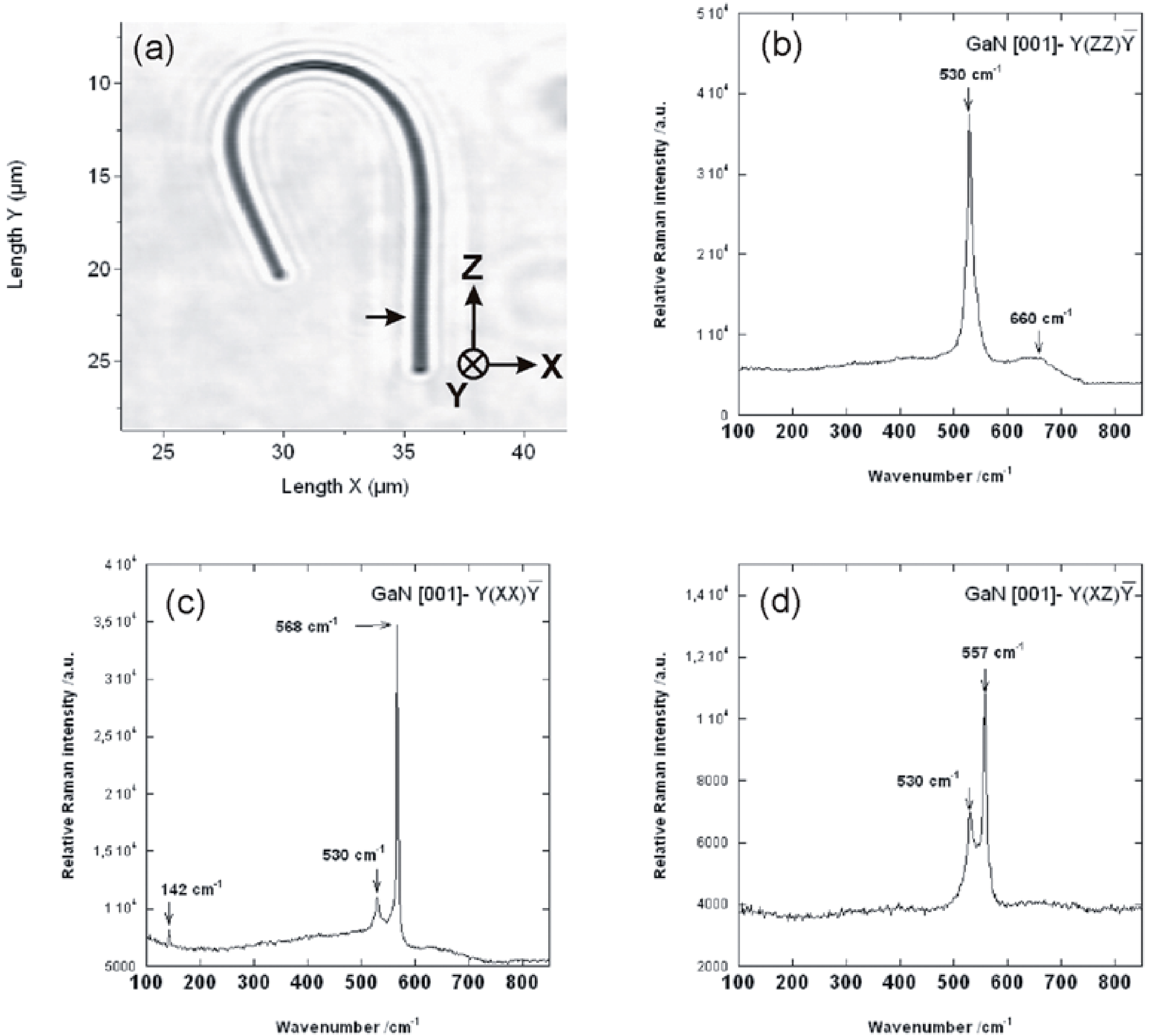


*Figure 2: Video image (a) and polarized Raman spectra of the GaN nanowire in the* $Y(ZZ)\bar{Y}$, $Y(XX)\bar{Y}$ *and* $Y(XZ)\bar{Y}$ *polarization configurations (b-d).*

Mapping of the nanowire was performed by recording step-spectra at every 200 nm with an integration time of 1s. By intensity integration of the [509-552 $cm^{-1}$] spectral domain around the $A_1$(TO) mode (530 $cm^{-1}$), the variations of the Raman signal over the full nanowire are investigated (Fig.3). The images show a lateral resolution better than 200 nm, with an acquisition time of about 1 hour for a polarized image. For the $Y(ZZ)\bar{Y}$ polarization configuration, fig. 3a shows that the signal is maximum on the straight portions of the nanowire, while it almost disappears on the bent portion of the nanowire. The complementary image (Fig. 3b) is obtained by integration of the E2 (high) mode at 568 $cm^{-1}$.

In $Y(ZZ)\bar{Y}$ polarization configuration, the opposite spectroscopic contrast is observed with a maximum signal of the 568 $cm^{-1}$ mode in the straight portions of the wire as observed in figure 3c and a maximum signal for the $A_1$ mode in the horizontal part of the nanowire.

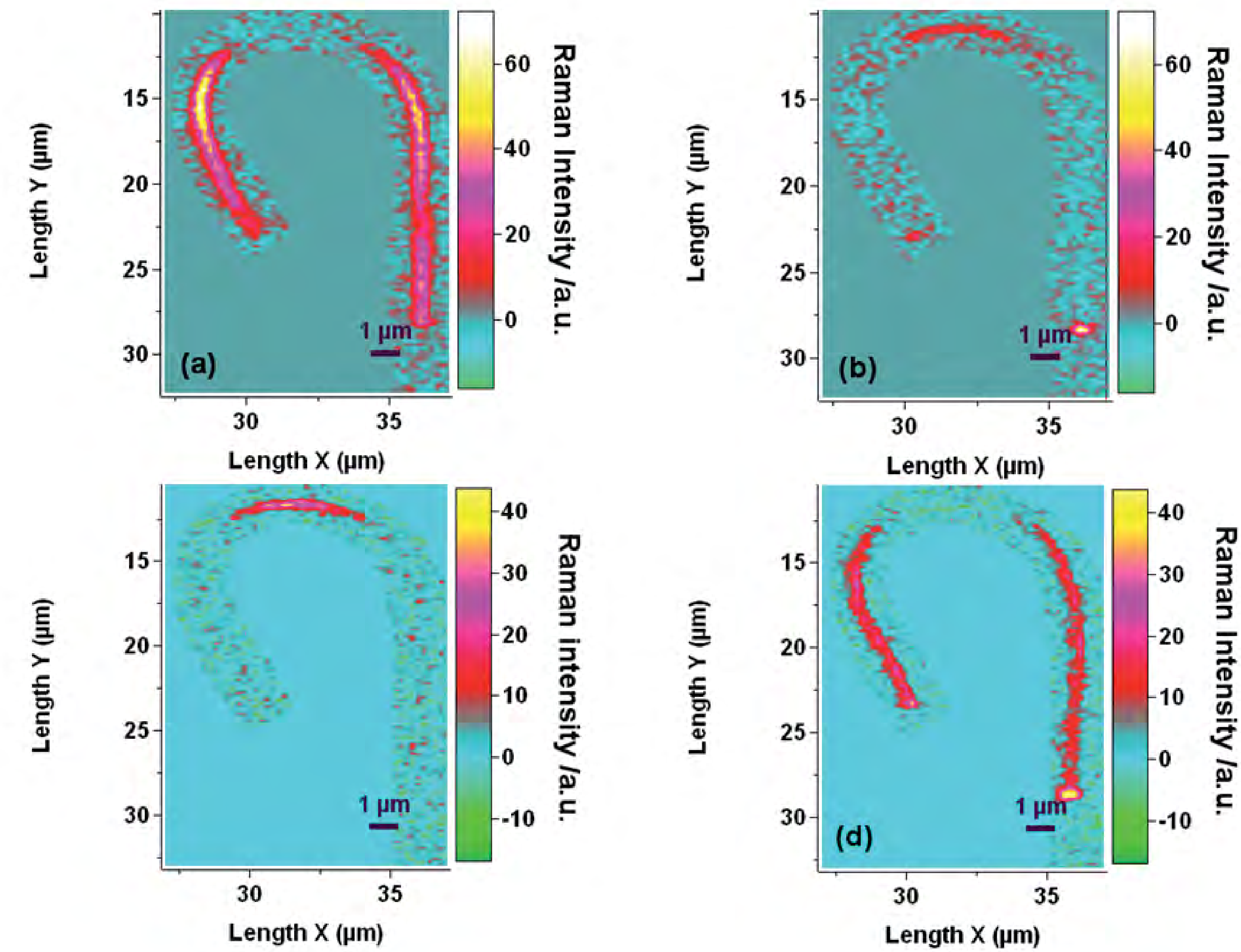


*Figure 3: Polarized Raman images generated by integration of the [509-552 $cm^{-1}$] (a) and [558-575$cm^{-1}$] (b) spectral ranges for $Y(ZZ)\bar{Y}$ polarization configuration. Polarized Raman images generated by integration [509-552 $cm^{-1}$] (c) and [558-575$cm^{-1}$] (d) spectral ranges for $Y(XX)\bar{Y}$ polarization configuration.*

In summary, we have performed a complete Raman polarized study of a single GaN nanowire using a confocal microscope together with a high resolution stage. The high spatial resolution of our Raman confocal instrument together with a piezoelectric stage demonstrates unambiguously the possibility to image the optical properties of nano-objects with a resolution better than 200 nm keeping the full advantages of the polarization control under a confocal microscope.

## Reference:

"Polarized Raman Confocal Microscopy of Single Gallium Nitride Nanowires", P.J. Pauzauskie, D.Talaga, K. Seo, P.Yang, F.Lagugné-Labarthet, J. Am. Chem. Soc., 2005, 127(49), 17146.



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info.sci@horiba.com
www.horiba.com/scientific

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**USA:** +1 732 494 8660 **France:** +33 (0)1 64 54 13 00 **Germany:** +49 (0)89 4623 17-0
**UK:** +44 (0)20 8204 8142 **Italy:** +39 0 2 5760 3050 **Japan:** +81 (0)3 38618231
**Spain:** +34 91 490 23 34 **China:** +86 (0)10 8567 9966 **Brazil :** +55 11 5545 1540
**Other Countries:** +33 (0)1 64 54 13 00