



Experiment title:

X-ray absorption and emission spectroscopy study of the structural and electronic properties of GaAsBi thin films and quantum wells: new materials for solar cells

Experiment number:

MA-778

Beamline:

BM29

Date of experiment:

from: 22 Avril 2009 to: 27 Avril 2009

Date of report:

27/07/09

Shifts:

12

Local contact(s):

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Received at ESRF:

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The experiment was performed from 22 to 27 April 2009. Of the original 24 shifts required (at ID26, BM29 or BM08) only 12 were assigned at BM29, indeed we concentrated on X-ray absorption measurements and neglected X-ray emission. Unluckily the achieved results fell below expectations because the main sample environment equipment necessary for the experiment and required in our proposal (the BM29 cryoturbine¹) was found to be in bad conditions just before starting the present experiment.

As a matter of fact, the cryoturbine showed a leak in the cooling circuit (exactly in the exit bellow), which we found out by using a leak detector. As a consequence, its behavior was rather irreproducible because of vibrations induced by some resonance related to this defect, and

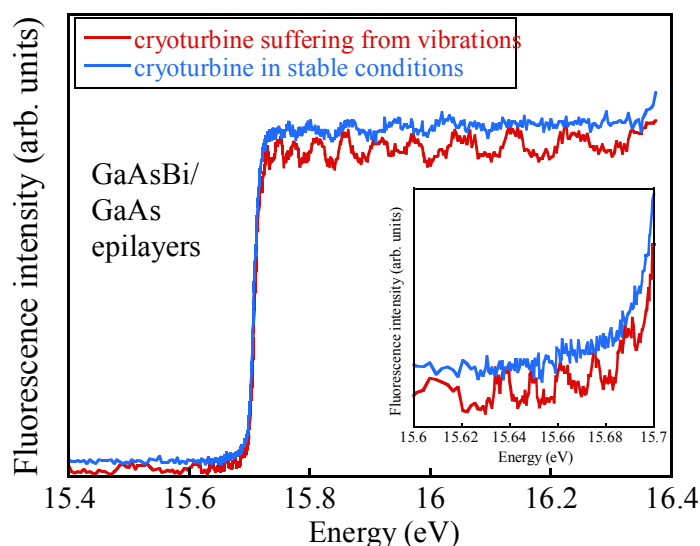


Fig. 1. Blu line: spectrum recorded with cryoturbine in stable condition. Red line: spectrum with cryoturbine affected by unwanted resonance. Inset: a zoom on the pre-edge region clearly shows the presence of spurious frequency in the red spectrum.

and

finding and maintaining stable working conditions (obtained using very low LN vapor flux) was extremely difficult and time consuming. Fig. 1 shows the distortions in the EXAFS spectra induced by the vibrations quoted above. A distorted spectrum (red line) is compared to a good one (blue line) recorded on the same sample, the former about two hours before the latter without changing any experimental condition. In the inset we show a zoom of the pre-edge region, which makes clear the periodic and mechanical nature of the distortion.

Despite these set-up difficulties, we were able to measure two of our samples (plus a third one, even if with insufficient statistics) and the preliminary results are interesting. The absorption spectra (reported in Fig. 2) show a decrease of the amplitude signal with increasing Bi concentration, which is probably related to the formation of nano-clusters or nano-voids in the semiconductor layer. We verified that such amplitude variation is not an experimental artifact. Please note that the spectrum of the sample with 2.5 % Bi in the figure has been picked up from our previous proposal MA436.

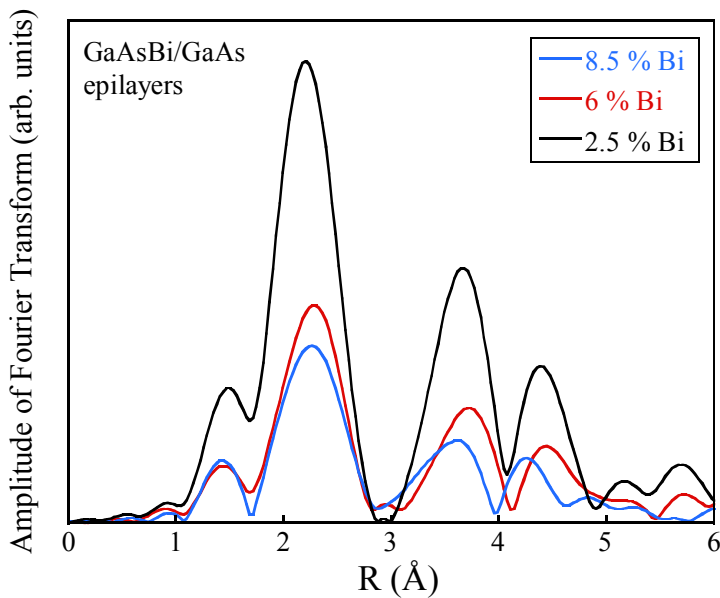


Fig. 2. Fourier Transform of the EXAFS spectra of GaAsBi/GaAs epilayers with increasing Bi % recorded at 90 K. Note the progressive decrease of the first, second and third shell peak amplitude.

Nevertheless, the measurement of (at least) other two samples with different Bi concentration (as actually planned in our original proposal) is necessary in order to 1) rule out that the trend observed with increasing Bi % is just a coincidence and that the amplitude decrease has a different origin 2) explore a wider concentration range in which the density/dimension of nanoclusters and the induced structural disorder could be not linear or not describable by a simple law (in any case, we need more points in order to determine an empirical trend and try to simulate it starting from structural models).

Complementary MAD, DAFS, electron microscopy analysis, and preliminary theoretical simulations are in progress or scheduled.

We point out that the cryoturbine sample holder, when it is in good state, permits to record very good fluorescence EXAFS data at BM29, as already demonstrated in a recent publication² for GaAsBi samples with lower Bi %. Based on this technical potential, on the particular situation we endured during the experiment (no technician available due to last-minute problems), on the fact that the failure of the cryoturbine was a too serious trouble to be fit during the scheduled shifts and, finally, on the interest of the preliminary spectra we have recorded, we are going to submit a continuation of proposal (9 shifts) to carry out our project. We hope that this can be done before the shutdown of BM29 for the relocation.

References:

- [1] S. Pasternak, F. Perrin, G. Ciatto, H. Palancher, and R. Steinmann, "Rotating sample holder at low temperature", *Review of Scientific Instruments* **78**, 075110 (2007)
- [2] G. Ciatto, E. C. Young, F. Glas, J. Chen, R. Alonso Mori, and T. Tiedje, "Spatial correlation between Bi atoms in dilute GaAs_{1-x}Bi_x: From random distribution to Bi pairing and clustering", *Phys. Rev. B* **78**, 035325 (2008)