PHENIX - mesures dans le Plan et Haute rEsolution de Nanostructures par dIffraction X

CONTACT
edith.bellet-amalric@cea.fr
stephane.grenier@neel.cnrs.fr

LABORATORIES: INAC, NEEL

PRINCIPAL INVESTIGATORS : Edith Bellet-Amalric and **Stephane Grenier** (INAC and NEEL contacts), Bernard Mongellaz and Christophe Bouchard (INAC and NEEL technical contacts), **Stephanie Pouget** (INAC)

At the end of March 2015, we welcomed a Smartlab x-ray diffractometer by Rigaku. Hosting a powerful x-ray source and offering a high measurement versatility, it is well-adapted to the diversity of samples and problems specific to crystalline layers of high structural quality and even crystalline nanoobjects. This project was jointly supported by NEEL and INAC with a co-financing of the Labex LANEF. It is jointly managed by the two institutes.

The main characterics of this equipment are: i) a 9 kW rotating Cu anode with high flux, ii) a versatile diffraction geometry, adaptable to sample morphologies, in particular for thin fims, with precise alignments of the diffraction vector either normal to the sample surface or in the plane of the sample (Fig. 1), iii) the ability to completely explore the reciprocal space, the detector having two independent movements, all angles guided by a powerful simulation and all-automated control software, iv) a modular design which enables powder diffraction, medium or high resolution diffraction, v) an oven reaching 1100°C (by Anton Paar).

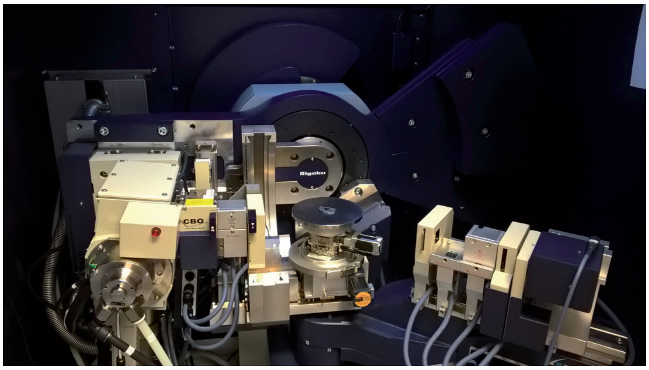

Fig.1: The equipment in the in-plane configuration mode.

A broad range of materials were studied:

- Nanostructures of nitrides semiconductors (c and m-plane growth, planar or nanowire geometry) for inter-band (UV) and intra-band (THz) emission: structural quality, strain and composition, using the high-resolution mode [1].
- II-VI semiconductors heterostructures: strain, detailed interface profile, epitaxial relation on (111) axis (fig 2).

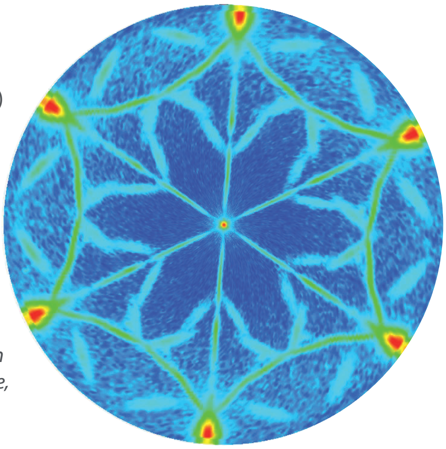

Fig. 2: Pole figure around the (1000) wurtzite reflection of a CdSe layer grown on a GaAs (111) substrate, showing an axiotaxy phenomena.

- PEDOT, organic nanometer-thick layers with very high conductivity for thermoelectric applications: in-plane and out of plane orientation of the PEDOT chains according to the type of doping molecules [2].
- Hybrid perovskite films for photovoltaic applications: crystal structure and microstructure (orientation, in-plane and out-of-plane domain size).
- Transition metal dichalcogenides, a new class of semiconducting two-dimensional materials, one to a few monolayers in thickness: crystal orientation, strain and grain size thanks to the in-plane measurements (Fig. 3) [3].
- VO_2, dependence of the electric properties of thin films on substrates, growth conditions, microstructure orientation and quality: reciprocal space mapping, in-plane measurements, dependence with temperature.

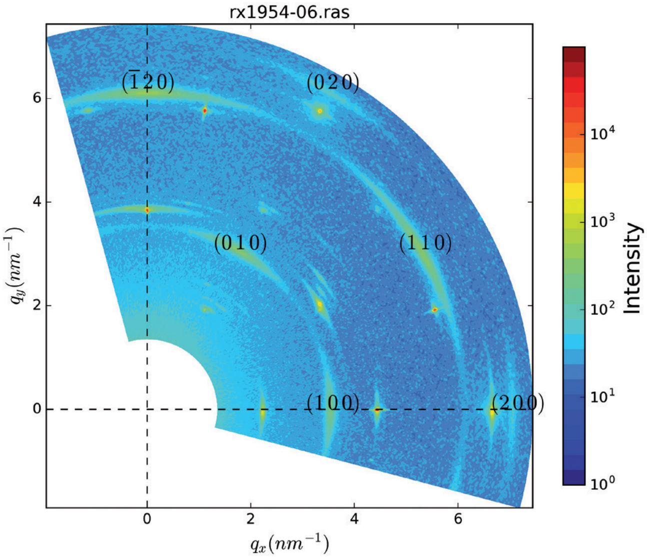

Fig.3: In plane reciprocal space map of WSe_2, 1.5 monolayer thick, epitaxially grown on mica.

OUTCOMES

[1] Effect of Ge-doping on the short-wave, mid- and far-infrared intersubband transitions in GaN/AlGaN heterostructures", Semicond. Sci. Technol. 32, 125002 (2017)

[2] Structure and Dopant Engineering in PEDOT Thin Films: Practical Tools for a Dramatic Conductivity Enhancement, Chem. Mater. 28, 3462 (2016)

[3] Millimeter-scale layered $MoSe_2$ grown on sapphire and evidence for negative magnetoresistance, Appl. Phys. Lett. 110, 011909 (2017)

Main users: Alain Marty and Eva Monroy (INAC), Aude Bailly and Laetitia Laversenne (NEEL)

Leverage: ANR Harvesters, 2017.