Grazing incidence X-rays diffraction: a powerful tool for 2D materials studies

A. Marty[1,2], M. T. Dau[1,2], C. Vergnaud[1,2], C. Beigné[1,2], M. Jamet[1,2], C. Alvarez[1,3], H. Okuno[1,3], P. Pochet[1,3], E. Bellet-Amalric[1,3], G. Renaud[1,3]
[1]*Université Grenoble Alpes, F-38000 Grenoble France*
[2]*INAC-SPINTEC, CEA/CNRS, F-38000 Grenoble, France*
[3]*INAC-MEM, CEA, F-38000 Grenoble, France*

Alain.marty@cea.fr

Layered, transition metal dichalcogenides (TMD), exhibit fascinating properties when the thickness is reduced to atomic size. For example, a transition from an indirect to a direct band gap can appear making them very attractive in electronics and optoelectronics [1]. The synthesis of high quality 2D TMD on large area is required to meet the microelectronics standards. For this purpose, we developed Se-based 2D TMDs ($MoSe_2$, WSe_2, $PtSe_2$ etc.) grown by molecular beam epitaxy [2] on various substrates. Determining the crystalline orientations, strains, and grain sizes is of great importance to understand properties and to improve the growth. The in-plane grazing incidence x-rays diffraction technique [3] is well suited for the structural analysis of these layered materials on large surface. Our measurements were performed using a laboratory set-up equipped with a rotating anode (45kV @ 200mA). Two in-plane scans types were performed: i) reciprocal radial scans along directions of the substrate in order to determine in-plane lattice parameters, strains and domain sizes. ii) Azimuthal scans performed at Bragg angles found in the radial scans in order to investigate in-plane orientation and mosaic of the 2D layers with respect to the substrate. An example of such measurements is shown on the figures below for a multilayer WSe_2/$PtSe_2$ grown on a Pt(111)/sapphire(0001). The results for the various TMD/substrates couples will be discussed, showing a large variety of epitaxial growths.

References

[1] Wang Q. H. et al. Nature Nanotech, 7 (2012) 699
[2] Dau M.T. et al., Appl. Phys. Lett., 110 (2017) 011909
[3] Gu X. et al., ChemSusChem, 7 (2014) 416

Figures

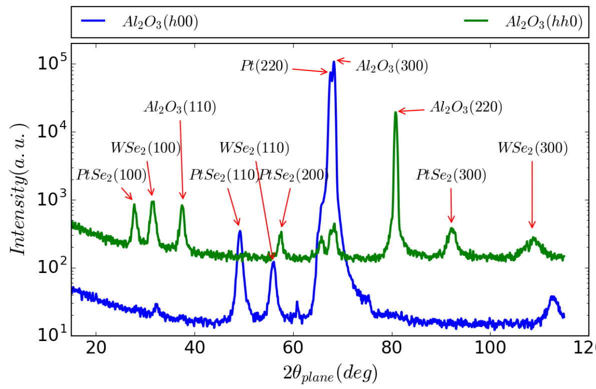

Figure 1: in-plane radial scans along <h00> and <hh0> sapphire substrate directions

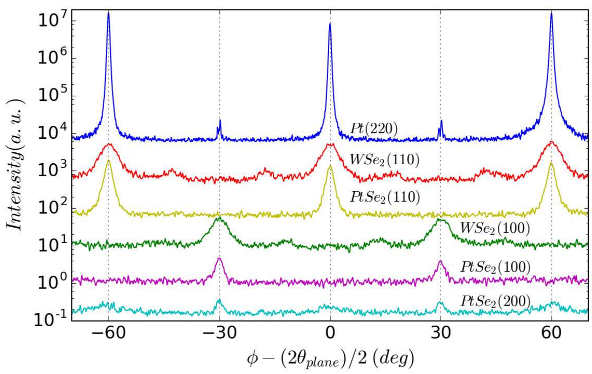

Figure 2: in-plane azimuthal scans for various Bragg reflections of the substrate and of the over-layers