Standard Project

Experimental Report template

Proposal title: Visualising the incipient growth of ZnO ALD ultra thin films on InGaAs by in situ Surface X-ray Diffraction, for tailoring contact resistivity		**Proposal number:** MA-2639
Beamline: ID03	**Date(s) of experiment:** from: **27^{th} January 2016** to: **2^{cd} February 2016**	**Date of report:** 31th March 2016
Shifts: 18	**Local contact(s):** *Dr. Francesco Carla*	*Date of submission:* *15th October 2016*

Objective & expected results (less than 10 lines):

We aimed to obtain a complete structural and chemical characterization of the early stages of ALD of ZnO on In0.57Ga0.43As/InP substrates. In particular, we would like to determine relationships between surface substrate crystallography and the ALD process parameters with the ZnO growth modes. We want to determine the best growth conditions to obtain a uniform ZnO ultrathin film (about 1nm thick) with a sharp In0.57Ga0.43As/ZnO interface, for achieving a low metal-to-semiconductor contact resistivity compatible with industrial processes.

Results and the conclusions of the study (main part):

Three kind of X-ray measurements were performed : X-ray Fluorescence with a Ketec detector, surface X-ray diffraction and reflectivity with a Maxipix detector and grazing incidence small angle scattering with a Pilatus detector. The X-ray beam energy was set at 24keV, that is well above the Zn, Ga and As K-edges for exploring a wide region in the reciprocal space. At whole, 14 samples where studied, among them 2 InGaAs, one with a cleaned surface and the other not. With the others 12 we measured the fluorescence yield, in plane diffraction maps (zap-scans), reflectivity and GISAXS as a function of the ALD cycle number. We explored the effect of the deposition temperature, the DeZn injection time, the sticking of the Si substrate holder (the In0.57Ga0.43As/InP substrate was not stick) as well as the effect of the X-ray beam on the deposition process.

Fluorescence measurements

Figure 2 displays the evolution of the Zn/As fluorescence yield ratio during growth (as a function of the ALD cycle number) for different substrate temperatures and for an incident angle of 1°. For avoiding X-ray beam effect on the deposition process, no signal was detected during growth.

In plane diffraction during growth

Figure 3 display two-dimensional in-plane reciprocal space maps for sample MOON 207 at different ALD cycle numbers. These figures reveal that the growing ZnO layer undergoes an “amorphous to crystalline transition”. Our measurements indicate that this happens quite systematically at a fixed amount of Zn deposited on the surface (as seen with the fluorescence yield). It could also be nanoparticles being too small to be detected by diffraction. Further investigations are necessary. Also, the ZnO layer seems to have an in-plane texture

Conclusion

Our first ZnO ALD in situ study at ID3 was very successful. It shed light on the early stage of ZnO ALD on InGaAs which turns out be very different compared with the one on Si or Sapphire substrates. The data analysis is in progress and complementary growth and characterization experiments are conducted at LMGP.

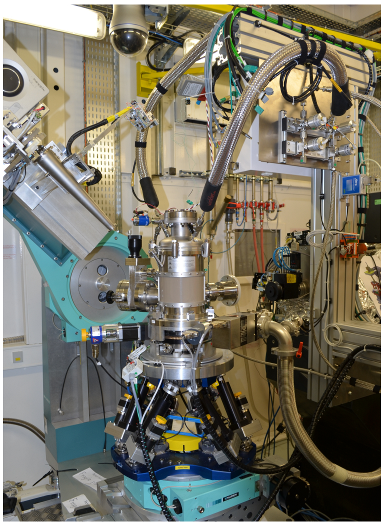

Figure 1: Experimental set-up at ID03 beamline.

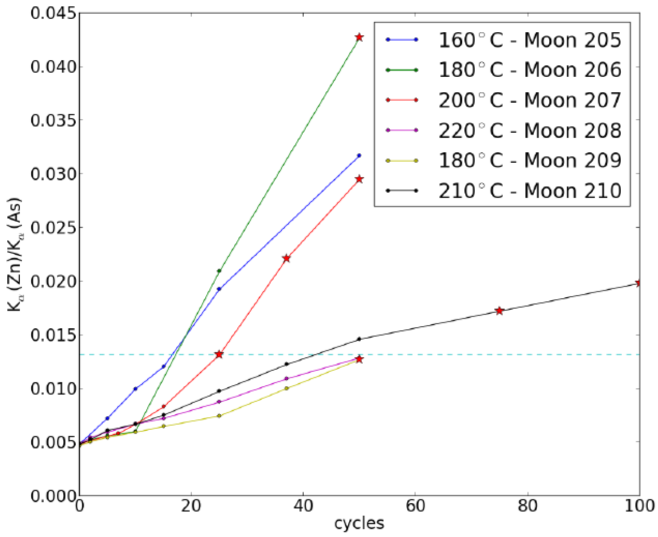

Figure 2: Zn/As fluorescence intensity ratio as a function of ALD cycle number. Evolution of the fluorescence ratio as well as the observation of a crystalline ZnO layer (red stars).

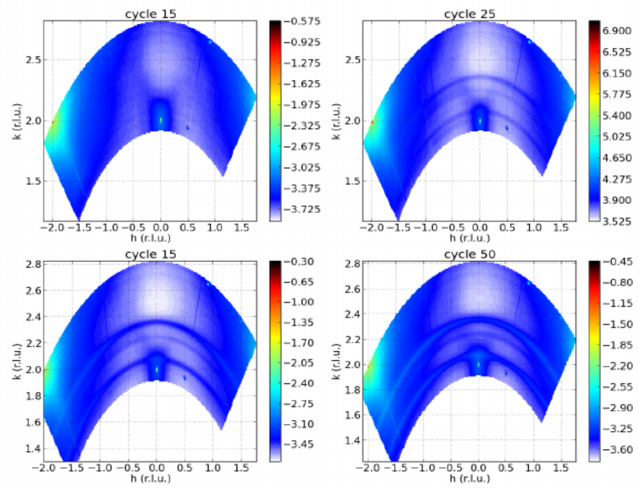

Figure 3: In-plane reciprocal space maps (zap scans) for sample MOON 207 at different cycle numbers.