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3D Reciprocal Space Maps measurements for ultrathin polycrystalline materials

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The engineering of materials has a significant importance in the miniaturization of microelectronic devices considering the fact that many mechanical and electronic properties of devices are strongly dependent on the coexistent phases and microstructure of the materials. Henceforth, the information regarding microstructure (grain size, grain boundary density etc), phases, texture and strain in these materials are of serious interest. One of the well-known non-destructive characterization tool to exploit these information is by using X-ray diffraction technique. Therefore, we rely on measuring full 3D Reciprocal Space Maps (3D RSM) measurement developed at ESRF BM02 beamline for ultrathin polycrystalline films for microelectronics applications. This technique gives a complete overview of the reciprocal space in a large range of Bragg angles to detect and characterize the nature and texture of all phases present in a polycrystalline film. These analyses will be demonstrated with various types of samples such as Ni (20 nm)/InGaAs/InP which is used in the framework of sub-20 nm FD-SOI transistors [1], ultra-thin 7 nm NiPt (5, 10 and 15 at.%) films with a Si0.7Ge0.3 layer [2]. In order to determine the texture and phases in these thin films, we rely on performing pole figure measurements. The 3D RSM are recorded by measuring full pole figures in a large range of Bragg angles. Pole figures are a representation of the diffracted intensity of a sample as a function of the azimuthal angles phi and chi at a given 2theta position of the detector. With the help of synchrotron sources and 2D detectors, larger volume of the reciprocal space can be explored by means of a series of pole figures in a feasible amount of time. A new toolbox (improved from the previous version [3]) is developed in-house at the BM02 beamline using Python programming language in order to rapidly analyze and treat the multidimensional data in an automatic way. The 3D RSM of samples were measured by in-situ annealing up to 550 °C and using a Kissinger methodology with several ramps approximately between 1 °C/min and 15 °C/min. The texture and possible phase sequence will be presented with the help of pole figures (figure 1a) and integrated intensities (figure 1b) mappings which were constructed using in-house toolbox.

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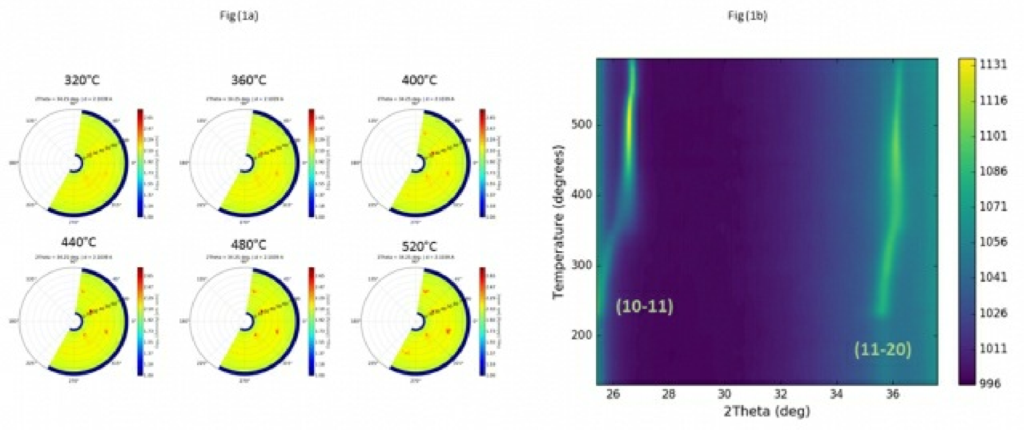

Fig. 1a: Pole figures corresponding to several annealed temperatures of the Ni (20nm)/InGaAs/InP sample

Fig. 1b: Color map of the evolution of integrated intensities according to 2θ angle and annealing temperature of the ramp performed at 15°C/min for the Ni (20nm)/InGaAs/InP sample showing the evolution of the (10-11) and (11-20) phases.

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