Microdiffraction mapping using versatile AFM and high resolution X-ray scattering setup

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Introduction and Objectives

As the dimensions in nanoelectronics approach an interatomic scale, the assessment of individual nanostructures becomes crucial in fabrication process of reliable devices. The shape and strain distributions in the nanostructure and at its interfaces are the parameters which influence the performance of a device [1]. X-ray scattering methods are well established for *in situ* and *ex situ* studies of shape and strain in nanostructures [2]. Using highly brilliant synchrotron sources, the coherent X-ray scattering techniques can be applied for non-destructive access to the interior of a nanostructure [3]. At the same time, the Atomic Force Microscopy (AFM) is one of the microscopy techniques to study surface morphology with nanometer resolution. Furthermore, by manipulating the AFM tip it is possible to apply local external stress to individual nanostructures and thus study their elastic properties [4]. Combination of X-ray scattering methods and AFM in one instrument enables to study locally strain fields in epitaxial nanostructures upon applying an external mechanical load by the AFM tip. This opens new research perspectives in the field of nanoscience, especially when the elastic properties of nanoscale objects are addressed.

Results and Discussion

Building on existing experience [4] we have implemented a standard AFM system with an optical cantilever feedback which ensures stable and controlled force on the sample surface, thus avoiding the tip oscillations inherent to a tuning fork AFM setups. The AFM setup is designed to be used in combination with synchrotron X-ray beam in scattering and diffraction geometries [5]. Proof-of-principle measurements were performed at the P10 coherence beamline of the PETRA III synchrotron at DESY, Hamburg [6]. Calibration measurements in grazing incidence small angle scattering (GISAXS) geometry were carried out using Si grating sample with 300 nm pitch. Individual spintronic Fe/MgO/GaAs microring structures were studied using the described AFM sample environment. 2D diffraction maps were collected using microfocused X-ray beam and 2D pixel detector Pilatus 300K. Shape details were evaluated from GISAXS data. Elastic strains in individual structure were studied in grazing incidence diffraction (GID) geometry as induced by external mechanical stress applied by the AFM tip.

Conclusions

Design, operation and example applications using the versatile AFM sample environment implemented at the synchrotron beamline will be presented.

References

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