IN SITU HIGH TEMPERATURE MAGNETIC AND DYNAMIC PROPERTIES OF Fe(110) NANOSTRUCTURES STUDIED WITH NUCLEAR RESONANT SCATTERING TECHNIQUES

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The developments of the third-generation synchrotron radiation sources during the last decades resulted in an enormous brilliance of the delivered x-ray beams, which has opened new possibilities in characterizing nanoscale objects. In particular, nuclear resonance scattering (NRS) of synchrotron radiation was brought to a stage, which allows one to systematically investigate electronic, magnetic, and dynamic properties of low-dimensional systems. In order to study well-defined nanostructures, one needs to prepare, characterize, and maintain the samples during experiments under controlled, preferably ultrahigh vacuum (UHV) conditions, which requires a dedicated sample environment. This is nowadays possible at the NRS beamline ID18 [1] of the ESRF using recently constructed UHV system [2], which combines the standard surface preparation and characterization techniques with the modern NRS-based spectroscopies. The capabilities of such methodology has been recently demonstrated in studies of epitaxial Fe/W(110) ultrathin films. The evolution of the spin structure was determined during the growth of Fe on W(110) single crystal with use of Nuclear Resonant Scattering of X-rays [3]. Analysis of the measured time spectra allowed for resolving the complex magnetic structure occurring in the 1 - 2 Fe monolayer coverages. For thicker Fe films the scenario of in-plane spin reorientation transition was determined indicating that during the transition an exotic non-collinear magnetization structure is formed.

In parallel, the dynamical properties of Fe nanostructures and surfaces were investigated by Nuclear Inelastic Scattering technique. The systematical investigation of the evolution of the thermo-elastic properties of Fe from the bulk to a single atomic layer (ML) by measuring the density of phonon states (DOS) were performed [4].

In this contribution we report on further progress in that field connected with the unusual structural and magnetic properties of epitaxial iron monolayers and nanostructures on W(110) observed at high temperatures.

Thermodynamic stability of Fe films on W(110) crucially depends on their thickness. The monolayer is believed to be stable at least to 1000 K [5], while thicker films (beyond 2 ML) break into islands already at 600 K as we have observed for 2.5 ML [6]. The morphology of islands depends strongly on the deposition/annealing temperature, but also on the morphology of the tungsten substrate. Using NRS we have observed entirely unexpected magnetic properties of Fe nanostructures formed from the 1.5 ML of iron after annealing. It will be shown that magnetic order persisting in such system up to approximately Curie temperature of bulk Fe diminishes during cooling from high temperature and disappears around room temperature. Moreover, this "inverse" magnetic transition seems to be reversible, i.e. magnetic order re-appear at subsequent heating to 500ºC.

As the second result a high temperature phonon density of states for Fe(110) monolayer measured with Nuclear Inelastic Scattering will be discussed.

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