ESRF	**Experiment title:** How magnetic nanoparticles are born	**Experiment number**: MA-498
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Report:

The aim of this in-situ experiment was to produce magnetic nanostructures by sputter deposition of iron onto different metal and polymer surfaces. A combination of nuclear forward scattering (NFS) and grazing incidence small angle x-ray scattering (GISAXS) was used to correlate the magnetism with the structural growth and changing morphology.

To this end a remote controlled sputter deposition system for in-situ x-ray grazing incidence experiments was implemented at beamline ID18 and a GISAXS setup was build up (including a 3m long flight tube, guard slits etc.). This was the first experiment of this kind and the first two days of the beamtime were necessary to overcome a malfunction of our deposition system and to optimize the experimental setup to each technique. However, it turned soon out that this challenging experiment became a complete success.

Within the remaining 4 days we performed two complete deposition runs using 2 polymer buffer layers with and without a nanostructured surface morphology. The experimental procedure was to performed a GISAXS measurement (30min to 1min), collect a NFS time spectra (around 5 to 10min) and take one electronic/nuclear reflectivity curve after each deposition step of 3Å. Figure 1 shows selected time spectra and GISAXS pattern of such a sputter run. At low deposition state (10Å) the time spectra reveal a nonmagnetic iron phase which is slightly oxidized (30% of the atoms due to interaction with the polymer surface). During the next deposition steps two different magnetic phase transitions occur which are attributed to spatially separated two different agglomeration states of the sputtered iron. The high quality of the GISAXS pattern (high statistics, high resolution as well low background) allowed resolving the particle shape and the spatial distribution of the iron nanostructure (see Figure 2). In combination with the electronic/nuclear reflectivity curves this led to an unambiguous and consistent picture of the growth mechanism and the magnetic transition of the iron nanostructure created on this specific polymer buffer layer.

This new combined in-situ experimental setup opens new possibilities to study the self assembled growth of magnetic nanostructure and helps to tailor their properties for future applications.

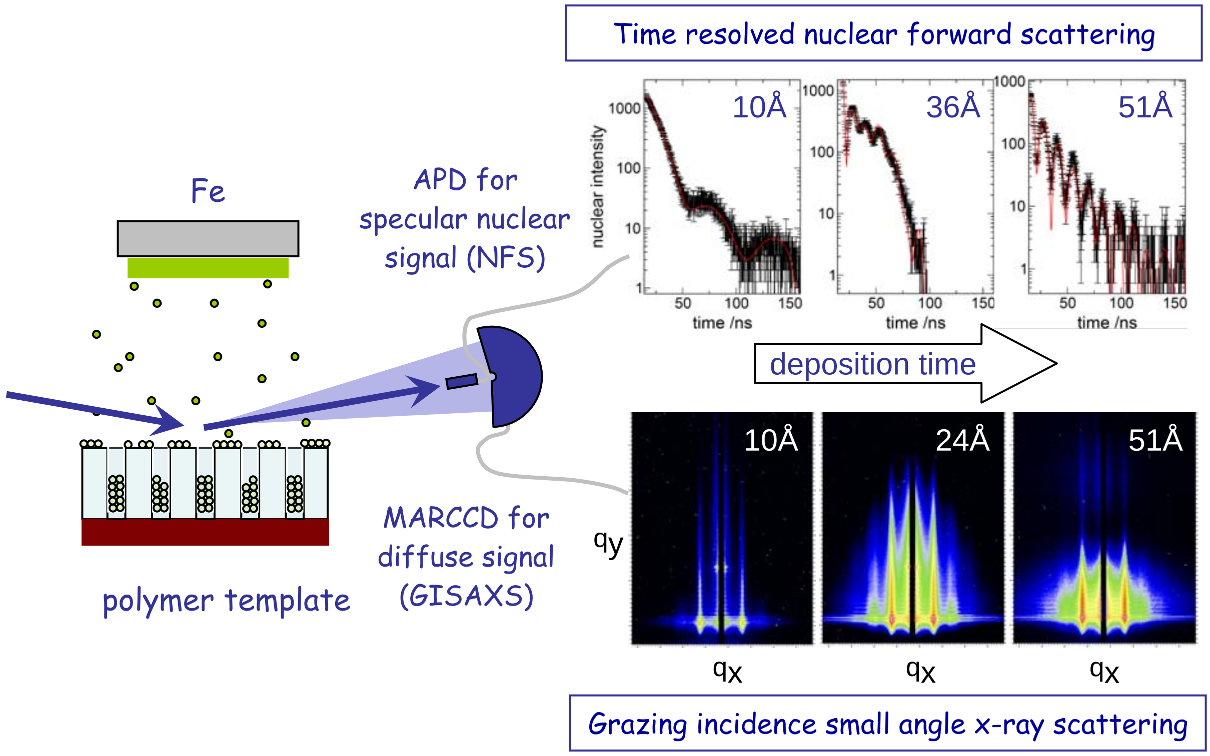

Fig. 1: Schematic drawing of the experimental setup and selected experimental results. Self assembled groth of iron achieved by deposition onto a polymer template (which presents in this case a regular array of empty vertical cylinders). Nuclear forward scattering (NFS) and grazing incidence small angle x-ray scattering (GISAXS) are used to follow and to correlate the magnetic transition and the chemical state of the nanostructure with its structural growth and its spatial arrangement.

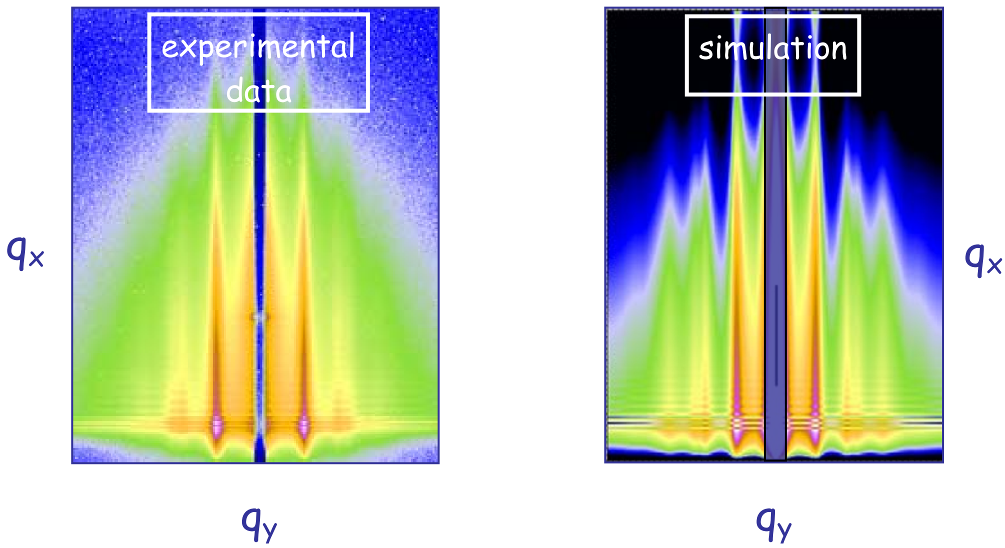

Fig. 2: These images present a measured 2D-GISAXS pattern after deposition of 2.4nm iron and the according simulation. The simulation of the GISAXS data reveals the information about the particle shape and the spatial arrangement of the iron nanostructure.