ESRF	**Experiment title:** Frequency dependent X-ray detected ferromagnetic resonance	**Experiment number**: HE-3294
Beamline: ID 12	**Date of experiment**: from: 13.07.2010 to: 23.07.2010	**Date of report**: 03.08.2011
Shifts: 24	**Local contact(s)**: A. Rogalev	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

K. Ollefs*, M. Farle, R. Meckenstock*, F. Römer, A. Rogalev, F. Wilhelm, C. Antoniak, A. Ney*, V. Ney*, H. Wende, (D. Spoddig*and Ch. Schöppner*)

Report:

The aim of this experiment was a proof-of-principle experiment to introduce a new experimental setup allowing frequency-dependent XDMR measurements in longitudinal geometry using hard X-ray spectroscopy. This setup is based on a stripline geometry which in principle allows to measure a wide (2-20 GHz) microwave frequency range in contrast to resonator-based XDMR which is limited to a few microwave frequencies. This new XFMR setup including electro-magnet was successfully implemented into the sample-cube endstation of beamline ID12 allowing to simultaneously detect conventional FMR and XFMR. In Fig.1 XANES and XMCD spectra are shown recorded with the cube's photodiodes and the XFMR setup for both Fe and Ni K-edge of our 200nm Permalloy sample respectively. Furthermore we recorded both conventional and X-ray detected FMR as shown in Fig. 2 at the photon energy of the maximum XMCD of the Ni K-edge.

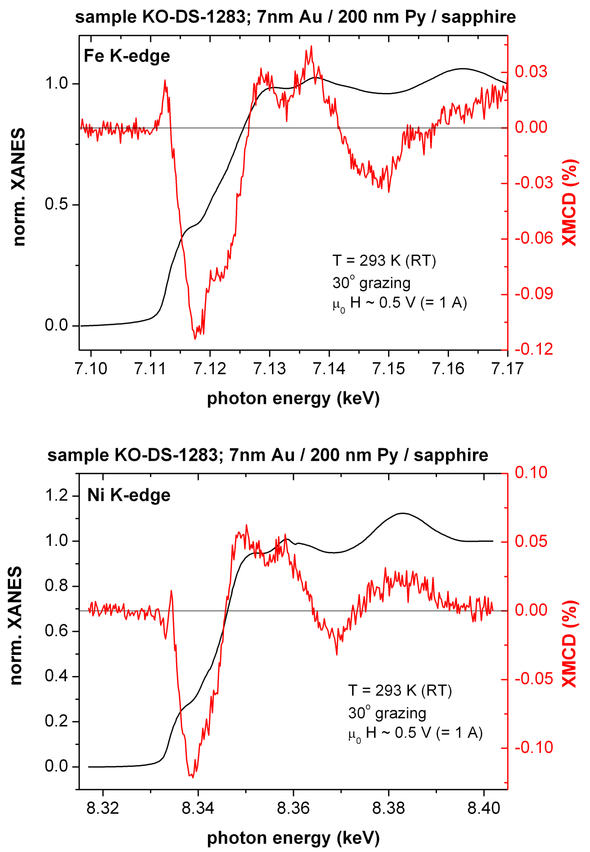

Fig 1: XMCD at Fe and Ni K-edges of the Permalloy sample.

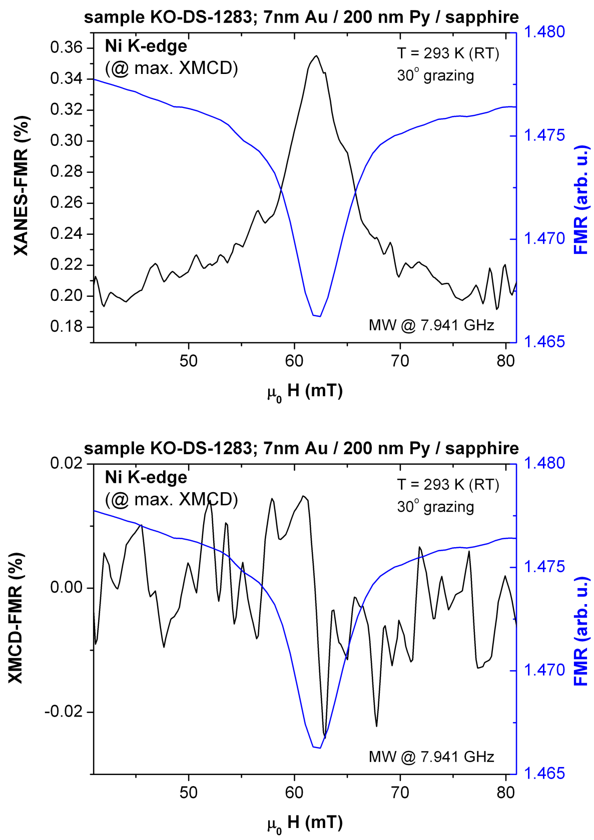

Fig 2: FMR (blue) and XFMR (black) at the Ni K-edge. The sum (top) or difference (bottom) of σ+ and σ- are shown .

The XFMR spectra were recorded for both helicities (σ+ and σ-) recording the absorption with the microwave power modulated on and off, respectively, to reduce background noise. For these spectra the photon energy was set to the value where the XMCD effect is maximal and the static magnetic field was swept. For the XANES-FMR spectra we added the spectra recorded for σ+ and σ- yielding a clear signal following the shape of the conventional FMR line detecting the reflected microwave power. For the XMCD-FMR we subtracted the spectra recorded for σ+ and σ- in order to extract a signal which is correlated to the change in XMCD due to the resonance. One can clearly see that the XMCD-FMR signal is hardly detectable despite accumulating spectra for almost one day. In order to yield better understanding of the XANES-FMR spectra we also recorded such spectra at the Fe K-edge shown in Fig. 3 (top) for different photon energies. The spectral shape is independent of the photon energy and therefore not associated with the element selective absorption as would be desirable. For further investigate this effect we put a Ni foil as filter in front of the photodiodes replacing the kapton filters in order to suppress not only the electrons but also the signal of lower energy photons at the Fe K-edge. With the Ni Filters the XANES-FMR signal was significantly reduced, see Fig. 3 (bottom) so that it is hardly detectable. One possible explanation might be that the Ni foils suppress photons from diffuse scattering which in turn is susceptible to the ferromagnetic resonance of the sample. With the Ni filters the Ni K-edge could not be measured anymore however the hope was that the XMCD-FMR signal for the Fe K-edge shown in Fig. 4 (top) would become more pronounced compared to the Ni (Fig. 2, bottom) and Fe (not shown) K-edge XFMR signal. This however was not the case. In order to be able to modulate the applied microwave power at a frequency of 67Hz to facilitate lock-in detection rather than taking on/off differences, we used a Femto current amplifier instead of the standard electrometers and measured both FMR and XFMR using an SR 830 lock-in as shown in Fig. 4 (bottom).

We also recorded XFMR spectra with constant applied magnetic field with the sample in resonance condition and sweeping the photon energy (not shown). For these spectra we found for some orientations of the sample with respect to the x-ray beam a Bragg peak susceptible to resonance of the sample leading to a strong signature in the spectra.

In summary, we implemented the new (frequency dependent) FMR setup into the sample cube of ID12 allowing to detect FMR and XFMR sweeping both magnetic field and photon energy. We found a photon energy independent x-ray detected signal susceptible to the resonance (XANES-FMR) but no sizable XFMR signal.

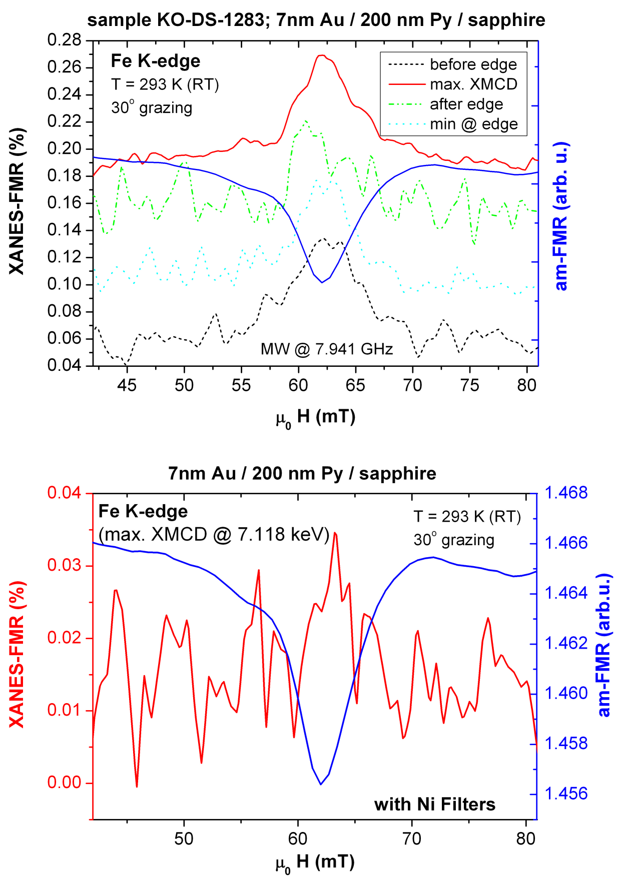

Fig. 3: XFMR without (top) and with (bottom) Ni filters.

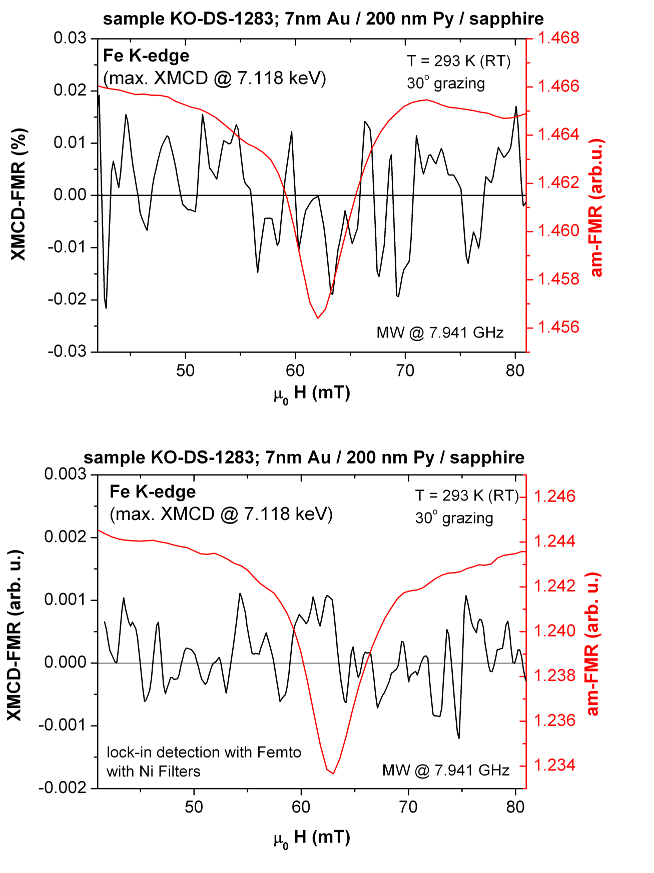

Fig 4: XMCD FMR with standard electrometers (top) and with Femto-Amplifier (bottom).