ESRF	**Experiment title:** Magnetic Spin Structure of the Native Oxide in Metal/Metal-Oxide Heterostructures	**Experiment number:** SI 903
Beamline: ID18	**Date of experiment:** from: 9.12.2003 to: 18.12.2003	**Date of report:** 18.08.2004
Shifts: 18	**Local contact(s):** O. Leupold, R. Rüffer	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):
R. Röhlsberger*
Technische Universität München, James-Franck-Str. 1, 85747 Garching, Germany

T. Klein* and K. Schlage*
Universität Rostock, August-Bebel-Str. 55, 18055 Rostock, Germany

G. S. D. Beach
Center for Magnetic Recording Research, University of California, San Diego, USA

Report:
The aim of the experiment was the determination of the spin structure in the native iron oxide that forms on sputtered Fe layers. Motivation for this study was the discovery of a new type of magnetic order in buried native Fe oxide layers [1]. The experimental method chosen here was nuclear resonant scattering due to its pronounced sensitivity to the orientation of magnetic hyperfine fields. The sample investigated here was produced by deposition of a thin layer of ^{57}Fe on natural Fe and subsequent oxidation at r.t. in an O_2 atmosphere, leading to a 9Å thick layer of native ^{57}Fe oxide. This layer system was then covered by a thin layer of natural Fe, as sketched inf Fig. 1a. To achieve the required sensitivity to the very small amounts of ^{57}Fe involved here, this layer system (Fe/Fe-oxide/Fe) was embedded in an x-ray waveguide structure. The strong enhancement of the signal enabled us to significantly reduce data acquisition times and perform systematic studies. To allow for a unique determination of the magnetic spin structure, the magnetized sample was oriented at various azimuthal angles φ relative to the incident beam. A selected set of time spectra is shown in Fig. 1b. The solid lines are theoretical simulations based on the hyperfine-field distribution shown in Fig. 1c, as determined from earlier Mössbauer measurements. The oxide consists of two components that differ with respect to their magnetic structure. The components centered around B = 34.4 T and 39.5 T are ferromagnetically aligned with the Fe metal. According to *Beach et al.* the broad component at low fields (shaded area) is attributed to a magnetically frustrated phase with zero moment. The present data do not yield an unambiguous assignment of its

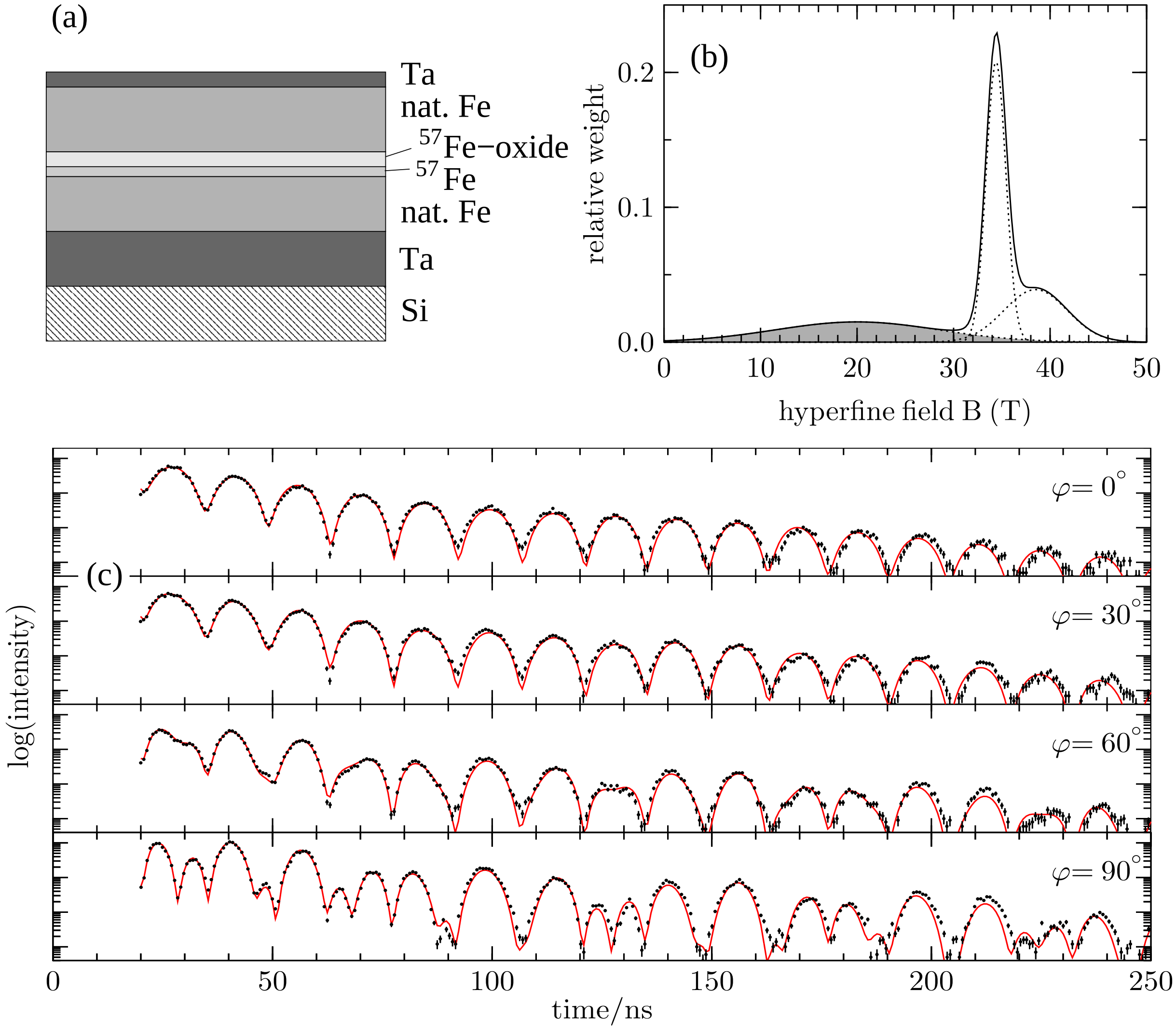

Fig. 3 a) Geometry of the sample investigated here. The native oxide layer is embedded in a x-ray waveguide structure to enhance the signal from the ^{57}Fe. b) Hyperfine field distribution in the native Fe oxide assumed for the simulation of the experimental data. c) Time spectra of grazing incidence reflection from the layer system sketched in a) for various azimuthal orientations φ of the magnetization direction relative to the incident beam. Solid lines are fits to the data.

magnetic structure. The assumption of an orientational glass leads to a slightly better simulation of the experimental data compared to a ferromagnetic alignment with the metal. Although this effect is not very pronounced, it is systematically observed for all samples investigated here. However, in the present study it is not possible to distinguish between an in-plane (2D) and an isotropic (3D) orientational disorder. The weakness off this effect is due to the relatively small fraction of the oxide phase, the presence of a high metallic fraction of ^{57}Fe and the rather broad hf field distribution. Due to the technological relevance of these oxide/metal heterostructures it is worthwhile to further investigate this system with respect to the spin structure of the minority phase. For this purpose the sample preparation procedure has to be improved so that ^{57}Fe is present only in the oxide phase. Then the contribution from the minority phase of the oxide would not be superimposed by the signal from the metallic ^{57}Fe. The construction of a dedicated UHV chamber for corresponding in-situ studies is on the way.

[1] G. S. D. Beach et al., Phys. Rev. Lett. 91, 267201 (2003).