

NREX: Neutron reflectometer with X-ray option

Max-Planck-Institut für Festkörperforschung
Heinz Maier-Leibnitz Zentrum

Instrument Scientists:

- Yury Khaydukov, Max-Planck-Institute for Solid State Research, Stuttgart, Germany
at Heinz Maier-Leibnitz Zentrum (MLZ), Garching, Germany, phone: +49(0) 89 289 14769,
email: y.khaydukov@fkf.mpg.de
- Olaf Soltwedel, Max-Planck-Institute for Solid State Research, Stuttgart, Germany
at Heinz Maier-Leibnitz Zentrum (MLZ), Garching, Germany, phone: +49(0) 89 289 14769,
email: o.soltwedel@fkf.mpg.de
- Thomas Keller, Max-Planck-Institute for Solid State Research, Stuttgart, Germany
at Heinz Maier-Leibnitz Zentrum (MLZ), Garching, Germany, phone: +49(0) 89 289 12164,
email: t.keller@fkf.mpg.de

Abstract: The high resolution neutron/ X-ray contrast reflectometer NREX, operated by the Max Planck Institute for Solid State Research, is designed for the determination of structural and magnetic properties of surfaces, interfaces, and thin film systems.

1 Introduction

The instrument is an angle-dispersive fixed-wavelength machine with a default wavelength of 4.28 Å. A horizontal focussing monochromator gives the possibility to switch between modes “high intensity/ relaxed resolution” and “high resolution/ reduced intensity” and provides a beam especially for small samples (down to 5 x 5 mm² and below). A Beryllium filter attenuates higher order reflections. Transmittance supermirrors $m = 3.5$ with a polarising efficiency of $P = 99\%$ and high efficiency gradient RF field spin flippers are used for a full 4 spin channel polarisation analysis.

The sample is aligned horizontally. By tilting the sample the incident angle is varied. The detector arm can move for GISANS horizontally as well as vertically for specular and diffuse scattering measurements. Neutrons are detected with a 20 x 20 cm² position sensitive or a pencil detector. An X-ray reflectometer can be mounted on the sample table orthogonal to the neutron beam. It allows for the in-situ characterisation of sensitive soft matter samples and neutron/ X-ray contrast variation experi-

ments.

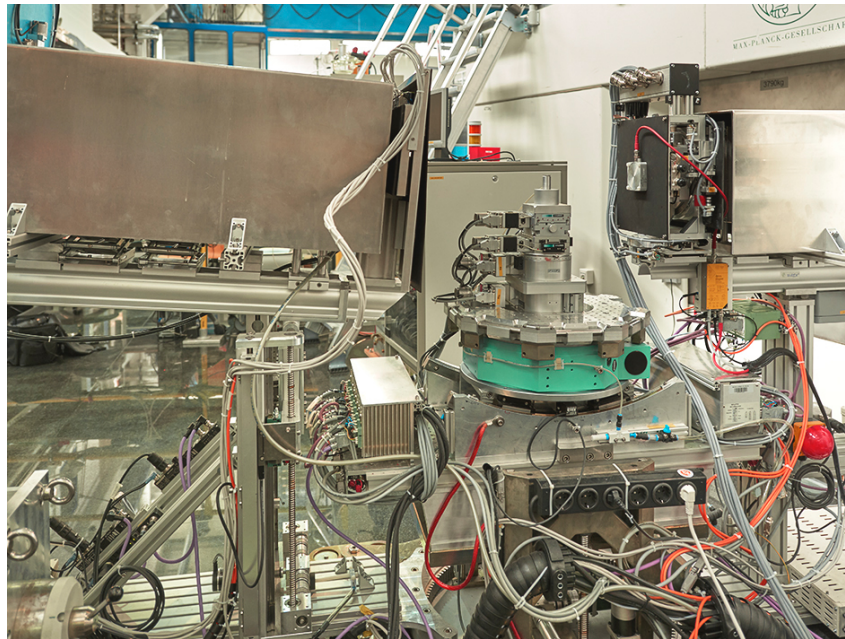


Figure 1: Instrument NREX (Copyright by W. Schürmann, TUM).

2 Typical Applications

The instrument provides specular and off-specular reflectometry as well as grazing incidence small angle diffraction both in polarised and non-polarised modes. While the specular reflectivity allows determining the scattering length density profiles (20 – 1500 Å) with nm precision along the surface normal, the off specular reflectivity is sensitive to in-plane-inhomogeneity like roughness, (magnetic) domains, vortices in superconductors- and clusters- in the μm -range. To probe lateral (in-plane) structures in the order of atom distance (down to few Å) at the surface, grazing incidence diffraction is provided.

3 Sample Environment

A closed cycle cryostat (down to 3.5 K) and an electromagnet for fields up to 0.5 T applicable in all three space-directions with restrictions in field strength are provided. Additionally the standard sample environment (magnets up to 7.5 T and ^3He inserts for the cryostat down to 50 mK) are available. To the instrument pool belong a cell for investigations at the solid/ liquid interface and a gastight chamber for experiments under defined environmental conditions (arbitrary atmospheres: for example defined relative humidity) at the solid/ air interface.

4 Technical Data

4.1 Monochromator

- Type
 - 7 x 5 HOPG crystals
 - Horizontal focussing
- Wavelength: 4.28 Å
- Wavelength resolution: 1...2 %

- Distance to sample: 2500 mm
- Higher order filter: cooled Be

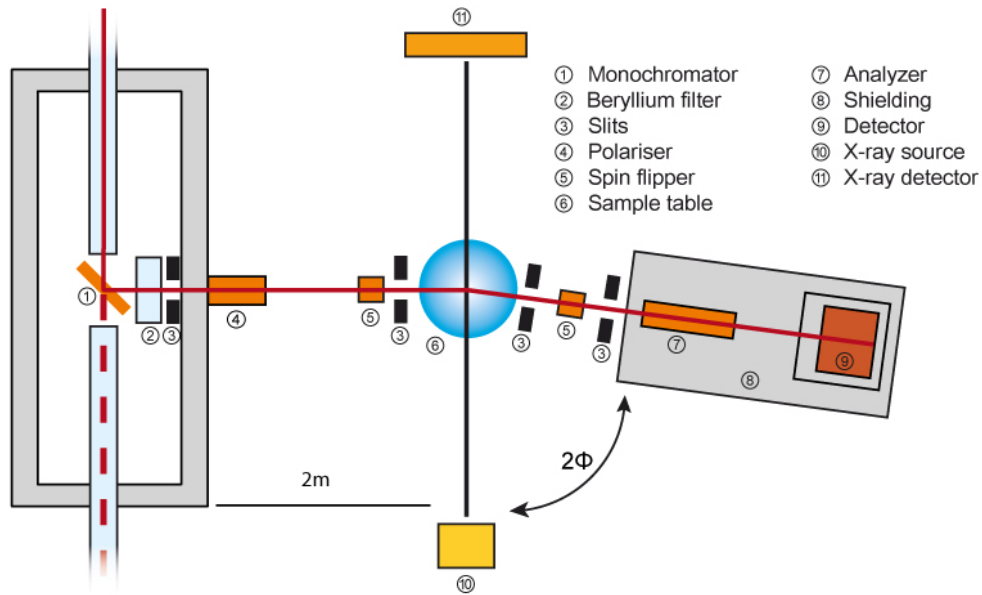


Figure 2: Schematic drawing of NREX.

4.2 Collimation

- Vertical
 Slit sizes: 0.2 – 6 mm
 Divergence: 0.05 – 1.4 mrad
- Horizontal
 Slit: 0.2 – 100 mm

4.3 Polarisation

- Beam polarisation > 99 %
- Flipper efficiency > 99 %

4.4 Detector

- 2 pencil detectors ^3He
- 2D area detector ^3He wire chamber
- Active area 200 x 200 mm²
- Lateral resolution 3 mm
- Distance to sample 2465 mm

4.5 Dynamical- and Q-Range

- Specular reflectivity: 1 : 1×10^{-6} (@ 5 x 5 mm² sample and full polarisation)
- Q_z : 0.005 - 0.5 Å⁻¹
- δQ_z ($0 < Q_z < 0.2 \text{ Å}^{-1}$) < 0.002 Å⁻¹

4.6 X-rays

- Source: Cu-K α fixed anode (1.54 Å)
- Monochromator: Goebel Mirror & Double Ge-Crystal
- Detector: 0-dimensional NaI scintillation counter