Thin film fabrication in a new laboratory

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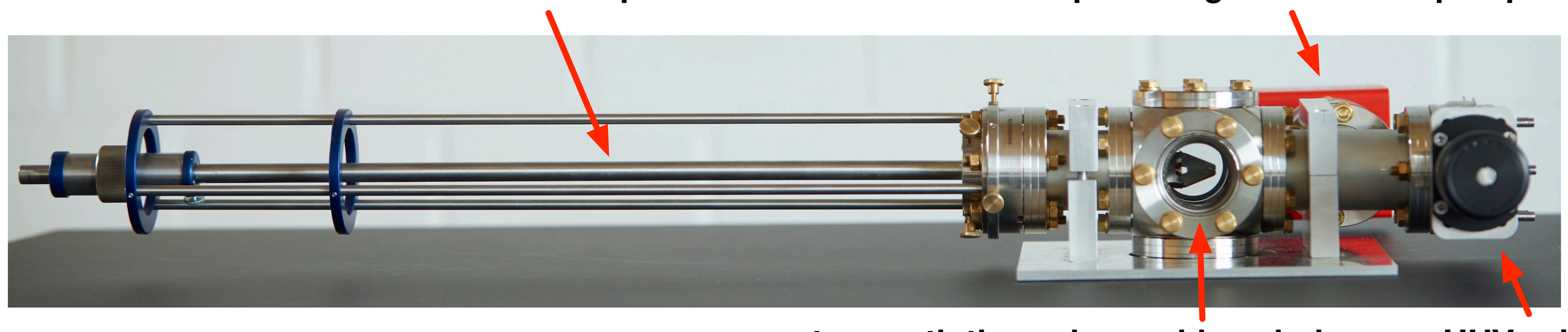
Introduction

Imagine you have an idea for a thin film system which you want to measure with polarised neutron reflectometry. But you do not have the expertise and/or the equipment for thin film fabrication.

We can help you!

The JCNS thin film laboratory runs an oxide MBE system for the growth of various types of samples, i.e. "classical" magnetic thin films, transition metal oxide heterostructures or thin metal films for soft matter studies, acting as defined surfaces.

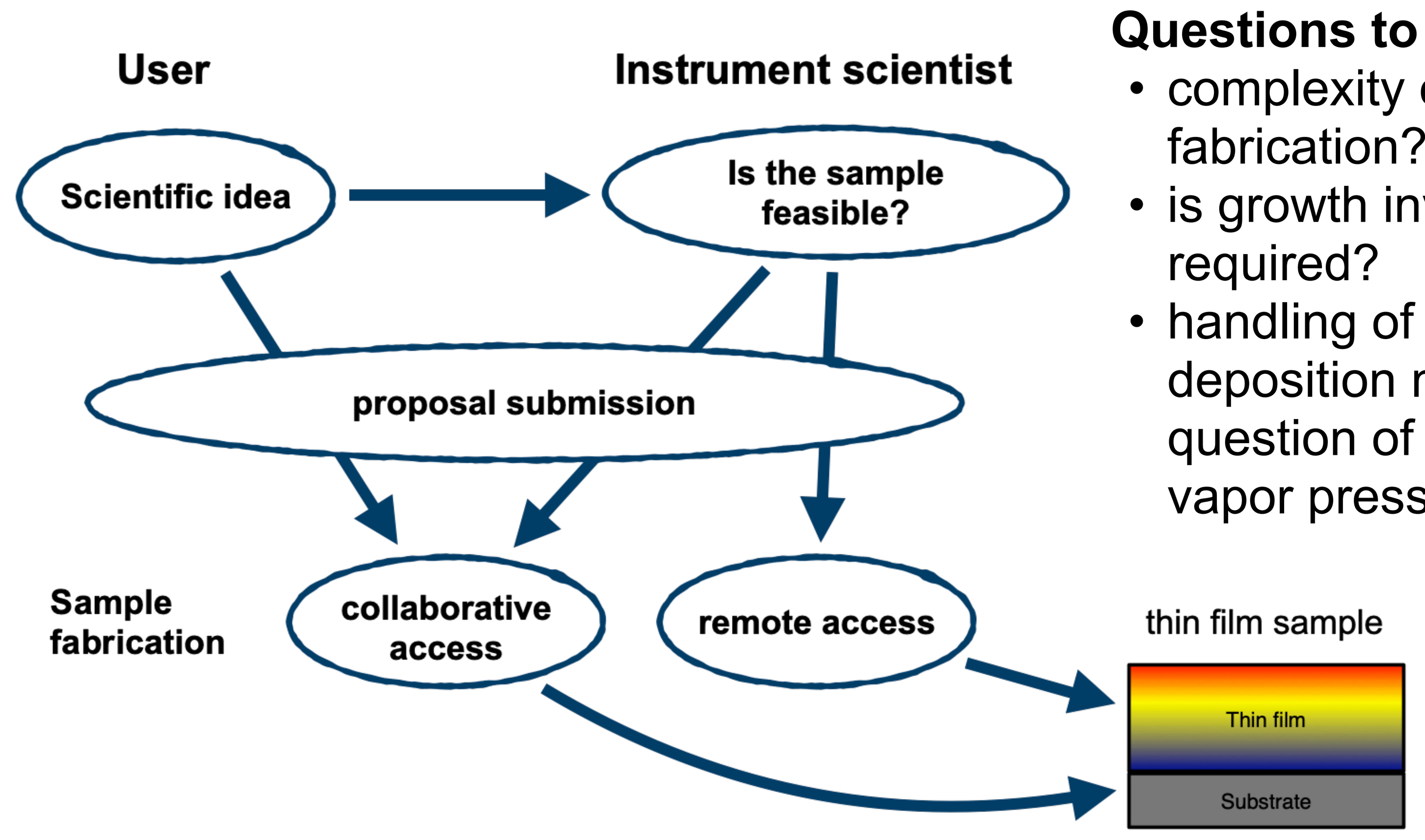
Mini UHV transfer chamber



base pressure $2 \cdot 10^{-10}$ mbar

A. Syed Mohd, S. Pütter, S. Mattauch, A. Koutsioubas, H. Schneider, A. Weber, and T. Brückel, Rev. Sci. Instrum. 87, 123909 (2016)

Acces to thin film fabrication



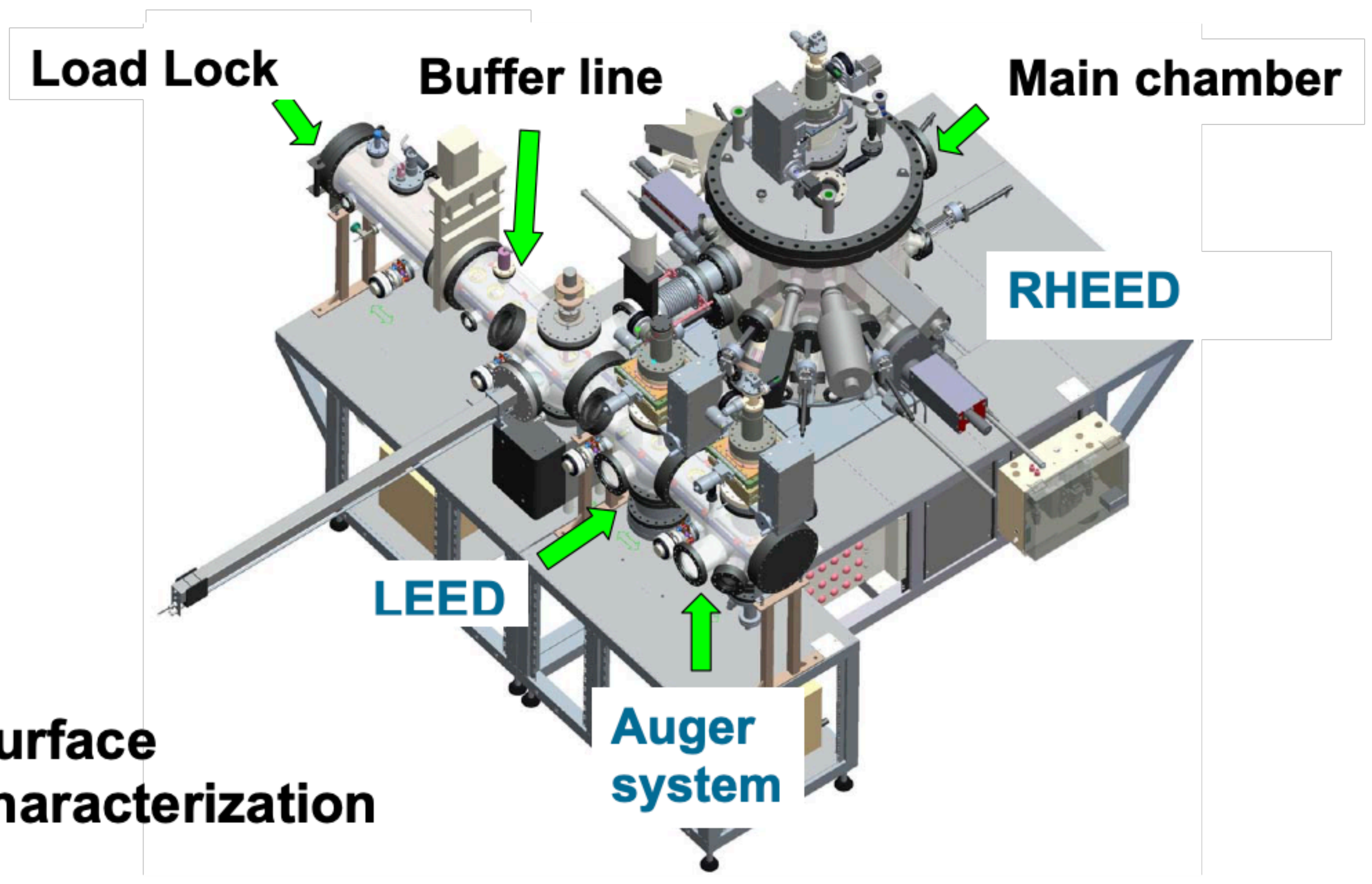
Questions to be solved:

- complexity of sample fabrication?
- is growth investigation required?
- handling of the deposition material: question of toxicity and vapor pressure

Access to the transfer chamber, sample fabrication with the MBE system and beam time at MARIA is provided via proposals at MLZ in Garching (http://mlz-garching.de/) and at nffa.eu

Molecular Beam Epitaxy (MBE) setup for sample fabrication

Main chamber: base pressure < 10^{-10} mbar
Sources: 6 Effusion cells, 2 e-guns (each 4 crucibles), plasma source
Growth control via Quartz micro balances and Reflection High Energy Electron Diffraction (RHEED)
Substrate manipulator temperatures up to 1000 °C
High reproducibility of sample growth:
Automated control of the growth procedure by scripts
Supplied evaporation material:
Ag, Al, Au, Co, Cr, Cu, Fe, La, Mn, Ni, Nb, Pt, Sm, Sr, and Ti, other material on request

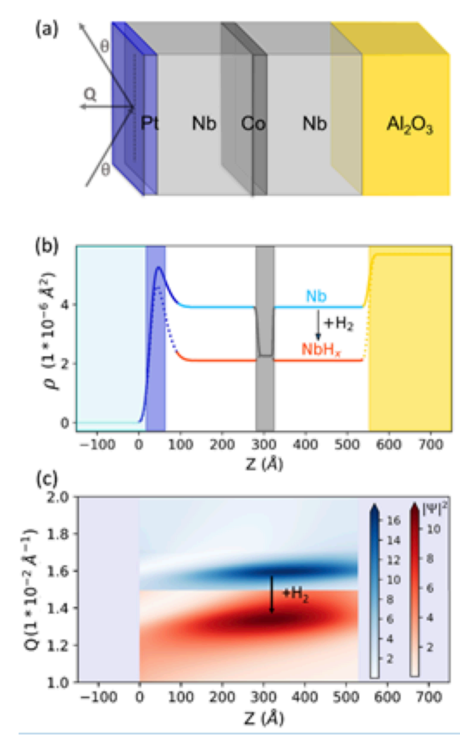


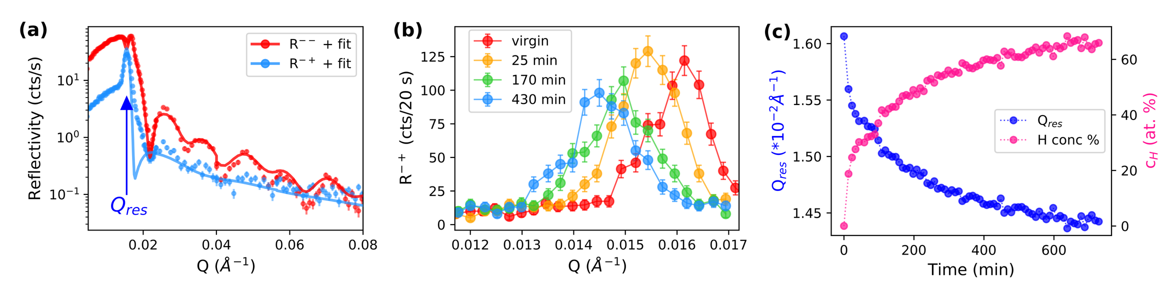
Examples

Hydrogen detection in thin Films by Neutron Waveguide

- Sample with staircase like scattering potential enclosing Nb layers, a well-known hydrogen absorber and form a neutron waveguide
- Pt(3nm)/Nb(25nm)/Co(3nm)/Nb(25nm)/Al_2O_3. When Nb absorbs H, its scattering length density decreases, changing the shape of the potential.
- The Neutron wave amplitude is modified and shifted in Q.

$$\Delta Q_{\rm res} \simeq \frac{8\pi \Delta\rho_2}{Q_{\rm res}} \simeq \frac{8\pi \bar{N}}{Q_{\rm res}} c_{\rm H}$$

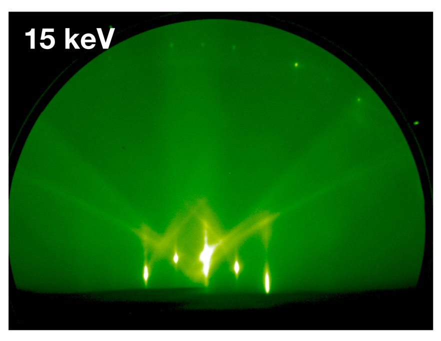




L. Guasco, Y. Khaydukov, S. Pütter, M. Paulin, T. Keller, and B. Keimer, submitted

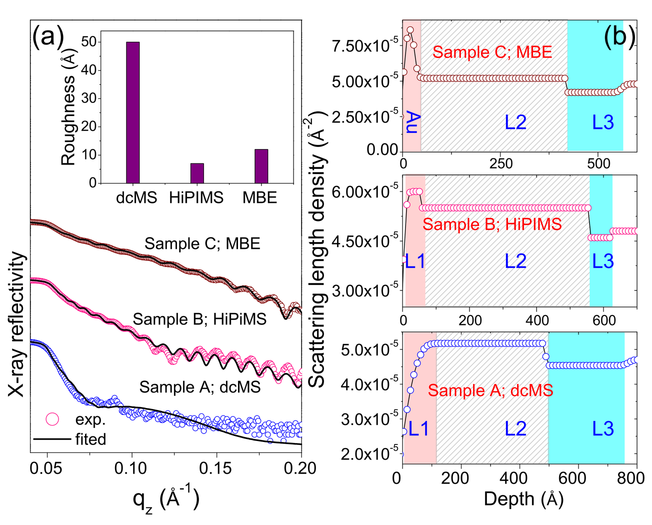
The magnetic moment of epitaxial $Fe_4N/LaAlO_3$

RHEED



38 nm $Fe_4N/LaAlO_3$

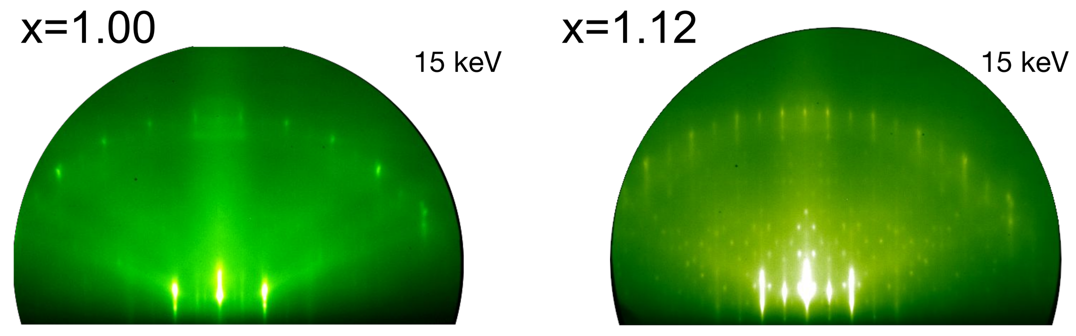
XRR

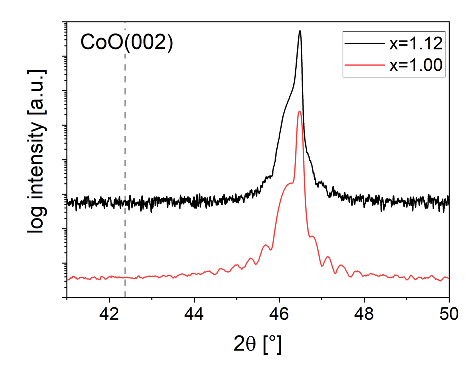


MBE growth is used as alternative to sputtering techniques for finding the best crystalline structure and highest magnetic moment of Fe_4N

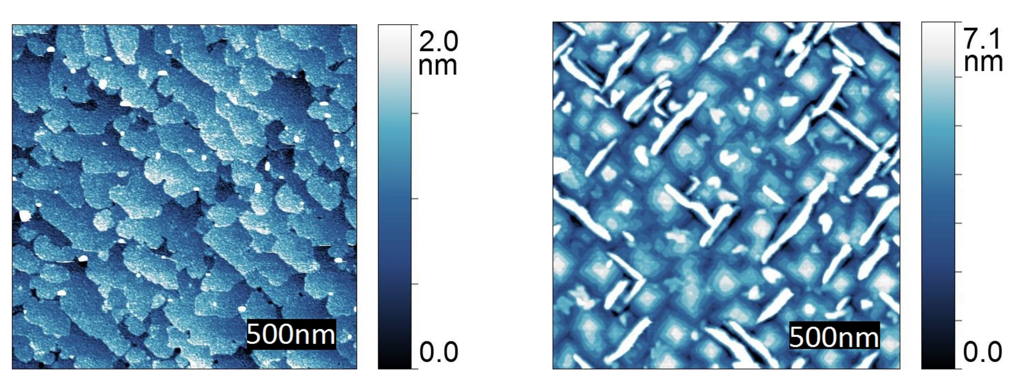
N. Pandey, S. Pütter, S. M. Amir, V. R. Reddy, D. M. Phase, J. Stahn, A. Gupta, and M. Gupta, Phys. Rev. Materials 3 (2019) 114414

RHEED assisted determination of the stoichiometry of $SrCo_xO_{2.5+\delta}$





AFM



While XRD is not able to distinguish between perfect stoichiometry and Co excess RHEED shows distinct features

P. Schöffmann, S. Pütter, J. Schubert, W. Zander, J. Barthel, P. Zakalek, M. Waschk, R. Heller, and T. Brückel, Mater. Res. Express 7 (2020) 116404

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