Growth and redox reaction at the transition metal monoxide/metal interface

General Scope:
The building of new interfaces between oxides is of mandatory importance for the search of magnetic and electronic properties at the nanoscale. For a decade, an intense research activity has focused on two dimensional electron gases forming at such interfaces [Ohtomo, A. & Hwang, H. Y., Nature 427, 423-426 (2004)]. These electronic states present a wide range of interesting properties including a modulation of the conductivity by applying a gate voltage, superconductivity, magnetoresistance and spin polarization. The elaboration of these interfaces requires a layer-by-layer tuning of their structure. More recently it has been shown that 2D electron systems can be generated more easily, simply by depositing aluminum on the surface of oxides like SrTiO$_3$ TiO$_2$, etc. [T. C. Rödel et al., Adv. Mater. 28, 1976 (2016)]. In this case Al gives rise to a redox reaction, resulting in an amorphous alumina layer and oxygen vacancies at the interface acting as an electron doping (see Fig.). This phenomenon seems to be quite general providing that a metal with low electronegativity is deposited. Our aim is to grow and characterize interfaces with a well-defined structure (unlike amorphous alumina) by depositing reactive metals like e.g. magnesium on simple and well defined monoxides surfaces such as CoO(100) or NiO(100).

Research topic and facilities available:
During the internship, samples will be grown by molecular beam epitaxy (MBE) and characterized by combining low energy electron diffraction (LEED), Auger spectrometry (AES) and scanning tunneling microscopy (STM). High quality CoO(100) or NiO(100) films will be obtained by reactive metal deposition in molecular oxygen atmosphere. Mg will be deposited on top in ultra-high-vacuum. The structure of the interfaces showing the desired epitaxial relationship will be determined using synchrotron radiation x-ray diffraction (as a function of the beam time allocation). This is an essential preliminary step to the measurement of their electronic properties. In situ resonant x-ray diffraction will be also employed, when adapted, to gather the onset of induced electronic state measuring the diffracted signal change at the transition metal adsorption edge. Such a technique is sensitive to the electronic properties of sharp interfaces.

Possible extension as a PhD: Yes
Required skills: Solid-State Physics, Nanoscience
Starting date: March 2019

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