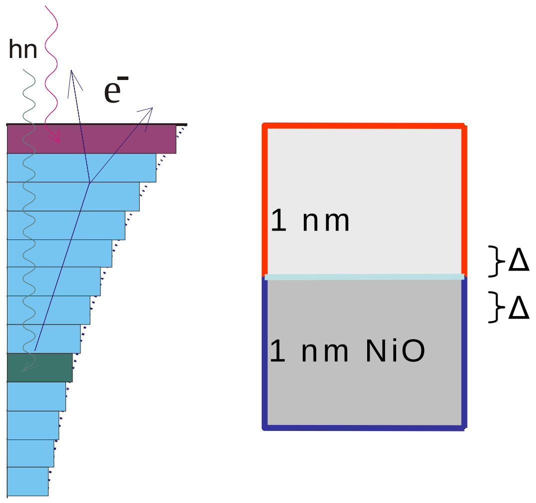
Übungen zur Oberflächenphysik

Blatt 4 – 16.4.2013

1) **Photon Polarization of Synchrotron Radiation**
Consider the case of synchrotron radiation from a bending magnet source on a storage ring filled with electrons. Now assume that the ring was operated with positrons instead of electrons with the particle trajectory remaining the same (this can indeed be done and has been tried at some synchrotron radiation facilities). Does the polarization of the emitted radiation change or remain the same?

2) **Interface sensitivity**
The probability that an electron generated at depth t is ~$e^{(-t/\lambda)}$. Our sample consists of 1 nm Co and 1 nm NiO. How much contributes the interface (Δ=0.2 nm in each layer) to our total signal for the Ni measurement and for the Co measurement.

a) Measured in total electron yield with mean free path λ=2.5 nm.
b) Measured in total electron yield with λ=2.5 nm but now the NiO is a single crystal.
c) For the NiO single crystal measured in fluorescence with λ=50 nm.
d) Comparing the Co measurement in b) and c) which one is better to measure the interface?



3) **Photoemission versus X-ray absorption in total electron yield**
What are the differences between both techniques?

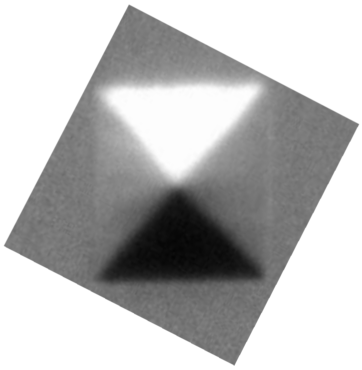
4) **Spatial resolution in PEEM**
The spatial resolution (r) in PEEM can be approximated by r ≈ (d ΔE) / (eU)

d: distance sample, objective lens
ΔE: energy spread of electrons
U: acceleration voltage

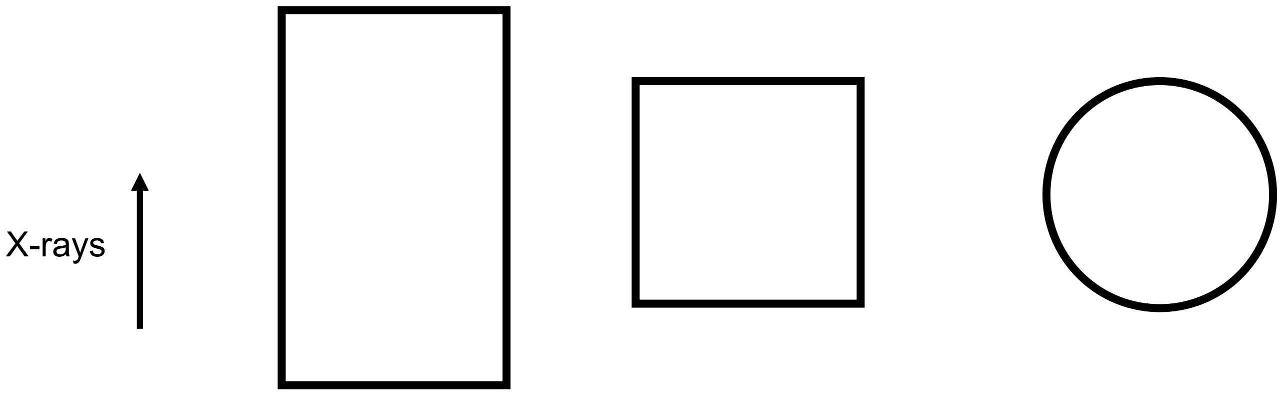
a) How can one improve the spatial resolution and what is limiting.
b) Calculate the spatial resolution with the values you think one might be able to achieve.
c) Give a qualitative explanation for this equation for the spatial resolution.

5) **Origin of XMCD image**
Shown is an XMCD image taken with a photon-energy of 780 eV (Co L_3 edge).

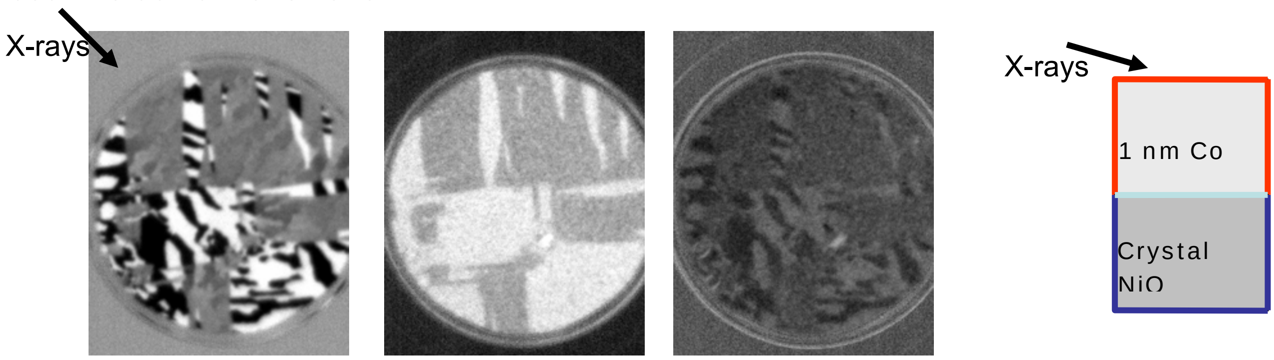
a) Give a brief explanation of the XMCD effect (e.g. two step model) for 3d transition metals like Co
b) How leads this to a contrast in the image
c) How would this image look if one would take it at the energy of the Co L_2 edge



6) **Magnetic domains in structures**
Draw the ground state configuration of these structures, i.e. the orientation of the magnetic domains and the contrast in a XMCD image.



7) **XMCD and XMLD images**
The images are taken at the very same spot (field of view 20 micrometer). What do you see? In which direction are the domains orientated? How can you get more information about the domain orientation?



a) XMCD image at Co L_3 edge

b) XMLD image at Ni L_3 edge

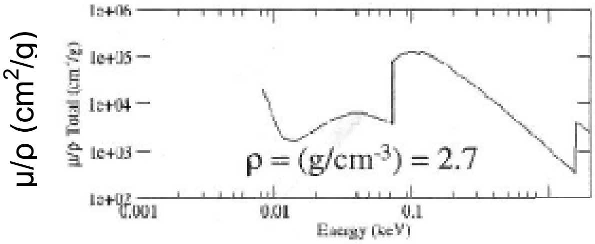
c) XMCD image at Ni L_3 edge

8) XAS (μ is the absorption coefficient)

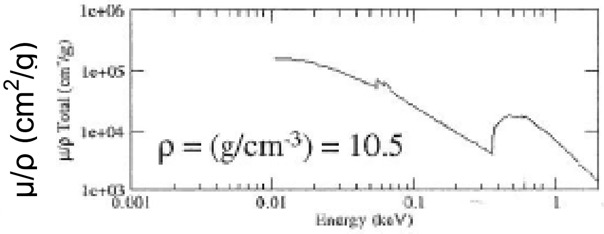
Preparing your experiment

You want to characterize by XAS the iron oxidation at Fe-MgO interface of a Fe/MgO/Fe tunnel barrier you grew in your Molecular Beam Epitaxy chamber under vacuum conditions. To do that you have to transfer your sample in another vacuum chamber which comports the exposure of the sample to the air conditions. In order to avoid modifications of your sample you decide to cover your tunnel barrier by depositing a protecting capping layer with a thickness of about 100 nm. You can chose among silver (Ag), samarium (Sm) and gold (Au). Which element do you chose and why? Would using aluminum even better or not?

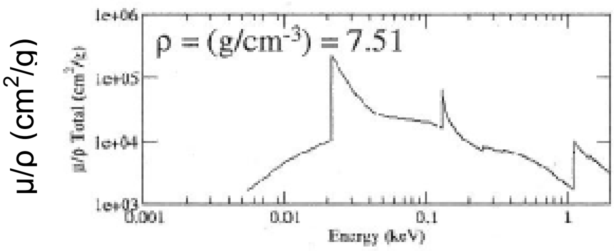
Al Z = 13, E = 0.001 - 2 keV



Ag Z = 47, E = 0.001 - 2 keV



Sm Z = 62, E = 0.001 - 2 keV



Au Z = 79, E = 0.001 - 2 keV