Studies on structural and magnetic properties of surfaces and thin metal films via grazing atom and ion surface scattering

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Fast noble gas atoms and light diatomic molecules with energies from 0.2 keV up to 60 keV are scattered under grazing angles of incidence (<2°) from a clean and flat KCl(001) surface. For scattering along low-index directions (axial surface channeling), one can observe pronounced peaks in the angular distributions of scattered projectiles. For projectile energies above 3 keV this can be attributed to so-called classical rainbow-scattering caused by the corrugated interaction potential. On the basis of classical trajectory calculations, one can derive from comparison with the experimental data the effective interaction potential of noble gas atoms in front of a KCl(001) surface. Fair agreement is found for individual pair and DFT potentials. The individual pair potentials were calculated from Hartree-Fock wave functions, where the charge state of K and Cl ions located at lattice sites of the ionic crystal is taken into account. For the generalized ZBL (Ziegler, Biersack and Littmark) and OCB (O'Connor and Biersack) potentials, the agreement for interaction energies below 20 eV is found to be poor.

For energies below 3 keV one can observe defined diffraction patterns in the angular distributions of scattered projectiles. The experimental results for the scattering of H, D, ^{3}He, and ^{4}He atoms as well as H_2, D_2, and HD molecules can be ascribed to atom diffraction with de Broglie wavelengths as low as about 10^{-3} Ångström. From the evaluation of diffraction patterns one can derive the widths of axial channels, the corrugation of the interaction potential across these channels and the rumpling of atoms in the topmost surface layer.

In the second part of the talk, the results of studies on the growth and magnetic properties of Fe_xMn_{100-x}, Ni_xMn_{100-x} single and Co/Fe_xMn_{100-x}, Co/Ni_xMn_{100-x} bilayer films on Cu(001) will be presented. The structure of the films were investigated using the technique of ion beam triangulation (IBT), where the ion-induced emission of electrons was monitored as a function of azimuthal angle of incidence for grazing scattering of protons. The detection of emitted electrons by means of a surface barrier detector has the advantages of very low projectile dose, surface sensitivity, and an efficient self-normalization of data. The magnetic properties of both bilayer systems in the ultrathin film limit with total thicknesses below 25 ML strongly depend on alloy composition and thickness and provides a classification into three regimes. Using scattering experiments on electron capture (EC) into excited levels of He atoms with projectile energies of about 20 keV, one can decuce the spin polarization of captured electrons from the circular polarization of the fluorescence light described by the Stokes parameter S/I measured for reversed settings of the magnetization. Due to the grazing scattering conditions, the probing depth of electron capture amounts to the topmost atomic layer at the surface. By comparison with MOKE experiments, a difference in reversal behavior of surface and bulk magnetizations was found for Co/Fe_xMn_{100-x} bilayer films on Cu(001). This difference may originate from weakened exchange interactions at the surface and from defects.