Contribution ID : **33** Type : **not specified**

Spin-polarized single and double electron spectroscopies

Spin-polarized single- and two-electron reflection spectroscopies with various kinematics for W(110) and W(100) crystals, with deposited thin films of Co, Fe, and/or Ag, reveal many aspects of structure and scattering asymmetries [1-5]. The experimental apparatus and methodology are a subset of the time-coincidence pulsed two electron scattering approach [2] in which the experimental variables include the incident electron energy and spin, the outgoing electron momenta and single or multilayered film structures.

Discussions will include extensive recent results which highlight electron correlations in exchange and spin-orbit interactions with spin and scattering dynamical asymmetries. For example, the emission of correlated electron pairs from Au(111) and Cu(111) surfaces with incident low-energy electrons indicates the contributions of surface states, d-states and spin effects [3]. The controlling spin-orbit interaction in a ferromagnetic Fe/Au double layer has been characterized [4]. Spin-dependent elastic electron scattering, from W(110) modified by irradiation with 200 eV argon ions to induce lattice defects, indicates a possible way to construct a spin-active interface with prescribed properties [5]. Further, a spin-dependence of plasmon excitations in Ag/W and Ag/Fe layers may be attributed to spin-active Ag/W or Ag/Fe interfaces.

The experimental measurements and their interpretations are guided by the following specific fundamental features of electron scattering from clean surfaces. The presence of the crystalline surface implies that the parallel-to-the-surface electron momentum is conserved. Refraction of the electron trajectories at the surface potential barrier occurs while passing through the interface. An ordered distribution of scattering centres at the surface implies that electrons (or electron pairs) undergo a diffraction. Imbalance of spin-up and spin-down electrons in the valence band in a ferromagnetic surface leads to the intensity asymmetry of spectra. The spin effects depend strongly on kinematics of scattering. The measurements are characterized geometrically by fixed angles between the incident electron beam and the axis of the detectors (analyzers) and the sample rotated around the axis perpendicular to the scattering plane containing the electron beam and detectors. Then the angles of incidence and detection can be varied conveniently.

Generally the SPEELS measurements are made with (i) specular geometry, when the incidence angle is equal to the detection angle; and (ii) off-specular geometry when the incident angle is not equal to the detection angle. It is assumed that in the specular geometry the mechanism of the electron energy loss is of dipole type, i.e. the energy loss does not involve a large momentum transfer and the interaction of the incident electron with the surface occurs through the electromagnetic field generated by the electron. In the second case, the off-specular geometry, the electron-electron encounter occurs with substantial momentum transfer from the incident electron to the valence electron of the target. It is also assumed that in the dipole-type of scattering no exchange effects can be observed.

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