Optical properties of nickel derived from reflection electron energy loss spectra

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Synopsis High energy resolution reflection electron energy loss spectroscopy (REELS) spectra measurements were performed for Ni. We present the differential excitation probabilities for electrons traveling in nickel extracted from the spectra by using the Werner's elimination-retrieved algorithm. The electronic structure and optical properties of nickel have been determined by using newly developed reverse Monte Carlo method.

Electron energy loss spectroscopy has been used extensively to study the material properties of various targets. Especially it has advantage to study multilayer systems, where the thickness of layers is in the nanometer range. One key quantities of interest is the response of a many-body system to an external perturbation: how does the interface between the solid-solid and solid-vacuum act and modify the excitations in the solid and in the vicinity of the interfaces.

In this work we present high energy resolution electron energy loss measurements of nickel sample. The measurements were performed by using the ESA-31 type electron spectrometer developed in ATOMKI. The REELS measurements were made in the fixed retard ratio (FRR) mode, using the retardation ratios (k) supplying 100 eV pass energy at the elastic peak. The incident angle of the electron beam was 50°, and the detection angle was 0° with respect to the surface normal of the specimen. The divergence of the excitation electron beam was ± 1°. During measurements the vacuum in the analysis chamber was better than 1.5×10^{-9} mbar. The nickel surface was cleaned about 1-2 minutes by Ar^+ ion sputtering with an ion flux of 40 μA/cm^2 and at 3 keV kinetic energy. The angle of the incidence of the Ar^+ ion beam was 40° relative to the surface normal.

The measurement time at one primary energy was about 30-35 minutes, surface cleanness was checked by x-ray photoelectron spectroscopy (XPS) after the REELS measurements. From the analysis of our XPS spectra of C 1s, O 1s, and Ar 2p we found that during the time of the REELS measurements the surface contamination changed the elastic peak with about 1%.

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Fig. 1 shows REELS spectra measured at 1, 3 and 5 keV incident energies. The differential excitation probabilities for electrons traveling in nickel are extracted from the REELS spectra by using the elimination-retrieved algorithm of Werner. Based on newly developed reverse Monte Carlo method, the optical properties of Ni have also been determined at 5 keV.

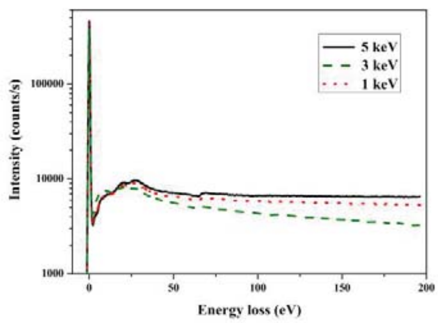

Figure 1. The measured REELS spectra for Ni.

The results improve significantly our knowledge of the optical properties of Ni which were gained by optical methods. Since the reflection energy loss process takes place in a space region of the order of the inelastic mean free path about the surface, it is possible, in principle, to apply this procedure to probe the electronic structure and physical properties of nanostructures with REELS.

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