ELECTRON FOCUSING IN THIN SINGLE-CRYSTAL COPPER FILMS

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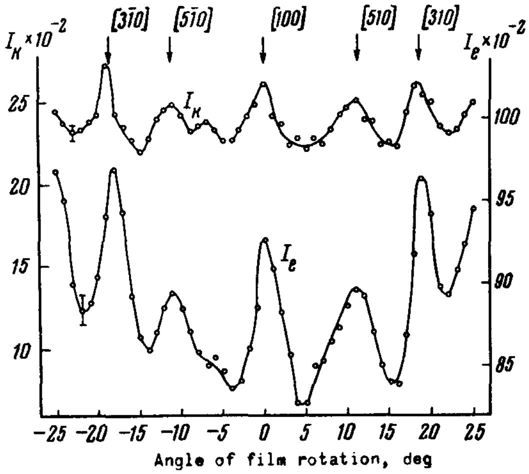
Submitted 4 June 1966
ZhETF Pis'ma 4, No. 7, 241-243, 1 October 1966

As shown in several theoretical and experimental papers, the main results of which are reported in Tulinov's review [1], the passage of a proton beam through single crystals differs from that through amorphous or polycrystalline matter. If the proton motion direction coincides with one of the crystallographic directions with low indices, then the protons move in channels between chains of atoms. Since the protons are then repelled from the atomic nuclei, a decrease takes place in the probability of processes characterized by small impact parameters, such as the ionization of the K and L shells, nuclear reactions, and large-angle scattering. When electrons pass through a single crystal under analogous conditions, we can expect them to become focused on the axis of the atom chain, an increase should be observed in the yield of K and L radiation, as well as an intensification of the large-angle scattering.

We have investigated the yield of K radiation from a thin (400 - 600 Å) single-crystal film of copper bombarded with 20 - 60 keV electrons. The measurements were made with an electronograph. The film was secured on a rotary device which made it possible to set its inclination relative to the electron beam accurate to $<0.5°$. The alignment of the beam direction with the principal crystallographic axes was determined from the electron-diffraction pattern. The copper L photons were counted with a proportional counter filled with an argon-methane mixture at atmospheric pressure. The entrance window of the counter was set at an angle of 80° relative to the electron-beam direction in the plane defined by the beam axis and the film-rotation axis. The range of photon energies corresponding to the copper K radiation was separated with a single-channel pulse-height analyzer. A beryllium plate was placed ahead of the entrance window of the counter, which was covered with a thin ($\sim 4\ \mu$) lavsan polyester film, to prevent the scattered electrons from entering the counter without hindering the free entry of the copper K photons. Removal of the plate made it possible to detect electrons scattered through 80°. Their number exceeded by a factor 100 - 1000 the number of photons entering the counter.

The figure shows plots of the yield of copper K-radiation (I_K) and of the number of electrons scattered through 80° (I_e) vs. the angle of film rotation for 55-keV primary electron energy. We see that both curves have peaks corresponding to the direction of motion of the primary electrons along the crystal axes indicated in the figure. In our case the relative increase in the K-radiation yield reached 15 - 20%. In the case of protons, the decrease in yield is ~50% [2]. The difference can be attributed, in our opinion, to the stronger scattering of the electrons in the substance, and in part also to the mosaic structure of the film. Since in our case the peak amplitudes decreased with decreasing primary-electron energy, we can expect a slight growth with increasing energy.



It can be assumed that the difference between the electron and proton motions is caused also by the fact that as the protons move through the channel they execute a certain number of oscillations during their travel. In the case of the electrons, ordered motion takes place probably only during the first quarter of the oscillation, i.e., until the electron crosses the axis of the atom chain, after which the electron, coming close to the next nucleus, is scattered through a large angle. From this point of view, a change in the number of electrons scattered into the rear hemisphere should lead to a change in the yield of the secondary electron, i.e., the coefficient of secondary emission from the side on which the beam enters should increase when the electron-motion direction coincides with a crystallographic axis. It is possible that this circumstance plays a certain role in the nonmonotonic angular dependence of the yield of secondary electrons from MgO and Ti single crystals, as observed in [3,4] and elsewhere. It must apparently be assumed that since the electron approaching the atom chain during the course of focusing transfers to the chain nuclei a momentum that increases continuously in magnitude, the focusing effect is accompanied by excitation of phonons. This distinguishes focusing from diffraction, in which the electron, interacting with the crystal as a whole, does not excite phonons.

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INFLUENCE OF MAGNETIC FIELD ON SPIN-ORBIT INTERACTION EFFECTS IN FERROMAGNETIC d-METALS

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Submitted 8 June 1966
ZhETF Pis'ma 4, No. 7, 244-248, 1 October 1966

Investigations of galvanomagnetic effects yield, as is well known, valuable information on the electronic structure of ferromagnetic metals. However, no measurements have been made as yet on magnetooptical effects in strong magnetic fields, which have a similar physical