Change in the sputtering of single-crystal nickel on going through the Curie point

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We investigate, for the first time, how the transition of a ferromagnet through the Curie point affects its cathode sputtering. It is observed that near the Curie point the sputtering coefficient of nickel changes abruptly, and a redistribution in the sputtering intensities along the different crystallographic directions takes place.

Several interesting details of the sputtering mechanism have been investigated recently. However, none of the published studies have dealt with the influence of the magnetic properties of the material on the amount of matter produced by ion bombardment. An investigation of this question could greatly add to our knowledge of the sputtering mechanism. The purpose of the present study was to determine the influence of the passage of the temperature of a ferromagnet through the Curie point on the sputtering coefficients of the faces (111) and (110) of single-crystal nickel, and on the redistribution of the sputtering intensities in the [110] and [100] directions when the (111) face is bombarded.

The sputtering was produced by neon and argon ions of energies 20 and 50 keV at a current density 1–3 mA/cm^2. During the course of the sputtering of the sample, all the secondary charged particles were trapped by a collector making electric contact with the sample. The sample temperature could be regulated in the range from 50 to 500 °C. The temperature was kept constant during the course of one experiment by a special automatic system. The sample was placed in the gap of an annular permanent magnet, the external field in which was 500 Oe.

The sputtering coefficient was determined by weighing the sample: the yield of matter in definite crystallographic directions was investigated by photometry of the deposits on spherical, cylindrical, and flat collectors surrounding the sample.

1. The sputtering coefficients of the faces (111) and (110) of single-crystal nickel are shown in Figs. 1 and 2, respectively, as functions of the target temperature. One can clearly see an abrupt increase and a break on the curves near 360 °C, which corresponds to the Curie temperature for nickel. It is well known that when the temperature of fcc metals is changed, the sputtering coefficient does not increase until the evaporation process sets in[1,2] According to our experiments, and also according to data by others,[1] there is practically no evaporation of nickel up to $T = 800$ °C.

Thus, the experimentally observed jump of the $S(T)$ dependence is connected with changes in the conditions of the yield of the sputtered particles when the material goes over from the ferromagnetic to the paramagnetic state.

2. We measured the intensities of the sputtering of the faces (111) in the close-packing directions [110] and [100] for the ferromagnetic ($T = 50$ °C) and paramagnetic ($T = 500$ °C) states of the sample.

It turned out that the density of the spot in the [110] direction relative to the spot in the [100] direction decreases by 7–8% for the sample in the ferromagnetic state (the accuracy with which the intensity was measured at the center of the spot was 0.5%).

Calculation performed within the framework of the focus on mode of sputtering, and using the data of[4,3], shows that the transition of the material from the ferromagnetic to the paramagnetic state changes the constants of the interaction potential in such a way that the yield of particles in the [110] direction becomes larger than in the [100] direction, as was indeed observed in the experiment.

In conclusion, we are deeply grateful to A.S. Borovik-Romanov, G.V. Spivak, and A.K. Belov for a discus-

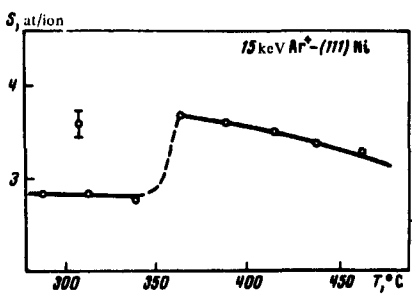

FIG. 1. Dependence of the sputtering coefficient of the (111) face of single-crystal nickel on the temperature following bombardment with Ar^+ ions of energy 15 keV.

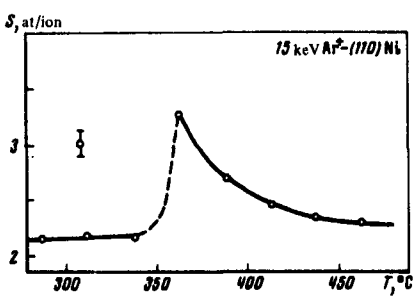

FIG. 2. Dependence of the coefficient of the sputtering of the (110) face of single-crystal nickel on the temperature following bombardment with Ar^+ ions of energy 15 keV.

sion of the results, and to V.V. Mosin for help with the experiment.

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