Letters to the Editor

Discrete Energy Losses of Electrons Reflected from a MoO_2 Surface

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WE have investigated by the method of electronic differentiation in a spherical capacitor circuit[1,2] the discrete energy losses of electrons reflected from a surface of molybdenum coated with MoO_2. The MoO_2 was obtained by heating molybdenum in air with an increased percentage of steam and at a temperature of 800° – 900°. Under these conditions the surface of molybdenum took on the copper-brown color characteristic of MoO_2.

The curves in Fig. 1 represent the energy distribution of the reflected electrons and were obtained at t = 400° and with different energies of the incident electrons V_p. All these curves, except the peak of the elastically reflected electrons, have a series of clearly defined peaks. These peaks, corresponding to the discrete energy losses, are situated near all the curves with identical values for the losses $V_p - V_k$.

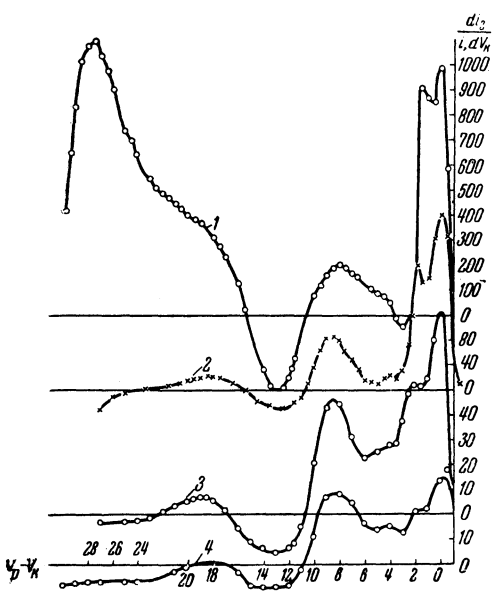

FIG. 1. The distribution curves of the electrons reflected according to (their) energies are obtained from the four values V_p: 1 – 30, 2 – 75, 3 – 150, 4 – 260 v. The maximum of curve 1 when $V_p - V_k$ = 27 v is dependent on the true secondary electrons.

TABLE I

h	k	l	W(ev)	$V_p - V_k$(v)
1	0	0	1,6	1,8
0	0	1	4,8	4,5
1	0	1	6,4	6,4
1	1	1	8	8,4
2	2	1	17,6	18,5
0	0	2	19,3	

TABLE II

$n^2=h^2+k^2+l^2$	W(ev)	V_p-V_k(v)
1	2,1	2
2	8,3	8,3
3	18,7	17,5

Taking the values $\pm 2\pi n/d$ for the oscillating vector determining the momentum transferred by the electrons of the crystal lattice (in conformance with the theory[3,4]), the discrete values of energies transferred to the incident electrons by the electrons of the crystal lattice can be expressed by the formula

$$W = (h^2 / 8m\pi^2)\,(2\pi n / d)^2, \qquad (1)$$

where h is Planck's constant, m the mass of the electron and n/d is determined by the corresponding interplane distances in the crystal lattices. For MoO_2, crystallized in a tetragonal lattice,

$$(n / d)^2 = (h^2 + k^2) / a^2 + l^2 / c^2,$$

where h, k and l are Miller indices and a = 4.86 A and c = 2.79 A are the lattice constants.

The energy losses according to (1) give only one value, W = 19.3 ev, which is close to the value of the losses obtained experimentally. The remaining peaks, corresponding to the smallest values of the losses, cannot be interpreted by this formula. However, if we take for the oscillating vector determining the momentum transmitted to

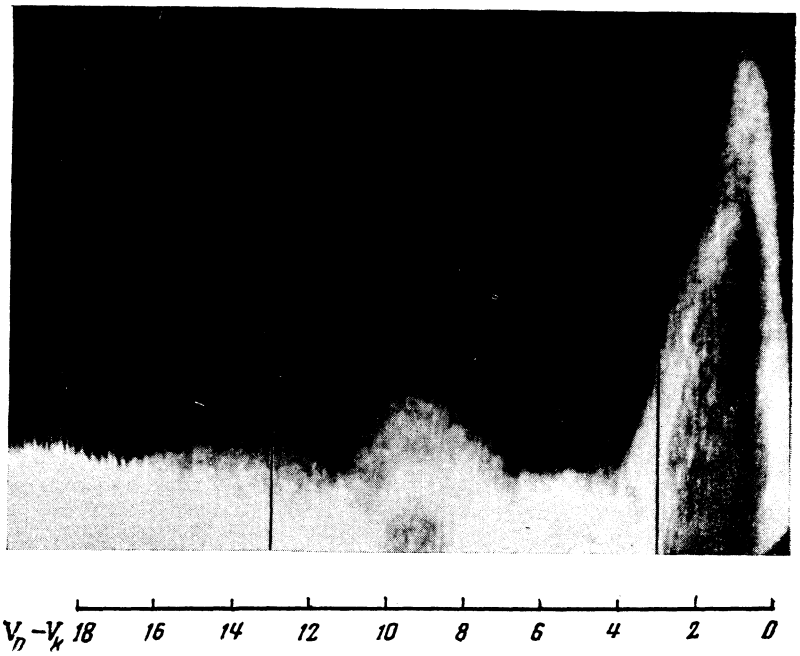

FIG. 2. Photograph obtained by the method described in the text when $V_p = 75$ v and when the exposure $t = 4$ min; in the figure only one-half of the photograph is presented, the second half, being symmetrical with the one presented, is cut off. The distance between the marks corresponds to 10 v.

the electron of the crystal lattice the values $\pm\pi n/d$, which corresponds to the Wulf-Bragg reflection of electron waves, then for the discrete energy losses we obtain the expression:

$$W = \frac{h^2}{8m\pi^2}\left(\frac{\pi n}{d}\right)^2, \qquad (2)$$

which describes well all the peaks of discrete losses which we obtained.

In Table I are introduced the values of the losses of energies which were calculated according to (2) for the series of values h, k and l, and likewise the experimental values obtained by us for the discrete losses $V_p - V_k$. All the peaks in the experimental curves for which the values in Table I are introduced are well-defined except for the one when $V_p - V_k = 6.4$ v. From Table I it is seen that the values of the discrete losses $V_p - V_k$, which we obtained experimentally correspond well with the values W calculated according to (2)

Comparing the curves of Fig. 1, one can notice that with the increase of the energy of the incident electrons V_p the possibility of discrete losses of large energies increases, and with the decrease of V_p the possibility of discrete losses of small energies increases. Thus, the ordinate of the peak corresponding to $V_p - V_k = 1.8$v, when $V_p = 30$ v, is almost comparable to the ordinate of the peak of elastically reflected electrons, and when $V_p = 260$ v, it decreases to ~ 0.65; the ordinate of the peak which corresponds to $V_p - V_k = 8.4$ v, when $V_p = 30$ v, is equal to 0.2 of the ordinate of the peak of the elastically reflected electrons, and when $V_p = 260$ v it increases to 0.9 (see Fig. 1, curves *1* and *4*).

In order to decrease the errors introduced into the measurements in consequence of some arbitrary variation in the system, it is necessary to make the measurement as quickly as possible. For this purpose we use the following method, presenting the smoothly changing collector potential and the signal from the output of the amplifier of the electrical differentiation to the oscillograph and photograph while this picture is on the screen of the tube of the oscillograph[5]. Figure 2 is a photograph obtained by us by such a method from the investigated sample when $t = 400°$. Comparing Fig. 2 and curve *2* in Fig. 1, which were obtained with the same V_p's, one can note the following:

1) the peak of the elastically reflected electrons and the peak of the nonelastically reflected electrons when $V_p - V_k = 1.8$ v are resolved well on curve 2 of Fig. 1, and in the photograph in Fig. 2 these two peaks unite into one wide peak; 2) on the photograph there is a peak when $V_p - V_k \sim 13$ v which, in fact, corresponds to the minimum (see Fig. 1, curve 2). This is explained by the fact that the sign of the output of the amplifier, characterizing the derivative, is presented to the oscillograph in the form of a variable voltage, and, therefore, the sign of the derivative cannot be shown--the minima will be recorded in the form of peaks, just as the maxima.

Considering the investigation of nonelastically reflected electrons from cuprous oxide[6] when $V_p = 21.5$ v, there were discovered three values of discrete losses from which it was possible to compare two with the values obtained by means of the formula (1), and the third value when $V_p - V_k \sim 2$ v was not explained. However, by means of the formula (2) there are obtained values of the discrete losses of energy which correspond well with all the experimental values of $V_p - V_k$ obtained by us (Table II).

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K-Shell Gamma Ray Internal Conversion Coefficients

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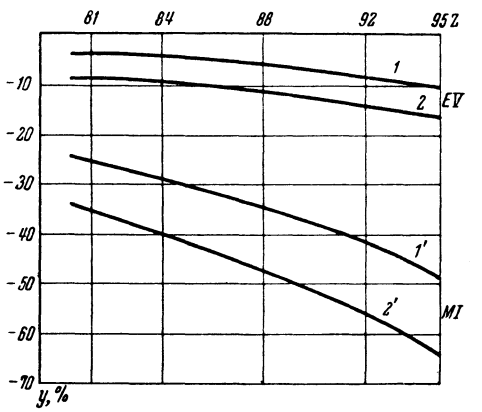
THE most complete of the tables of the K-shell gamma ray internal conversion coefficients * which we have at present (Rose's tables) were established without accounting for the influence of the finite dimensions of the nucleus and of the screening effect. Besides that, there are no data in them for small values of the energies.[1] Consequently, we undertook anew work on the establishment of tables of coefficients of internal conversion (c. i. c.) which would not possess the defects indicated.

Calculations were carried out for 16 elements from $Z = 25$ to $Z = 98$ and for 13 values of energy beginning with energies close to the threshold values and going to $k = 5$ (in units of mc^2). The values of the energies were chosen by such a method that later on it might be possible to interpolate with a sufficient degree of accuracy. In each point the c. i. c. were obtained for the first five electrical and the first five magnetic multipoles.

The relativistic wave functions of the electron were calculated from the potential which inside of the nucleus corresponds to a uniform distribution of the charge and outside of the nucleus has the following form:

$$V = -(\alpha Z'/r)\,\varphi(r) - D + K.$$



For the curves 1, 1′, $k = 0.5$, for the curves 2, 2′, $k = 5$.