ATOMIC FIRST IONIZATION POTENTIALS DETERMINED BY THE METHOD OF SURFACE IONIZATION

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Atoms of the rare-earth metals Er, Tb, and Ce, together with the molecule $ThCl_4$, have been studied using the method of surface ionization on polycrystalline tungsten. It is shown that the temperature dependence of the ion current agrees with the theory of surface ionization on complex surfaces. The ionization potentials of the atoms Er, Tb, Ce, and Th have been found by comparing the temperature dependence of their respective ion currents with the same quantity for positive In ions.

THE method previously described[1,2] has been used to study the ionization of several rare earth metals on a tungsten surface. In Fig. 1 the logarithm of the relative positive ion current log (I/I_m) for the atoms of Er, Tb, Ce and In is plotted against the inverse temperature, 1/T, of the tungsten wire. At sufficiently high temperatures the graph is a straight line, as predicted by the theory.[1,3]

The ionization potential V of an atom can be found by comparing the temperature dependence of the positive ion current for the unknown atom with the same quantity for a known atom. This method has been used in work reported earlier to obtain V for atoms of U,[1] Nd, and Pr.[2] Our measurements were made relative to In, whose ionization potential is known spectroscopically to be V_{In} = 5.79 ev.

Let I_1 denote the current of positive In ions, and I_2 the current of positive ions of Er, Tb or

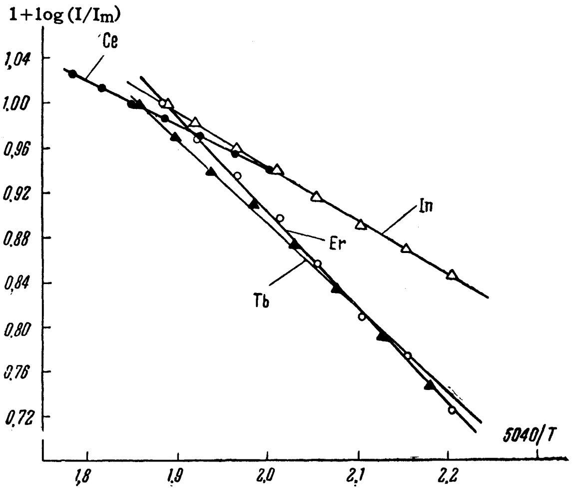

FIG. 1

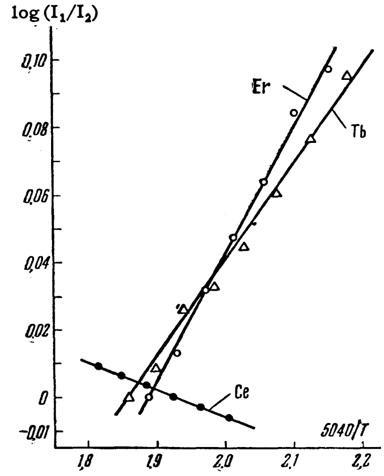

FIG. 2

Ce, as the case may be. In Fig. 2, the logarithm of the ratio I_1/I_2 is plotted against the inverse temperature 1/T.[1,3] The three curves are straight lines to a good approximation. The slopes can be used to obtain the differences between the ionization potentials of the three elements and that of indium. Eight independent measurements were made of V for Er, nine for Tb and five for Ce. The results are as follows:

$$V_{Er} = 6{,}08 \pm 0{,}03 \text{ ev}, \qquad V_{Tb} = 5{,}98 \pm 0{,}02 \text{ ev},$$
$$V_{Ce} = 5{,}60 \pm 0{,}05 \text{ ev}.$$

The ionization potential of Th was obtained in a similar manner, molecules of anhydrous $ThCl_4$ being ionized on a tungsten wire together with atoms of In. The temperature of the wire was 2500 to 2900°K. The ionization potential of Th turned out to be 6.95 ± 0.06 ev.

The calculations took into account those excited states of In atoms and ions which lie close to the ground states. Excited states in the atoms and ions of Er, Tb, Ce and Th were not taken into account since the energy levels for these elements are not known.

[1] I. N. Bakulina and N. I. Ionov, JETP **36**, 1001 (1959), Soviet Phys. JETP **9**, 709 (1959).

[2] N. I. Ionov and M. A. Mittsev, JETP **38**, 1350 (1960), Soviet Phys. JETP **11**, 972 (1960).

[3] É. Ya. Zandberg and N. I. Ionov, Usp. Fiz. Nauk **67**, 581 (1959), Soviet Phys. Uspekhi **1**, 255 (1955).

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