satisfies the Saha-Langmuir equation. Similar results for magnesium were obtained in the work reported in reference 6.

Attempts to increase the effectiveness of surface ionization of calcium by a preliminary oxidation of the tungsten did not give positive results. However, when a continuous stream of oxygen was directed at the incandescent tungsten, the ion current at first increased by two orders of magnitude, after which the equilibrium current, and the time required to establish it, were observed to depend on the pressure of oxygen near the filament, over a small range of pressure (of the order of 10^{-6} to 10^{-5} mm Hg). A further increase in pressure did not affect the magnitudes of the ion currents. At tungsten filament temperatures of about 2000°K there was a maximum in the ion current, and with increasing oxygen pressure the location of this maximum shifted slightly in the direction of higher temperatures. If the glowing filament were suddenly heated to temperatures above 2600°K and then reduced to its former temperature, a sudden initial jump in ion current was observed, followed by a drop to values noticeably lower than the initial current and then by a gradual recovery to the initial value. The recovery time decreased at higher pressures.

The intensity of the calcium beam was varied over such wide limits that the time required to form a monomolecular layer of calcium oxide on the filament would have required from a few seconds to several hours. None the less, an interruption in the oxygen supply invariably led to a sharp decrease in the ion current. Consequently, under these conditions the increased effectiveness of surface ionization of the calcium cannot be due to the formation of a layer of calcium oxide on the tungsten[5].

Analogous results were obtained with strontium, magnesium and sodium. In the case of sodium, the increased surface ionization at the much lower filament temperatures persisted even after the oxygen supply was cut off, as is usually observed on oxidized tungsten. (It is known that lithium is also effectively ionized on incandescent tungsten which is kept in a stream of oxygen[7]).

Thus in our experiments we have observed the surface ionization of calcium, strontium and magnesium on oxidized tungsten, under conditions of continuous regeneration of the decomposing layer of tungsten oxide. The greatest effect was obtained in a narrow interval of high temperatures and at suitably high oxygen pressures, where apparently adsorption of calcium, strontium or magnesium atoms on the surface does not play a substantial role but the rate of oxidation of the tungsten is considerable, so that the values of temperature and mean work function of the surface are optimal. It is to be expected that an increased degree of surface ionization, due to the increased work function of the tungsten when it becomes oxidized, would occur under definite conditions regardless of the type of atoms. It is proposed to make use if this effect to detect atomic beams of the alkaline earth metals in measuring their nuclear moments.

[1] L. N. Dobretsov, *Electronic and Ionic Emission*, (1952), p. 245.

[2] A. N. Guthrie, Phys. Rev. **49**, 868 (1936).

[3] R. H. Hay, Phys. Rev. **60**, 2 (1941).

[4] G. A. Morozov, Zh. Tekhn. Fiz. **17**, 1143 (1947).

[5] L. N. Dobretsov, S. V. Starodubtsev and Iu. I. Timokhina, Dokl. Akad. Nauk SSSR **55**, 303 (1947).

[6] S. V. Starodubtsev and Iu. I. Timokhina, *Collection in Honor of the 70th Year of Academician A. F. Ioffe* (1950) p. 117.

[7] J. H. Manley and S. Millman, Phys. Rev. **51**, 19 (1937).

Translated by D. C. West
309

Phosphorescence of the Crystal Phosphor ZnS-Cu during Excitation by an Electron Beam

T. P. BELIKOVA
P. N. Lebedev Physical Institute, Academy of Sciences, USSR

(Submitted to JETP editor July 19, 1955)
J. Exper. Theoret. Phys. USSR **29**. 905-906
(December, 1955)

NOTWITHSTANDING the large number of investigations of cathodoluminescence, there are almost no works in the literature in which a comparison is carried out, on the very same specimens, of the kinetics of the after-glow of phosphors under excitation by light and electrons. For the beginning stages of afterglow (about 10^{-3} sec) such an investigation has been carried out[1]. In this work it was shown that the decay takes place nonspecifically with regard to the sort of excitation and that the difference in the observed decay curves can be explained by means

of the difference in density of excitation during various types of excitation (light $\lambda = 365$ or 313 mμ, or an electron beam).

In the present work the continuous decay of luminescence of a ZnS-Cu phosphor (10^{-4} g/cm^3) was measured during excitation by an electron beam (energy of 2000 v, current density of 3μamp/cm^2) and, for comparison, under excitation by light with $\lambda = 365$ mμ. Figure 1 gives decay

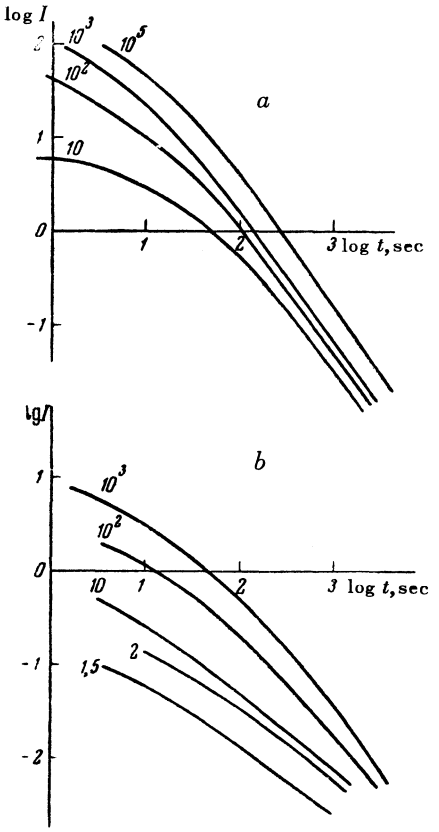

FIG. 1

curves in double logarithmic coordinates, obtained with various intensities of exciting light *a* and with various densities of current *b*. The numbers on the curves indicate, respectively, the relative intensity of exciting light and the relative stationary brightness of luminescence under excitation by electrons.

According to these data, the decay of cathodoluminescence to the last stages of after-glow follows, as in photoluminescence, a hyperbolic law, in which the slope of the decay curves during electron excitation is somewhat smaller than is the case with light, despite the fact that in the first case with the very same brightness of phosphor the density of excitation is much larger than in the second case.

The appearance of the decay curve must essentially depend on the initial distribution of the exciting electrons in the phosphor according to different levels of localization. In Fig. 2 are curves of the temperature induced glow of the investigated phosphor during light (curve 1) and

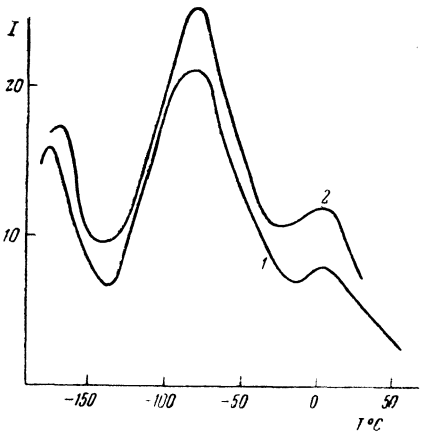

FIG. 2

during electron (curve 2) excitation*. The similarity of these curves shows that the system of local levels and their filling is essentially unchanged by electron excitation as compared with excitation by light. The reason for the difference in the decay curves can consequently not be found directly from the obtained curves of temperature induced glow. Clarification of the difference requires a more detailed investigation.

The author expresses his gratitude to V. L. Levshin, who suggested this work.

---

* In taking the curves of temperature glow, the intensity of excitation was matched by means of the maximum of the intensities used in obtaining the decay curves.

[1] V. A. Arkhangelskaia, A. M. Bonch-Bruevich, N. A. Tolstoi and P. P. Feofilov, J. Exper. Theoret. Phys. USSR **21**, 290, 297 (1951).

Translated by L. A. D'Asaro
309