ANOMALOUS THERMOLUMINESCENCE OF ELECTROCHEMICALLY OBTAINED ALUMINUM-OXIDE FILMS

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We observed temperature-stimulated luminescence from Al_2O_3 films obtained by oxidation in an electrolyte without preliminary excitation with ultraviolet. The activation energy of the emission centers was determined.

The thermoluminescence curve of aluminum oxide films, plotted after prior excitation with ultraviolet, shows usually [1, 2] several peaks, from whose positions and shapes one can determine the depths of the corresponding trapping centers.

We have investigated the thermoluminescence of aluminum-oxide films obtained by electrochemical oxidation, with alternating current, of an aluminum foil in an aqueous solution of oxalic acid. We have observed that even without prior UV excitation a freshly prepared aluminum oxide film emits an appreciable light sum when heated. The temperature dependence of the brightness of such an anomalous luminescence is shown in Fig. 1. It should be noted that at sufficiently high temperatures the brightness of the observed anomalous thermoluminescence exceeds by several orders of magnitude the brightness at the maxima of ordinary thermoluminescence with prior UV excitation.

As seen from Fig. 1, the temperature dependence of the luminescence is well described by a formula of the type

$$B = B_0 \exp\left(-\frac{E}{kT}\right)$$

and the presence of two slopes can be interpreted, according to [3], as participation of two types of traps in the luminescence, with depths 0.6 and 1.6 eV. For the second and subsequent emissions without a prior UV excitation, a decrease in the luminescence brightness is observed; this decrease is greatest in the low-temperature region, but the slopes of the lines in Fig. 1, which are determined by the depths of the trapping centers, remain the same. The high luminescence level apparently indicates a large concentration of these centers. It should be noted that one observed sometimes one relatively weakly pronounced luminescence maximum (Fig. 1, curve 3). The second maximum is apparently masked by the action of the thermal emission at high temperatures.

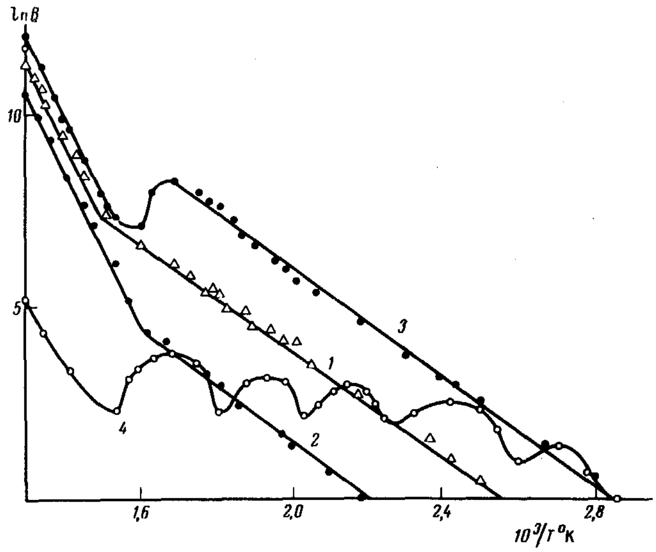

Fig. 1. Temperature dependence of the brightness: 1, 3) anomalous thermoluminescence of freshly prepared samples: 2) anomalous thermoluminescence after second heating; 4) ordinary thermoluminescence with prior excitation with light of λ = 366 nm.

The intensity of the anomalous thermoluminescence at constant temperature decreases with time, but

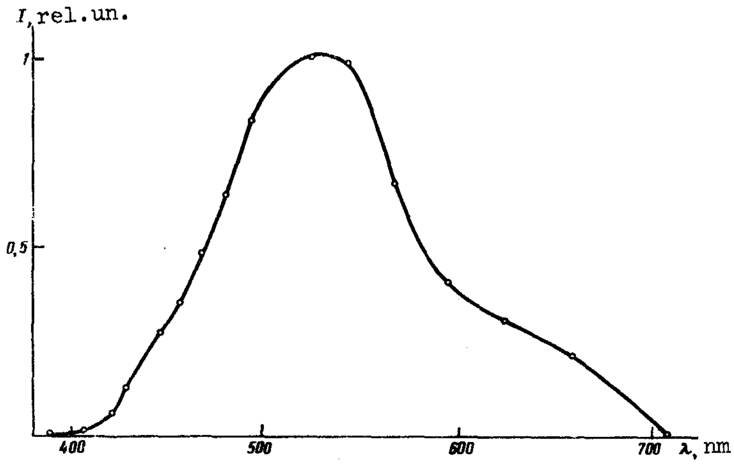

Fig. 2. Spectral distribution of anomalous thermoluminescence.

its rate of change is quite small. Thus, for example, at T = 250°C the brightness decreases 10 - 15% after 30 minutes. The high luminescence intensity and its insignificant variation with time have made it possible to plot the spectral distribution of the luminescence (Fig. 2). The measurements were made with a UM-2 monochromator, an FEU-18A photomultiplier, and an automatic recorder.

The light sum is apparently stored during the formation of the oxide film and is due to the high degree of hydration of the Al_2O_3. The luminescence observed upon heating is apparently due to the release of electrons when the water bound with the Al_2O_3 is desorbed in a definite manner. The release of electrons upon desorption of water from a number of substances was observed in [4] in a study of exoelectronic emission. Favoring this assumption is also the partial restoration of the luminescence by hydration of the aluminum-oxide in water or in its vapor.

The transition from anomalous thermoluminescence to the usually observed peaks (Fig. 1, curves 4) is a result of multiple heating of the samples and subsequent excitation with UV.

[1] J. Kelly and M.J. Laubitz, J. Amer. Ceram. Soc. 50, 540 (1967).
[2] V.V. Mikho, A.L. Fedchuk, and L.M. Stambol'skaya, Fiz. Tverd. Tela 14, 3107 (1972) [Sov. Phys.-Solid State 14, No. 10 (1973)].
[3] V.V. Antonov-Romanovskii, Kinetika fotoluminestsentsii kristallofosforov (Kinetics of Crystal-phosphor Luminescence), Nauka, 1966.
[4] I.V. Krylova, Phys. Stat. Sol. (a) 7, 359 (1971).

INVESTIGATION OF SEMICONDUCTOR PARAMAGNETISM USING LUMINESCENCE POLARIZATION IN A WEAK MAGNETIC FIELD

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The paramagnetism of carriers and impurity centers can lead to the appearance of a noticeable circular polarization of recombination radiation of a semiconductor placed in a weak magnetic field. The theory of this effect was considered by D'yakonov and Perel' [1].