THE INFLUENCE OF EXCITATION CONDITIONS
ON THE DEAD VOLTAGE OF PHOSPHORS

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(Received 6. VI. 1960)

In some previous papers [1—3] the cathodoluminescence efficiency and the voltage dependence of brightness of thin phosphor layers was studied. As it was described, the brightness $L_v$ versus accelerating voltage $V_0$ curves show a low voltage tail below 3—5 kV and for higher voltages they exhibit a strictly linear relationship. Fig. 1 shows some typical $L_v$ versus $V_0$ curves, characteristic for various types of phosphors and scintillator crystals.

The intersection of the linear section with the horizontal $V_0$ axis is called the dead voltage $V_d$ [4]. $V_d$ is a characteristic value for each phosphor sample, it varied between 1—3.3 kV for the luminescent microcrystals studied.

In a previous paper [3] the effects of artificial surface films, surface deterioration and chemical surface treatments on the dead voltage were discussed. In this paper some experiments dealing with the influence of excitation conditions on the $L_v$ curves and $V_d$ are described.

The experiments were carried out with a demountable cathode ray tube described in paper [1]. Only some technical details shall be mentioned here: to prevent condensation of vapours on the phosphor layer, a liquid air cold trap was used in the vacuum system [5]. The $L_v$ curves were determined by a photoelectric cell coupled with a D. C. galvanometer, thus the average number of photons emitted/unit time was detected. The phosphor layers were settled without any binder [3].

The experiments are summarized in the following:

1) Only a slight difference was found between the $L_v$ curves resp. $V_d$ (50—80 V) for defocused D. C. resp. focused scanning electron beam (raster) excitation, using the same average (moderate, $< 2 \mu A/cm^2$) current density. The raster excitation is equivalent with high intensity subsequent pulsed excitation of the single microcrystals.

2) A small variation of $V_d$ with $i_0$ current density ($\sim 100$ V for 1—4 $\mu A/cm^2$) was observed. $V_d$ is slightly increasing with $i_0$. This can be explained presumably by the voltage drop on the phosphor layer [6].
3) The dead voltage does not vary with the particle size of the phosphor. Several fractions of $\text{Zn}_2\text{SiO}_4-\text{Mn}$, $\text{ZnS}-\text{Ag}-\text{Cl}$, $\text{ZnCdS}-\text{Ag}$ phosphors were prepared by the settling process and the $L_V$ curves of the fractions were determined.

4) $V_d$ is not dependent on the thickness of the phosphor layer, the same value was found on the excited resp. glass side of the layers, proving that $L_V$ and $V_d$ are not influenced by diffuse optical effects.

5) It might be supposed that the dead voltage is caused possibly by charging up of the phosphor layer (sticking potential). This assumption was disproved by two experiments:

   a) A fine grid (electroformed mesh) was applied in immediate contact with the layers (experiment proposed by Prof. KALLMANN).

   b) Layers were settled on glass plates and plates provided with a conducting $\text{SnO}_2$ coating. No effects were found in experiments 5a resp. 5b.

6) The shape of the $L_V$ curve and the magnitude of $V_d$ are identical for two separate emission bands of the phosphor samples. This was observed for the blue resp. green emission band of several hex. ZnS$-10^{-4}$Ag$-x$Cu$-Cl$ samples ($x = 10^{-8}-10^{-4}$).

7) It may be assumed that the dead voltage is an effect caused by traps (proposed explanation of RUPPEL). To check the validity of this supposition, the influences of simultaneous 3650 Å U. V. resp. $> 0,8\mu$ I. R. irradiation and cathode ray excitation were studied. As it was found by some authors, the effect of traps can be eliminated in some crystal counters by applying U. V. resp. I. R. radiation [7, 8].

   a) The application of strong U. V. irradiation besides C. R. excitation caused the superposition of steady state photo- resp. cathodoluminescence emission. This appeared in the constant vertical shift of the $L_V$ curves.

   b) The application of I. R. irradiation caused a nearly constant decrease of brightness (quenching), not varying with $V_0$. A slight horizontal shift of the $L_V$ curves was observed, but the increment of $V_d$ was negligible (80$-$120 V).

Summarizing the results of our experiments, the form of the $L_V$ curve and the magnitude of $V_d$ can be only slightly influenced by conditions of excitation. The experiments made to suppress the dead voltage by chemical [3] or physical manipulations were not successful. The $L_V$ curve resp. $V_d$ are characteristic for the phosphor material.

A detailed theoretical discussion of the $L_V$ curve will be given in another paper [9].

The author wishes to express his sincere thanks to Professor Dr. H. KALLMANN and to Dr. W. RUPPEL for valuable discussions.

REFERENCES