Frequency dependence of double band electroluminophors

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In the present paper an attempt has been made to study the emission characteristics of the two peaks, blue and green of a (ZnS : Cu) double band electroluminophor, particularly the frequency effect. As regards voltage, both the peaks are found to behave in the usual way but the frequency relations give rise to somewhat new results With a rise in applied field frequency, the green band suffers a peak shift towards lower wavelength side, whereas the blue one is always shouldered and is little affected as far as peak position is concerned. The light output is observed to fall down at higher frequencies instead of showing a constant intensity of emission.

INTRODUCTION

The blue or green emitting electroluminescent-phosphors are more commonly studied than the double band electroluminophors, having simultaneously two peaks of emission, as the latter could be realized only for certain specific conditions of preparation. The most common blue-green double band phosphors generally employ Cu as activator (Mattler & Cova, 1962) which in the presence of Mn as an additional activator may exhibit blue-yellow or green-yellow emissions (Ostaszewicz 1965). In all such systems according to the Curie Model both the blue and green emissions belong to the same Cu centre, the former transition being from the conduction band and the latter from the donor levels to the same fundamental Cu level (Cuire, 1969). Upon excitation both these peaks are simultaneously evolved and belong to the same Cu centre but they behave independently as far as frequency and voltage relations are concerned. With an increase in applied voltage both the blue and green intensities rise in an exponential way hand in hand *i.e.*, the energy required to excite both the centres is the same. The frequency is a time dependent factor and it modifies the emissions differently because of different transition times involved. Since the green transition is indirect, as it is through donor levels, it is not favoured at high frequencies because of rapidity and less available time and consequently the blue, the direct one, predominates. This rise of blue intensity at the cost of green is usually accompanied by a peak shift towards lower wavelength side for the same reason.

This behaviour is common in general, but each phosphor has got its own individuality. In the present communication we have studied a blue green

(ZnS : Cu) double band phosphor which has been found to possess some specific characteristics of emission.

EXPERIMENTAL

For the purpose of study a standard (ZnS · Cu) double band phosphor was chosen in the form of a permanent electroluminescent panel. The voltage in the AF range was generated by an oscillator cum amplifier unit and was fed to the EL cell. The light output was recorded by an RCA IP21 photomultiplier tube and an ultrasensitive dc microammeter assembly. For spectral analysis purpose a grating monochromator was used and the recorded intensity was corrected for the spectral response of the photomultiplier tube.

RESULTS AND DISCUSSION

All the observations can be discussed under the following heads.

(a) *Spectral Distribution* : The spectral distribution of total light output shows two peaks of emission, one in the blue range (4600Å) and the other in the green range (5200Å). As the excitation frequency is increased the green emission peak is observed to shift gradually towards shorter wavelength side, whereas the blue one remains shouldered on the green band. In this process the overall intensity of the blue band increases with almost no shift in peak position. At the higher frequencies the phosphor becomes more and more blue emitting At 10 Kc/s, applied frequency, the green peak is found at 4800Å, thereby showing a shift of the order of 300Å as compared to its 50 c/s position. (figure 1). This shift is due to the fact that with the increased frequency the green transition,
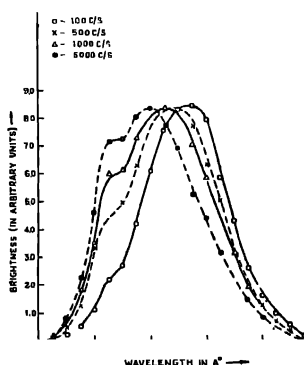

Figure 1.   The spectral distribution of electroluminescent light output for different exciting frequencies keeping the voltage constant.

which is indirect does not find enough time for normal behaviour. Because of rapidity of the exciting frequency, the transition tends to be direct and consequently takes place more and more from the upper part of the donor level, which is supposed to have a finite width. As regards the blue one, since this transition is already from the edge of the conduction band, no more shift is possible. No such peak shift was observed with the change in applied voltage. At small voltages no blue band is visible but as the voltage is increased it develops slowly.

It may be recalled here that the existing double band phosphors either show a peak shift for both the bands or do not show any shift at all (Prakash & Mohan, 1969).

(b) *Voltage Effect* : As regards the voltage dependence of brightness for the individual peaks the universal exponential law $B = B_0 \exp(-b/\sqrt{v})$, where the symbols have the usual meanings, is found to hold good (figure 2). Graphs between $1/\sqrt{v}$ versus $\log B$ is found to be parallel straight lines (figure 3). This
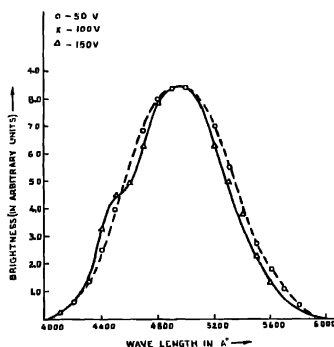

Figure 2   The spectral distribution of electroluminescent light output at different voltages keeping the exciting frequency constant.

means that the energy required to excite both the blue and green centres is just the same and hence they must belong to the same fundamental Cu level which is in accordance with the Curie Model (Curie & Curie 1960).

(c) *Frequency effect* : The frequency curves show some deviations from the usual behaviour. With the rise in applied frequency first the intensity increases and beyond 2.5 Kc/s it falls down, thereby giving rise to a peak instead of usual saturation (figure 4). This behaviour is uncommon but few authors have reported decrease of intensity at higher applied frequencies (Piper & Williams 1958).
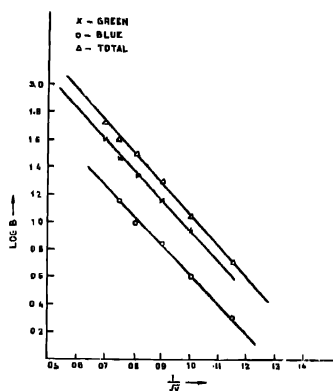
Figure 3. Variation of individual peak intensities of EL emission as a function of applied voltage (Intensity curves not drawn on same scle).
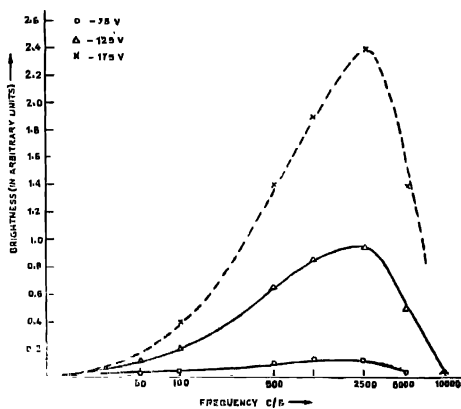

Figure 4. Variation of total intensity of EL emission as a function of applied frequency at different fixed voltages.

The fall of intensity seems due to some kind of quenching effect because of sufficiently large life-time of charge carriers. If the time period of applied ac cycle becomes comparable with the life-time of charge carriers, they will not find enough time for normal transitions and the intensity is bound to decrease at high

frequencies. This gives a life time ($\tau = 1/f$) of the order of 0.0004 sec which may be due to deep traps introduced by the traces of oxygen.

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