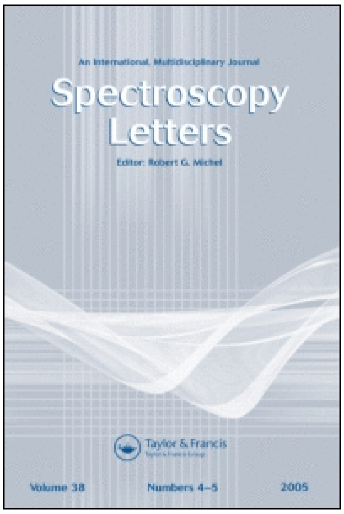

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AC EL STRUCTURES RED LIGHT EMISSION AND THEIR OPTOGALVANIC ANALOGUE

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AC EL STRUCTURES RED LIGHT EMISSION AND THEIR OPTOGALVANIC ANALOGUE

Key words: AC EL structures, Hollow cathode discharge, Optogalvanic effect, Absorption

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ABSTRACT

Some emission properties of Alternating Current Electroluminescencent (AC EL) structures containing thin chalcogenide films of the systems *As-S* or *Ge-Sb-S* are investigated by means of optogalvanic effect. The optogalvanic characteristics of red emitting structures at different conditions of their excitation are presented. Conclusions about the behaviour of the emission are drawn and some possibilities of the proposed method for the examination of the AC EL structures are analysed.

INTRODUCTION

The AC EL structures are a new type of alternating current structures created by the combination of two technologies, i.e. the binder and vacuum ones [1, 2].

Besides the constructive, technological and operative advantages AC EL structures save electric power and are of ecological importance [3]. They are applied in devices and equipment displaying colour information. That is why the behaviour of their brightness is an important problem.

The Optogalvanic (OG) method [4] is developed as an alternative of the absorption one. It is direct measurement of the conductivity change, induced by light absorbed in the OG detector. Thus the OG technique avoids some disadvantages of the conventional photometry. The frequency selectivity of the absorbing centres (one or more certain optical transitions of the gas discharge plasma) may be used analysing the spectral composition of the incident light and its dynamic interval. In this investigation we first apply the OG technique to AC EL structures containing various protective chalcogenide films. Here the protective films are As_2S_5 and $Ge_{35}Sb_5S_{60}$ ones and the AC EL emission through them is the object studied.

The peculiarities of this type of AC EL light sources are analysed by means of the emission spectroscopy as well as the optogalvanic one. The OG analogue of the spectral distribution shift is also found.

Experiment

The investigated AC EL structure is shown in Fig. 1. It is a multilayer sandwich type structures. An industrial electroluminophor of the type ELS - 670 I emitting in (670 ±10) nm (400 Hz, 220 V) spectral region is used as an active layer. The electroluminophor is dispersed in one-component phenolytic polyepoxy oligomer and is deposited with a thickness $50 \mu m$ on transparent conductive $SnO_2:F$ film. As protective layer vacuum evaporated As_2S_5 or $Ge_{35}Sb_5S_{60}$ film with thickness $1.2\ \mu m$ is used. The electrodes are prepared from vacuum evaporated pure aluminium.

In a typical OG detecting scheme (FIG. 2) the AC EL sample (1) irradiates the OG detector. The OG detector, i.e. Ne/Cu Hollow Cathode Discharge (HCD) lamp ("Narva") (3) absorbs a certain amount of the AC EL emission and transforms it into light induced change of the discharge conductivity. This change forms voltage ΔU_L across the resistor $R = 7\ M\Omega$ in series with decoupling capacitor C. The ΔU_L values are measured by a selective nanovoltmeter type 237 tuned at the power supply frequency.

The optimal discharge current of the OG detector corresponding to a maximal ΔU_L value is $4.8\ mA$.

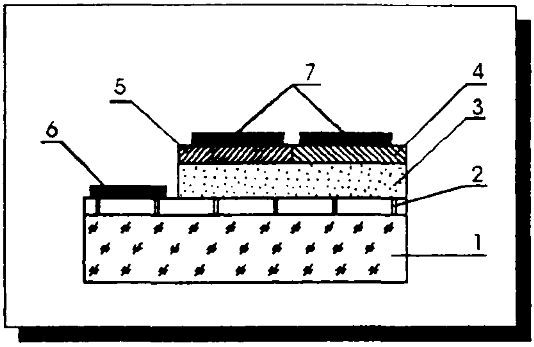


FIG.1: The cross-section of the AC EL sample:

1 - plane-parallel glass substrate; 2 - transparent conducting SnO_2:F film (d=200 nm); 3 - active electroluminescent layer with red emission (d=50 µm); 4 - protective As_2S_5 film (d=1.2 µm); 5 - protective $Ge_{35}Sb_5S_{60}$ film (d=1.2 µm); 6,7 - aluminium electrodes (d=300 nm)

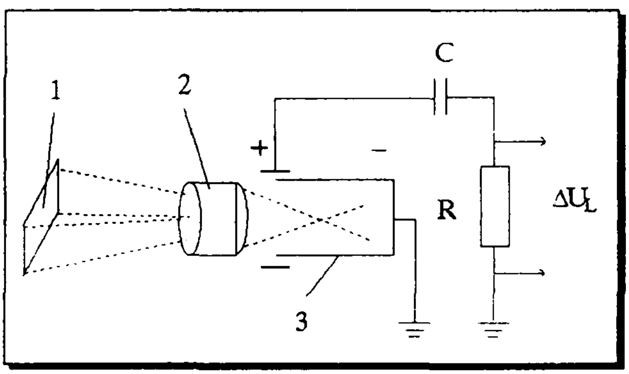


FIG.2: Experimental scheme - 1 - AC EL sample; 2 - lense; 3 - hollow cathode discharge lamp

The Emission Spectrum Distribution (ESD) $\Phi(\lambda)$ is measured by using a high resolution monohromator MDR-2, combined with a photomultplier PMP 106. The detection is based on choped light emission and lock-in nanovoltmeter type 232B (Unipan). The dependence of the AC EL sample emission on the applied voltage and frequency is investigated and compared.

Results and Discussions

1. FIG.3 illustrates the measured spectral emission distributions $\Phi(\lambda)$. The scanning step is short enough to detect some details. The profiles are shifted relative to one another depending on the protective film, the power supply frequency and voltage. A shift is found for blue and green emitting structures too in control measurements. The measured red $\Phi(\lambda)$ distributions are approximated by a Gaussian.

2. OG analogue of the AC EL structures red emission

As a galvanic aspect (modification) of the absorption spectroscopy, in general, the OG analogue ΔU_L of the distribution $\Phi(\lambda)$ arises due to two succession processes, i.e. the absorption of the AC EL emission by the OG detector followed by the transformation of the light induced population in additional conductivity. Then ΔU_L may be expressed as

$$\Delta U_L = \int_{\lambda_1}^{\lambda_2} \Phi(\lambda)\, S(\lambda)\, d\lambda \qquad (1)$$

where $S(\lambda)$ is the OG efficiency of the absorbing optical transitions in the OG $\Phi(\lambda)$ detector, and $\Phi(\lambda) \in [\lambda_1 \div \lambda_2]$ (FIG. 3).

FIG. 4 illustrates the OG responses, light induced by the red emission of AC EL structures.

3. OG response and shift of $\Phi(\lambda)$ distribution

In the laser OG experiment the function $S(\lambda)$ is a single function S_λ describing the absorbing transition properties. In our case $S(\lambda)$ includes all transitions under $\Phi(\lambda)$ distribution. The OG detector used, i.e. Ne/Cu HCDL ("Narva"), absorbs under measured distribution by the transitions showed in FIG.3. The line height corresponds to the calculated coefficient of absorption k. The value

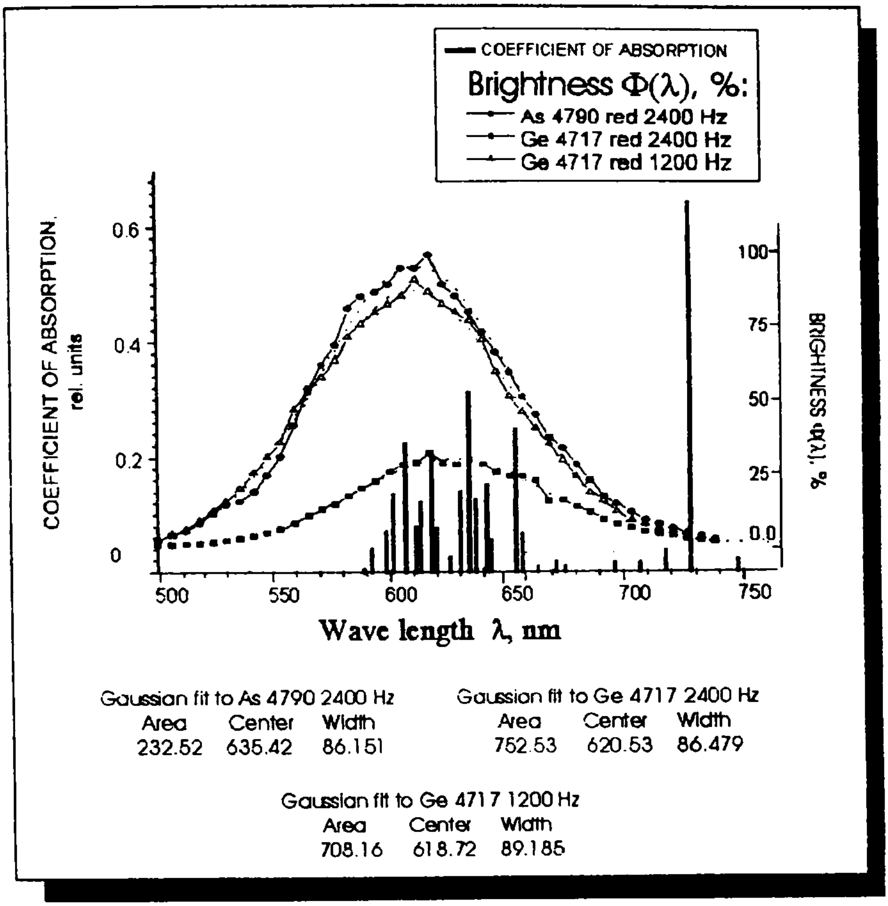
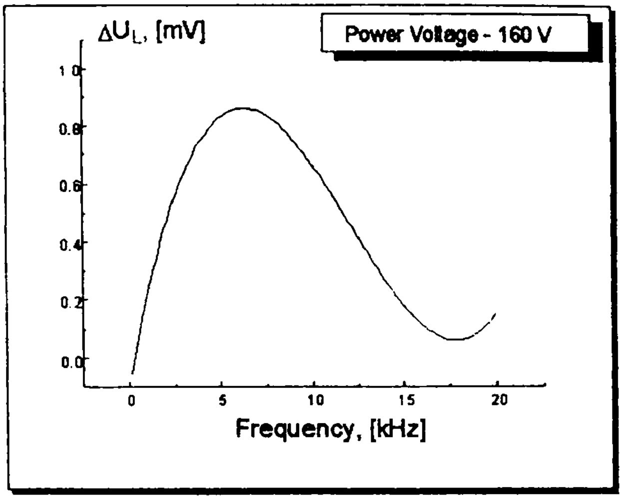


FIG.3: Spectral distribution $\Phi(\lambda)$ of the AC EL red light emission, its Gaassian approximation and distribution of the neon absorbing transitions in this spectral region

of k is computed by the Exp. (2):

$$k = 1.23 \times 10^{-23} \frac{g_k}{g_i} \lambda_{ki} \frac{A_{ki}}{\Delta \lambda_D} N_i \qquad (2)$$

where $\Delta\lambda_D$ is the Doppler width, A_{ki} - probability of the transition, $g_{k,i}$ - stat. weights, N_i - the population of the transition low level. The values N_i are measured by using the method of the absorption [5] at 400 K.



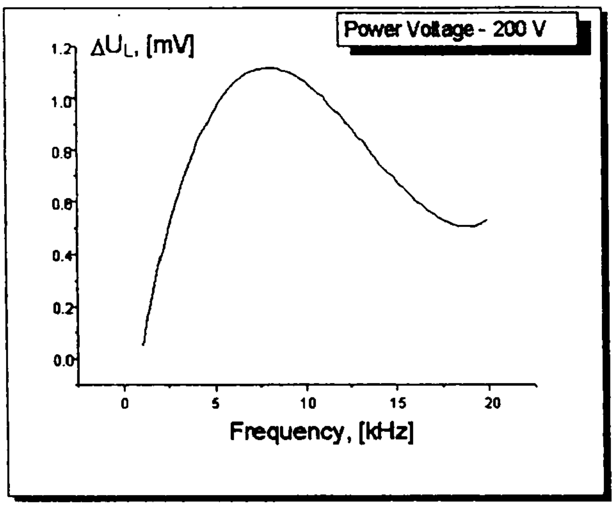


FIG. 4: Optogalvanic responses of Ne/Cu HCDL ("Narva") to AC EL red emission $\Phi(\lambda)$

The discrete and irregular distributed spectrum of the OG detector predetermines the same type of the absorption. How does this irregularity influent the OG analogue of $\Phi(\lambda)$? FIG.5 suggests, that the shift of the integrated interval $[\lambda_1 \div \lambda_2]$ (see Exp(1)) acts upon the OG response amplitude. It is adduced by our estimation based on the absorption of the AC EL light emission. The Total Absorption (TA) of the red emitting AC EL structures is calculated numerically versus the $\Phi(\lambda)$ shift (FIG.5, curve *a*). Every TA - value is the sum

$$\sum_{im} k_{\lambda_i} \Phi_{\lambda_m}, \text{ where if } m = i,\ \Phi(\lambda) \text{ is not shifted.}$$

In order to bring our estimations nearer the real ΔU_L - value the metastable level OG contribution is taken into account. Some of the absorbing transitions are with metastable low level. It forms light-induced conductivity of negative sign. Then, in first approximation, the measured total OG signal ΔU_L is proportional to the difference between two contributions, i.e. of the metastable (*M*) and nonmetastable (*N*) levels:

$$\Delta U_L \approx \sum_i k_{\lambda_i}{}^M \Phi_{\lambda_i} - \sum_n k_{\lambda_n}{}^N \Phi_{\lambda_n} \tag{3}$$

where λ_i, $\lambda_n \in \Phi(\lambda)$ distribution.

The curve *b* in FIG.5 illustrates two tendencies in the shift interval $\Delta\lambda$ within (0 - 40) nm, i.e. increasing of ΔU_L when $\Delta\lambda \in$ (0 - 30) nm and saturation for $\Delta\lambda \in$ (30 - 40) nm. The comparison between the behaviour of the curves *a* and *b* suggests the important contribution of the metastable level to the formation of the OG response.

In our consideration the distribution $\Phi(\lambda)$ changes its λ - localization only but no other parameters. That has to be taken into account when comparing the computed and the measured ΔU_L values. Hence, our model does not take account of the possible brightness variation due to the power frequency and voltage; these effects should be estimated in Exp.(1) additionally.

Two upper spectral distributions in FIG. 3 characterise the emission at two power frequencies. They are shifted relative to one another 1.81 nm taken between the Gaussians and the higher frequency removes the spectrum to the red spectral region. According to our estimation, based on Exp. (1) and FIG. 5 (curve *b*), the value ΔU_L should increase. Indeed such a tendency is observed in the OG responses in FIG.4, but it is a quantitative estimation.

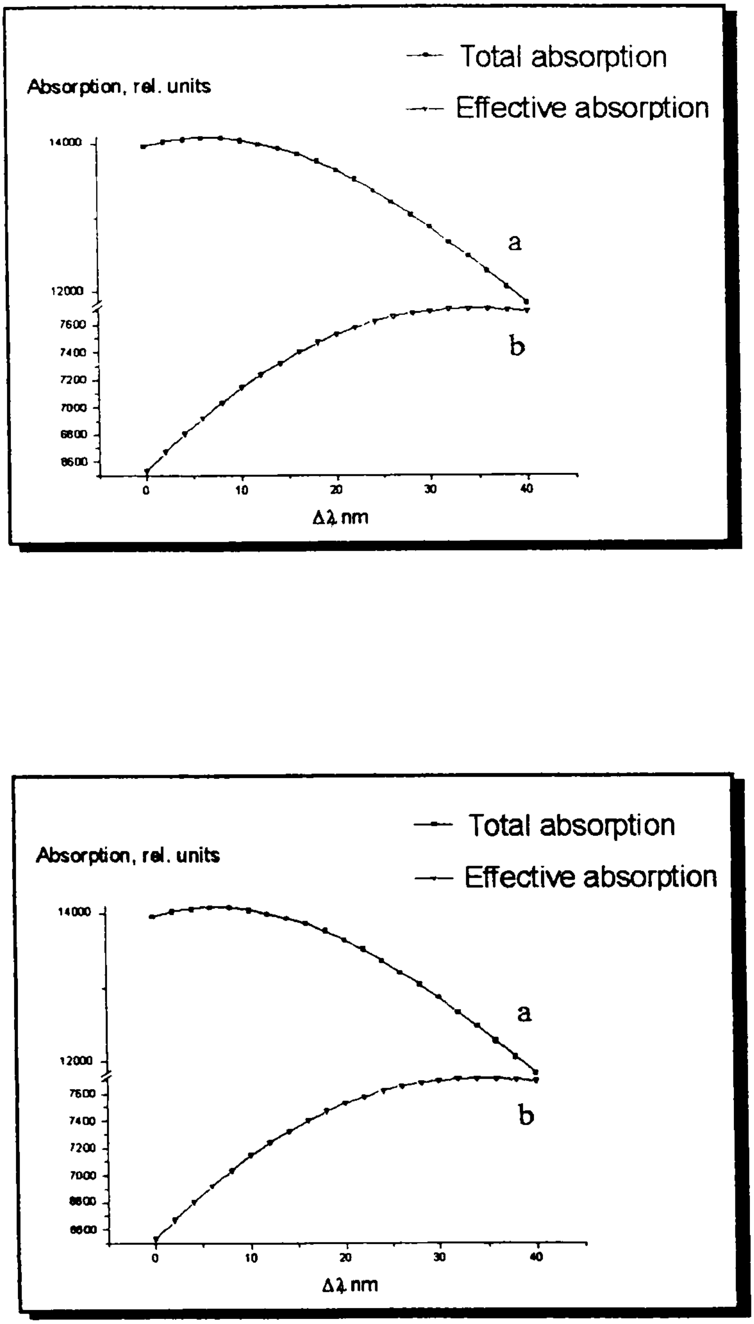


FIG 5: Total absorption (curve *a*) and effective absorption (curve *b*), calculated according to Exp.(1) and FIG. 3

CONCLUSIONS

1. The spectral emission distribution $\Phi(\lambda)$ of the red emitting AC EL structures is found to be of Gaussian type and removes to red spectral range at increasing power supply voltage and frequency.

2. The OG analogues of the $\Phi(\lambda)$ distribution depending on the voltage and frequency are obtained.

3. The discrete and irregular distribution of the absorbing transitions in HCD gives a changing OG amplitude.

4. The observed shift of the distribution $\Phi(\lambda)$ is calculated to show as an OG amplitude variation.

5. The metastable neon level OG contribution is estimated to compete with that of the other levels.

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