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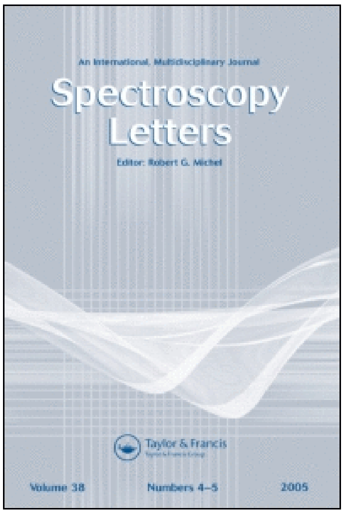

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Spectroscopical Effects Arising Under Application of Pulse Supply to Zinc Hollow Cathode Discharge

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SPECTROSCOPICAL EFFECTS ARISING UNDER APPLICATION OF PULSE SUPPLY TO ZINC HOLLOW CATHODE DISCHARGE

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ABSTRACT

The intensity and width of the Zn 330,2 nm spectral line emitted from hollow cathode discharge in pulse mode depending on pulse parameter changes are investigated.The purpose of this study is to obtain the effect of pulse mode supply and to find the optimum values of pulse parameters for stable emission of intensive as well as narrow zinc spectral lines.The line intensity gain is maximum 100,while the line width is less or equal to that obtained at the d.c.mode.

INTRODUCTION

Application of pulse supply to the hollow cathode discharge increases its advantages: stable emission of intensive as well as narrow spectral lines[1,2,3,4].It is considered that the effect from the application of pulse supply is predominantly due to decreased discharge sensitivity towards the cathode thermal regime.This implies that the pulse supply will be considerably useful for the investigation of elements like zinc,easily entering the discharge zone.Zinc is characterized

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by a high sputtering rate[5],low evaporation temperature and high vapor pressure[6].As a result its atoms enter very intensively in the discharge zone at d.c.mode which leads to discharge instabilities and broadening of the emitted spectral lines[7].Investigations on zinc discharge in pulse mode indicate that the Zn 201,3 nm spectral line intensity can by enhanced[8] and the quality of zinc atomic absorption analysis-improved[9].

In the present paper the intensity I and width $\Delta\nu$ of the Zn 330,2nm spectral line excited in a hollow cathode discharge in pulse mode as a function of pulse parameter changes (amplitude a,width t and pulse period T) are investigated.The results are compared with those (I_0,$\Delta\nu_0$)obtained from discharge in d.c.mode for the same value of the mean current.The purpose of this study is to estimate the advantages of pulse mode supply and to find the optimum values of pulse parameters for stable emission of intensive as well as narrow zinc spectral lines emitted from a hollow cathode discharge in pulse mode.

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EXPERIMENTAL

Fig.1 shows our experimental set-up.The discharge tube is supplied with monopolar rectangular pulses and d.c.component not exceeding 2 mA.Pulse parameters are changed to its maximum values at which the discharge is stil stable and arc mode does not appear.The hollow cathode discharge tube consists of a replaced cylindrical cathode and ring shaped anode put at the distance 1 mm from the cathode front.The cathode length is 15 mm and its inner diameter is 3 mm.Pure zinc as cathode material is not suitable because of the very intensive entering of zinc atoms in the discharge zone,which leads to the discharge instability at lower values of pulse parameters and easier appearing of arc mode.That's why the alloy 50% Zn + 50% Al was used.The pressure of neon in the discharge tube is about 1,5 torr.The profile of the investigated Zn 330,2 nm spectral line was recorded using a scanning Fabry-Perot interferometer by changing the air pressure in the barocamera.

RESULTS AND DISCUSSION

Figs.2 and 3 represent the behaviour of the function $I/I_0=f(\alpha,t,T)$.The following conclusions can be made having in mind the figures:1)I/I_0 depends at the same time on the three pulse parameters (α,t,T);2)$I/I_0=f(t)$ is most pronounced; 3)$I/I_0=f(\alpha)$ is more strongly expressed at lower values of T; 4)The maximum value of I/I_0- about 100 -almost does not change at the increasing of T from 220 μs to 1597 μs but only shifts

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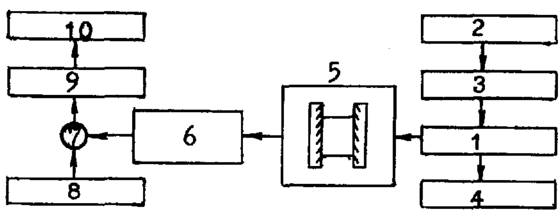

FIG.1

Experimental set-up principal scheme:1-discharge tube with a hollow cathode;2-pulse generator;3-pulse amplifier;4-oscillograph;5-Fabry-Perot interferometer in the barocamera;6-monochromator DMR-4;7-photomultiplier FEU (39,106);8-photomultiplier supply;9-d.c.amplifier;10-recorder G1B1.

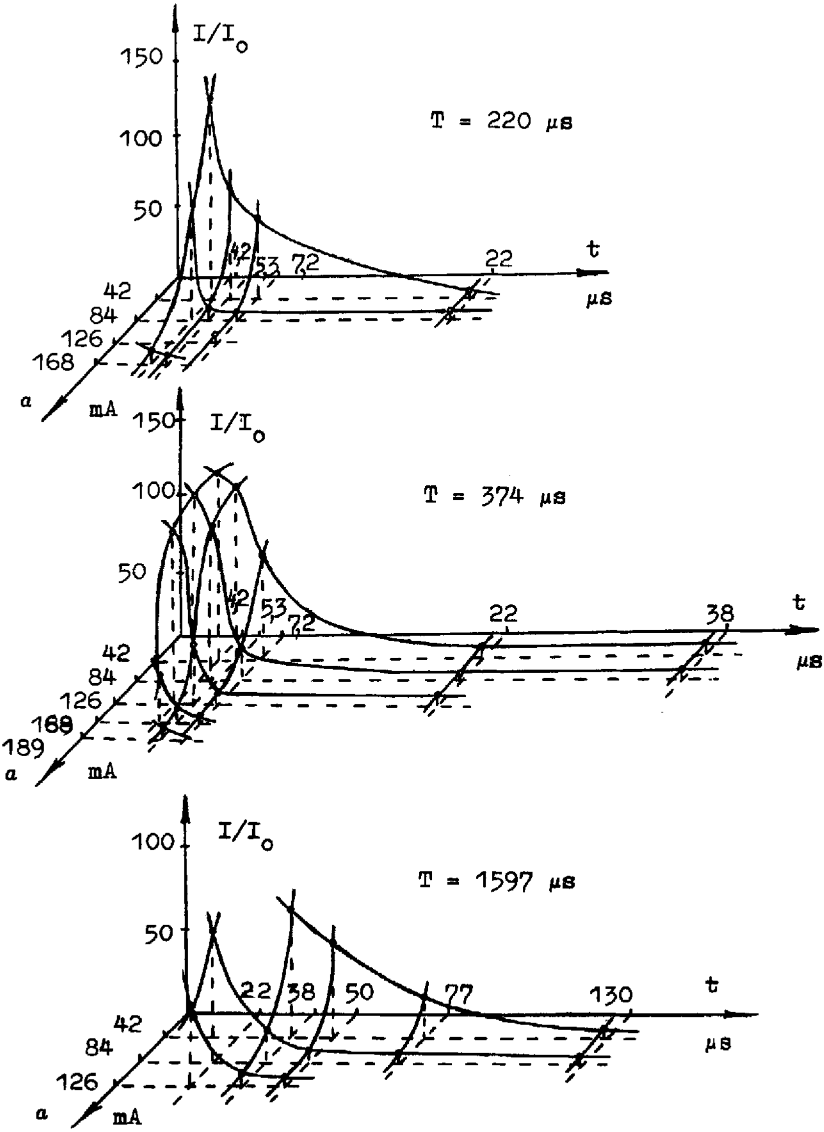

FIG.2

Dependence of Zn 330,2 nm spectral line intensity increase I/I_o on the parameters of pulse supply.

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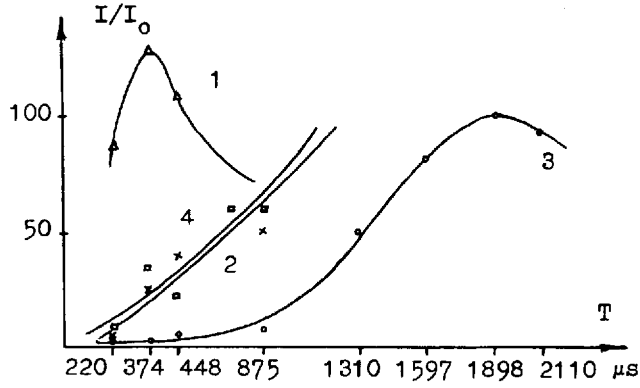

FIG.3

Dependence of Zn 330,2 nm spectral line intensity increase I/I_0 on T: 1-t=4,2 μs at a=84 mA; 2-t=7,2 μs at a=84 mA; 3-t=22 μs at a=84 mA; 4-t=4,2 μs at a=168 mA.

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to higher values of t and a; 5) I/I_0 decreases at T≥ 1597 μs. In tables 1and 2 the widths of the Zn330,2nm spectral line emitted from dc. and pulse mode discharge correspondingly are summarized.

The Gaussian ($\Delta\nu_G$, $\Delta\nu_{Go}$) and the Dispersion ($\Delta\nu_D$, $\Delta\nu_{Do}$) components of the recorded widths ($\Delta\nu$, $\Delta\nu_0$) are obtained according to Ballik method[10]. Corrections for Gaussian type broadening (due to the round diaphragm $\delta\nu_1$ and to the surface mirror deffects $\delta\nu_2$) and of Dispersion type (as a result of the mirror reflection R - $\delta\nu_R$) were made by the equations given in[11]:

$$\delta\nu_1 = \frac{\nu r^2}{2F^2}, \quad \delta\nu_2 = \frac{\Delta l}{l}\nu, \quad \delta\nu_R = \frac{1-R}{2\pi l\sqrt{R}},$$

where r is the radius of the round diaphragm, F is the focus distance of the collimating lens, l is the distance between the mirrors. Having in mind the corrections in our case ($\delta\nu_1$=15 mK, $\delta\nu_2 \approx$ 24mK, $\delta\nu_R$=24mK at R=90%, l=0,7sm, r=0,05sm, F=50sm, $\Delta l \approx \lambda/60$)

we obtain the proper Gaussian ($\delta\nu_G$, $\delta\nu_{Go}$) and the proper Dispersion ($\delta\nu_D$, $\delta\nu_{Do}$) components. Tables 1 and 2 indicate that: 1) $\delta\nu_D$ and $\delta\nu_{Do}$ do not depend on pulse parameters a, t and T; 2) $\delta\nu_G$ and $\delta\nu_{Go}$ are 5÷10 times higher than $\delta\nu_D$ and $\delta\nu_{Do}$. This coincides with the results obtained for the predominantly Gaussian character of the profile of the lines emitted from hollow cathode discharge[11]. Besides it can be concluded that application of pulse supply gives rise mainly to thermal changes in the discharge. More clearly the dependence $\delta\nu_G$=f(t,T) at a=168 mA and $\delta\nu_{Go}$=f(i_o) /dashed line/ is shown on fig.4. Having in mind the results in tables and fig.4, the following conclusions can be made: 1) $\delta\nu_G$ increases with a and t increasing; this increase is faster at a>100 mA; 2) $\delta\nu_G$ at T=220 μs, T=374 μs and T=448 μs has approximately equal values, smaller or equal

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TABLE 1

Dependence of Zn 330,2 nm widths $\Delta\nu_o$, $\Delta\nu_{Go}$, $\Delta\nu_{Do}$, $\delta\nu_{Go}$, $\delta\nu_{Do}$ [mK] on the discharge current i_o.

i_o [mA]	$\Delta\nu_o$	$\Delta\nu_{Go}$	$\Delta\nu_{Do}$	$\delta\nu_{Go}$	$\delta\nu_{Do}$
3,1	186,0	140,0	46,0	136,5	22,0
3,7	204,0	151,5	52,0	148,5	28,0
4,1	210,0	164,0	46,0	161,5	22,0
5,5	217,5	173,0	46,0	170,7	22,0
6,6	226,5	181,0	46,0	178,8	22,0
7,6	238,0	190,0	49,3	200,0	25,3
8,6	248,5	202,0	49,3	200,0	25,3
10,0	258,5	214,0	46,0	212,0	22,0

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TABLE 2

Dependence of Zn 330,2 nm spectral line widths $\Delta\nu$, $\Delta\nu_G$, $\Delta\nu_D$, $\delta\nu_G$, $\delta\nu_D$ [mK] on the pulse supply parameters (α,t,T).

T μs	α mA \ t μs	4,2					5,3					7,2					22				
		$\Delta\nu$	$\Delta\nu_G$	$\Delta\nu_D$	$\delta\nu_G$	$\delta\nu_D$	$\Delta\nu$	$\Delta\nu_G$	$\Delta\nu_D$	$\delta\nu_G$	$\delta\nu_D$	$\Delta\nu$	$\Delta\nu_G$	$\Delta\nu_D$	$\delta\nu_G$	$\delta\nu_D$	$\Delta\nu$	$\Delta\nu_G$	$\Delta\nu_D$	$\delta\nu_G$	$\delta\nu_D$
220	42	155,5	113,0	44,5	109,2	20,5	163,0	120,0	44,5	116,5	20,5	177,3	134,0	46,0	131,0	22,0	197,5	160,0	40,0	157,7	16,0
	84	172,0	132,0	40,0	129,0	16,0	175,0	135,0	44,5	132,0	20,5	178,6	137,0	45,5	134,2	21,5	197,0	162,0	41,5	159,6	17,5
	126	175,0	134,0	44,5	131,0	20,5	180,5	143,0	41,5	140,3	17,5	183,2	145,0	42,8	142,7	18,8					
	168	190,5	148,0	46,0	145,7	22,0	195,5	155,0	41,5	152,3	17,5	220,0	174,0	46,0	172,3	22,0					
374	42	150,3	107,0	44,5	103,0	20,5	161,2	115,0	46,0	111,4	22,0	174,3	132,0	44,5	129,0	20,5	195,5	152,0	44,5	149,7	20,5
	84	160,0	119,0	41,5	115,7	17,5	173,8	131,0	44,5	128,0	20,5	177,4	135,0	44,5	132,6	20,5	169,9	160,0	40,0	157,4	16,0
	126	168,8	127,0	41,5	123,8	17,5	179,5	139,0	42,8	136,0	18,8	182,2	143,0	42,8	140,3	18,8					
	168	189,5	147,0	44,5	144,3	20,5	194,0	151,0	44,5	148,3	20,5	215,0	170,0	46,0	167,7	22,0					
448	168	189,0	146,0	46,0	143,4	22,0	193,0	150,0	46,0	147,3	22,0	218,0	171,0	47,6	168,7	21,6					
875	168	190,0	146,0	44,5	143,4	20,5	193,0	149,0	44,5	146,0	20,5	209,0	167,0	42,8	164,3	18,8	246,5	203,0	47,6	201,0	21,6
1597	168																242,0	200,0	46,0	198,0	22,0
2299	168																251,0	209,0	46,0	207,0	22,0

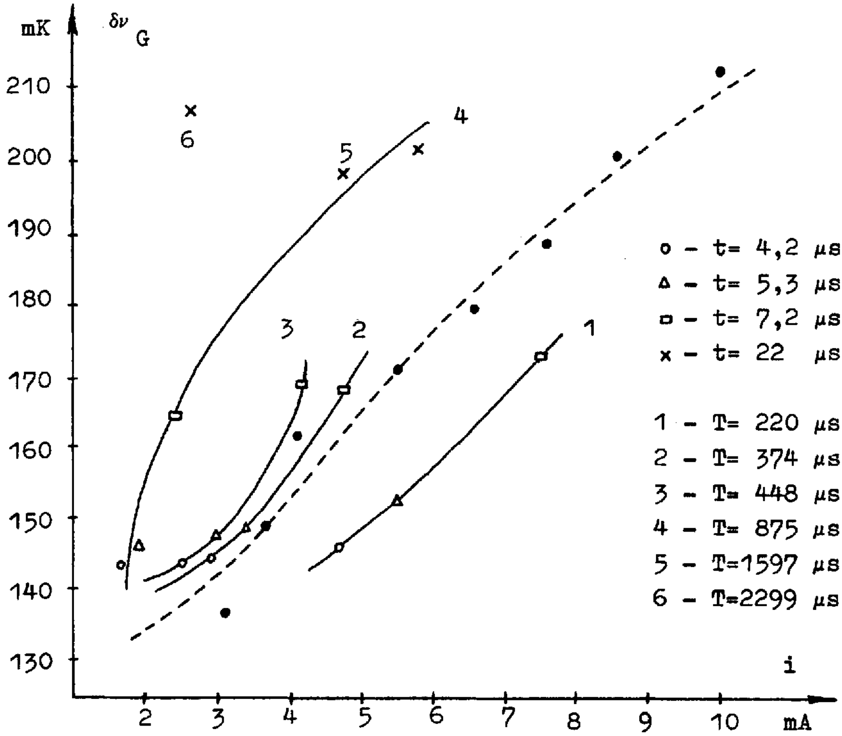

FIG.4

Dependences of proper Gaussian components $\delta\nu_G$=f(t,T) at a=168 mA and $\delta\nu_{Go}$=(i_o) /dashed line/ at the corresponding mean current values

to $\delta\nu_{Go}$;3) $\delta\nu_G$ at T$\geqslant$875 μs increases and becomes bigger than $\delta\nu_{Go}$.While the first result can be explained by Doppler broadening and self-absorption because of mean current increasing in the discharge,such explanation for the second and the third results is not satisfactory.On the other hand our observations on the discharge at T$\geqslant$875 μs show that the shining diffused volume between the cathode and anode begins

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to increase.Drawing a general conclusion from all these experimental results we can assume that at the given conditions the effect of the directed movement of the atoms from the cathode cavity outwards is manifested.Atomic transport phenomena from the cathode have been observed by other authors too[12,13,14].Detailed study of the investigated zinc line profile can lead to a more precise conclusion concerning the possibility of the assumed transport phenomena.The qualitative differences between our results and those for other elements obtained by the above cited authors regardless of some distinctions in the discharge tube constructions is predominantly due,in our opinion to the different properties of the investigated elements.

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Generalizing the results obtained for the intensity and width of the Zn 330,2 nm spectral line emitted from hollow cathode discharge for our discharge tube construction in pulse mode,we can conclude that the optimum conditions for stable emission of zinc lines with increased intensity and at the same time with widths smaller or equal to that obtained at the d.c. mode are: $t=4,2\div5,3$ μs, $a=40\div80$ mA and $T=220\div448$ μs.

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