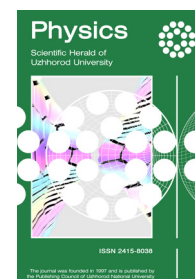


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## Parameters of Gas-Discharge Plasma of Barrier Discharge on Mixtures of Vapours of Diiodide, Dibromide and Mercury Dichloride with Helium

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### Abstract

**Relevance.** In the last decade, the rapid development of solutions to the problems of preserving the planet's energy resources and improving “artificial” photosynthesis, which arose with the development of science and technology, have required the creation of effective sources of spectral radiation that simultaneously emit bands and lines in given spectral ranges. It is relevant to find ways to increase the radiation power of spectral bands in the violet-blue and blue-green spectral ranges.

**Purpose.** The purpose of the study was to determine the plasma parameters in mixtures of diiodide, dibromide and mercury dichloride vapours with helium at which the maximum value of the radiation power was obtained in the experiment and to find their values at which the radiation power in the spectral bands can be maximum.

**Methods.** The parameters of the plasma discharge were determined by a numerical method based on finding the value of the electron energy distribution function (EEDF). EEDF was determined by solving the kinetic Boltzmann equation in a binomial approximation using the Bolsig+ programme. On the basis of EEDF, the average electron energies, electron mobility, specific losses of discharge power for elastic and inelastic processes of electron collisions with mixture components, and constants of elastic and inelastic electron scattering velocities were found.

**Results.** The results of studies of the parameters of a gas-discharge plasma barrier discharge on a mixture of vapours of diiodide, dibromide and mercury dichloride with helium depending on the reduced electric field strength ( $E/N$ ) are presented. The value of the average energy, drift velocity, concentration and temperature of electrons is in the range: 0.31 eV–24.2 eV,  $2.8 \cdot 10^5$  m/s– $2.0 \cdot 10^5$  m/s,  $5.9 \cdot 10^{18}$  m<sup>-3</sup> –  $8.3 \cdot 10^{18}$  m<sup>-3</sup>, 3,644.7 – 278 632 °K when changing the  $E/N$  parameter from 1 to 200 Td. Dissociative excitation rate constants  $B^2\Sigma$  – the state of the exciplex molecules of monobromide, monoiodide and mercury monochloride by electrons reached a maximum value of  $2.03 \cdot 10^{-14}$  m<sup>3</sup>/c,  $3.39 \cdot 10^{-14}$  m<sup>3</sup>/s and  $3.44 \cdot 10^{-15}$  m<sup>3</sup>/c for the reduced electric field is 97.07 Td, respectively. The losses of specific discharge power reach the maximum of 11.4%, 29.5%, 40.7%, 4.9% and 3.1% for values of the  $E/N$  parameter equal to 14.7 Td, 7.8 Td, 26.1 Td, 15 Td and 15 Td for electronic state of mercury monobromide  $B^2\Sigma_{1/2}^+$ ,  $X^2\Sigma_{1/2}^+$ , mercury dibromide ( $HgBr_2$  (D)) and  $B^2\Sigma_{1/2}^+$  states of mercury monoiodide and mercury monochloride, respectively.

**Conclusions.** The results of numerical modelling give grounds to conclude that it is possible to improve the energy characteristics of gas-discharge emitters based on a mixture of vapours of diiodide, dibromide and mercury dichloride with helium and by reducing the reduced electric field strength to a value of 26.1 Td

**Keywords:** low-temperature plasma, mercury diiodide vapours, mercury dibromide vapours, mercury dichloride vapours exciplex molecules, plasma parameters

### Suggested Citation:

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## Introduction

In the last decade, the rapid development of solutions to the problems of preserving the planet's energy resources and improving "artificial" photosynthesis, which arose with the development of science and technology, have required the creation of effective sources of spectral radiation that simultaneously emit bands and lines in given spectral ranges. Among such sources emitting simultaneously spectral bands is gas-discharge plasma on mixtures of mercury dihalogenide vapours with helium, which emits spectral bands in the violet-blue, blue-green and green spectral ranges with maximum intensity at wavelengths ( $\lambda_{\max.} = 444 \text{ nm}$ ,  $\lambda_{\max.} = 502 \text{ nm}$ ,  $\lambda_{\max.} = 557 \text{ nm}$ ) [1-3].

In previous studies of gas-discharge radiation sources of spectral bands in the visible, ultraviolet and infrared ranges (excilamps), the authors used mixtures of individual metal dihalogenide vapours of the second group of the periodic table with gases [4; 5]. Regularities were established: in the change in the brightness of radiation in the spectral bands depending on the partial pressures of the components of mixtures and on changes in the temperature and frequency of following pump pulses. In addition, the dependence of the parameters of a low-temperature plasma on the reduced electric field strength applied to the inter-electrode gap was determined, including its value for the maximum radiation power in the spectral bands. However, the plasma parameters, their dependence on the reduced electric field strength, and the effect on the radiation power in the spectral bands in a vapour-gas mixture simultaneously of three mercury dihalogenides with gases were not studied.

This circumstance was the motivation for determining plasma parameters on triple mixtures of diiodide, dibromide, and mercury dichloride vapours with helium under the experimental conditions presented in the article [1].

*The purpose of the research* was to establish physicochemical regularities in the dependences of the parameters on the reduced electric field strength and on their basis to identify the possibility of increasing the energy parameters of the emitters.

## Materials and Methods

Measurement of plasma parameters at atmospheric pressure of the mixture, which was used in experiments, is a complex task in methodological and technical terms [6]. In this regard, the authors of the article used a theoretical method that was successfully tested in discharges based on other mixtures of dihalide vapours with gases [7-9]. According to this method, the parameters and characteristics of a gas-discharge plasma were determined on the basis of the known electron energy distribution function (EEDF). To determine EEDF the kinetic Boltzmann equation is used for quasi-stationary electron energy distribution functions [10]:

$$\frac{\partial f}{\partial t} + v \cdot \nabla_v f - \frac{e}{m} \cdot E \cdot \nabla_v \cdot f = C[f] \quad (1)$$

where  $f$  – electron distribution function in six-dimensional phase space,  $v$  – speed coordinates,  $e$  – elementary charge,  $m$  – the electron mass,  $E$  – electric field strength,  $\nabla_r$  – coordinate gradient operator,  $\nabla_v$  – speed gradient operator,  $C$  – indicates the rate of change of EEDF due to collisions.

The kinetic Boltzmann equation (1) for quasi-stationary electron energy distribution functions can only be applied for experimental conditions under which the plasma medium is spatially homogeneous, characterised by a constant composition of components, and is located in an electric field, the strength of which does not change during the establishment of the electron energy distribution function. These experimental conditions were provided in the study [1].

Plasma parameters were defined as general integrals of the electron energy distribution function (EEDF) in discharge on mixtures of diiodide, dibromide, and mercury dichloride vapours with helium. EEDF was determined by solving the Boltzmann kinetic equation in a binomial approximation using the well-known Bolsig + programme [11]. On the basis of EEDF, the following parameters were determined: the average electron energy, specific power losses of an electric discharge, and constants of elastic and inelastic electron scattering rates on mercury dihalides molecules and helium atoms depending on the value of the reduced electric field. Range of changes in the parameter  $E/N = 1-200 \text{ Td}$  ( $1 \cdot 10^{-17} - 2 \cdot 10^{-15} \text{ In}^* \text{ cm}^2$ ) and included the value of the parameter  $E/N$ , which was implemented in the experiment. All calculations were performed for the partial vapour pressure of mercury diiodide 133 Pa, mercury dibromide 270 Pa, mercury dichloride 900 Pa, and helium 109400 Pa, at which the emission of spectral bands of exciplex molecules of monoiodide, monobromide, and mercury monochloride was observed [1].

The integral of electron collisions with helium atoms and mercury dibromide, diiodide, and dichloride molecules takes into account the following processes of elastic and inelastic collisions of electrons with the components of the mixture: elastic scattering, excitation of the electrical levels of the atom He ( $2^3S$ ,  $2^1S$ ,  $2^3P$ ,  $2^1P$ ,  $3SPD$ ,  $4SPD$ ,  $5SPD$ ), ionization of the helium atom, vibrational excitation of molecules  $\text{HgBr}_2$ , excitation of  $\text{HgBr}_2(D)$  – the state of  $\text{HgBr}_2$  molecules, dissociative excitation of mercury monobromide ( $X^2\Sigma^+_{1/2}$ ,  $B^2\Sigma^+_{1/2}$  – states), adhesion, ionization, dissociative excitation  $B^2\Sigma^+_{1/2}$  state of mercury monoiodide, dissociative excitation  $B^2\Sigma^+_{1/2}$  states of mercury monochloride, ionization of mercury dichloride molecules. Data on the absolute values of the effective cross-sections of these processes, as well as their dependence on electron energies, are taken from the works [7; 12; 13].

Electron concentration ( $N_e$ ) was calculated using the well-known formula [14]:

$$N_e = j/e \cdot V_{dr} \quad (2)$$

where  $j$  is the current density in the discharge,  $E$  is the charge of the electron,  $V_{dr}$  is electron drift velocity.

The electron drift rate was determined from the expression [14]:

$$V_{dr.} = \mu_e \cdot E \quad (3)$$

where  $\mu_e$  is the electron mobility and  $E$  is the electric field strength on the plasma.

The electric field strength at plasma  $E$  was calculated by the formula:

$$E = U_{pl.}/d \quad (4)$$

where  $U_{pl.}$  is plasma voltage,  $d$  is discharge gap.

The plasma voltage was determined according to Kirchhoff's second rule using experimentally measured values of the time course of the voltage applied to the electrodes of the gas-discharge cell  $U$ , as well as the voltage drop across the dielectric capacitance  $U_{dl.}$  [15]:

$$U_{pl.} = U - U_{dr.} \quad (5)$$

Voltage  $U_{dl.}$  was calculated from the displacement of the charge  $Q$  and the capacitance of the dielectric barrier  $C_d$ :

$$U_{dr.} = Q/C_d \quad (6)$$

The charge moved in the circuit was determined by current integration taking into account the initial conditions:

$$Q(t) = \int_0^t I(t)dt + Q_0 \quad (7)$$

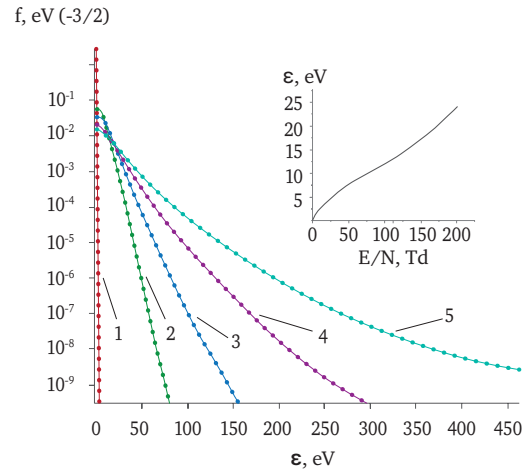
where  $Q_0=Q(t=0)$ .

As a result, the electric field strength at the plasma gap was 1,275.000 V/m, and the reduced electric field (E/N)=67.1 Td for the value of the total concentration of the components of the mixture (N) = 1.896\*10<sup>+25</sup> m<sup>-3</sup>, in which an experiment was conducted to study the spectral composition of gas-discharge plasma radiation on a mixture of mercury dihalides and helium [1].

### Results and Discussion

Figure 1 shows the characteristic type of EEDF when changing the E/N parameter in the range of 1-200 Td for a mixture of HgI<sub>2</sub>- HgBr<sub>2</sub>- HgCl<sub>2</sub>-He. An increase in its value leads to an increase in the number of "fast" discharge electrons. The average energy of discharge electrons increases sharply from 0.31 to 2.3 EV with increasing E/N from 1 to 7.8 Td. With a further increase in the reduced

electric field, the average electron energy also increases and reaches a value of 24.2 EV for E/N equal to 200 Td.



**Figure 1.** Functions of electron energy distribution (EEDF) for the mixture: HgBr<sub>2</sub> : HgI<sub>2</sub> : HgCl<sub>2</sub> : He = 0.0024: 0.0012: 0.00816: 0.9951 at total mixture pressure P=110.7 kPa for values of the E/N parameter: 1 (1), 50,8 (2), 100 (3), 150 (4), 200 (5) Td; on the insert – dependence of the average electron energy on the E/N parameter

The temperature of electrons in the gas-discharge plasma of the emitter was determined by the well-known formula (8) [9]:

$$\varepsilon = 3/2 \cdot kT \quad (8)$$

where  $\varepsilon$  is average electron energy,  $k$  is the Boltzmann constant,  $T$  is the temperature in degrees Kelvin. It increases from 3 644.7 to 278 632 °K.

The product of electron mobility and density, as follows from the numerical calculation data, varies in the range of 0.4181 E+25·N – 0.2913E+25·N (1/m/ V/s) when the parameter E/N changes in the range of 1-200 Td, which gives the value of the electron drift velocity 2.8·10<sup>5</sup> m/s and 2.0·10<sup>5</sup> m/s, respectively, at the field strength on the plasma V/m and electron concentration values 5.9·10<sup>18</sup> m<sup>-3</sup> – 8.3·10<sup>18</sup> m<sup>-3</sup> at a current density of 265·10<sup>3</sup> A/m<sup>2</sup> on the surface of the inner electrode.

The values of the reduced electric field strength at which the experimental studies were conducted, as well as the value of the average electron energy and temperature, were 67.1 Td, 9.53 eV and 110548 °K, respectively (Table 1).

**Table 1.** Electron transport characteristics: average energy ( $\varepsilon$ ), temperature ( $t^0$ K), drift velocity ( $V_{dr.}$ ) and concentrations ( $N_e$ ) in the category on the mixture Ne : HgCl<sub>2</sub> : HgI<sub>2</sub> : HgBr<sub>2</sub> = 109.4 kPa: 900 Pa : 133 Pa: 270 Pa when the total pressure is 110, 703 kPa

E/N, Td	$\varepsilon$ , eV	T, °K	$V_{dr.}$ m/c	$N_e$ , m <sup>-3</sup>
67.1	9.533	110 583	1.6 *10 <sup>5</sup>	1.0410 <sup>19</sup>

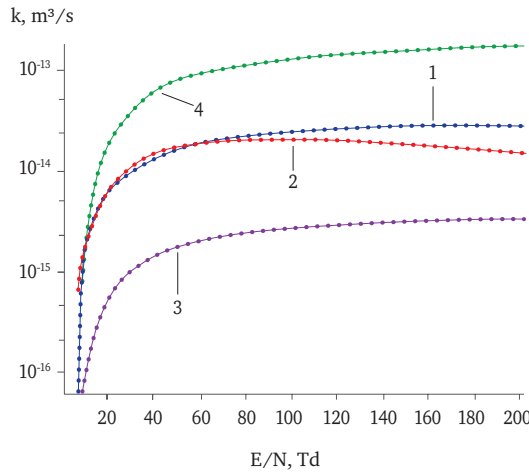
The electron concentration for the maximum value of the current amplitude of 265 A was 1.04·10<sup>19</sup> m<sup>-3</sup>. Excitation rate constants B<sup>2</sup>Σ<sub>1/2</sub><sup>+</sup> – the states of exciplex molecules of monobromide, monoiodide and mercury monochloride reached a value of 1.96·10<sup>-14</sup> m<sup>3</sup>/s, 1.97·10<sup>-14</sup> m<sup>3</sup>/s and

2.19·10<sup>-15</sup> m<sup>3</sup>/s, respectively. The maximum value of the excitation rate constant was observed for the excitation of the D – state of mercury dibromide molecules 1.05·10<sup>-13</sup> m<sup>3</sup>/s (Table 2).

**Table 2.** Values of excitation rate constants ( $k$ ), ionization rate constants ( $k_{He+}$ ), elastic collision ( $k_r$ ) with electrons:  $B^2\Sigma_{1/2}^+$  – state of exciplex molecules  $HgCl^*$ ,  $HgI^*$ ,  $HgBr^*$ , D – state of mercury dibromide molecules, helium atom levels ( $k_{He^*}$ ), in a mixture of helium, dichloride vapours, diiodide and mercury dibromide at a ratio of 109.4 kPa : 900 Pa : 133 Pa : 270 PA at a total pressure of 110.7 kPa for a reduced electric field strength of 67.1 Td

E/N, Td	$k_{HgCl^*}, \cdot 10^{+14}, m^3/s$	$k_{HgI^*}, \cdot 10^{+13}, m^3/s$	$k_{HgBr^*}, \cdot 10^{+13}, m^3/s$	$k_{HgBr_2(D)}, \cdot 10^{+12}, m^3/s$	$k_r, \cdot 10^{+13}, m^3/s$	$k_{He^*}, \cdot 10^{+15}, m^3/s$	$k_{He^+}, \cdot 10^{+16}, m^3/s$
	$\lambda=557\text{ nm}$	$\lambda=444\text{ nm}$	$\lambda=502\text{ nm}$				
	HgCl <sub>2</sub> : HgI <sub>2</sub> : HgBr <sub>2</sub>				He		
67.1	0.2196	0.1973	0.1963E	0.1051	0.7724	0.2043	0.8308

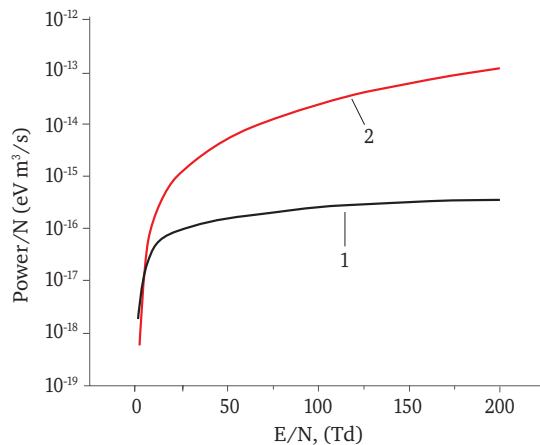
Excitation rate constants  $B^2\Sigma_{1/2}^+$  – the states of exciplex molecules of monobromide, monoiodide and mercury monochloride reached a maximum value of  $2.03 \cdot 10^{-14} m^3/s$ ,  $3.39 \cdot 10^{-14} m^3/s$  and  $3.44 \cdot 10^{-15} m^3/s$  for the reduced electric field 97.07 Td, 200 Td, and 200 Td, respectively (Fig. 2)



**Figure 2.** Dependence of electron collision velocity constants with gas-discharge plasma components on a mixture of He: HgCl<sub>2</sub> : HgI<sub>2</sub> : HgBr<sub>2</sub> = 109.4 kPa : 900 Pa : 133 Pa : 270 Pa when the total pressure is 110.703 kPa of the E/N parameter  
**Notes:** 1 is dissociative excitation of  $B^2\Sigma_{1/2}^+$  states of  $HgI^*$  molecules, 2 is dissociative excitation of  $B^2\Sigma_{1/2}^+$  states of  $HgBr^*$  molecules, 3 is dissociative excitation of  $B^2\Sigma_{1/2}^+$  states of  $HgCl$ , 4 is excitation ( $HgBr_2(D)$ ) states of  $HgBr_2$  molecules

Figure 3 shows the dependence of the specific power of discharge losses on elastic and inelastic processes of electron collisions with helium atoms, dichloride, diiodide and mercury dibromide on the reduced electric field strength in the plasma of the mixture He: HgCl<sub>2</sub> : HgI<sub>2</sub> : HgBr<sub>2</sub> = 109.4 kPa : 900 Pa : 133 Pa : 270 Pa at a total pressure of 110.703 kPa. There is an increase in specific powers with an increase in the values of the reduced electric field

strength. For inelastic processes of electron collisions with plasma components, they are larger than elastic ones ( $3.8 \cdot 10^{-15} \text{ eV m}^3/\text{s}$ ) and reach a value of  $1.2 \cdot 10^{-13} \text{ eV m}^3/\text{s}$  for  $E/N=200 \text{ Td}$ . The values of the specific power of discharge losses on the elastic and inelastic processes of collisions of electrons with helium atoms, dichloride, diiodide and dibromide molecules observed at the reduced electric field are given in Table 3.



**Figure 3.** Dependence of the specific power of discharge losses on elastic (1) and inelastic processes (2) of collisions of electrons with helium atoms, mercury dichloride, diiodide and dibromide molecules from the reduced electric field strength in plasma on the mixture He: HgCl<sub>2</sub> : HgI<sub>2</sub> : HgBr<sub>2</sub> = 109.4 kPa : 900 Pa : 133 Pa : 270 Pa at a total pressure of 110.703 kPa

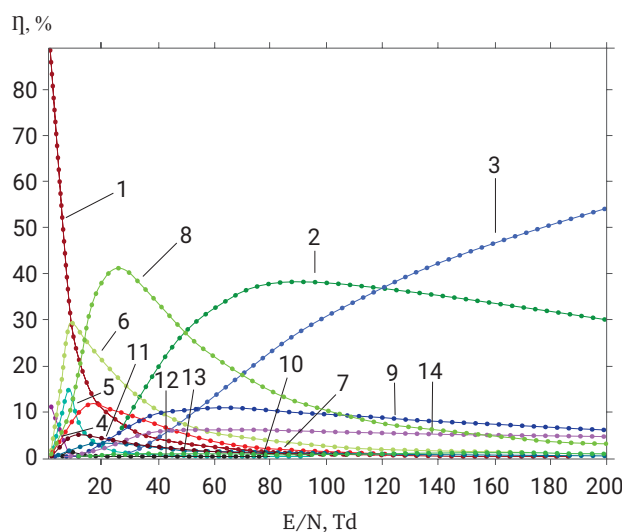
**Table 3.** Value of the specific power of discharge losses at elastic and inelastic processes of electron collisions with helium atoms and molecules Mercury dichloride, diiodide and dibromide at the ratio: 109.4 KPa: 900 Pa: 133 Pa: 270 Pa when total pressure 110.7 KPa for the reduced electric field strength 67.1 Td and 14.7 Td

Mixture He: HgCl <sub>2</sub> : HgI <sub>2</sub> : HgBr <sub>2</sub> = 109.4 kPa: 900 Pa : 133 Pa: 270 Pa.		
E/N, Td	Elastic, power /N(eV m <sup>3</sup> /s)	Inelastic, power /N(eV m <sup>3</sup> /s)
67.1	0.1988E-15	0.1107E-13

The distribution of specific discharge power losses to the main processes is shown in Figure 4.

The value of specific discharge power losses during dissociative excitation of exciplex molecules of monobromide, monoiodide, and mercury monochloride increases with increasing E/N. It reaches its maximum of 11.4%, 29.5%, 40.7%, 4.9% and 3.1% for values of the E/N parameter equal to 14.7 Td, 7.8 Td, 26.1 Td, 15 Td and 15 Td for

electronic states of mercury monobromide B<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub>, X<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub>, mercury dibromide (HgBr<sub>2</sub> (D)) and B<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub> – the states of mercury monoiodide and mercury monochloride, respectively, and with a further increase in the parameter E/N it decreases. For the reduced field strength at which the experiment was performed (67.1 Td), the fraction of the specific power of the discharge for B<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub> – state were: 3.3% (HgBr), 1.3% (HgI), 1.2% (HgCl) and for HgBr<sub>2</sub> (D) 20.6%.



**Figure 4.** Dependence of specific discharge power losses on electron collisions in a mixture of mercury dibromide and diiodide vapours with helium on the reduced electric field strength (E/N)

**Notes:** 1 – elastic electron scattering by helium atoms, 2 – excitation of helium atoms, 3 – ionization of helium atoms, 4 – vibrational excitation of HgBr<sub>2</sub> molecules, 5 – resonant oscillation of HgBr<sub>2</sub> molecules, 6 – dissociative excitation X<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub> states of HgBr molecules, 7 – dissociative excitation B<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub> states of HgBr molecules, 8 – dissociative excitation of the electronic state of mercury dibromide – (HgBr<sub>2</sub> (D)), 9 – ionization of mercury dibromide molecules, 10 – electron adhesion to mercury dibromide molecules, 11 – dissociative excitation of the state B<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub> molecules of HgI, 12 – ionization of mercury diiodide molecules, 13 – dissociative excitation of the state in<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub> molecules of HgCl, 14 – ionization of mercury dichloride molecules

As it is known [2], the excitation rate constants of a state are a quantitative measure of the efficiency of its excitation, on which the population of the energy level depends respectively. That is, by changing the reduced electric field strength, the excitation efficiency of mercury monohalides changes and, accordingly, the radiation intensity in their spectral bands changes, which is observed in experimental studies of the dependence of the intensity on the temperature of the mixture and, accordingly, on the total pressure of mercury and helium digalides [1].

**Conclusions**

Based on the established parameters of the gas-discharge plasma of the barrier discharge on the vapour-gas mixture HgI<sub>2</sub> : HgBr<sub>2</sub> : HgCl<sub>2</sub> : He = 0.0012 : 0.0024 : 0.00816 : 0.9951 at total pressure of the mixture P=110.7 kPa detected the

possibility of improvement of radiation output characteristics (radiation power in spectral bands and efficiency of coherent (lasers) and spontaneous (exciplex lamps) sources in the violet-blue, blue-green and green spectral ranges (λ<sub>max</sub> =444 nm, λ<sub>max</sub> =502 nm, λ<sub>max</sub> =557 nm) due to a change in the reduced electric field strength. In further studies of the parameters of gas-discharge plasma of barrier discharge on mixtures of vapours of diiodide, dibromide and dichloride of mercury with helium, it is advisable to establish the parameters of plasma when changing the total pressure of the mixture, as well as the reduced electric field strength. This study will establish the possibility of increasing the energy characteristics in the spectral bands emitting exciplex molecules of monoiodide, monobromide and mercury monochloride.

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## Параметри газорозрядної плазми бар'єрного розряду на сумішах парів дйодиду, дибромиду та дихлориду ртуті з гелієм

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### Анотація

**Актуальність.** В останнє десятиліття стрімкий розвиток вирішення проблем збереження енергоресурсів планети та удосконалення «штучного» фотосинтезу, що виникли з розвитком науки і технологій, потребують створення ефективних джерел спектрального випромінювання, які одночасно випромінюють смуги та лінії в заданих спектральних діапазонах. Актуальним є знаходження способів збільшення потужності випромінювання спектральних смуг у фіолетово-синьому та синьо-зеленому спектральних діапазонах.

**Мета.** Метою дослідження було визначити параметри плазми в сумішах парів дйодиду, дибромиду та дихлориду ртуті з гелієм при яких в експерименті було отримано максимальне значення потужності випромінювання і знайти значення їх при яких потужність випромінювання в спектральних смугах може бути максимальною.

**Методи.** Параметри розряду плазми визначили чисельним методом на основі якого лежить знаходження значення функції розподілу електронів по енергіях (ФРЕЕ). ФРЕЕ визначили шляхом розв'язанням кінетичного рівняння Больцмана у двочленному наближенні за допомогою програми Bolsig+. На основі ФРЕЕ були знайдені середні енергії електронів, рухливість електронів, питомі втрати потужності розряду на пружні і непружні процеси зіткнень електронів з компонентами суміші, константи швидкостей пружного та непружного розсіювання електронів.

**Результати.** Приведені результати досліджень параметрів газорозрядної плазми бар'єрного розряду на суміші парів дйодиду, дибромиду та дихлориду ртуті з гелієм в залежності від приведеної напруженості електричного поля (E/N). Величина середньої енергії, швидкості дрейфу, концентрації та температури електронів знаходиться в межах: 0,31 eV – 24,2 eV, 2,8·10<sup>5</sup> м/с – 2,0·10<sup>5</sup> м/с, 5,9·10<sup>18</sup> м<sup>-3</sup> – 8,3·10<sup>18</sup> м<sup>-3</sup>, 3 644,7 – 278 632 °K при зміні параметра E/N від 1 до 200 Тд. Константи швидкостей дисоціативного збудження B<sup>2</sup>Σ – стану ексиплексних молекул монобромиду, монойодиду і монохлориду ртуті електронами досягали максимальної величини 2,03·10<sup>-14</sup> м<sup>3</sup>/с, 3,39·10<sup>-14</sup> м<sup>3</sup>/с і 3,44·10<sup>-15</sup> м<sup>3</sup>/с для приведеного електричного поля 97.07 Тд відповідно. Втрати питомої потужності розряду досягають максимуму 11,4 %, 29,5 %, 40,7 %, 4,9 % і 3,1 % при значеннях параметра E/N рівних 14,7 Тд, 7,8 Тд, 26,1 Тд, 15 Тд і 15 Тд для електронних станів монобромиду ртуті B<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub>, X<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub>, дибромиду ртуті (HgBr<sub>2</sub> (D)) і B<sup>2</sup>Σ<sup>+</sup><sub>1/2</sub> – стану монойодиду ртуті та монохлориду ртуті відповідно.

**Висновки.** Результати чисельного моделювання дають підставу зробити висновок про можливість підвищення енергетичних характеристик газорозрядних випромінювачів на основі суміші парів дйодиду, дибромиду та дихлориду ртуті з гелієм за допомогою зменшення приведеної напруженості електричного поля до значення 26,1 Тд

**Ключові слова:** низькотемпературна плазма, пари дйодиду ртуті, пари дибромиду ртуті, пари дихлориду ртуті ексиплексні молекули, параметри плазми