Nonselfsustained uniform DC discharge with controlled electron energy.

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Nonselfsustained DC discharge supported by preionization from barrier discharge (BD) (Fig.1a) and discharge sliding over a dielectric surface (SD) (Fig.1b) was investigated. The scheme of experimental set up is shown in Fig.1. Two dielectric plates 220x30x2 mm^3 made of alumina and two copper water cooled electrodes 200 mm long spaced at 20 mm apart each other served as sidewalls of the discharge chamber thus forming the slab with cross section of 20x2 mm and total length of 200 mm. The additional water cooled electrodes with cross section of 200x20 mm^2 were pressed to the external sides of dielectric plates. The preionization from barrier discharge was provided by application of the high voltage pulses to the external pair of electrodes. DC voltage Udc was applied to the internal pair of electrodes. To produce the preionization from the discharge sliding over a dielectric surface the high voltage pulses and DC voltage were applied to the internal electrodes simultaneously. External electrodes were grounded at that time. The voltage pulses up to 10 kV with duration of ~ 0.2μs at repetition rate (PRR) of 5-30 kHz have been applied. Udc was varied up to 1 kV. Typical Volt - Ampere Characteristics of the discharge in the mixture CO_2:N_2:He (1:4:8) at pressure 40 Torr and different powers of the preionization Pp are shown in Fig.2 (BD) along with theoretical curves. The nonselfsustained character of the discharge is clearly seen. The stable homogeneous discharge burning is possible up to a certain DC power Pdc* which depends on the Pp. At Pdc > Pdc* the

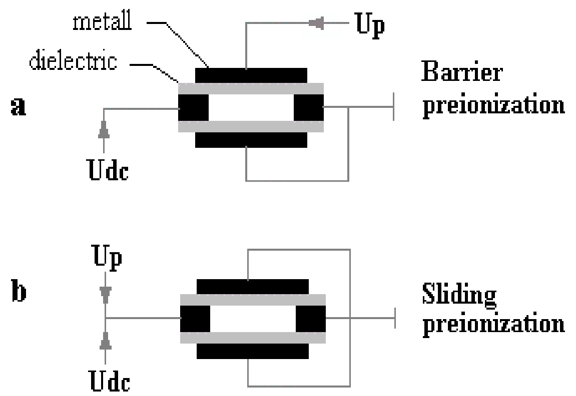

Fig.1.

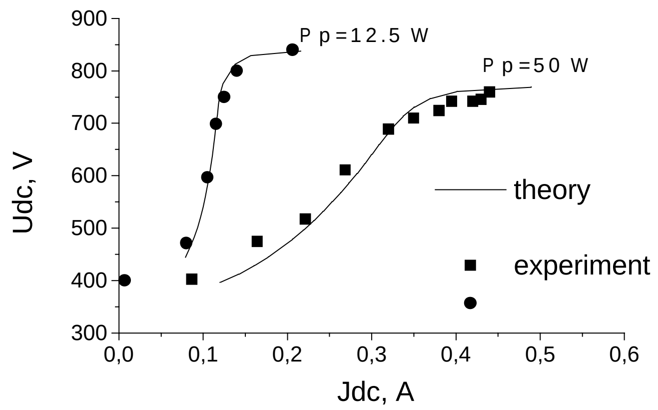

Fig.2.

discharge falls to arcing. The values of Pdc* are plotted in Fig.3. versus Pp. The solid curve is the result of simulations and points are experimental results. It is seen that the increase of the Pdc* up to ~ 800 W requires ~ 200 W of power of the preionization unit Pp. It should be noted that the efficiency ε of the preionization unit, used in our experiment was only ~ 0.1% ($\varepsilon = N_e I_i F V / Pp$, where N_e – plasma density, produced by the high voltage pulse, I_i – ionization potential of the CO_2 molecule, F – PRR, V – the discharge volume). This efficiency can be increased up to ~ 10% [1] thus the main operational parameters could be improved.

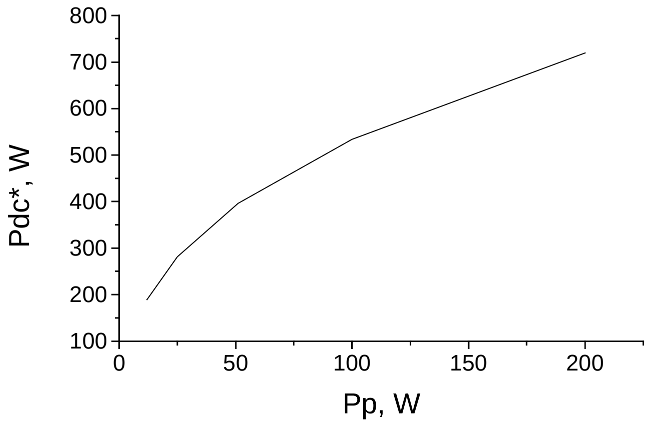

Fig.3.

The attractive feature of the nonselfsustained discharge is the possibility to control the electron energy at constant level of Pdc. The reduced electric field E/N values at different Pp and Pdc are shown in Fig.4 (BD). It is seen that E/N changes significantly with changing of preionization power. It makes an easy tool to control the electron energy compared to all kinds of selfsustained discharges. Applications of this type of discharge to CO_2 and atomic Xe lasers will be discussed.

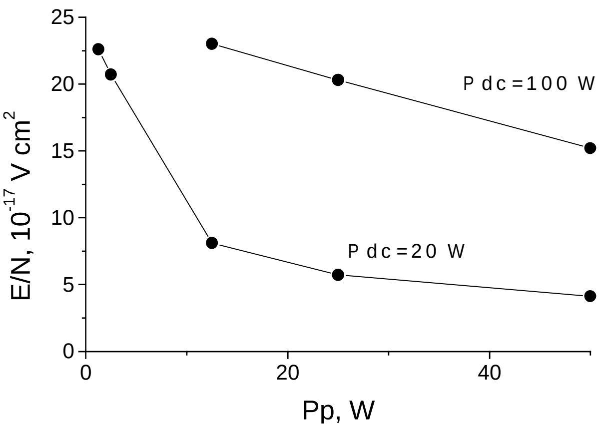

Fig.4.

The process of CO_2 decomposition was also investigated. Gas and vibrational temperatures were measured for CO_2 molecule by methods of diode-laser spectroscopy. These measurements showed that it is possible to operate at E/N varied in a wide range. Fig.5 (SD) represents the dependence of the gas temperature Tg and temperature of antisymmetric vibrational mode Tv on E/N. One can see that at 17… 25Td the slope of the curve Tv is considerably higher compared those for Tg . In particularly, at 22Td Tv exceeds Tg more than 3 times.

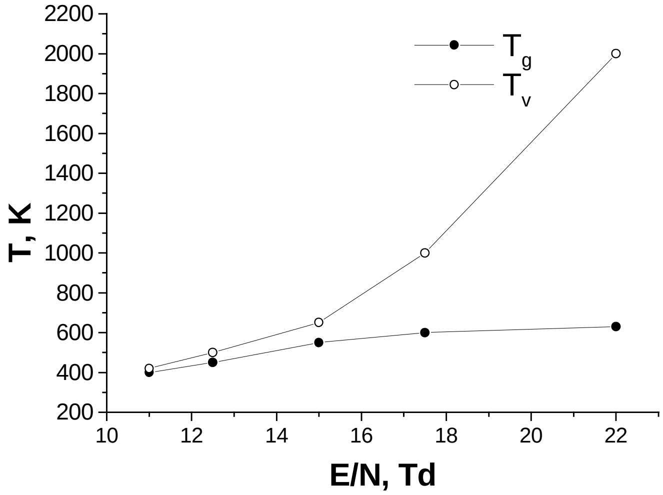

Fig.5.

Fig.6 (SD) shows the dependence of the efficiency (energy per dissociation of the one molecule) of CO_2 dissociation on E/N. These measurements were performed by mass-spectrometer. One can see that dissociation energy cost has minimum value of 9ev/diss at 22 Td. This value is more than 12 times smaller than in case of glow discharge (36Td). It was shown, that this efficiency increase was due to the change of the CO_2 decomposition mechanism compared to the glow discharge. The main dissociation mechanism in case of glow discharge (E/N ~ 36…60Td) is direct electron impact. In the range of E/N ~ 20…25Td the main mechanism is related to the excitation of antisymmetric vibration mode of CO_2 molecule (see fig.6).

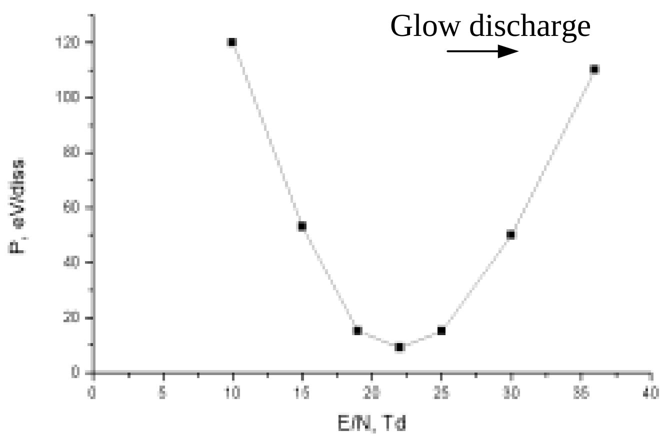

Fig.6.

From our point of view, the possibility of the operating at variable electric field intensity E/N is very prospective method for the plasma chemical reaction optimization.

References

1. Aibatov L.P., Orlov B.V., Polskii Yu.E., Chochlov Yu.M. Radiotechnika i Elektronika. v.7. 1986. pp. 1352-1357 (in Russian)