PHOTOIONIZATION OF CO₂ AND CO LASER MEDIA CONTAINING
LOW-IONIZATION-POTENTIAL NO-NO₂ ADMIXTURES

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Photoionization as a means for sustaining gas discharges has
been extensively investigated in connection with the excitation of
dense CO₂ laser media [1]. Plasma produced from spark discharges
have been used as a photon source; their UV-radiation acts on a
low-ionization-potential admixture intentionally added to the working
gas mixture. These admixtures have been organic liquid vapors with
the ionization potential Eᵢ = 7.1 to 7.5 eV. The subsequent use of
molecular gases possessing a low ionization potential, particularly
NO, for which Eᵢ = 9.25 eV [2,3] has been associated with attempts
at expanding the application field of photoionization-sustained
discharges to include low-temperature gas flow laser systems (CO₂
lasers, plasma chemical reactors, etc.).

The present report shows that the action of a high-repetition-
rate UV-radiation on NO molecules added in optimal concentrations
to CO₂ and CO-based mixtures makes it possible to sustain success-
fully a quasi stationary gas discharge with performance character-
istics no worse than those of the cw E-beam controlled discharges
[4]. In addition, it deals with the plasma chemical processes
affecting the electrical and energy characteristics of photo-
ionization-sustained gas discharges.

EXPERIMENTAL RESULTS

Figure 1 illustrates the experimental set up used. The set up
enables us to simulate conditions realized in cw gas flow systems.
The gas chamber is 10 liters in volume and contains two 3 x 11 cm
plane parallel discharge electrodes spaced 2 cm apart. The discharge
Fig. 1. Schematic diagram of UV sustained discharge apparatus.

electrodes are placed between two surface-glow UV-sources, the distance between the electrodes and the sources being 2 cm. The discharge circuit of the UV-sources is of LCR-type in series with a hydrogen thyatron. With $C_1 = 2.5 \, \text{nF}$, $U_1 = 20 \, \text{kV}$, and $L = 1 \, \mu\text{H}$, the ionization pulses are stable at frequencies up to 25 kHz. The discharge electrodes are connected across a capacitor $C_2 = 0.5 \, \mu\text{F}$, charged to $U_2 = 0 - 15 \, \text{kV}$. Discharge is initiated in $\text{N}_2$-$\text{NO}$ and $\text{N}_2$-$\text{CO}_2$ (CO)-$\text{NO}$ mixtures at a pressure of 0.5 to 1 atm. The NO gas used as an admixture has been obtained in laboratory conditions via the reaction

$$3\text{KNO}_2 + \text{KNO}_3 + \text{Cr}_2\text{O}_3 \rightleftharpoons 2\text{K}_2\text{CrO}_4 + 4\text{NO}$$

that required heating the reagents to 500°K. The partial pressure of the admixture varies in the range 0 - 5 Torr.

In the course of the experiments we have recorded the voltage drop across the capacitor $C_2$, current pulse oscillograms for the main and ionizing discharges, and the intensity of UV-radiation in the range 110 to 200 nm. Typical current pulse oscillograms are presented in Figure 2 and the current of the non-self-sustained discharge as dependent on the NO concentration in Figure 3.

The photoionization efficiency of the auxiliary discharges are compared when made to glow directly in the working mixture and on the surface of various hydrogen-containing dielectric plates, and we find the intensity of emission of photons with an energy in excess of $E_{\text{NO}}$ to be much higher in the latter case. Apparently, this is due to the excitation of the $L_{\alpha}$ line of atomic hydrogen.