Electron Drift Velocities In Gas Mixtures Of He, N2, And CO 2

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An electron swarm experimen has been used to obtain electron drift velocities in the He:CO_2:N_2 mixtures 0:1:1, 3:1:2, and 3:1:1 The E/N range of 3 to 57 Td was studied with total gas pressure varied from 50 to 200 Torr. These particular mixtures have not been previously studied experimentally. Good agreement is observed between theoretical calculations and experimental data.

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INTRODUCTION

Optimal operation of high power CO_2 lasers requires a detailed understanding of the electron transport parameters in the gas discharge. These lasers operate with gas mixtures of helium, nitrogen, and carbon dioxide, for which the electron drift velocities differ markedly from the values which are well known for the pure gases. Previously, results have been published for the drift velocities in He:CO_2:N_2 mixtures 0:1:4, 0:4:1, 12:4:1, and 8:1:1.[1,2] In this paper we present results for three additional gas mixtures: 0:1:1, 3:1:2, and 3:1:1.

EXPERIMENT

The experimental procedure used in this work has been detailed previously.[1,3] Figure 1 shows a schematic diagram of the apparatus. A Lumonics TE-261 excimer laser was used as a source of 12-ns pulses of ultraviolet radiation at 248 nm using a KrF laser gas mixture. An Applied Photonics XL-4 gas processor was used to maintain gas composition, providing constant output pulse energy over extended periods of operation. The electrodes in the sample chamber were made from 20-cm-diam stainless steel plates, whose separation is controlled by a linear motion feedthrough to an accuracy of 0.12 mm. The vacuum chamber was evacuated by means of an ion pump to a pressure of less than 10^{-7} Torr, then filled with high purity samples of He, N_2, and CO_2 to a final pressure of between 50 and 200 Torr. Ultraviolet photons striking the cathode photoeject electrons, and the resulting current arriving at the anode is integrated using a high resistance anode load R_a and a high impedance buffer amplifier. The signal is fed to an AEL 9300 transient recorder with a resolution of 10 ns per channel. The data is then processed with a Smoke Signal Broadcasting Chieftan I online microcomputer.

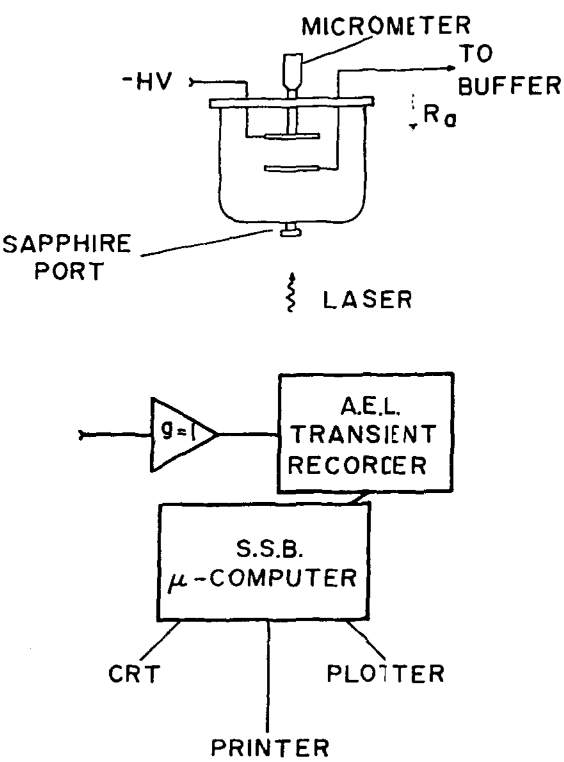

FIG. 1. Block diagram of apparatus.

RESULTS

Figures 2–4 present the electron drift velocity data, as a function of the reduced field strength E/N, for each of the

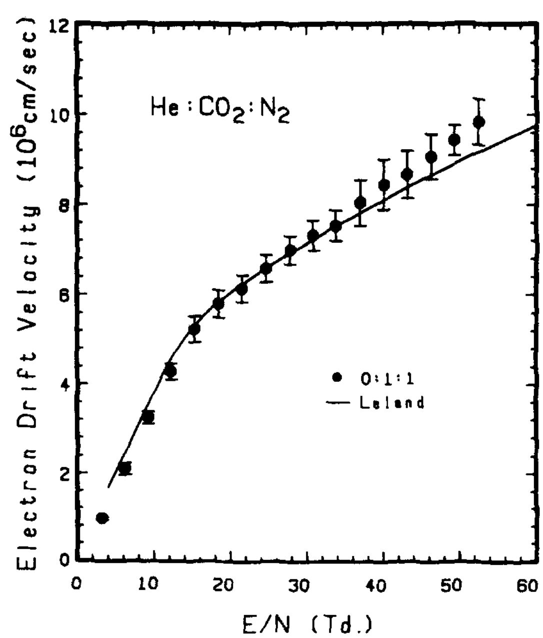

FIG. 2. Electron drift velocity in He:CO_2:N_2::0:1:1.

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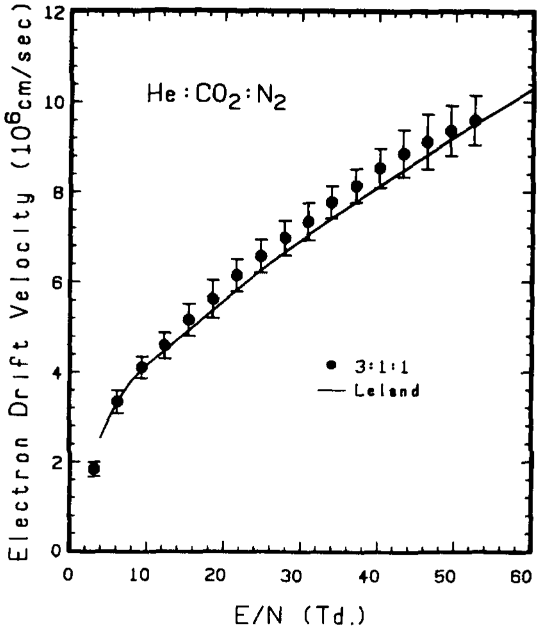

FIG. 3. Electron drift velocity in He:CO_2:N_2::3:1:1.

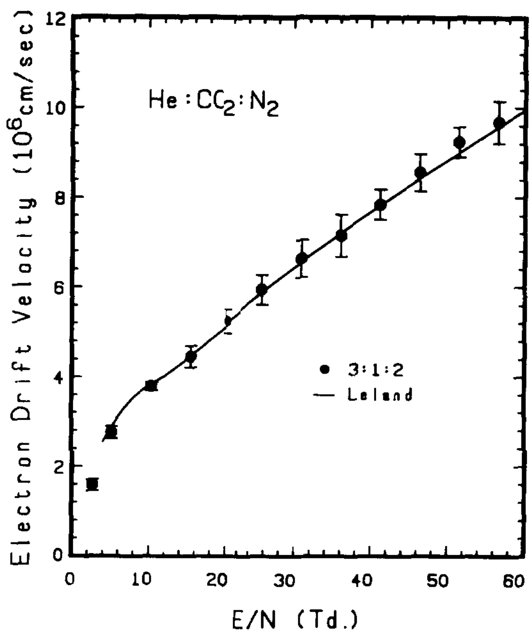

FIG. 4. Electron drift velcity in He:CO_2:N_2::3:1:2.

gas mixtures. In each case the results were averaged over three gas pressures and three electrode spacings. There was no indication of any dependence of the drift velocities on gas pressure or electrode spacing. The solid line in each figure is the theoretical curve calculated by W. T. Leland for each mixture. The error bars represent one standard deviation in the data.

Figure 2 contains the data for the 0:1:1 mixture. Below 20 Td there is an increase in the drift velocity in the mixture above that encountered in either of the pure gases. This phenomenon has been observed previously in the 0:1:4 mixture below 15 Td.[1] Above 50 Td the experimental points lie above the theoretical curve, although the difference is less than 10%.

Figures 3 and 4 present the data for the helium-rich mixtures 3:1:1 and 3:1:2. In the latter mixture the electron drift velocities are substantially the same as previously measured for the 12:4:1 and 8:1:1 mixtures. However, in the case of the 3:1:1 mixture the drift velocities are up to 10% higher.

Overall agreement between theory and the experimental results is very good. The subtle differences between these data and previous work indicates the complex nature of electron behavior in gas nixtures. It is not possible to predict the drift velocities based only on the relative concentrations of the various gases in the mixture.

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