ELECTRON-DRIFT VELOCITY DETERMINATION IN CF_4

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We report the values of the electron-drift velocity in CF_4 within the range $E/p \approx 200$ - 1000 V cm^{-1} Torr^{-1}. We have used the recorded coordinate of the turning point on the breakdown curves of the rf capacitive discharge. Our data are in good agreement with those of other authors having used different approaches. We have also obtained the results on the electron-drift-velocity values within the E/p region where no other techniques are applicable. Our findings are also supported by numerical simulation data obtained with the application of a conventional Bolsig code.

The electron-drift velocity in CF_4 is determined from the recorded breakdown curves of the rf capacitive low-pressure discharge. We have used the technique of determining V_{dr}, suggested in papers [1 - 3], and obtained the electron-drift velocity values within the range $E/p \approx 200$ - 1000 V cm^{-1} Torr^{-1}. While for other techniques the breakdown of the self-sustained glow discharge is undesirable, the technique of determining the electron-drift velocity employed in our paper is based just on studying the electric breakdown of the gas.

The RF gas discharge was ignited in CF_4 within the pressure range $p = 10^{-2}$ –10 Torr and at the rf field frequency f = 13.56 MHz. The distance between planar round stainless-steel electrodes was changed within the limits L = 8 – 29 mm. The electrodes were 100 mm in diameter. The RF voltage amplitude might vary within the range U_{rf} = 0 – 1000 V.

In order to determine the electron-drift velocity in CF_4, we have used the coordinates of the turning point on the recorded breakdown curves of the capacitive rf discharge. As is known [3], within the low-pressure range to the left of the breakdown-curve minimum of the rf discharge one observes the region of multi-valued dependence of the rf breakdown voltage U_{rf} on the gas pressure p. Fig. 1 depicts several breakdown curves for the rf discharge in CF_4. This figure also shows such a singular point as a turning point (at the pressure value $p=p_t$ and the rf voltage value $U_{rf} = U_t$). The existence of the turning point on the rf breakdown curve is associated with the following circumstance. At $p = p_t$ and $U_{rf} = U_t$ the amplitude of the electron displacement is approximately equal to one half of the inter-electrode gap thus leading to the increased losses of electrons on the electrodes.

Figure 2 shows the values of the electron-drift velocity in CF_4 obtained in this way. The same figure shows the measured and calculated V_{dr} values in CF_4, obtained in papers [4 - 9]. To our knowledge there are no measured or calculated data of other authors on the V_{dr} values within the range $E/p > 200$ V cm^{-1} Torr^{-1}. Therefore we have performed the calculations of V_{dr} with the help of the Bolsig code (Kinema Research and Software) [10]. The drift-velocity values obtained with the Bolsig code within the range $E/p = 1 - 1000$ V cm^{-1} Torr^{-1} are shown in Fig. 2. For strong fields of interest to us (to the left of the minimum of the function $V_{dr}(E/p)$) the Bolsig code predicts the V_{dr} values, which approximately 1.2 times less than our data as well as the results of other authors. For $E/p \geq 500$ V cm^{-1} Torr^{-1} the Bolsig code ceases to find the steady value of the average electron energy. Therefore within this range of E/p the Bolsig code becomes to be inapplicable for calculating the parameters of electron motion in the strong electric fields.

Thus in this report we have determined the values of the electron-drift velocity in CF_4 within the range $E/p \approx 200 - 1000$ V cm^{-1} Torr^{-1} accumulated in fig.2. In order to find the V_{dr} values, we have used the recorded coordinates of the turning point on the breakdown curves of the rf capacitive discharge. The data we have obtained with our technique are in good agreement with those of other authors having used different approaches. Besides, we have obtained the results on the electron-drift-velocity values within the E/p region where no other techniques are applicable. Our findings are also supported by numerical simulation data obtained with the application of a conventional code.

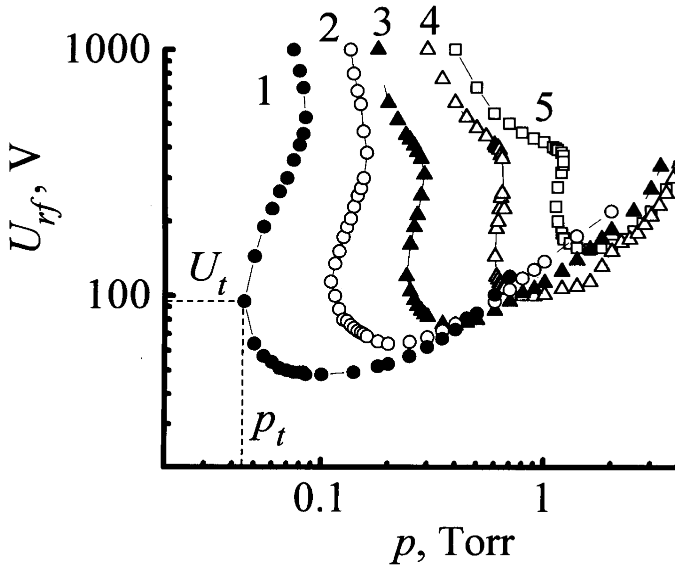

Fig. 1. Breakdown curves of rf discharge in CF_4 for different inter-electrode gaps.1 is for L=29 mm, 2 is for 20 mm, 3 is for 14 mm, 4 is for 10 mm and 5 is for 8 mm.

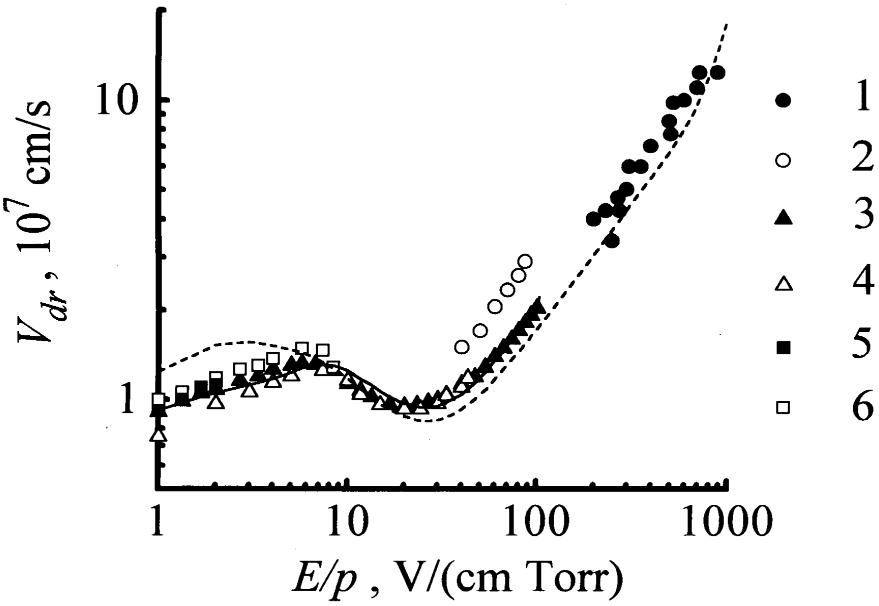

Fig. 2. Electron-drift velocity values in CF_4 against E/p obtained by different authors: 1 is for our data, 2 is for measured data given in [5], 3 is for measured data given in [6], 4 is for measured data given in [7], 5 is for measured data given in [9], 6 is for measured data given in [4], solid line is for simulation data given in [8], dashed line is for the data furnished with the Bolsig code.

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