Topic number: 2

Electron Drift Velocity Measurement in Argon with Small Admixture of N_2, H_2 or O_2

M. Stano(1), N. Pinhão(2,*) Z. Donkó(3), M. Kučera(1), D. Loffhagen(4) and Š. Matejčík(1)

(1) Comenius University, Mlynska Dolina F2, 84248 Bratislava, Slovakia
(2) Nuclear and Technological Institute, Estrada Nacional 10, 2686-953 Sacavém, Portugal
(3) Research Institute for Solid State Physics and Optics, H-1525 Budapest, P.O. Box 49, Hungary
(4) Leibniz Institute for Plasma Science and Technology, 17489 Greifswald, Germany
(*) **npinhao@itn.pt**

Introduction

Electron drift velocity measurements in argon with admixtures of up to 2% of nitrogen, hydrogen or oxygen are presented for reduced electric fields ranging from 0.5 to 2.5 Td. The results are compared with those obtained by Monte Carlo simulations and two different solution techniques of the electron Boltzmann equation: a multiterm method based on Legendre polynomial expansion of the velocity distribution and an integral representation.

Experimental setup

The experiment was performed at ambient pressure using a single shutter drift tube shown schematically in figure 1 and described in detail in [1]. The electrons are obtained from a discharge in point-to-plane geometry. The point electrode is a 100 μm diameter tungsten wire tip, and the plane electrode is a fine Ni mesh. The distance between the electrodes is 10 mm and the applied voltage is between 2 and 2.5 kV with negative polarity on the tip. The discharge is fed by an Ar-N_2 mixture with a mixing ratio of 97:3 and the discharge current is stabilized using a 6 MΩ resistor. The purity of the gases used is 99.996% for argon and 99.999% for H_2, N_2 and O_2. Gas mixtures are prepared using MKS® mass flow controllers.

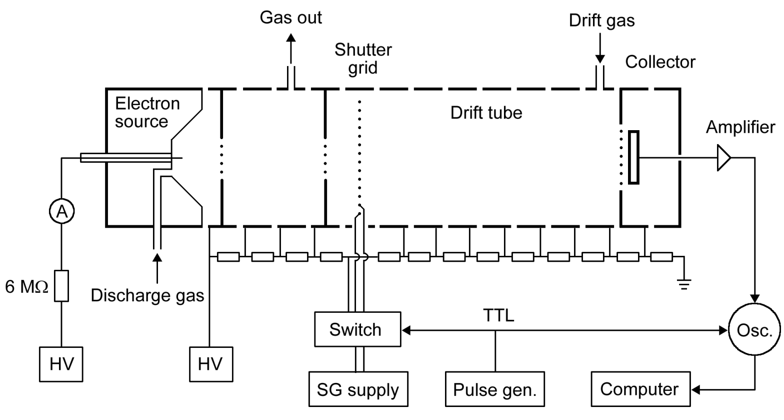

Fig. 1: Schematic view of the drift tube.

The drift tube is 111 mm long and is composed of discrete metal rings separated by Teflon. Electrons are introduced into the drift tube in 1 μs pulses controlled by a shutter grid. The electron current is measured at the end of the drift tube, amplified, averaged and recorded by an oscilloscope. The amplification varies from 10^4 to 10^7 (14 MHz to 220 kHz bandwidth) depending on the amplitude of the electron signal.

Numerical methods

The experimental results are compared with drift velocity values computed using three different approches: Monte Carlo simulation [2] and the solution of the electron Boltzmann equation by (a) a multiterm method based on Legendre polynomial expansion of the velocity distribution [3] and by (b) an integral representation [4]. The electron collision cross sections are taken from the following references: Ar [5], H_2 [2, 6], N_2 [2, 7] and O_2 [2, 7], respectively.

Results

Results for Ar with admixtures of N_2, H_2 or O_2 were obtained for values of admixture concentration between 0 and 2% and reduced electric field strength, E/n, between 0.5 and 2.5 Td. However, it was not possible to obtain results for $E/n \geq 1.5$ Td in Ar-O_2 mixtures for an oxygen concentration above 0.2% due to electron attachment to O_2. The uncertainty (one σ) of the results ranges from 2% to 5%, increasing with E/n. These uncertainties may be attributed to impurities in the argon gas and/or inaccuracies of the collision cross section data used. Figure 2 shows the comparison between experimental results obtained in Ar-N_2 and Ar-H_2 mixtures and computed values.

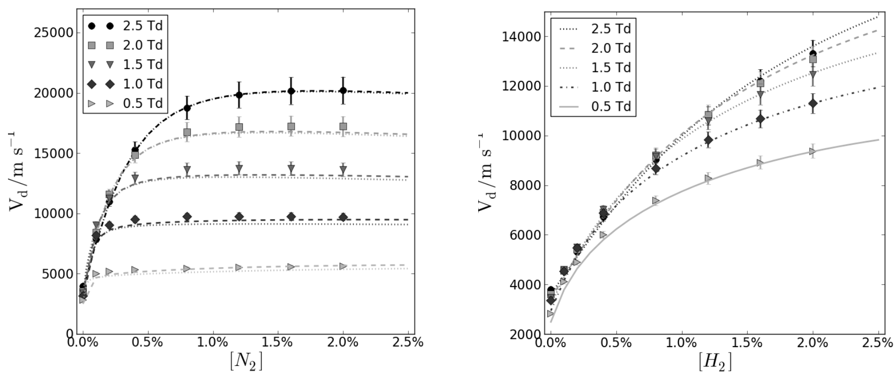

Fig. 2: Drift velocity in Ar-N_2 and Ar-H_2 mixtures. Symbols: experimental values; lines: numerical calculations. Ar-N_2: $--$ integral representation, $\cdots\cdot$ Monte Carlo and multiterm method; Ar-H_2: all numerical methods show identical results.

The experimental results were obtained with good precision with most of the results having uncertainty below 4%. Good agreement between experimental and calculated results was obtained with most of the calculated results lying within the one sigma uncertainty band of the experimental results. The three numerical methods used show almost identical results.

Acknowledgments

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