THE CATHODE EFFECTS ON THE MEAN ENERGY OF ELECTRON SWARM IN ARGON

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INTRODUCTION

The present paper studies the variation of electron energy near the cathode in argon by using a simulation technique on a digital computer (FACOM 230-60 at the Hokkaido University Computing Center). The presence of fluctuation of mean electron energy near the cathode has been suspected experimentaly [1], and demonstrated recently by a Monte-Carlo simulation for helium [2]. However, this study examined only the case in which electrons are started at the cathode with zero energy. The present paper treats the cases in which the energy of electrons starting at the cathode is a) zero, b) lower than, c) equal to and d) higher than the equilibrium one in order to investigate further the way the electron energy is randomized.

SIMULATION TECHNIQUE

The digital computer simulation technique employed in the present paper is essentially the same as that by Itoh and Musha [3], which is later modified by Thomas and Thomas [2], except for the method of energy sampling. The collision cross sections adopted were those summarized by Heylen and Lewis [4]. It was assumed that an average excitation energy of 12 eV was lost from an incident electron after excitation collision. Isotropic scattering for all collisions and the share of the rest energy after an ionization collision between two electrons obeying a uniform distribution were also assumed.

The electron energy was sampled for various distances from the cathode. The electrons moving towards the cathode as well as those moving towards the anode were sampled. Therefore, the electron energies obtained in the present study correspond to that at positions between the electrodes, whereas the energies given by Thomas and Thomas [2] were that at virtual anodes since they sampled only electrons moving towards the anode.

It was assumed that electrons colliding on the cathode by back diffusion are absorbed by the cathode.

RESULTS AND DISCUSSION

The simulation was made in argon for E/p_0 = 200 volts $cm^{-1}torr^{-1}$, with the gas pressure p_0 = 1 torr. Here E represents the electric field intensity. This relatively high value of E/p_0 was used for efficiency of the calculation. About a thousand electrons were started at the cathode and their motion was traced on computer.

Four kinds of the cathode electron energy, i.e. 0, 10, 12.2 (=equilibrim energy) and 16 eV, were used. Electrons were assumed to start from the cathode perpendiculary to it for each of the cases.

The curves in the .igure show that there is an oscillatory component in the mean energy near the cathode also in argon, even though the electrons leaving the cathode have the equilibrium energy.

These results may be interpreted in terms of the variation of electron velocity distribution with the distance from the cathode. Possible factors at the cathode which affect the distribution are :
1. The electron speed distribution (randomized by inelastic

Collisions)

2. The angular distribution (randomized mainly by elastic collisions)
3. The presence of the cathode which absorbs colliding electrons

When well randomized, the distribution 1 and 2 are such that they are not varied as the electrons drift towards the anode with inelastic collisions which change the energy of electrons suddenly. Under the condition in which the simulation was made, the speed and angular distribution had a delta-function-like feature at the cathode. The randomization begins as the electrons drift. Since the electrons have the same energy at first, they lose energy more or less at the same time, giving a big fluctuation in energy. The fluctuation, however, is gradually damped since the inelastic collision cross sections are gradually increasing functions. The angular dependency decides the rate of energy loss in the field direction. The effect of the presence of the cathode could be understood by considering the fact that for a position at which the energy is randomized the electrons that once passed the position in the cathode direction contribute to the energy distribution now moving in the anode direction. This way of contribution can not be made near the cathode. The example c) shows that the randomization in the angular distribution is important. The variation of ionization and other coefficients should be decided by considering this distribution as well.

CONCLUSION

The mean electron energy fluctuation near the cathode in argon for various cathode-starting energies has been calculated by a computer simulation. A possible account for the presence of the oscillatory component has been made in terms of the randomization of electron velocity distribution. It can be said that a method to avoid the cathode effects completely is to start electrons with the equilibrium velocity distribution and to get rid of the cathode. The well-randomized part of the curves demonstrates this.

REFERENCES

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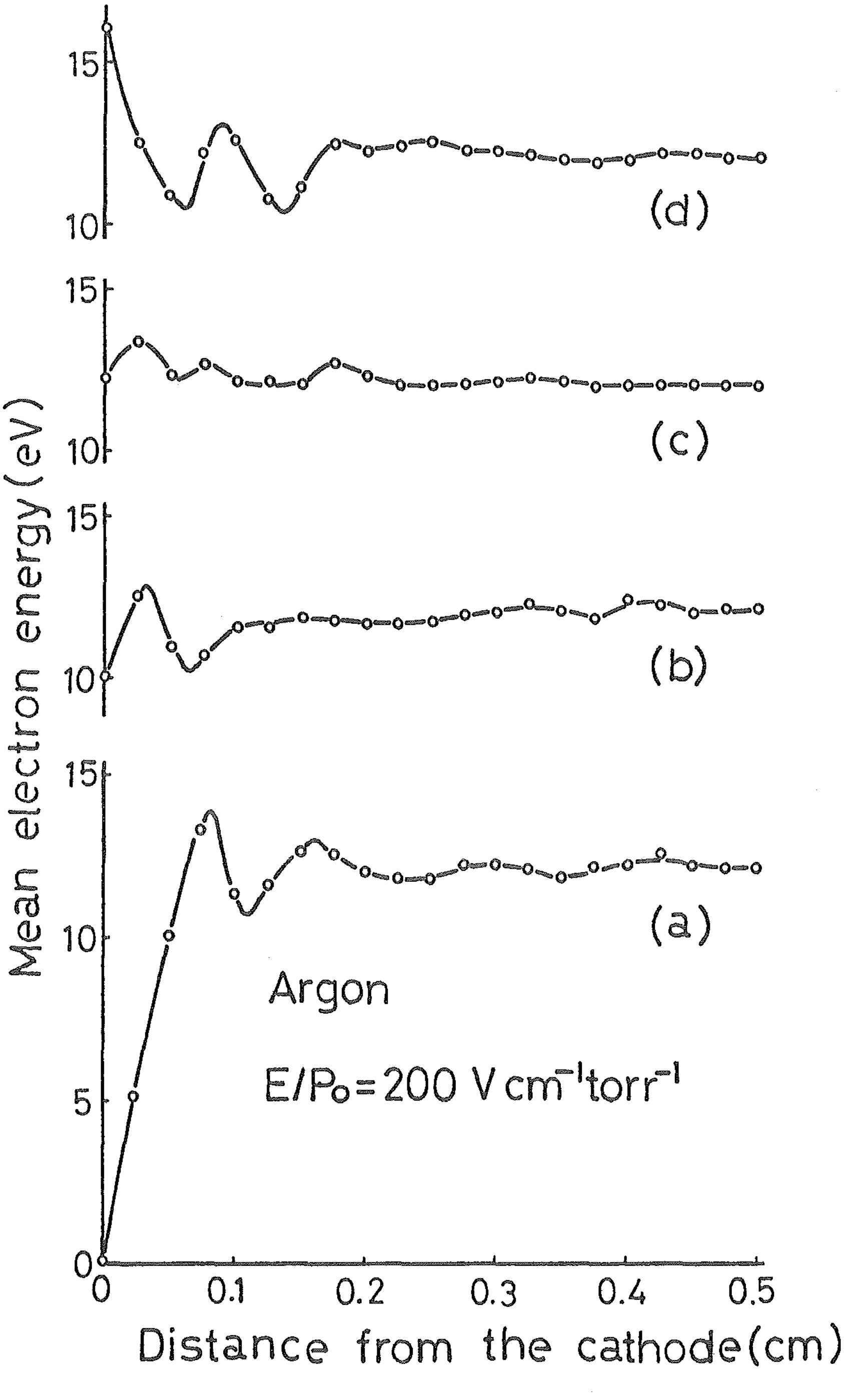

FIGURE

THE VARIATION OF MEAN ELECTRON ENERGY