Topic number: 01

Electron collision cross section set of C_2F_4 gas

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Electron collision cross section set of perfluoroethylene (C_2F_4) gas is proposed in this work. The proposed cross section set consists of an elastic collision, two kinds of vibrational excitation, ten kinds of electronic excitation, ten kinds of ionization, and seven kinds of electron attachment cross sections. Electron transport coefficients, such as electron drift velocity, effective ionization coefficient, and longitudinal diffusion coefficient, in C_2F_4 gas and C_2F_4/Ar mixtures are calculated exactly by Monte Carlo simulation using the proposed cross section set, and those calculated transport coefficients are found to agree well with measured data. This confirms the reliability of the proposed cross section set.

1. Introduction

C_2F_4 gas has attracted attention as a substitution of CF_4 and *c*-C_4F_8 [1], which are used in the plasma etching of SiO_2 film and have high global warming potential. The electron collision cross section set of C_2F_4 gas was reported by Yoshida *et al*. [2] However, the values of electron drift velocity, longitudinal diffusion coefficient, and effective ionization coefficient calculated from the cross section set do not necessarily agree with measured data [2, 3]. Three partial ionization cross sections are included in the cross section set, but electron attachment cross sections are not. Furthermore, ten kinds of partial ionization [4] and six kinds of dissociative electron attachment cross sections [5], which are not included in Yoshida's s set, have been reported, so that these partial cross sections must be considered to increase the accuracy of cross section set.

In this work, detailed and reliable cross section set of C_2F_4 gas is proposed. The proposed cross section set includes the information on partial ionization and electron attachment cross sections obtained from the experiments [4, 5]. Electron transport coefficients in C_2F_4 gas and C_2F_4/Ar mixtures are calculated exactly by our Monte Carlo simulation [6] and the reliability of the proposed cross section set is confirmed by comparing the calculated transport coefficients with the measured data [2, 3].

2. Cross sections and simulation conditions

The proposed cross section set consists of an elastic collision q_{el}, two vibrational excitation q_{vib}, ten electronic excitaion q_{ex}, ten ionization q_i, and seven electron attachment q_a cross sections. The shape of q_{el} follows the data measured by Panajotovic *et al*. [7] For q_{vib}, two cross sections q_{v1} and q_{v2}, whose threshold energies are respectively 0.12 eV and 0.23 eV, are considered, based on measured electron energy loss spectra [7]. The shape of q_{v1} follows the integral cross section reported by Panajotovic *et al*. [7], and that of q_{v2} is estimated. For q_{ex}, ten kinds of cross sections theoretically calculated by Winstead and McKoy [8] are used, but q_{ex} for $^1B_{1u}$(V) and the others are multiplied by factors of 1.7 and 0.6, respectively. For q_i, partial cross sections related to the generation of $C_2F_4^+$, $C_2F_3^+$, $C_2F_2^+$, C_2F^+, CF_3^+, CF_2^+, CF^+, C_2^+, C^+, and F^+ follow the data measured by Haaland and Jiao [4]. For electron attachment, the yield curves of F^-, CF^-, F_2^-, CF_2^-, CF_3^-, and $C_2F_3^-$ by electron collision with a C_2F_4 molecule, measured by Illenberger *et al*. [5] are used as the shapes of q_a, and those magnitudes are estimated. Furthermore, q_a for the generation of $C_2F_4^-$ is added to fit calculated effective ionization coefficient to the measured data.

For simulating the behaviour of electrons in C_2F_4/Ar mixtures, the cross section set of Ar recommended by the institute of electrical engineers of Japan [9] is used, and electron collisions with C_2F_4 or Ar molecules are only considered. Reported differential cross sections [7, 10] are used to simulate electron scattering after the elastic collision with the C_2F_4 molecule exactly, and isotropic electron scattering is assumed after the other collisions.

3. Results and discussion

The calculated values of electron drift velocity *W*, effective ionization coefficient, and longitudinal diffusion coefficient in C_2F_4 gas are found to agree with the measured data [2, 3]. Furthermore, good agreement on *W* in C_2F_4/Ar mixtures between calculated and measured data [3] is found. This confirms the reliability of the proposed set.

4. References

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