Detachment rate for negative ions in Ar/BF_3 discharges

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In this work we present rate coefficients for negative ions in Ar/BF_3 mixtures for the conditions used in plasma assisted technologies for semiconductor production. Boron produced in plasma devices continues to be the main p-type dopant in ion implantation of semiconductor devices. Yet plasma parameters of most frequently used Boron rich gas BF_3, often in mixture with Ar are not well established. The cross sections for scattering of F^- and BF_4^- ions on Ar atom and on BF_3 molecule are calculated by using Nanbu's theory separating elastic from reactive collisions. A Monte Carlo simulation technique was applied to perform calculations of transport parameters in DC electric fields.

Boron trifluoride (BF_3) alone or with addition of other gasses (O_2, Ar, N_2, CH_4, N_2) is the most commonly used gas in plasmas for implantation of the N-type dopant boron[1] as well as for detectors of neutrons and as catalyzer for several chemical reactions.. Negative ions usually observed in weakly electronegative BF_3 plasmas are F^-, F_2^-, BF_2^- and BF_4^-. While the main source for the first three ions is high energy dissociative electron attachment (~10 eV) the super halogen ion BF_4^- is a product of both, F^- and F_2^- ion collisions with BF_3 and electron attachment [1].

Most abundant negative ions observed in BF_3 plasmas are F^- and BF_4^-. Their number density is hard to predict in a pulsed BF_3 discharge afterglow due to poorly known reaction rates. Since F^- ions undergo detachment with BF_3 at minimum energy of 4.35 eV these ions and clusters formed around F^- ion [2] could be responsible for electron production in the afterglow. Influx of the electrons close to the energy of about 4.35 eV is visible in EEPF's measured only in the afterglow measurement [3]. The electron loss process in afterglow is slow and negative ions are trapped by the remaining space charge field.

Super halogen ions are very stable in respect to detachment [4] and one may expect that these heavy ions are present in the afterglow with long lifetimes defined by diffusion to the walls.

The cross sections for scattering of BF_4^- ions on Ar and BF_3, and for F^- ions on BF_3 are calculated by using Nanbu's theory [5, 6] separating elastic from detachment collisions. The cross sections for F^- on Ar [6] were used to calculate rate coefficients for detachment. The dipole polarizability of $3.31\cdot10^{-30}$ m^3 [7] and $1.64\cdot10^{-30}$ m^3 [8] is used for BF_3 and Ar target respectively. Monte Carlo simulation was applied to perform calculations of transport coefficients as well as rate coefficients in DC electric fields. In Figure 1. we show detachment rate coefficient as a function *E/N* for F^- and BF_4^- ions in Ar and BF_3.

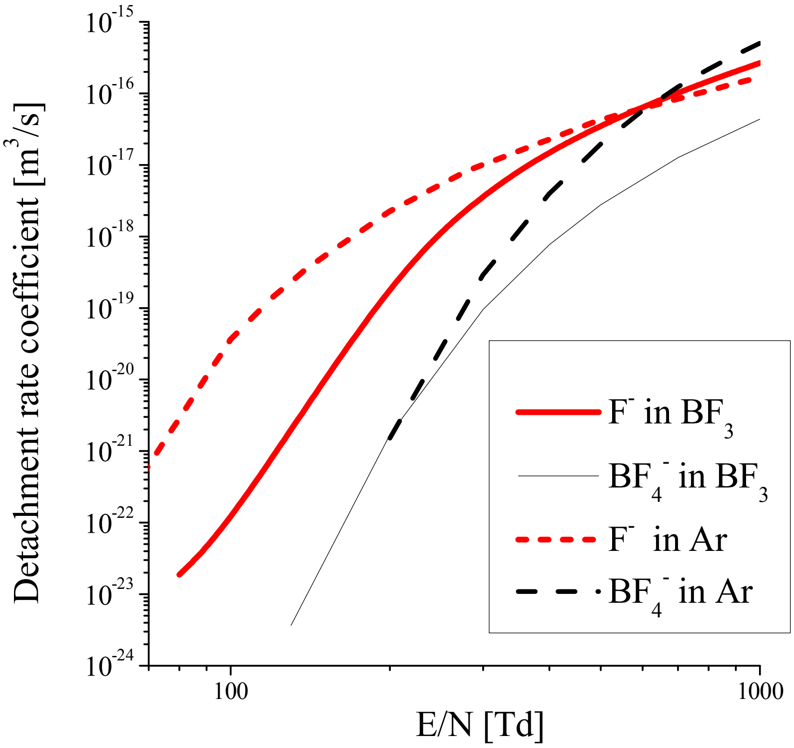

Fig. 1: Calculated detachment rate coefficients for F^- and BF_4^- ions in Ar/BF_3 mixture.

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