Theoretical Exploration of UW IEC Device Operation at Moderate Pressures*

John F. Santarius, Gilbert A. Emmert, and Eric C. Alderson

Fusion Technology Institute, University of Wisconsin
1500 Engineering Drive, Madison, WI 53706, USA
santarius@engr.wisc.edu

The integral equation theoretical approach models atomic and molecular ion and neutral transport in IEC devices [1,2]. Calculations based on the model predict that neutral D and D_2 stemming from interactions of D^+, D_2^+, and D_3^+ with background D_2 fuse with background gas and dominate the fusion reaction rate. In the theory and in experiments [3], the energy spectrum of the fast neutrals falls exponentially with energy. The results imply that, at ~1 mTorr gas pressure, the fusion rates will be significantly lower than predicted by the assumption that the bombarding ions are largely monoenergetic at energies near the cathode-anode potential difference. The positive ions and fast neutrals also produce negative ions [4] that typically account for ~10% of the fusion reactions. The negative ions have been added to UW's Volterra Integral Code for Transport in Electrostatic Reactors (VICTER). [See presentations at this workshop by Emmert and Alderson.] This has been done via a subroutine that uses the predicted positive-ion and neutral energy spectra at all radii to calculate the production of negative ions and their possible subsequent fusion reactions or attenuation by electron stripping reactions with the background gas. Because the negative ions constitute only a relatively small (~10%) fraction of the total current and their mean free paths for creating positive ions are long, we do not treat negative ions as a separate species in the integral equation formulation. This presentation will explore the effects of varying selected parameters on positive-ion, negative-ion, and fast-neutral energy distributions and fusion product production, with the objective of finding optimized parameters that maximize the total fusion reaction rate.

1. G.A. Emmert and J.F. Santarius, "Atomic and Molecular Effects on Spherically Convergent Ion Flow I: Single Atomic Species," *Physics of Plasmas* **17**, 013502 (2010).

2. G.A. Emmert and J.F. Santarius, "Atomic and Molecular Effects on Spherically Convergent Ion Flow II: Multiple Molecular Species," *Physics of Plasmas* **17**, 013503 (2010).

3. D.R. Boris, G.L. Kulcinski, J.F. Santarius, D.C. Donovan, and G.R. Piefer, "Measuring D(d,p)T Fusion Reactant Energy Spectra with Doppler Shifted Fusion Products," *Journal of Applied Physics* **107**, 123305 (2010).

4. D.R. Boris, E. Alderson, G. Becerra, D.C. Donovan, B. Egle, G.A. Emmert, L. Garrison, G.L. Kulcinski, J.F. Santarius, C. Schuff, and S.J. Zenobia, "Deuterium Anions in Inertial Electrostatic Confinement Devices," *Physical Review E* **80**, 036408 (2009).

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