DISOCIATION OF NITROGEN IN GLOW PLASMAS

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A major purpose of plasma chemistry studies is to interpret quantitatively the products formed inside or in the effluents of a plasma chemical reactor in terms of the cross sections of elementary atomic/molecular processes and energy distribution of the reacting species. Analysis is complex because often the processes themselves, and more so the cross sections thereof, are unknown; yet this is an essential first step for evolving efficient application of plasma reactors for synthetic and other useful purposes. We report here some results from an ongoing investigation on nitrogen dissociation in glow/arc plasmas.

The experimental work involves use of a flow system constructed out of pyrex, with a set of electrodes at fixed distances to generate dc glow or arc, and connected to a fast pump with linear flow rate 30 m/sec, that can be constricted for lower flow rates. Matheson UHP nitrogen is used. Flow rates are measured with rotameters, pressure with pressure transducer, N atom concentration with the chemiluminescence reactions initiated by NO (Matheson UHP), and the afterglow intensity measured with 1P28 photomultiplier with filters. Plasma diagnostics are carried out using double probes.

Experiments are conducted in pressure range 1-6 torr. The CW (IV) power dissipated in the discharge is in the range 75-325 watts. The electron density n_e varied in the range 1.9 x 10^{10}/cm^3 - 7.4 x 10^{10}/cm^3 and the electron temperature T_e varied in the range 2.7 eV-4.8 eV. The n_e T_e product increased with the power. In the isobaric n_e T_e -IV plots, the isobars shift to higher values of IV at higher pressures.

A model based on electron impact dissociation (rate coefficient k_1, total cross section from [1] for generating N atoms and three-body recombination (rate coefficient k_2 [2] and effect of surface recombination (rate coefficient k_3 [2] gives \[ [N] = \frac{k_1(T_e)[N_2]n_e}{k_2(T_e)[N_2] + k_3(T_e, T_g)} \] . The k_1 -T_e curve has exponential rise in the 1-4 eV range and is nearly linear in the 4-6 eV range (k_1 peaks at ~40 eV). With increasing pressure the range of T_e drop for a given power increase is lower at higher pressures; n_e change is less sensitive. As a result, the model predict [N] increase with power increase beyond a certain pressure. The model is compatible with the experimental results we have thus far.

Diagnostic data of nitrogen glow along with [N] variations will be presented. Comparison of optical emission with theoretical models such as [3] and direct mass spectrometric sampling of these plasmas are in progress.

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References


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