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Validation of gas-chemistry models for intense electron-beam induced gas breakdown*

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Experiments have been carried out at the Naval Research Laboratory to measure the air response to an intense electron beam created using a 4 kA, 100 kV, 50 ns pulsed-power source. The electron beam is extracted through a pair of thin foils and injected directly into an 11-cm-long, 17.8-cm-diameter, gas-filled chamber. The properties of the plasma produced by the rapidly varying electron-beam pulse are characterized with an array of diagnostics including laser interferometry to measure the line-integrated electron density and plasma spectroscopy to measure important molecular and atomic nitrogen lines. The measurements are being used to validate gas chemistry and plasma dynamics models. A weakly-ionized-gas model can be used when the electron-neutral collision frequency is small compared to the electron-electron collision frequency. This translates into a rough condition for the validity of the weakly-ionized model given by n_e/n_gas<0.01. In the opposite limit, other collision processes must be considered. An important collision for molecular nitrogen is dissociative recombination which can be a significant source of atomic nitrogen during the beam pulse. This significantly complicates the gas chemistry model. In addition to the gas chemistry model, the plasma electron dynamics can be modeled either as a fluid or fully kinetic. A fluid model can be used at high pressure when the collisional mean free path is small compared to the gradient scale length. A kinetic model is needed at low gas pressures where the mean-free-path becomes comparable to the gradient scale length. Modeling of the experiments has begun and progress toward the validation of both the gas chemistry and the plasma dynamics models will be presented.

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