DPP10-2010-000042

Abstract for an Invited Paper
for the DPP10 Meeting of
the American Physical Society

Traveling wave model for laser-guided discharges[1]

MARTIN LAMPE, NRL (now retired)

We have developed a 1-D traveling wave model for laser-guided discharges, which is easily solvable and provides insight into discharge structure, range, and propagation requirements for positive and negative discharges. The hydro, electrodynamic and chemistry equations are reduced to ODE's in retarded time $\tau \equiv$t-z/u by assuming constant propagation speed u. We show negative discharges propagate only if u> μE_b, where μ is the electron mobility and E_b is the breakdown field, and positive discharges propagate only if channel pre-conductance exceeds 6×10^{-11}m/ohm. At the discharge head, the axial electric field E spikes up to several$\times E_b$, and then quickly relaxes to a value $\sim E_b$ which persists as long as the gas is cold and unexcited. In this "streamer" stage, the current, channel conductance and potential all increase linearly with τ, nearly identically in attaching and non-attaching gases. The transition to the "leader" stage, where E is much smaller, occurs in two steps, first excitation of vibrational and low-lying electronic states, and then gas heating. The propagation range, which scales inversely with E, increases strongly if the initial discharge radius is decreased. For given maximum driving voltage, the range is a decreasing function of the voltage rise rate. Radial expansion of the heated channel is a major contributing factor to increased range. This work was done in collaboration with R. F. Fernsler, S. P. Slinker, and D. F. Gordon.

[1]Supported by ONR and ARDEC.