CHARACTERIZATION OF ELECTRON DENSITY DEPLETION IN A CATHODE SPOT DRIVEN DUSTY PLASMA FOR REENTRY VEHICLE COMMUNICATIONS APPLICATIONS

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Communications blackout, which is experienced by spacecraft re-entering the atmosphere at hypersonic velocities, is caused by the formation of a dense plasma envelope produced by shock heating. Communication signals at frequencies below the plasma cutoff frequency cannot propagate through this layer. Methods suggested for mitigating blackout have included aerodynamic shaping, magnetic windows, and the use of quenchants to reduce plasma densities. The Gemini 3 mission in 1965 successfully used water as a quenchant to cool the reentry plasma and increase communication signal strength.

A novel system for plasma quenching featuring fine particle dispersal via cathode spots is being investigated. Cathode-spot plasma plumes are utilized to disperse particulate into a background radio-frequency (RF) plasma, which is used to simulate the reentry plasma. The dust particles collect a net negative charge as they travel through the overhead plasma, reducing the electron density. Typically during cathode spot initiation, resulting plasma impedance changes can affect operation of the RF source. Such interactions make it difficult to distinguish between density reduction due to changes in source operation or due to dust-driven depletion. To understand this interaction better, multiple Langmuir probes are used to characterize the source plasma and the downstream electrode region near the site of cathode spot initiation. The sensitivity of source impedance relative to the source position, background gas pressure, and source plasma mode operation (capacitive or inductive) is characterized. Additionally, cathode spot operation in the limit of zero dust ejection is investigated to differentiate cathode spot plasma effects on impedance and depletion due to particulate ejection.

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