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NASA TECH BRIEF

Marshall Space Flight Center

Properties of Ionization Breakdown of Air at Microwave Frequencies and Optimization of Component Dimensions for Maximum Microwave Power

The analytical approach to the determination of ionization breakdown fields in gases at microwave frequencies is the solution of a differential equation developed for particular gases from Boltzmann's ionized gas equation. This approach has been successful for hydrogen, helium, neon, argon, and mixtures of these gases. Analytical treatment of air, oxygen, nitrogen, krypton, and xenon has not been successful primarily because a simple analytic formulation for the collision frequency has not been found which can be used in Boltzmann's equation. However, the accumulation of experimental data and the development of phenomenological theory for the utilization of the experimental data have provided reasonably accurate ionization breakdown predictions for the latter gases, especially air. Recently, considerable interest has developed for the use of vented rf components because of the difficulties and uncertainties that are associated with leakage from the hermetically sealed types.

Leakage from hermetically sealed types is unpredictable, and rf breakdown will occur when the pressure drops to critical value, provided that the rf fields within the component are above threshold breakdown limits. They usually are above threshold breakdown, because greater power handling capability is the primary reason for sealing the components.

Microwave breakdown occurs in gas when the rf field imparts sufficient kinetic energy to a sufficient number of electrons for ionization due to the collision of the electrons with gas molecules. The kinetic energy of the electrons must be equal to or greater than the ionization potential energy of the gas. The kinetic energy is acquired by acceleration of the electron in the rf field. A gas discharge occurs when the electron density from the ionization of the gas becomes equal to the loss of electrons by diffusion, recombination, and attachment.

Design techniques have been formulated for vented rf components, which eliminate the leakage problem at the expense of restricted rf bandwidth and rf power handling capabilities, and which permit the use of such vented components through the critical pressure region without corona breakdown. The method provides optimization of dimensions in rf components for predictable performance at critical pressures in the vented configuration. Special emphasis was given to coaxial rf multicouplers.

Note:

Requests for further information may be directed to:

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No patent action is contemplated by NASA.

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