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Review of high voltage breakdown: from multipactor to ionization discharge*

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High-voltage breakdown in the vicinity of a dielectric or conducting surface is examined across a wide range of conditions using theoretical and experimental treatments. DC and RF power sources are considered, across a wide pressure range. DC multipactor along an insulating surface can lead to local heating-driven gas desorption and ultimately to gaseous breakdown. In microwave driven systems, at low pressure, a single-surface multipactor absorbs about 2% of the microwave energy and has a mean energy of hundreds of eV. At 10-50 Torr for L-band radiation, a transition occurs from a single surface multipactor to a detached ionization discharge. Above 50 Torr, the multipactor disappears and the discharge forms a typical sheath, with mean electron energy below 10 eV. Simple scaling laws fit results in the low and high pressure regimes for several gases. Experimental results demonstrate a variable long statistical delay time, followed by a rapid breakdown. UV illumination of the dielectric surface reduces the statistical delay time, making onset of breakdown more consistent. Experiments recently demonstrated arrays of plasma filaments aligned along electric field lines, spaced ≤ ¼ wavelengths at low pressure, with filaments coalescing into more continuous diffuse plasmas at higher pressure. A 1D drift-diffusion fluid model combined with an analytic model for EM wave propagation though plasma slabs of arbitrary profile was able to demonstrate the propagation and filament spacing mechanisms, including decreasing spacing with increasing microwave power, as well as the diffuse plasma transition at higher pressure. Finally, an open breakdown reference platform and validated models are proposed to standardize breakdown and mitigation studies.

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Authors: Prof. VERBONCOEUR, J. (Michigan State University); BOOSKE, J. (University of Wisconsin); GILGENBACH, R. (University of Michigan); LAU, Y. Y. (University of Michigan); NEUBER, A. (Texas Tech University); SCHARER, J.; TEMKIN, R. (Massachussets Institute of Technology)

Presenter: Prof. VERBONCOEUR, J. (Michigan State University)

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