Study of Anode-Initiated Surface Flashover in Vacuum with Spatiotemporally Resolved Optical Emission Spectroscopy

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Improving the flashover holdoff of electrode-insulator junctions in vacuum systems is a critical step in developing future large-scale pulsed power devices. The insulator stacks in such environments are typically positive 45 degree systems. This configuration exhibits improved voltage holdoff over 90 degree systems due to the suppressed field at the cathode triple junction at the cost of an enhanced field at the anode triple junction. One finds a roughly three times higher field amplitude at the anode, and it is thus argued that the flashover mechanism for these geometries is anode-initiated. To investigate the underlying physical mechanisms of anode-initiated surface flashover, a positive 45-degree flashover fixture has been developed using a hemispherical anode.

The specific geometry localizes the flashover path for improved diagnostic accessibility while maintaining comparable fields to the traditional ring-link insulator stack structure. The source is an eight-stage, 240 kV Marx generator with rise times of a few tens of nanoseconds, resulting in anode triple junction fields in excess of 500 kV/cm for a cross-linked polystyrene (Rexolite) insulator. In addition to electrical diagnostics and imaging, spatially-resolved optical diagnostics are implemented to interrogate the developing plasma light from the UV through the visible. Light emitted from insulator regions near the anode and the cathode is focused into fiber optics by two pairs of rod lenses. The fibers are fed into nanosecond fast photomultiplier tubes for spectrally-integrated light intensity waveforms, which are compared against voltage waveforms to determine initiation fields. Results have indicated that early anode light precedes early cathode light by several nanoseconds during the early stages of the flashover. Time-resolved anode and cathode spectra are obtained with an Oriel MS-257 spectrograph and accompanying intensified CCD camera. The spatiotemporal development of desorbed gas species, electrode involvement, and bulk insulator involvement in the flashover process are examined.

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