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Ultra-High Voltage NanoDielectrCapacitor Development, and Testing for Compact Pulsed Power*

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The Center for Physical and Power Electronics has developed a nanodielectric material (MU100) to reduce the size of ultra-high voltage (UHV) pulsed power capacitors. In the discharge regime of interest the dielectric constant of the material is 200. The UHV dielectric, 3.4 cm diameter, 2 cm thick substrates with voltage ratings on the order of 260 kV, were assembled into a series stack of 4 each using a eutectic solder. Nine of these encapsulated capacitors were paralleled in a modular 130 pF capacitor assembly, and physically tested for operational capability. Results of the development and testing demonstrated two full-scale devices capable of withstanding over 1E04, 500 kV pulses with 55% voltage reversal, showing no signs of degradation; exceeding all pre-specified performance specifications. The test capacitor was part of a peaking circuit placed at the output of a 15 stage compact Marx bank to achieve the voltage amplitudes and reversals to meet the performance specifications. The capacitor was subjected to 2-second bursts of 100 Hz repetition rate pulses with 10 seconds between bursts, which was required for the thermal management of the Marx bank. The submodules demonstrated a thermal rise of less than three degrees centigrade during continuous operation.

Further testing of the capacitor sub-modules, demonstrated reliable performance under pulses of greater than 1 MV at a lifetime of 1E03 pulses. The smaller capacitance of the submodules allowed for voltage doubling across the test capacitor when connected to the 15 stage Marx bank through a charging inductor. The capacitor submodule was subjected to 2-second bursts of 100 Hz repetition rate pulses with 6 seconds between bursts. The results of the ultra-high voltage capacitor tests are discussed as well as the impact of the technology for compact pulsed power applications.
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Author: CURRY, Randy (University of Missouri)

Co-authors: MADDY, Aaron (University of Missouri, Center for Physical and Power Electronics); CAMP, J. Thomas (Naval Surface Warfare Center, Dahlgren Division); BROWN, Luke (University of Missouri, Center for Physical and Power Electronics); DICKERSON, Samuel (Univeristy of Missouri); MOUNTER, Sarah (University of Missouri, Center for Physical and Power Electronics)

Presenter: CURRY, Randy (University of Missouri)

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