Localized Plasma and EM Field Measurements of High Energy Density Pulsed-Power Systems using Visible Spectroscopy

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Experiments were conducted on the RITS-6 accelerator and the Z Machine at Sandia National Laboratories to determine localized plasma and electromagnetic field profiles within high intensity, particle beam diodes and power flow MITLs. RITS-6 is a six-stage, induction voltage adder (IVA) accelerator capable of producing electrical pulses of 70 ns with currents and voltages in the range of 7-10 MV and 150-200 kA. The Z Machine delivers 80 TW of electrical power and 26 MA of current to a load within a 100 ns pulsewidth. Within these extreme environments, visible spectroscopy is used to collect light from plasmas generated at or near electrode surfaces and within the vacuum A-K gap. Spectroscopic analysis of these data yield parameters of spatially distributed plasmas, such as densities, temperatures, species composition, and ionization extent. In addition, detailed analysis of spectral line shapes is used to determine the magnitude of the localized electric and magnetic fields. The magnetic fields (tens of Tesla) are determined from the Zeeman effect on the line shapes of species naturally present or doped in the plasma. Diamagnetic effects of plasmas and their relation to the B-field distribution, including “shielding,” are discussed along with implications on the effective time dependent A-K vacuum gap distances. Spatial distributions of the electric field in the A-K gap are measured using the Stark shift of emission lines. Since these plasmas are not uniform and contain many localized formations and propagations, spectroscopy using doped elements is the most efficient approach, employing a number of lines of sight and time-resolved detector systems. In addition to pinched-beam diodes, these spectral techniques have potential applications for use on larger area, relativistic, particle beam diodes used as radiation sources.

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