Experimental Observation of the Electrothermal Instability Under a Dielectric Inertial Tamper

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Abstract:

How do metallic conductor surfaces evolve when driven with electrical current sufficient to vaporize the metal? This question is informed by an understanding of the electrothermal instability, which will be discussed in detail in the thick-rod regime (where the metal is thicker than the current penetration depth). More specifically, the first direct observation of the stratified electrothermal instability on the surface of thick metal is reported. Aluminum rods coated with 70 μm Parylene-N were pulsed with rapidly-rising (3 × 10^{15} A m^{-1}s^{-1}) lineal current density for 100 ns. The dielectric coating inertially tamped expanding metal and suppressed plasma formation. Plasma suppression facilitates highly resolved (3 μm), gated images of visible emissions from the ohmically heated aluminum surface showing discrete azimuthally-correlated stratified structures perpendicular to the electric current. Assuming blackbody emission, radiometric calculations indicate these are stratified temperature perturbations, growing exponentially with rate γ = 0.05 ns^{-1}, in aluminum at 0.25 – 0.8 eV temperature.

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