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Photonic Doppler Velocimetry (PDV) of Bare and Dielectric-Coated Aluminum Exploded by Intense Current

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Understanding the evolution of ohmically heated conductors is a fascinating physics challenge with numerous applications. The expansion of aluminum-6061 rods pulsed with rapidly rising lineal current density (3×10^{15} A m^{-1}s^{-1} for 80 ns, from the SNL-Mykonos linear transformer driver) has been measured with photonic Doppler velocimetry (PDV). The 400-μm rod radius was much larger than the electrical skin depth. Bare rods were compared with rods coated with 5, 17, and 41 μm-thick transparent Parylene-N [poly(p-xylylene) $(C_8H_8)_n$]. The results are compared with those from magnetohydrodynamic simulations and from previous shadowgraphy and streak imaging of aluminum exploded using the UNR-Zebra generator. PDV shows the aluminum surface starts expanding when the surface magnetic field reaches 85±10 T, consistent with previous data. Interestingly, PDV observes a gradual, continuous, fairly constant acceleration, over tens of nanoseconds, in contrast to previous measurements, which were consistent with a nanosecond explosion to fairly constant vapor expansion speed. Coatings tamp the expansion, with thicker coatings slowing the expansion more than thinner ones. The expansion rate was not affected by varying the aluminum surface finish under the 41-μm-thick coatings. Later, if self-emission indicates plasma formation, the breakdown appears correlated with a rapid decrease in PDV signal.

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