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Experimental observation of power coupling insensitivity to electrode contamination in a pulsed power fusion target

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Sandia National Laboratory's Z Pulsed Power Facility compresses electrical energy in space and time to deliver a 100 ns, 20 MA current pulse to cm-scale inertial confinement fusion targets. The efficiency with which Z couples power to a fusion platform is presently limited by near-target transmission line plasmas that shunt MA-scale current from the load. As these plasmas are seeded by field-emitted electrons and thermally-desorbed surface contaminants, conventional wisdom suggests that their current-shunting capacity should be generally sensitive to changes in the contaminant inventory. However, recent relativistic electromagnetic particle-in-cell (PIC) simulations indicate that, while increased contaminant inventory does increase the peak plasma density, it can also reduce the efficiency with which charge carriers are transported across the transmission line gap. These competing effects can, in some cases, oppose each other in a manner that renders the load current delivery relatively insensitive to the contaminant inventory.

We tested this non-intuitive prediction by comparing the current delivery in a magnetized liner inertial fusion (MagLIF)-style target across two Z experiments, one in which we employed a nominal power feed and another in which we functionalized the power feed surfaces with an octylphosphonic acid to add approximately 25 layers of contaminant atoms to both the anode and cathode. The current delivered to the target differed by just 1% between the two experiments, indicating that the power coupling efficiency was indeed insensitive to the contaminant inventory. Our preliminary findings bolster confidence in predictions made by PIC models of transmission line plasmas at the MA scale.

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