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SIMULATIONS OF THE EVOLUTION OF RECYCLABLE TRANSMISSION LINE ELECTRODES FOR Z-PINCH IFE

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The motion and rate of magnetic diffusion through electrode plasmas evolving from the recyclable transmission line (RTL) determine the efficiency of the RTL that delivers the power to the load for Z-pinch Inertial Fusion Energy (Z-IFE). This work has been carried out with the hybrid electromagnetic particle-in-cell code LSP[1] and a simple but fast one-dimensional MHD code. The simulations focus on the motion of contaminant plasma of order $5x10^{18}$ cm^{-3} densities evolving from the cathode into the magnetically insulated transmission line gap. One and two dimensional LSP simulations of the contaminant plasma of total 100 monolayers show little motion (100 micron) into the gap, but the rise time of the current pulse was 10-20 ns (expect 100-200 ns for Z-IFE applications). LSP also examined the diffusion of magnetic fields into a solid density cathode with 20, 60 and 90 MA current and a 5-cm wire array radius. These two-dimensional fully electromagnetic and inertial simulations made use of the detailed conductivity model coupled with an approximate equation of state for gold. The results suggest a 1-1.6 micron/ns rate of penetration of the magnetic field for Z-IFE parameters scaling with the square root of the current rise. The heating of the material is roughly 1 eV in the highest current case at peak current but with a 10-ns current rise time. Although we expect up to ten times this heating in a 100 ns rise time pulse, the motion of the electrode material due to thermal or magnetic field stress should be very slow. The impact of strong radiation heating near the Z pinch is currently being addressed. These simulations suggest smaller thickness and, hence, lower inductance RTL designs are feasible.

[1] T. P. Hughes, S. S. Yu, and R. E. Clark, Phys. Rev. ST-AB 2, 110401 (1991); D. R. Welch, D. V. Rose, B. V. Oliver and R. E. Clark, Nucl. Instr. Meth. Phys. Res. A 464, 134 (2001).