Large-Area Electron Beam Diode and Gas Cell Design for a KrF Laser IFE System*

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In a KrF laser inertial fusion energy (IFE) power plant [1] an array of *N* laser amplifiers would focus and symmetrically illuminate a fusion target with a total of ~3 MJ of laser light. The lasers are pumped by large-area electron beam diodes, whose technology is presently being developed on the Electra [1] and Nike [2] facilities at the Naval Research Laboratory in Washington, DC. Sufficient progress has been made on these facilities that we can start evaluating the laser amplifier concepts for a fusion power plant. We are currently evaluating two such concepts where both have an the amplifier that is pumped by two opposing arrays of electron beams that are driven by solid state pulsed power systems. One concept has a 30 kJ laser output and is pumped with two large electron beams. The other is a 50 kJ design that is pumped by two arrays of four electron beams. Each beam is injected through its own foil support structure (hibachi) into a common laser cell. The former "monolithic cathode" (30 kJ case) minimizes KrF physics risks and has potentially higher efficiency; whereas the latter "segmented approach" (50 kJ case) minimizes the pulsed power costs and stresses on the foil support (hibachi).

We have carried out a preliminary design study of the electron beam transport for both these concepts using large-scale numerical simulations with the particle-in-cell code LSP [3]. The simulations include detailed geometric representations of the cathode, foils, and hibachis as well as gas transport models. This integrated modeling procedure has been successfully benchmarked against recent Electra large-area diode experiments [4,5]. The simulations provide estimates of the magnitude and spatial distribution of the electron beam energy deposited in the gas, foils, and hibachi. The estimates of energy deposition in the laser gas from the simulations will be integrated with existing system designs.

The amplifier performance has been examined with Orestes [6], a first principles KrF physics code that self-consistently couples the various physical processes such as e-beam pumping and amplified spontaneous emission. Orestes has been successfully benchmarked against Electra oscillator experiments [7] for a number of KrF gas compositions and pressures.

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