CONCEPTUAL DESIGN OF AN ANGULAR MULTIPLEXED 50 kJ KrF AMPLIFIER FOR ICF

D.D. Lowenthal, J.J. Ewing, R.E. Center
Mathematical Sciences Northwest, Inc.
2755 Northup Way, Bellevue, WA. 98004
(206) 827-0460

P. Mumola
Perkin-Elmer Corporation
Mail Stop 952, Electro-Optics Div.
100 Wooster Heights Road, Danbury, CO. 06810

T. Olson
Maxwell Laboratories, Inc.
8835 Balboa Avenue, San Diego, CA. 92123

ABSTRACT

The results of a conceptual design for an angular multiplexed 50 kJ KrF amplifier for ICF are presented. Optical designs, amplifier scaling with a KrF kinetics code and limitations imposed by pulsed power technology are described. This paper would be appropriate for a poster session.

CONCEPTUAL DESIGN OF AN ANGULAR MULTIPLEXED 50 kJ KrF AMPLIFIER FOR ICF

D.D. Lowenthal, J.J. Ewing, R.E. Center
Mathematical Sciences Northwest, Inc.
2755 Northup Way, Bellevue, WA 98004
(206) 827-0460

P. Mumola
Perkin-Elmer Corporation
Mail Stop 952, Electro-Optics Div.
100 Wooster Heights Rd., Danbury, CO 06810

Tom Olson
Maxwell Laboratories, Inc.
8835 Balboa Ave., San Diego, CA 92123

SUMMARY

A conceptual design of an angularly multiplexed 50 kJ KrF laser module, for Inertial Confinement Fusion, capable of delivering a 10 nsec pulse, is presented. Optical designs for encoding, beam packing, beam transfer, beam separation and stacking after the final amplifier are developed. A KrF kinetics code and multipass extraction code, that includes the effects of amplified spontaneous emission (ASE), were developed and used to construct scaling maps for the 50 kJ amplifier. These results were integrated with the bounds imposed by the pulsed power technology.

An axisymmetric optical design that uses identical spherical optics in each beam line was identified as optimum in terms of achieving acceptable optical quality, minimum cross talk and prepulse problems, minimum cost, and ease of alignment. Beam packing geometries including square, linear and circular arrays were studied; in terms of the amplifier volume left unextracted a linear array using cylindrical optics was found to be most efficient. However, circular arrays were chosen to avoid the high cost of cylindrical components, to facilitiate alignment and to maintain good optical quality.

The goal to maintain efficient volume extraction limits the amplifier aspect ratio to below about 2.0 where the maximum angle a beam can make with the optical axis is limited to ~ 0.5 degrees. This maximum angular deviation together with the window and mirror damage thresholds sets the length needed for beam separation at several hundred meters after leaving the 50 kJ amplifier. Imaging is used to relay beams between amplifier stages; beam separation occurs in this process and allows control of the angular separation between adjacent beams as they are amplified and expanded along the optical amplifier train.

From the KrF kinetics, scaling maps for the 50 kJ amplifier were constructed that allow trade-offs to be made between: run time, pumping rate, laser mixture, pressure, amplifier size, and g_0L limits. In deriving these maps, the amplifier extraction efficiency was determined using a steady state, multi-pass extraction code that includes the effects of ASE. The ASE flux is determined throughout the amplifier volume by solving an integral equation using an iterative technique. Both the laser and ASE flux is determined based on an axial gain distribution, the flux is then used to redefine a loaded gain distribution and the process is repeated until self-consistent gain and flux distributions are obtained. The results show the KrF amplifiers must use two pass geometries to obtain 40 percent extraction efficiency, the gain to loss ratio must be 10 or greater, the aspect ratio must be larger than unity and the power gain is constrained below ~ 20.

The run time is constrained by the pulsed power technology and acceptable values of g_0L. Both PFLs and PFNs were considered along with their associated diode, hibachi and guide field requirements. A trade-off study between e-beam energy deposition uniformity and the guide field magnitude was completed; guide field magnitudes of at least twice the e-beam self-field appear to be required. Segmented cathodes were considered as a technique for reducing the guide field magnitude. A base line design for a 50 kJ module including amplifier staging, layout and overall size is discussed.