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DEVELOPING AND MODELING FIBER AMPLIFIER ARRAYS

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Technical Note

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High Energy Lasers (HEL) are required for a number of military applications including missile defense. Electric lasers are considered the laser of choice in the long term since the energy supply is rechargeable and clean. The preferred type of electric laser is the semiconductor diode-pumped solid state laser, which integrates well with other sensors and electro-optical elements in an aerospace, land, or maritime environment. One method for scaling solid state lasers to high power is combining beams of a large number of lower power laser modules. These modules can be either oscillator (laser) modules or power amplifier modules. This effort was to analyze arrays of coherent fiber amplifiers and the beam quality associated with the fill factor, beam shape, and degree of coherence.

15. SUBJECT TERMS
HEL-High Energy Laser, Coherent Beam Combination, electric laser

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INTRODUCTION

High Energy Lasers (HEL) are required for a number of military applications including missile defense. Electric lasers are considered the laser of choice in the long term since the energy supply is rechargeable and clean. The preferred type of electric laser is the semiconductor diode-pumped solid state laser, which integrates well with other sensors and electro-optical elements in an aerospace, land, or maritime environment. One method for scaling solid state lasers to high power is combining beams of a large number of lower power laser modules. These modules can be either oscillator (laser) modules or power amplifier modules. However, increased brightness is also necessary for long range propagation and limits the methods of beam combination to spectral[1-4] or coherent beam combination techniques[5-13]. Incoherent beam combination[14] may be used for tactical applications at relatively shorter ranges.

One limiting factor of coherent beam combination is the fill factor of the array. This detrimental effect is enhanced by the near Gaussian intensity profile of the individual elements. Analysis shows that the "**optimum truncation of a Gaussian beam through a fixed diameter circular aperture occurs for wo/a ~ 0.89. This produces a maximum far-field intensity of approximately 81%**" [15] as compared to a single aperture if it were uniformly illuminated with the same total power. The total far field intensity, composed of a 2-D array of these individual Gaussian-like beams, is further degraded by the fill-factor that approaches 76% for a closed-packed array.

There are however methods of beam shaping to obtain near top-hat intensity profiles. The three basic types of beam shaping are 1) the simple aperture mask; 2) the beam integrator; and 3) the remapping beam shaper.[17]

SUMMARY

This contract was initiated in June 2004 with the University of New Mexico to fund a graduate student under the direction of Dr. Thomas Shay. The technical effort was the modeling of coherent fiber amplifier arrays to determine optimal beam combining formats. The student self-eliminated from the program prior to completion; therefore this effort was terminated.

A preliminary Fraunhofer diffraction[18] based model for a two dimensional rectangular array was accomplished. The model allowed for phase errors between elements of the array and was analyzed for both plane waves and truncated Gaussian beams optimized for power in the central spot[15]. Since these results are available elsewhere, they will not be reported here.

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