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Department of Laser and Optoelectronics Engineering

Thermal Model Analysis for Double End Diode Pumping of Solid-State Lasers with Super-Gaussian Profile

Thesis

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ABSTRACT

A simplified analytical solution of the axis-symmetry heat equation was proposed to provide an optimum temperature distribution and hoop stress within a CW Nd:YAG laser with double end-pumped cylindrical rod (1.2mm in radius and 4mm in length) utilizing a Super Gaussian pumping profile with different exponent factors (i.e. n=2, 4, 6, 10, 30).

The effects of utilizing constant and temperature-dependent thermal conductivity, in addition to various pumping ratios (r_p) and exponent factors (n) of the Super-Gaussian profile on the temperature distributions, were examined to evaluate the behavior of temperature distributions under lasing ($\eta_h = 32\%$) and non-lasing ($\eta_h = 43\%$) operating modes. For the case of constant thermal conductivity and Gaussian pumping (exponent factor n=2), the maximum temperature difference on each rod face was obtained under non-lasing operation, to be 72.93 K, 62.6 K, and 47.45 K, for r_p=1/4,1/3, and1/2, respectively. The results were considerably more notable in the case of utilizing temperature-dependent thermal conductivity. However, the temperature gradient decreased exponentially with the increase of the exponent factor (n) and if converted to lasing operation.

Analytical thermal stress expression is obtained for the Super-Gaussian pumping profile with various exponent factors (n) and various pumping ratios (r_P). The obtained results show that the generated thermal stresses within the laser medium can be significantly reduced with the increase of both (n) and (r_P), due to more uniform distributions, and hence the prospect for pumping power scaling can be improved. Furthermore, the proposed analysis was examined and the total maximum pump power of 120 W under lasing and 90 W under the non-lasing operations, were obtained respectively at an exponent factor of (n=30) with a pump ratio of 1/2.