# TRANSIENT ANALYTICAL SOLUTION OF TEMPERATURE DISTRIBUTION AND FRACTURE LIMITS IN PULSED SOLID-STATE LASER ROD

by

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*The exact analytical solution of axis-symmetry transient temperature and Tresca failure stress in pulsed mode solid-state laser rod is derived using integral transform method. The result obtained from this work is compared with previously published data and good agreement is found. The effect of increasing period is studied, and it is found that at constant pulse width as the period is increased, the allowable pumping power is increased too. Furthermore, the effect of changing pulse width with a constant period is studied, and it is found that as the pulse width is increased, the allowable pumping power is decreased. The effect of duty cycle is studied also and it is found that as duty cycle is increased the allowable pumping power is decreased. This work permits proper selection of pulse width, period and duty cycle to avoid laser rod fracture while obtaining maximum output laser power in the designing of laser system.*

Key words: *pulsed solid-state rod, heat, Tresca failure stress, integral transform method*

## Introduction

The main factor that limits the power scaling of diode-end-pumped solid-state lasers is the heat induced inside gain medium. The generated heat inside the laser gain medium causes steep temperature gradients inside the crystal which produce stress that may lead to fracture [1]. Fracture occurs when the thermally induced stress exceeds the ultimate strength of the material. The temperature gradient in the gain medium causes laser beam distortion due to thermal lensing, depolarization loss due to stress induced birefringence and ultimately fracture of the laser rod [2]. Stresses inside the laser rod are induced due to the hotter inner region of the rod that is restricted from expansion by the cooler outer region [3]. Moreover when the induced stresses in the laser rod exceed the tensile strength of the material, the rod will fracture and cause the pump and laser beams to be heavily distorted. The severe distortion losses might even cause the laser to no longer operate. Crystal fracture is one of the primary limiting factors in the power scaling of diode-end-pumped solid-state lasers which makes it an important effect that has to be considered in the design process [1].

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