The Johns Hopkins University

Whiting School of Engineering

Department of Electrical and Computer Engineering

Characterization and Modeling to Improve Efficiency of the 0.946um Nd:YAG Laser

Dissertation Defense by

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Abstract

The Nd:YAG laser has become a critical part of optical science since it was first demonstrated at Bell Labs in 1964. The 0.946 um transition in Nd:YAG is of particular interest for two reasons: the proximity of 0.946 um to the peak responsivity of silicon photodiodes and the increased transmittance through ocean waters of the frequency doubled 0.946 um emission. The author hypothesizes that a more through characterization and modelling of Nd:YAG gain media will enable more accurate laser design models leading to improved efficiency and greater average power 0.946 um Nd:YAG laser systems.

Materials under study include undoped, 1, 1.5, 2, 4, 6, and 10% atomic (at.) Nd doped polycrystalline YAG, and undoped and 1% at. Nd doped single crystal YAG. Advantages of polycrystalline vs single crystal material include higher maximum doping percentage, tailored non-uniform doping deposition, and reduced material strain.

Room temperature transmittance measurements for all samples are performed between the mid-infrared and ultraviolet edge of absorption band. Temperature dependent transmittance measurements are conducted on 1% and 6% polycrystalline Nd:YAG material. The temperature dependent stimulated emission cross section is determined for Nd:YAG at 0.946 um.

In-plane bidirectional scatterance distribution function (BSDF) measurements are collected at multiple wavelengths from 0.405 um to 1.55 um for all samples. Scatterance data is fit to standard models and a total integrated scatter (TIS) for each sample at various wavelengths is determined. A coated sphere anomalous diffraction (ADA) model is developed and applied to polycrystalline material. A Kubelka-Munk wavelength dependent diffuse scatter coefficient model is developed using our ADA model.

Fluorescence and absorption derived line width measurements for polycrystalline Nd doped YAG are reported. Polycrystalline YAG material is found to have broader intrinsic line width than single crystal material.

This work is the first known full characterization of the optical properties with this polycrystalline host. A comparison of strengths and weaknesses of single crystal and polycrystalline is presented.

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10am

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