

Characteristics of Diode-Pumping Erbium Ytterbium-Doped Glass Laser

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Abstract:

The various aspects of erbium glass laser characteristics were carefully examined, including the influences of pumping pulsewidth, dopant concentration, output wavelength, relaxation oscillation and energy transfer processing between Yb^{3+} and Er^{3+} .

Keywords: Erbium glass, relaxation oscillation, energy transfer

Kigre has been under contract with the United States Army Night Vision & Electronic Sensors Directorate (NVESD) to investigate laser diode pumped, passively Q-switched Er:Glass lasers. Under this project we have studied various aspects which influence the passive Q-switching of Er:Glass lasers. Some of the parameters studied include resonator geometry, configuration, and losses, in addition to gain media geometry, and dopant concentration.[1] In comparison with the traditional flashlamp pumping technology, laser diode pumping is inherently more efficient.

Diode pumping induces lower thermal loading which in turn results in a more stable output. Evidence of this is observed in the stable spike free output produced during our study of diode pumped Er:Glass lasers. This phenomenon is not readily observed under flashlamp pumping. Diode pumped Er:Glass laser studies have revealed many new possibilities for the development and production of high peak and average power eye-safe laser transmitters.

The experimental pumping geometry utilized a total of 48 laser diode bars. The pumping array consisted of 11mm, 60watt quasi-CW bars arranged in three 16 bar radial segments. A 3mm diameter, 35mm long Er:Glass rod was centered in the 6mm diameter array. The maximum tested pumping pulsewidth duration of the array was 4ms, yielding a maximum pump energy of 11.5J.

the possibility to lase at longer wavelengths, say 1556-1564nm, in which area there is little or no absorption. The lasing wavelength shifts to shorter wavelengths gradually as the inversion level is increased to the peak gain region 1535nm. In our measurements 1556nm corresponds to a 90% output coupler. When the output coupler reflectivity is lower than 80% or when the laser is operating in a Q-Switched mode the output wavelength is confined to 1535nm.

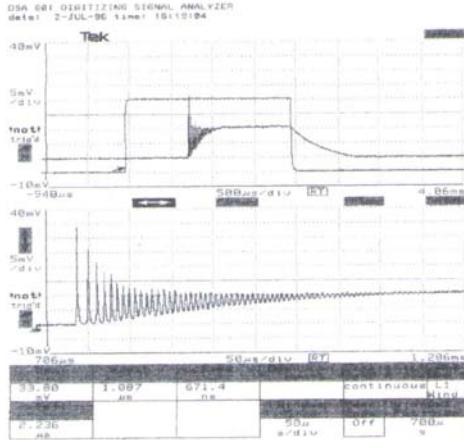


Fig.4 Relaxation oscillation

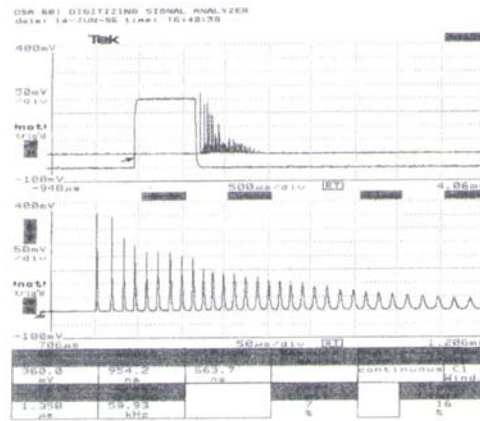


Fig.5 Relaxation oscillation

The laser's relaxation oscillation behavior were observed under various conditions. The diode pump output is much more stable and less noisy than lamp pumping. Perfect relaxation oscillations were observed in the TEM₀₀ output as shown in fig.4,5. The pulse begins with a perfectly damped relaxation oscillation then is then followed by a noise free steady state laser pulse output. It was found to be easier to obtain perfect relaxation oscillations and a steady state output by using lower doping concentration rods. The narrow pulse train observed near threshold was attributed to saturable absorption of Er³⁺ ions. The first pulse is narrowest and then the pulses gradually get wider. The pulses widths were found to be in the range of 500-1500ns. The stable, low noise diode pumping allow more than 1ms relaxation oscillation free laser output with total output energies of up to 400mj.

In Fig 5, the laser output is shown to begin to drop immediately after the pumping pulse has ended. This shows that at least a portion of pumping energy is transfer to Erbium ions faster than the average energy transfer time between Yb³⁺ and Er³⁺. According the oscilloscope trace the transfer time for some of the energy is less than 0.1ms.

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- [3] Shibin Jiang, J.D.Myers, D. Rhonehouse, G. Bishop, M.J. Myers, S.J. Hamlin, "Further Investigation of 1.5um Er³⁺ Doped Novel Phosphate Glasses and Lasers", CLEO, 1995.