Performance of free-running end -pumped Nd:YAG laser system

*Jassim Mohammed Jassim, **Yaseen Hasan Kadhim, ** Fadhel Hasan Ali
*Babylon University - College of Science for Woman, P.O.BOX4.Iraq
**Babylon University - College of Science, P.O.BOX4.Iraq

Abstract:
Experiments on a end-pumped Nd:YAG rod laser will be presented, the high performance of this laser in terms of output power, laser slope efficiency, single longitudinal and transverse mode operation and stability. This high performance of these laser devices attractive for a variety of applications.
Keywords : Beam quality , free- running , diode pump

1- Introduction :

In the last decade, diode pumping has become a mainstream technique for solid-state laser optical excitation , due to a combination of favorable parameters, including high efficiency, reliability, output stability, compactness, long operational lifetime, easy maintenance, low-voltage power supply, etc. [1]. There already exists a large variety of diode-pumped systems developed, differing in pumping geometry (transversely-pumped vs. collinearly-pumped), pump pulse duration (cw-pumped vs. quasi-cw pumped), outputpulsewidth (continuous wave, Q-switched, mode locked) [2]. beam mode structure (single-mode vs. multimode), method of pulse modulation (passive vs. active-switching or mode locking), and geometry of the laser-active crystal (rod vs. slab). Despite their obvious advantages, the higher cost of diode-pumped lasers better justifies their use in critical applications, where conventional flash lamp-pumped systems may be less suitable [3].

2- Experimental setup:

A schematic diagram of the laser setup is shown in Fig. 1. The pump laser diode (808nm, 500mw) was delivered into the Nd: YAG crystal (ϕ 4mm*15 mm,) with a pump spot radius of 0.256 mm. one surfaces end of the laser crystal were a high-reflection coating for the 1064nm wavelength to function as a mirror (M2) for the resonator and an antireflection (AR) coating for the 808nm wavelength to allow the pump beam to enter the rod. The other end has an anti-reflection coated at 808 and 1064 nm. The laser cavity consisted of input Mirror (M_2) with a curvature radius infinity and Concave output mirror (M_1) with Radius of curvature of coupler mirror is 800mm and different transmission (1, 2, 5 and 10% at 1064nm). The Nd- YAG output beam was filtered by a narrow band pass interference filter to reject the (LD) wavelength (808nm) and allow the (1.064 nm) only. In the experiments, the output power was measured and analyze by apower meter (power meter mobiken), CCD camera (BEAMAGE-CCD12) and storage Oscilloscope (ADS1202CML 250 MHz).

3- Results and Dissociations

3-1 CW operation

At first, we examined the CW laser operating characteristics of Nd:YAG using a simple plano-concave cavity with a length of 60 mm. In order to find the effective operation, three flat mirrors with various transmittances (1, 5, and 10% at 1064 nm) were used as the output coupler (OC).Figure 2 shows the variation of output power with absorbed pump power for these lasers. The maximum output power of 36 mW was obtained at an absorbed pump power of 290 mW with the 1% OC, giving a slope efficiency of 14.9%, with the 5% OC, giving a slope efficiency of 14.9%, with the 10% OC, giving a slope efficiency of 15% the slope efficiencies decrease with increasing output coupling.This might be caused by effects of inhomogeneous spectral broadening [4]. and/or increased up conversion losses at higher inversion densities.

3-2 Free- running (long pulse) mode

In free-running (long-pulse mode) operation, Nd : YAG laser output energy measurements were performed at an L = 60 mm resonator length (Fig. 3),which represents the shortest possible cavity with mirrors and rod alone, and is characterized by the lowest diffractive losses [5]. The Fig. 3 plots show that free-running operation yields output pulse energy up to 6.5 mJ for incident optical pump energy of 22.5 mJ, while optical slope efficiency up to = 15% can be obtained.

3-3 Output Laser Beam Shape

When enough energy was used to excite the Nd:YAG crystal the laser beam started to trace. In this experimental the input energy was verified by increasing the input current of the optical pumping source(Laser diode). The invisible of infrared produce from Nd:YAG laser was recoded and analyze by using CCD camera. Figure 4 (a, c and d) illustrates the shape of the output laser beam at different input energies, observably the beam diameter is change from 1174.1μm to 1841.6 μm and the transfer electromagnetic mode it also is changed. This might be caused by effects of focal length of the thermal lens [6] .

3-4 Multi- mode operation

Operation of the Nd:YAG laser in many longitudinal modes commonoly occurs due to the wide value of the Nd gain band width [7]. ,shows in fig.5.

In the source Nd: YAG laser absolute spectral mode shifts come about due to slight variation in the length of the laser cavity [8]. and the width of the individual modes depends on the reflectivity of output mirror, Fig 6. (a and b) Shows the width deceasing with increases the reflectivity of mirror.

Conclusion :

1- A free-running a diode pumped Nd:YAG laser will produce an output pulse of approximately 10 μs duration and energy mJ.

2-In a free-running laser, during the pump emission, the gain of the laser will increase and quickly overcome the losses depend on reflectivity of mirror.

3-These results show that it is possible to scale rod lasers to producer output power in a fundamental transversal mode with minimum beam diameter

References:

1- D. Khaled Abdel Hamid al-Khatib, D. Walid Khalf Hamoudi, 1989, "Photic quantum laser", 190.
2- Dr. Susumu Kinoshita, Dr. Kenichi Iga,1996,Process Technology for Semiconductor Lasers, Vol.30,pp1-7.
3- K. Shimada, 1986, Introduction to Laser Physics, 2nd edn., Springer Ser. Opt. Sci., Vol.44 Springer, Berlin Heidelberg.
4- Findlay, D. and Clay, R.A., 1966, The measurement of internal losses in 4-level lasers, *Phys. Lett.*, Vol.20, p 277-278.
5- Favre, S.; 2Sidler, T.; 2Salathe, R. P., 2003, Second harmonic generation with free running Nd : YAG laser, vol. 5147p. 41-47.
6- Koechner, W., 1996, *Solid State Laser Engineering* 4th ed. Berlin, Springe.
7- Zayhowski and A. Mooradian, 1989, Single-frequency microchip Nd lasers, Optics Letters, Vol.14, pp. 24-26.
8- Thomas J. Kane and Robert L. Byer, 1985, Monolithic, unidirectional single-mode Nd:YAG ring laser, Optics Letters, Vol. 10, Issue 2, pp. 65-67.

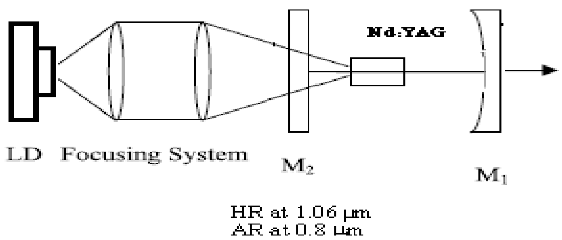


Fig . 1. Schematic diagram of the laser set-up

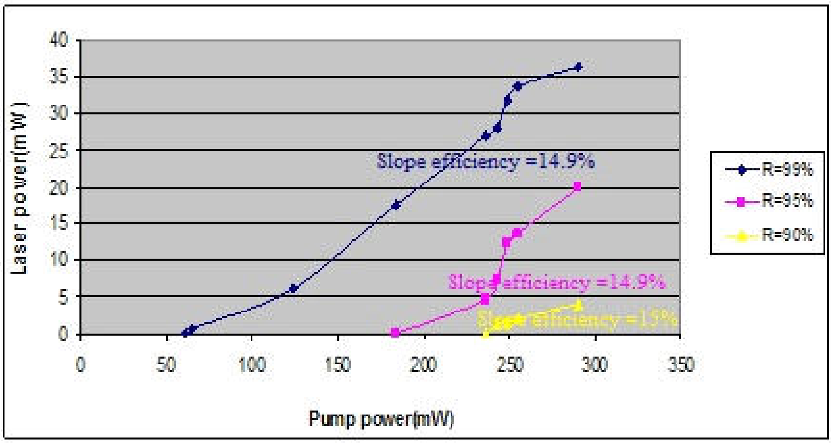
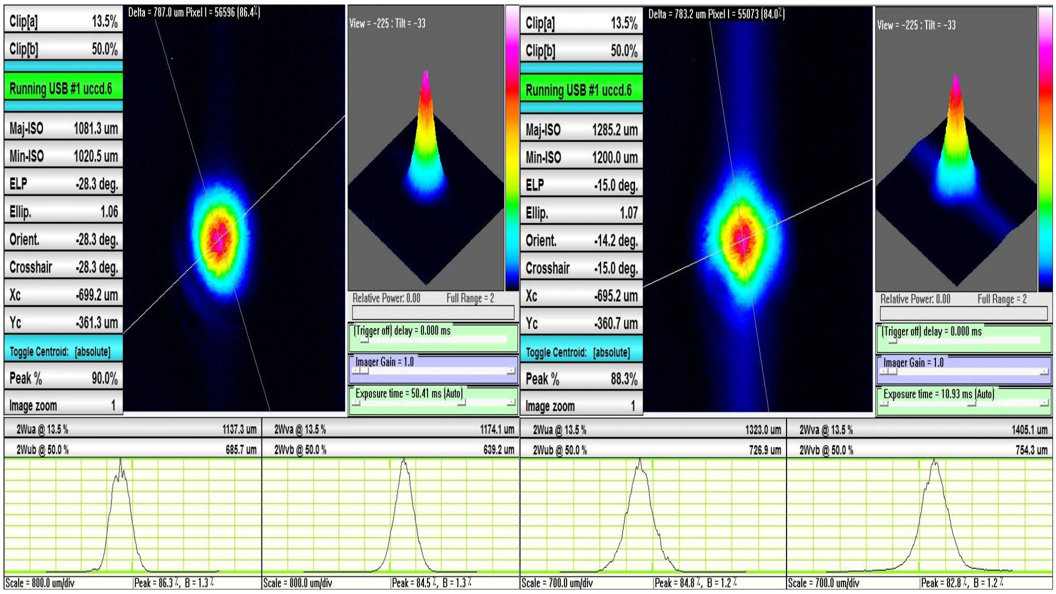
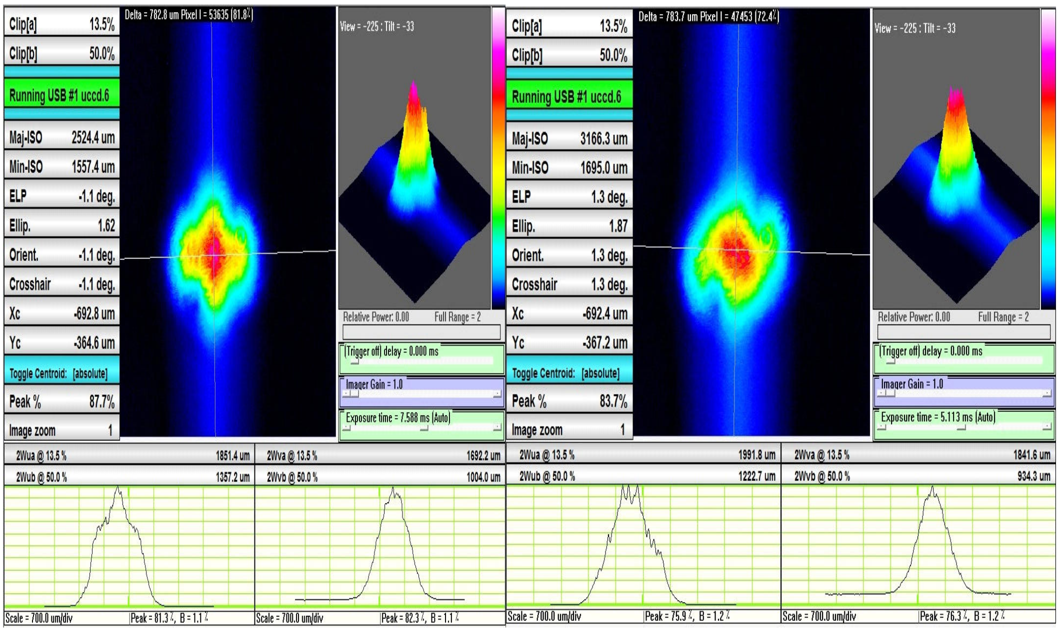


Fig. 2. Variation of output power with absorbed pump power for 808nm wavelength CW operation



a b

Fig. 3. Laser output pulse energy in free-running (long -pulse) operation vs. optical input pump energy, for severaloutput coupler (O.C.) mirror reflectivities.



c d

Fig . 4. The laser beam profile for various input energies a –275 b- 375 c -475 d -575 mA with and mirror reflectivity (99 %) and the length of the resonator (60mm)

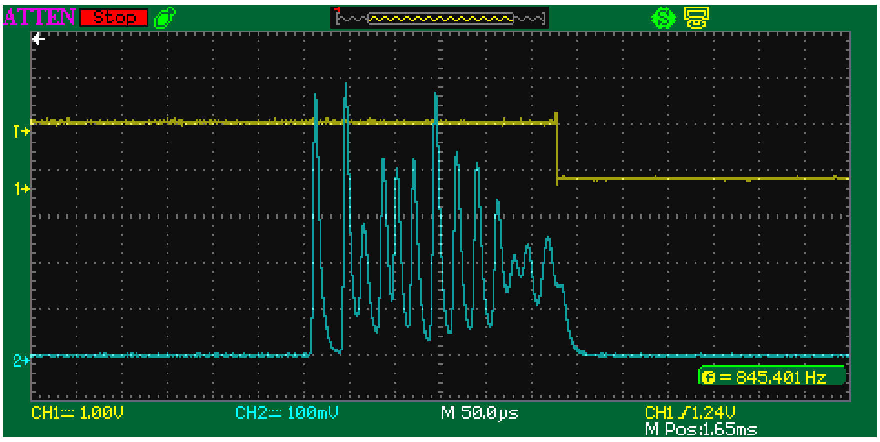
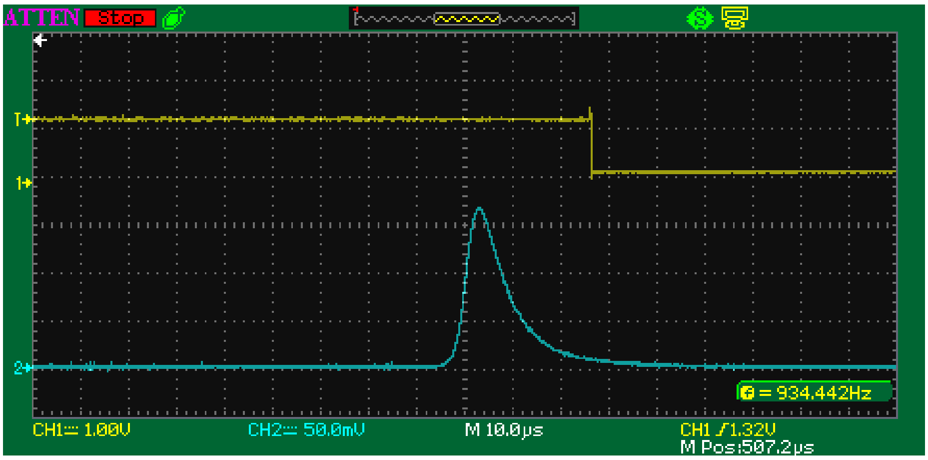
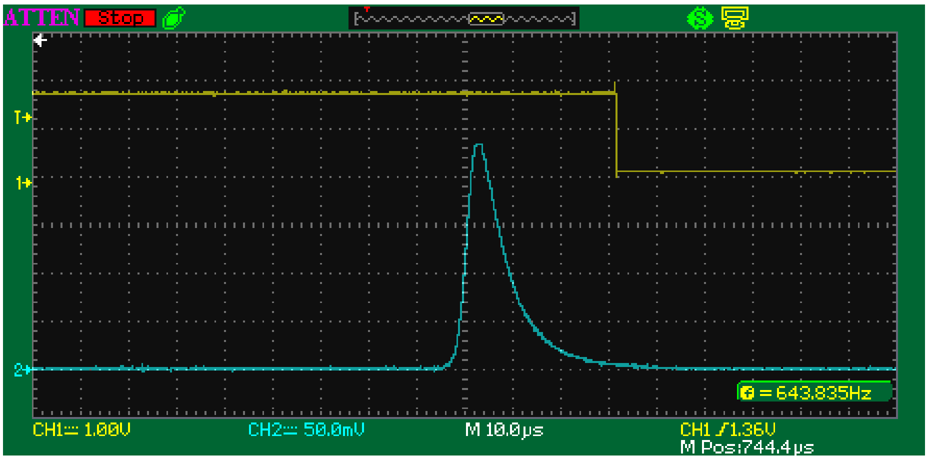


Fig. 5. Oscillation on thirteen consecutive longitudinal modes



a



b

Fig.6. The width of the individual modes for various input mirror reflectivity a –99 b- 90%. the length of the resonator (60mm).

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar