1.2J High Energy Diode Pumped 1535 nm Er3+,Yb3+:Glass Laser

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Abstract:

A diode pumped Er3+, YB3+ glass laser was demonstrated which is capable of output energies of 1.2J in long pulse mode. In the same apparatus, a 5 mj 33 ns pulse was obtained using a tetraval ent actinide, saturable absorbing, passive Q-switch.

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Laser emission at 1535 nm from Er3+ :glass is interesting due to its eyesafe wavelength and high atmospheric transmission. Diode laser pumping of the Er: Glass laser rod dramatically reduces thermal effects when compared to flashlamp pumping, allowing operation at higher repetition rates with higher average output power, This technology opens new opportunities for use in many applications such as ranging, target designation, laser radar, environmental sensing, collision avoidance, law enforcement and wind shear detection.

We have demonstrated, what we believe to be the highest energy laser diode pumped Er3+:glass laser reported to date. As the absorption cross section of erbium is relative week, the laser glass material was sensitized with a high concentration of Yb3+ ions which exhibits a wide absorption band (Yb3+ 2F7/2 - 2F5/2). This absorption band matches the commercially available InGaAs laser diode arrays with output in the range of 900-1000 nm [1]. A cylindrical laser diode array was fabricated consisting of 48 1.1cm long diode bars. The array was divided into 3 sections in which 16 diode bars were evenly spaced in a cylindrical shape about the 3 mm diameter Er:Glass rod. Each segment was spaced 1 mm from the next; so, the total length of three sections was 3 5 mm which matched the length of rod. The central pumping wavelength of the diode array was 929 nm with a 4 nm FWHM line width. The corresponding absorption coefficient of the erbium glass rod is about 5 cm- 1.

The slope efficiency measured about 9.5%. Considering the electrical - optical efficiency of the laser diode arrays is about 33% and the quantum efficiency is 60.4%, the optical - optical quantum slope efficiency is about 45%, which represents the highest efficiency recorded to date with a Er:Glass laser in our laboratory. The maximum output energy of 1.2 Joules corresponded to a pump energy of 17.5 Joules.

The purpose of our experimentation is to produce a Q-switched laser to be used as a rangefinder transmitter. In a preliminary q-switching experiment, a tetravalent actinide passive Q-switch sample with a 760μm path length was inserted into the laser resonator. A 1.5mJ TEM00 pulse with a 33 ns pulse width was observed. In a different configuration, a 5 mJ TEM00 pulsewidth a 55 ns pulse width was also demonstrated. These Q-switch results were obtained with the same saturable absorber sample used in previous studies[2].

References

1. B. Labranche et. al., "Side pumped Eyesafe Laser", OSA Proceedings on Advanced Solid-State Lasers, 1994, Vol. 20, pp. 151.

Yasi Jiang et. al., "Bleaching and Q-Switching of divalent Uranium Doped Glass and crystal at 15 3 5 nm", Technical Digest, Advanced Solid-State Lasers, 1995, Memphis, paper MC8-1.

1.2 Joules High Energy Diode Pumped 1535nm Er^{3+},Yb^{3+}:Glass Laser

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OUTLINE

- **Side Pumping Er-Glass Laser Modeling**
- **Experimental Setup**
- **Experimental Results**
- **Result of Passive Q-Switch**

Configuration of Diode Side-Pumping

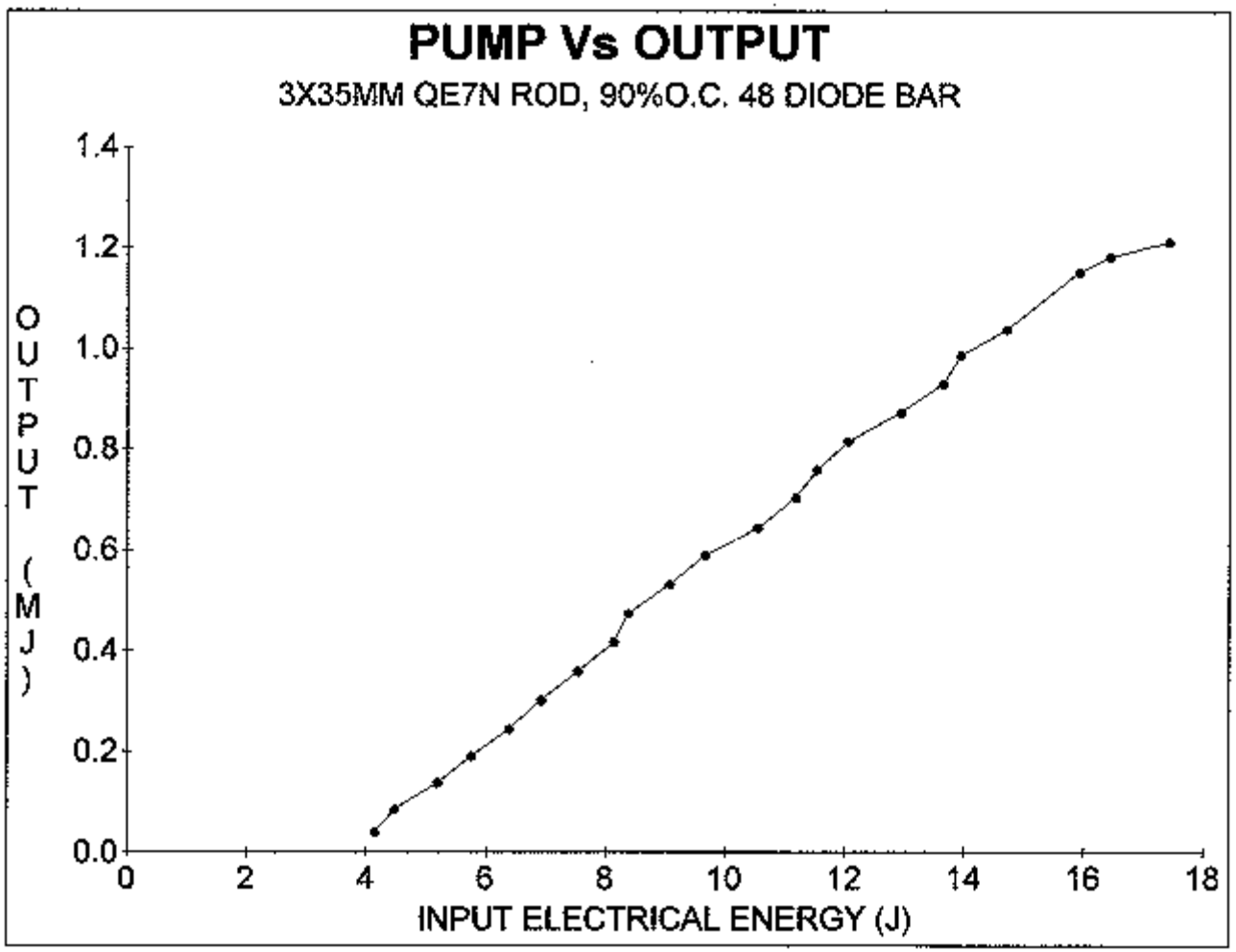
D **:Diameter of Pumping Circuit**

d **:Diameter of Active Laser Material**

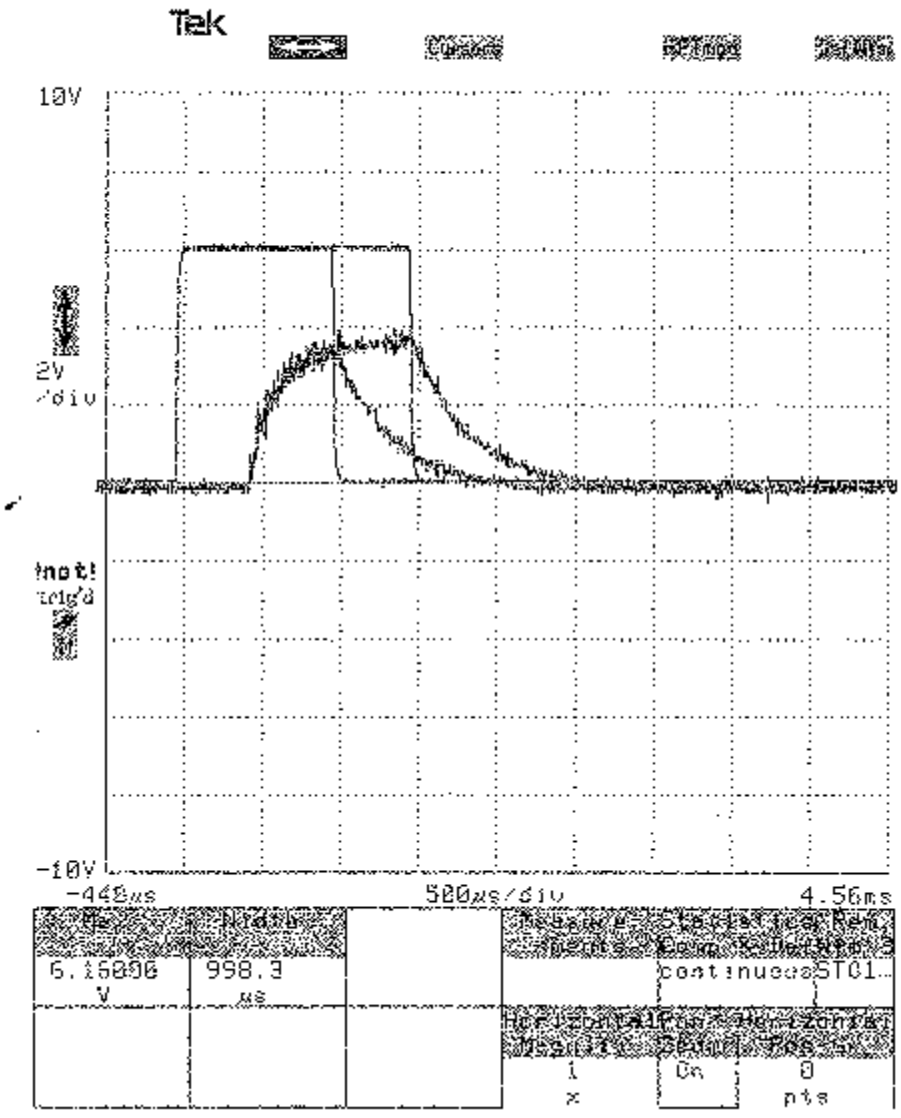
N **: Number of Diode**

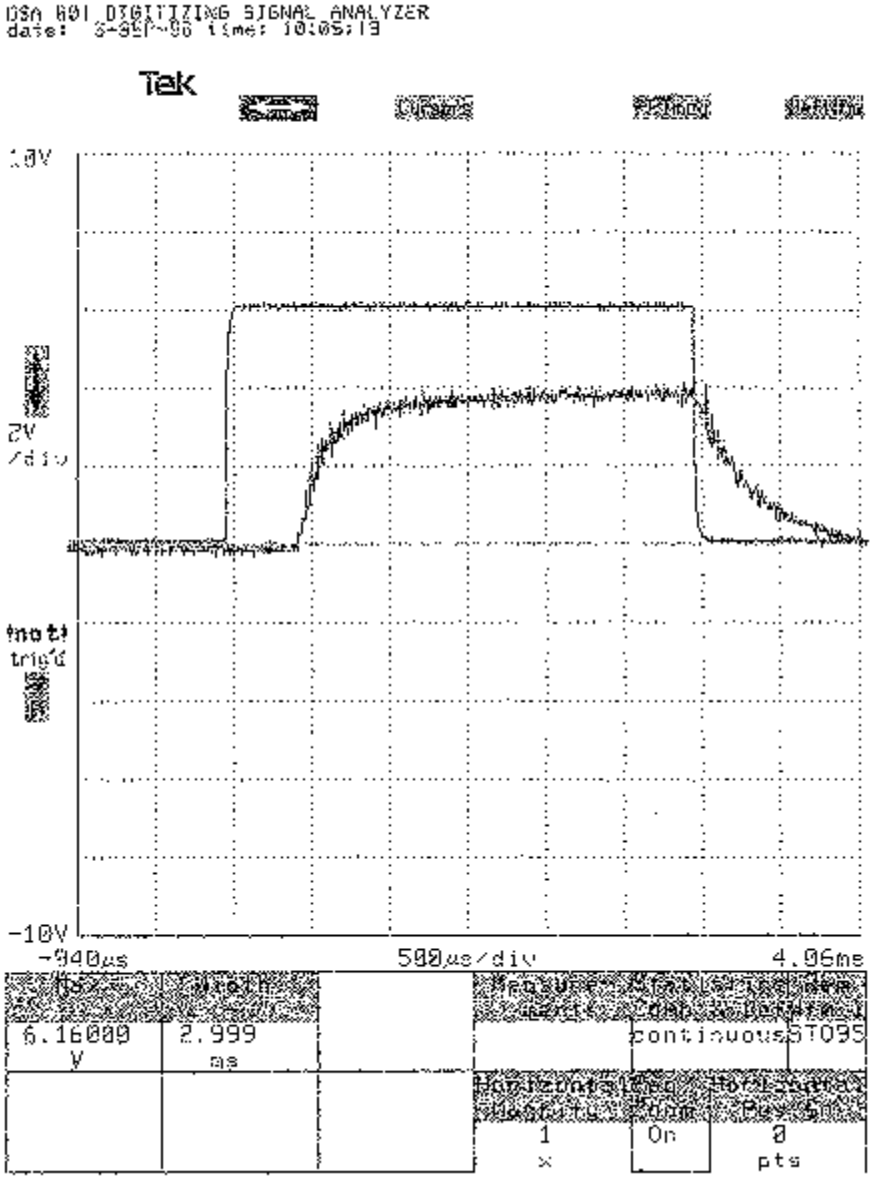
Lambda **: Wavelength of Diode**

Alpha **: Absorption Coefficient of Laser Medium**


PUMP Vs OUTPUT
3X35MM QE7N ROD, 90%O.C. 48 DIODE BAR
OUTPUT (MJ)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
18
INPUT ELECTRICAL ENERGY (J)

DSA 601 DIGITIZING SIGNAL ANALYZER
date: 3-SEP-05 time: 10:18:54




DSA 601 DIGITIZING SIGNAL ANALYZER
Tek
10V
2V
/div
-10V
-940µs
500µs/div
4.06ms
6.16000
V
2.999
ms
continuous
On
1
x
0
pts

Calculation of Storage Energy

- **Rod Size** **:3X35mm**
- **Er doping** **:0.13%wt** **$1.2X10^{+19}$ ions/cm^3**
- **Yb doping** **:16%wt** **$1.54X10^{+21}$ ions/cm^3**
- **Bleaching Energy of Er** **:0.414 j**
- **Bleaching Energy of Yb** **:83.7 j**
- **Number of Cycles** **: 6**
- **Output Wavelength** **:1556nm**

The Study of Passive Q-Switching

- **Sample: Tetravalent Actinide: CaF2**
- **The Influence of AR Coating**
- **Mode Structure of Laser Resonator**
- **Laser Resonator Configurations**
- **Mode Size**
- **Ratio of Beam Size(TEM_{00} Mode) in Rod to Absorber**
- **Rod Size, Length.**
- **Doping Level of rod**

The Results of Passive O-Switching

Sample Source : Spectragen.

Doping Level : T = 87%/mm

Thickness of Sample : 2.12mm

Pumping Current : 50A

Pumping Width : 2.Oms

Pumping Energy : 3.3 J

Output Energy : 3-5mj

Pulse Width :25nsec

Conclusion

- **1.2J output was demonstrated at eye safe wavelength with slope efficiency of 9.5%. The optical-optical quantum slope efficiency is about 45%.**

- **During the 3ms period The Er 3 + ions recycling at least 6 times. It means the energy transfer from Yb 3 + ions to Er 3 + ions and final lasing take less than several hundred microseconds**

- **Further exploration of passive Q-Switching by tetravalent actinide leads to 3-5mj output energy with 25nsec pulse width which were the specifications of a normal rangefinder.**