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DIODE-PUMPED 1.53μm Er,Yb:GLASS LASERS FOR EYE-SAFE LIDAR APPLICATIONS

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1. Introduction

The recent development of near-infrared tunable solid-state lasers opens new applications such as high resolution spectroscopy, pollution monitoring, eye safe lidars and fiber optic communications[1]. Eye safe condition must be considered for most open-space practical applications of the lasers and the lidars. It is readily known that the near infrared wavelength of 1530-1550 nm gives maximum permissible exposure (MPE) to the eye of 10^4 J/m^2 for 10^{-9} - 10^{-6} s pulses, which is 2×10^5 higher than the 1.06 μm Nd:YAG laser and visible wavelength beams and is extremely eye safe[2]. The Er:glass laser oscillates at 1535 nm[3] and also Er doped fiber amplifiers and lasers have been developed in the optical fiber communication. High power oscillation of the Er:glass laser is not yet fully investigated.

The purpose of this paper is to develop the diode (LD) pumped high-efficiency cw and pulsed Er,Yb:glass lasers for eye safe lidar applications. High power and high efficiency oscillation is limited in this material by the relatively low thermal coductivity, the three-level Er system, energy transfer up-conversion and excited state absorption of the Er^{3+} ions.

2. Diode-pumped cw Er,Yb:glass micro-lasers

We have previously developed the diode-pumped $Nd:YVO_4$ micro-lasers and single frequency, high power and widely tunable oscillation has been realized at 1.06 μm[4]. Similar approach has been adoped for this generating 1535 nm cw output. As the laser material, we used Er,Yb:phosphate glass (HOYA, LYE-31) doped with 0.17 cat% Er and 18 cat% Yb, which has wideband fluorescence width of 22 nm and a large absorption coefficient of 42 cm^{-1} at the pump wavelength of 960 nm.

Schematic of the diode-pumped cw Er,Yb:glass is shown in Fig.1. An Er,Yb:glass disk is 3x3 mm^2 width and 1 mm thickness with the pumping face HR coated at 1530 nm and AR coated at 960 nm. The other face is coated with 2 % transmission at 1535 nm and HR at 960 nm. The disk temperature is controlled by using a micro-heater with a control circuit.

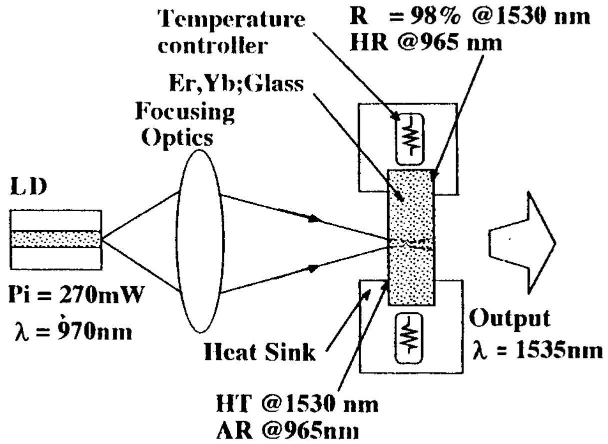

Fig. 1 Schematic of the diode-pumped cw Er,Yb:glass micro-laser.

Figure 2 shows the pump and output power relations of the Er,Yb:glass micro-laser. The pump threshold power is 60 mW and the slope efficiency is 17.1 %. TEM_{00} single axial mode output was obtained up to 3 mW. The temperature coefficient of the axial mode frequency was dν/dT= -1.5 GHz/K, and the pump power dependence was dν/dp= -600 MHz/mW. Oscillation frequency can be modulated by the heat sink temperature and the pumping LD power. This characteristics is useful for realizing frequency locking and stabilization of the local lasers of heterodyne lidars.

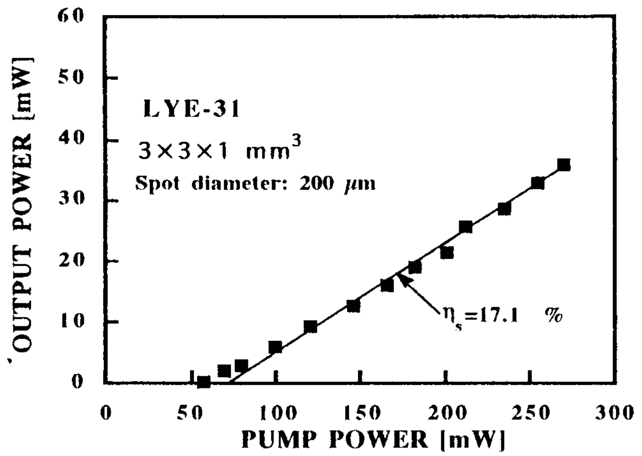

Fig. 2 Cw laser output power at 1535nm versus pump power for the Er,Yb:glass micro-lasers.

3. Diode pumped Q-switched Er,Yb:glass lasers

Scaling of Er:glass lasers to high average power is limited by the thermal properties of the phosphate glass. Low thermal conductivity leads to strong thermal lensing. In pulsed oscillation, 20 mJ output was reported for diode-pumped Er,Yb:glass laser using 210 mJ pump energy with side-pumping configuration[5]. To develop high efficiency diode laser pumped Er,Yb:glass lasers, we have calculalted the pumping intensity, gain and temperature distributions in the rod. Schematic

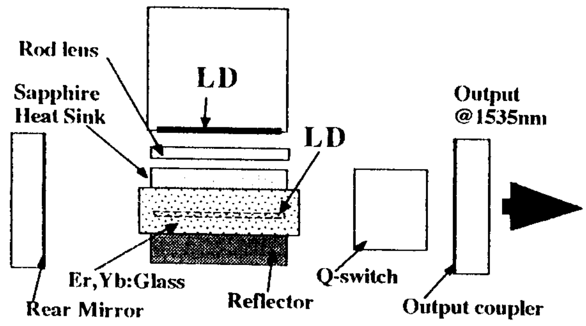

Fig. 3 Schematic of the diode-pumped, Q-switched Er,Yb:glass laser.

of the Q-switched Er,Yb:glass laser with side-pumping cofiguration is shown in Fig.3. Two InGaAs diodes are used with 48 mJ output energy and the beam is transmitted through a rod lens and a sapphire heat sink plate into the $1x1x10mm^3$ Er,Yb:glass square rod (Kiger QE -7). An AO Q-switch is used for the Q-switching. The threshold energy is estimated to be 7 mJ and the laser output is 5 mJ with 30 Hz repetition rate. The experimental result will be reported in detail.

References

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