In-Band Pumped Conical Refraction Nd:KGW Laser

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***Abstract* – We have demonstrated an in-band pumped conical refraction (CR) Nd: KGW laser. The CR laser was diode-pumped at 910 nm and produced an output power of 1.15 W at 1069 nm.**

Keywords – conical refraction; diode-pumped; Nd-lasers.

I. Introduction

The conical refraction phenomenon was predicted by Hamilton and after that experimentally demonstrated by Lloyd [1]. Conical refraction happens once light is propagating along one of the optical axes of a biaxial crystal. Conicity of the emerging light depends on the length of the crystal and its refractive indices. Another condition to clearly observe CR is that the ratio of the CR ring radius to the incident beam waist radius should be much greater than one [1]. CR has the potential application in the fields of optical trapping, free space communication, super-resolution microscopy, quantum computing, cryptography, polarization demultiplexing and multiplexing, polarimetry and mode conversion [2-4]. The output power of the CR Nd: KGW lasers, however, is limited by moderate thermal conductivity of the crystal. This issue can be overcome by in-band pumping which significantly reduces heating due to quantum defect [5-8]. In this work we have demonstrated the first CR Nd:KGW laser with in-band pumping at 910 nm instead of traditional 808 nm [9]. In the initial experiments the laser operated at 1069 nm and produced an output power of 1.15 W.

II. Experimental setup and results

Fig. 1(a) shows the schematic diagram of a laser cavity containing the Nd: KGW gain medium which was cut along one of the optical axes to get CR [9]. The crystal was 2x4.2x18 mm-long, had 3at% Nd-ion doping, and was antireflection coated at the laser and pump wavelengths. The crystal was wrapped in indium foil and held by a water-cooled (16 ^{0}C) metallic holder. The pump at 910 nm was provided by a fiber coupled laser diode which had 105 µm fiber core diameter and numerical aperture of 0.22. A dichroic mirror (DM) was used to introduce the pump light into the cavity which was designed taking into account thermal lensing [10]. L1, L2 and L3 distances were 24 mm, 398 mm and 439 mm, respectively, and produced a beam diameter of 550 µm in the crystal. M1 is a concave mirror (r=500 mm) and the output coupler (OC) had 2.4% transmission. A red He-Ne laser was used to observe a conical refraction ring pattern at the plane of the DM using a CCD camera. The propagation direction of the He-Ne laser was aligned to be collinear with the generated laser light, thus ensuring alignment close to the CR condition. A further careful adjustment of cavity mirrors could be used to operate the laser in the CR mode as well as in the normal non-CR regime. A transition between two regimes was accompanied by the change in the position of the generated laser mode at the DM. In addition, in the non-CR regime lasing took place at 1067 nm and in the CR regime - at 1069 nm. In both cases laser had an excellent beam quality and produced maximum output powers of 1.8 W and 1.15 W, respectively. The threshold pump powers were measured to be 0.55 W for 1067 nm and 1.52 W for 1069 nm lasing. Fig 1(b) shows the output power versus the absorbed power for both regimes with the slope efficiencies of 46% and 32% for 1067 nm and 1069 nm lasers, respectively. Lower output power in the CR regime can be explained by the laser beam walk-off and agrees with the previous report [11]. The output beam did not produce the CR ring pattern in the current setup due to a big mode size in the crystal. This will be addressed in the future experiments.

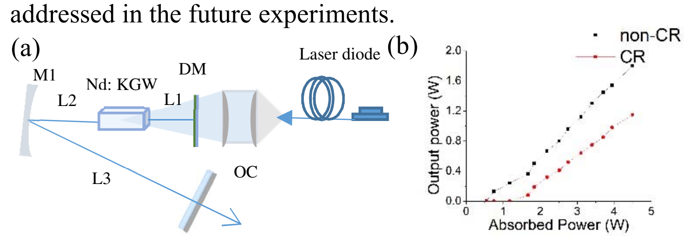

Fig. 1: (a) Experimental setup of the Nd:KGW CR laser and (b) its output power vs the absorbed pump power.

In summary, a simple three mirror cavity CR laser with in-band pumping was demonstrated. The laser was also operated in the standard regime which had a higher slope efficiency than the CR laser. Further experiments will include optimization of the pump spot to produce a clear CR pattern and possibly nonlinear frequency conversion [12-15].

III. References

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