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Disc Laser System Construction and Characterization

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Abstract: In this work a Nd:YVO_4 thin disc laser setup is designed and fabricated. The disk laser system is designed to be compact. The laser crystal was pumped by a 808 nm diode laser. The effect of input current and pulse frequency on the output energy at pulse operation mode, and the effect of the input current on the output power at CW mode operation are tested. At the pulsed mode, the output energy increased linearly with the input current and decreased with pulse frequency. The threshold current increased with increasing pulse frequency increasing. The maximum output energy from the thin disc laser was 0.98 μJ at 1.3 kHz frequency, with 0.49A. A minimum threshold current for CW mode of operation. The maximum output power from the disc laser was 22 mW.

Introduction

A thin disc laser head is a very successful concept suitable for diffraction limited laser operation at high average output power [1]. The thin disc gain material, in many designs, is mounted with one end face onto a heat sink. The cooled face of the disc is coated for high reflectivity (HR) at the laser and pump wavelength, while the other side has an antireflection (AR) coating for both wave lengths [2].

As the diameter of the pump beam is large compared to the thickness of the disc, the heat flux is nearly one-dimensional and directed along the optical axis of the laser [3]. This leads to a nearly homogenous temperature profile within the pumped region in radial direction and thus to only weak thermal lensing and low stress-induced birefringence. Aberrations due to the thermal lens are confined to the border region of the pumped volume [4]. The Nd:YVO4 crystal is used because of a very good spectroscopic, thermomechanical and thermoptical properties of this crystal [5].

Experimental details

A schematic setup of the thin disc laser system in present work is shown in Figure (1).

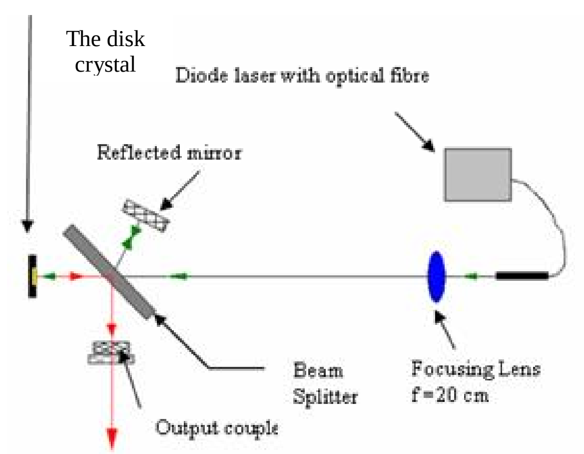

Fig. (1): Thin disc laser setup

The setup consists of a power supply to provide different voltages to the setup, a diode laser (808) nm used as pumping source, a focusing lens to focus the pumping beam, a beam splitter with an anti-reflecting face to the pumping beam (808) nm and a totally reflecting face to (1064) nm. The thin disc crystal is made from Nd:YVO_4. The host material YVO_4 is doped with 3% at Nd. The crystal dimensions are 4x5 mm with 1 mm thickness placed on Indium material of thickness 0.1 mm and in front of Al disc plate with 4 mm in diameter circular hole making a crystal as a disc. This hole is used to enter the pumping power to the crystal and to exit the laser beam. The Indium material is placed on a Cu plate. The Cu plate is used as a heat sink. All these parts are fixed on a homemade holder made from Al with 44x50x15 mm in dimensions and fixed to the base. The output coupler has reflectivity of 90% at 1064 nm, allowing 10% to pass as a laser output.

Results and discussion

In the pulse operation mode, the relation between the input current of the diode laser with output energy of the thin disc laser at different pulse frequencies (1.3, 1.4, 1.6, 1.8, 1.9) kHz is shown in Figure (2) It is obvious that the output energy is increasing with input current. The increase at low frequency was higher than at high frequency. This happens because at high pulse frequency the duty cycle is very short so the time is not enough for the disc material to absorb the pumping power by the thin disc crystal.

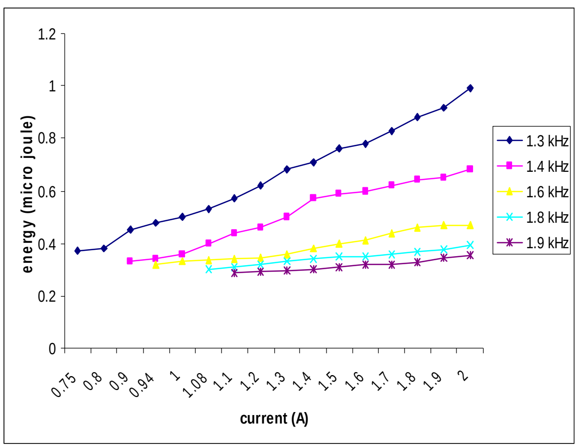

Fig. (2): The relation between input current of the diode laser with output energy of the thin disc laser at different frequencies.

Figure (3) represents the relation between the output energy and the pulse frequency. It is clear that the output energy is decreasing with the of pulse frequency.

The maximum pulse frequency needed to get output energy from the thin disc is equal to 1.9 kHz, above that there is no output energy from the thin disc.

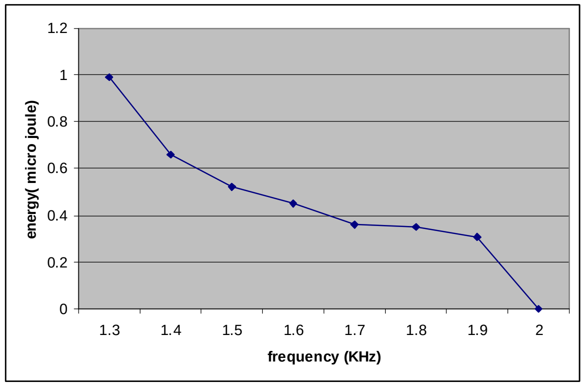

Fig. (3): Relation between pumping pulse Frequency and maximum output energy of the thin disc

Figure (4) shows the relation between the pulse frequency of the diode laser and the threshold current of the thin disc crystal. The relation is almost linear

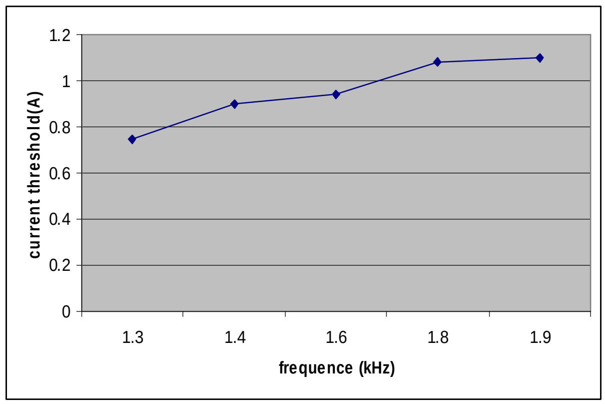

Fig. (4): The effect of increasing pulse frequency on thin disc laser threshold current

Figure (5) represents the relation between the input and the output energy of the thin disc laser at 1.3 kHz pulse frequency. The total efficiency of the system is about 2%.

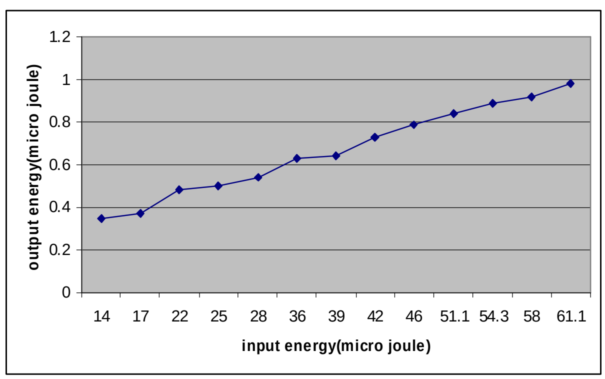

Fig. (5): The relation between input energy and output energy of the thin disc laser at 1.3 kHz pulse frequency.

The results of the thin disc laser in pulse mode operation are summarized in Table (1):

Table (1) Summary of thin disc laser system in pulse mode operation condition

Frequency (kHz)	Diode laser Threshold current(A)	Thin disc threshold current (A)	Diode laser Output energy (micro joule)	Thin disc laser Output energy (micro joule)
1.3	0.49	0.75	61.1	0.99
1.4	0.51	0.9	41.1	0.67
1.6	0.52	0.94	33	0.47
1.8	0.53	1.08	26	0.37
1.9	0.56	1.1	21	0.34
2	0.58	X	18	X

For CW mode of operation, Figure (6) represents the relation between the input current of the pumping laser, and the output power of the thin disc laser. The threshold current of the diode laser is enough to excite the active medium of the thin disc crystal. The output power of the thin disc laser is increasing with the input current of the diode laser. Maximum output power of the thin disc laser system is 22 mW.

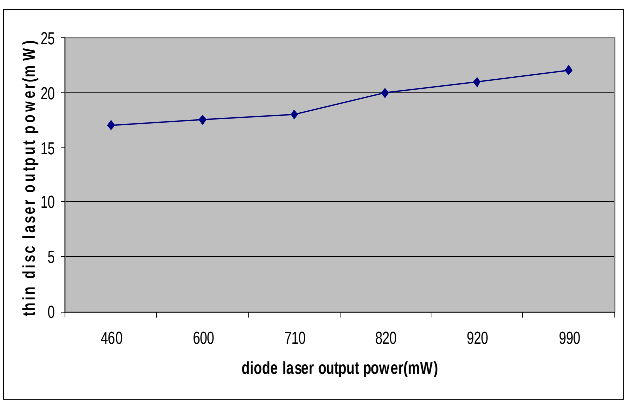

Fig. (6): Relation between the input current of pumping laser "diode laser" and output power "thin disc laser" (1064 nm)

Figure (7) shows the relation between the output power of the diode laser (808 nm) ”pumping power” and the output power of the thin disc laser.

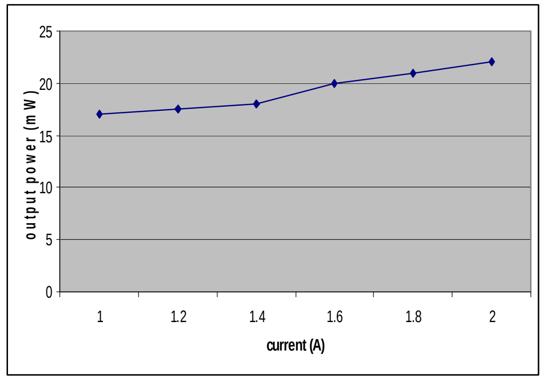

Fig. (7): Relation between output power of the diode laser (808 nm) ”pumping power” and output power of the thin disc laser (1064 nm)

Table (2) shows the effect of the input current of the diode laser on the output power of the diode and the thin disc laser. It is found that between (0-0.45 A) of input current of the diode laser, there is no output power. Also between (0.46-0.9 A) of input current of the diode laser there is an output power from the diode laser "pumping laser" but there is no output power from the disc laser "output laser" .Also from (1-2A) of input current of the diode laser there exists an output power from the pumping laser and the thin disc laser.

Table (2): The effect of increasing the input current of diode laser on output power for diode laser and thin disc laser

Input Current of Diode laser (A)	Output Power from Diode laser (mW)	Output Power from Thin Disc laser (mW)
0	0	0
0.2	0	0
0.4	0	0
0.46	90	0
0.6	190	0
0.8	300	0
0.9	380	0
1	460	17
1.2	600	17.5
1.4	710	18
1.6	820	20
1.8	920	21
2	990	22

Conclusions

In pulsed mode operation the threshold current becomes lower with lower pulse frequency. In pulsed mode operation the output energy increases as the pulse frequency decrease. Also in pulsed mode operation at pulse frequency higher than 1.9 kHz there is no output energy from thin disc laser.

Best pulse frequency is 1.3 kHz. In CW mode the threshold current to get output power from thin disc laser is 1A and maximum output power from thin disc laser is 22 m W with conversion efficiency of 2.5% power from thin disc laser is 22 m W with conversion efficiency of 2.5%

Also in pulsed mode operation at pulse frequency higher than 1.9 kHz there is no output energy from thin disc laser.

Best pulse frequency is 1.3 kHz. In CW mode the threshold current to get output power from thin disc laser is 1A and maximum output power from thin disc laser is 22 m W with conversion efficiency of 2.5%.

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تركيب وتوصيف منظومة الليزر القرصي

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الخلاصة في هذا البحث تم تصميم وتنفيذ منظومة ليزر قرصي نوع Nd:YVO4. لقد صمم الليزر القرصي بحيث يكون صغير الحجم ويضخ بواسطة ليزر الدايود ذي طول موجي 808 نانو متر. وكذلك تم اختبار تأثير التيار الداخل الى المنظومة و التردد النبضي على الطاقة الخارجة في حالة العمل بالنمط النبضي، وتأثير التيار الداخل للمنظومة والقدرة المضخخة في حالة العمل بالنمط المستمر. فقد وجد ان الطاقة الخارجة تزداد خطيا مع التيار الداخل وتقل مع زيادة التردد النبضي كما ازداد حد العتبة للتيار الداخل يزداد بزيادة التردد النبضي. اقصى طاقة خارجة من المنظومة هي 0.98 مايكروجول عند التردد 1.3 كيلو هرتز واقل قيمة لحد العتبة للتيار الداخل الازم لتشغيل المنظومة هو 0.49 امبير عند نفس التردد. اما بالنسبة الى العمل بالطور المستمر فاقصى قدرة خارجة من المنظومة هي 22 ملي واط