TITANIUM DOPED SAPPHIRE CRYSTAL EXCITED BY DIODE PUMPED SOLID STATE LASER

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ABSTRACT

The laser crystal emission property is the crucial factor to produce laser. An appropriate pumping source is needed to pump atom in the crystal to an excited state which depend to the absorption band of the crystal. The emission only occurs when the threshold value is exceeded. The aim of this research is to study the absorption and emission spectrum of the laser crystal during pumping process. Ti:sapphire crystal was employed as an active medium. High power diode pumped solid state (DPSS) laser was used as a pumping source. A spectrum analyzer was utilized to detect the absorption and emission spectrum of the crystal. The absorption spectrum comprised of 532.01 nm, 807.23 nm and 1064.07 nm. The major of emission spectrum is 806.80 nm with intensity achieved up to 97.46 %. The optimum emission was occurs at corresponding pumping current of 22 A.

Keywords: Ti:Sapphire, diode pumped solid state laser (DPSS), absorption and emission spectrum

INTRODUCTION

Nonlinear optical conversion is commonly used to produce visible radiation from solid state laser operating in the near IR [1]. The Potassium Tantalum Phosphate KTP crystal is usually used for the conversion to the green. In this case the KTP operate as a frequency doubled for 1.064 μm beam. This process was used in the Diode pumped solid state (DPSS) laser.

DPSS lasers have a wide variety of applications due to their high efficiency, compactness and good frequency stability. Since the early 1980s, with the development of the reliable highpower Laser Diodes, Laser diode-pumped solid-state lasers have been attracting a great deal of attention [2]. The diode pumped solid-state (DPSS) lasers, compared to the traditional flashlamp pumped ones, have the characteristics of being more efficient, compact, versatile, stable and reliable, which allowed them to be used in a wide range of applications with improved performance [3].

For the commercial Ti:sapphire laser, frequency doubled Nd:YAG or Nd:YLF lasers were used as a pumping source [4]. A very important application of Ti:sapphire lasers is generation and amplification of femtosecond mode-locked pulse [5].

Titanium doped Sapphire (Ti^{3+}:Al_2O_3 or Ti:Sapphire) was developed late in laser evolution. However, since the discovery of laser action in Ti:sapphire in 1982, Ti:sapphire become one of the most widely used solid-state laser material [6]. It combines the excellent thermal, physical and optical properties of Sapphire with the broadest tunable range of any known material [7].

The solid-state tunable laser medium, Ti:sapphire has great potential for the next generation of femtosecond lasers and amplifiers, since it has three times broader bandwidth spread from 680 to 1050 nm. Futhermore, this material is easy to handle and free from degradation. Besides these advantages, the wavelength of Ti:sapphire laser is suitable for application to III – V semiconductors and its second harmonic generation wavelength is suited to II – VI or I –VII semiconductor [8].

Ti:Sapphire crystals are active media for highly efficient tunable solid-state lasers. They demonstrate good operation in the pulsed-periodic, quasi-CW and CW modes of operation. Ti:Sapphire is a 4-level, Vibronic laser with fluorescence lifetime of 3.6 μm. Ti:sapphire can be pumped by variety of sources operating in the green-argon ion, copper vapour, frequency-doubled Nd:YAG, and dye lasers are routinely used. Crystals have also been flashlight pumped by lamps designed to allow short fluorescence lifetime. These factors and broad tunability make it an excellent replacement for several common dye lasing materials.

In this present paper, Diode Pumped Solid State Laser was used to pump Ti:sapphire crystal. The absorption and emission band of Ti:sapphire crystal were characterized.

METHODOLOGY

Ti:sapphire crystal has dimension of $5\times5\times3$ mm^3. The crystal is cut at Brewster angle of 60.3^o with refractive indeks of 1.75. The amount of Ti doped into the sapphire was 0.15% in weight. Ti:sapphire also have many other desirable characteristics such as very high damage threshold ($\approx$8-10 J/cm^2), high thermal conductivity (46 W/mK at 300 K), and suitable peak gain cross section ($\approx 2.7 \times 10^{-19}$ cm^2) [9].

A Diode Pumped Solid State (DPSS) laser was used as a pumping source to pump the crystal. The wavelength of the laser was 532 nm and operated in continuous mode. A lens with focal length of 10 mm was used to focus the DPSS beam on the crystal. The spectrum of the absorbance beam and the fluorescence beam were measured via an Ophir spectrum analyzer. The power of the diode pumped solid laser was verified by adjusting the pumping current. Filters were used to avoid over exposure in light detection. The whole experimental setup is shown in Figure 1.

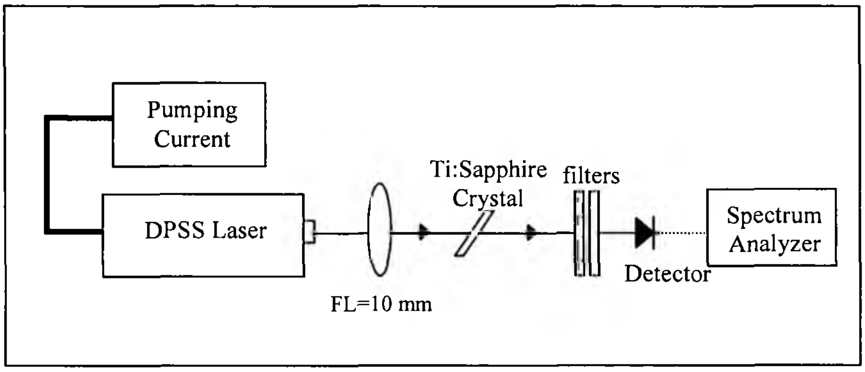

Figure 1: Schematic diagram of the whole experimental setup.

RESULT AND DISCUSSION

Initially the experiment was carried out to observe the spectrum of diode pumped solid laser. High power diode laser with wavelength of 808 nm was used to pump the solid state material of Nd:YAG laser crystal. After pumping the crystal produced 1064 nm line. The 1064 nm was then frequency doubled by using KTP. As a result 532 nm beam was produced. The three lines 532 nm, 808 and 1064 nm were displayed on the screen. The spectrum of diode pumped solid state laser comprised the three lines such as shown in Figure 2.

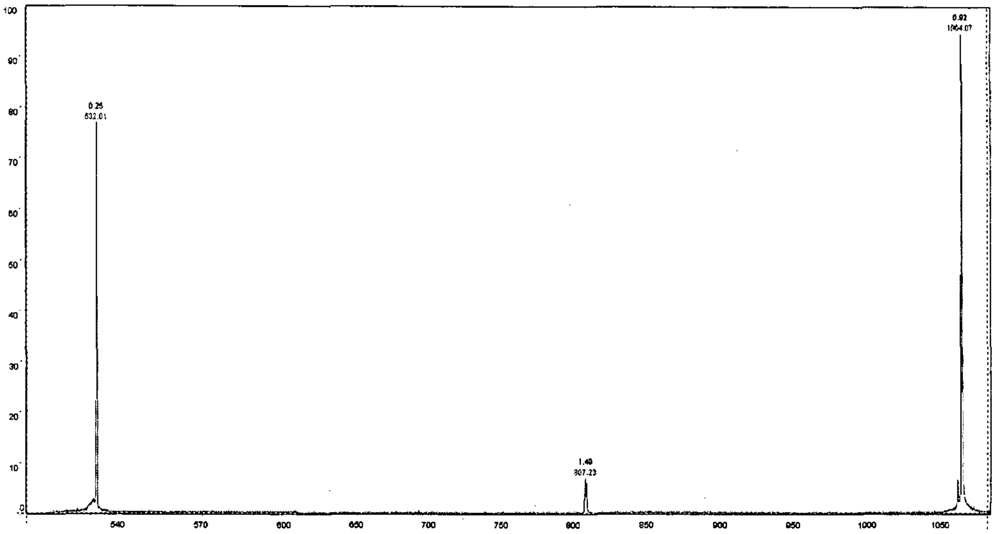

Figure 2 : The spectrum of DPSS laser output

Typical result obtained after pumping the titanium dopes sapphire crystal with 532 nm DPSS laser is shown in Figure 3. The filter was used so that no green light will be detected. Hence, the majority line emitted after focusing the green light into the crystal is 806 nm. Other minor line also observed in the fluorescence of Ti:sapphire is 898 nm. The spectrum in Figure 3 was taken at correspond pumping current of DPSS laser at 25 A. The intensity of the major emitted band achieved as high as 97.46 %.

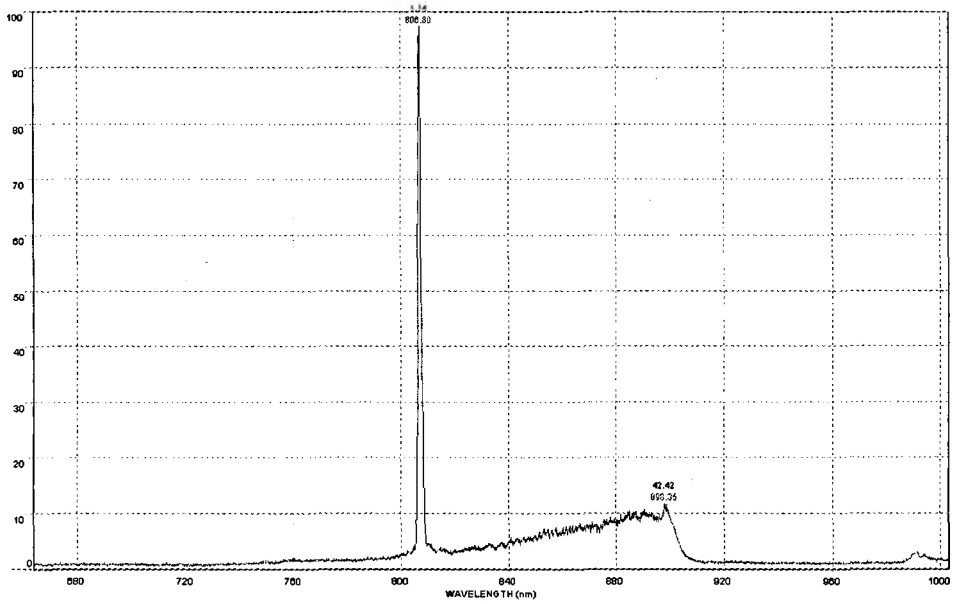

Figure 3: The fluorescence spectrum of Ti:sapphire crystal.

The fluorescence beam of ti:sapphire was studied further by adjusting the pumping current of diode pumped solid state laser. The intensity of the majority line that is 806 nm was measured from the spectrum of fluorescence beam. The data measurement are represented in Figure 4. Obviously en that the emission of Ti:sapphire crystal is started to appeared after the pumping current of DPSS laser greater than 8 A. This is referred as threshold current to fluorescence. Beyond that threshold point, the intensity of emission been drastically increased. However, we really do not understood why at 14 to 16 A the emission beam is stagnant. Then the emission drastically increased again. Up to 22 A the fluorescent is really brilliant. The intenaity of the emission achieved more than 90%. However, after the optimum point, increasing current cause the intensity decreasing. This showed that at higher current the spontaneous emission is reduced due to the collision of too much excited Ti atoms. As a result reduce the emission of photon during deexcitation. The kinetic motion and vibration of atoms at higher current induced more heat. However, further greater current injected into DPSS laser cause the increase of the fluorsence emission of Tisapphire crystal such as shown after pumping current of 28 A. The fluctuation occur at higher current is due to balance between the emission and heating of the Ti;sapphire laser. In this studied to avoid overheat and the fluctuation of emissionat higher current, is better to cool the Ti:sapphire crystal.

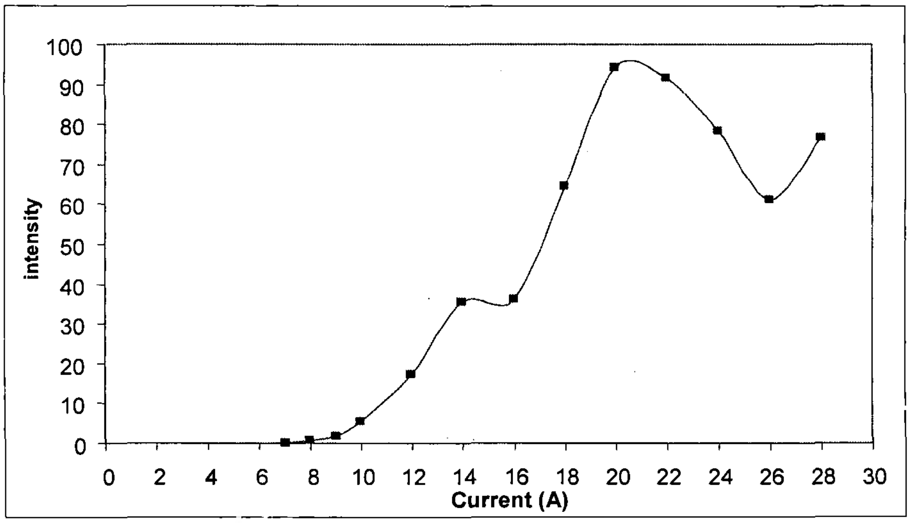

Figure 4: The emission of Ti:Sapphire as a function of pumping current

CONCLUSION

Titanium doped sapphire crystal was excited by green light of diode pumped solid state DPSS laser. The DPSS laser is an absorption band of Ti:sapphire. The spectrum of absorption band comprised of 532, 808 and 1064 nm. After the Ti:sapphire crystal was excited the fluoresce beam comprised the majority line of 806 nm. The intensity of the fluorescence beam is dependent on the injected current of DPSS laser. The threshold current to fluorescence is 8 A. The optimum intensity of the fluorescence beam obtained after 22 A. At higher injected current the fluorescence becomes fluctuated due to the collision of the excited atoms as well as heating librated from the crystal.

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