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LED Pumped Lithium Neodymium Tetraphosphate Lasers

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Laser oscillation of lithium neodymium tetraphosphate (LNP) crystal pumped with LED's is reported in this paper. A highly efficient miniaturized solid state laser is expected because the Nd concentration of LNP is about 30 times as high as that of Nd:YAG. Experimental results and theoretical considerations on LNP lasers, which are end- and side-pumped with $Al_xGa_{1-x}As$ LED's are reported.

The experimental arrangements are shown in Figs. 1(a) and 1(b) for end- and side-pump schemes, respectively. The LNP crystal used for each pump scheme is a pseudoorthorhombic a-plate. Crystal thicknesses are 0.3 mm and 4.85 mm for end- and side-pump, respectively. The optical resonator consists of a plane mirror M_2 and a spherical mirror M_1, arranged in hemispherical configuration. Both mirrors are highly reflective with more than 99.9% reflectivety at 1.047 µm. The main pump source is a dome-type $Al_xGa_{1-x}As$ LED, whose center wavelength is selected around 0.8 µm. A pair of condenser lenses (F= 0.71) are used for end-pump scheme. With this system, 31% of the LED power can be focused on the LNP crystal. For the side-pump, a gold plated hemispherical reflector with 80% reflectivety at 0.8 µm is used as a pump scheme.

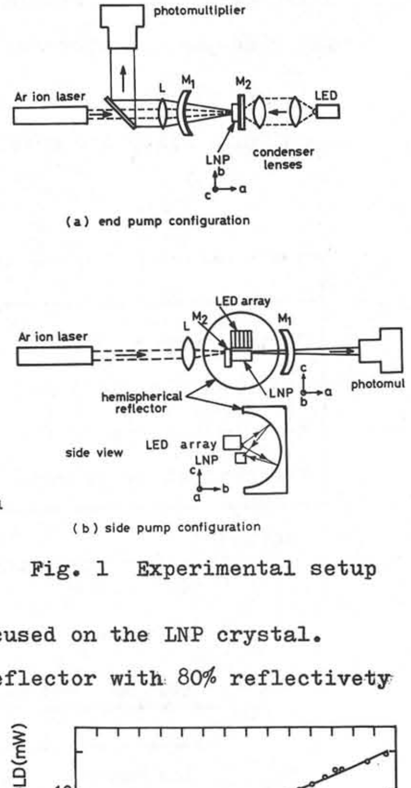

Fig. 1 Experimental setup

Experimental results show the temperature dependences of both LNP lasers pumped with an Ar ion laser, as is shown in Fig. 2. The characteristics of the threshold are expressed by the calculations based on the temperature dependences of the effective stimulated emission cross section and the round trip resonant loss originated in the thermalized population of the laser lower levels. The LNP laser oscillates

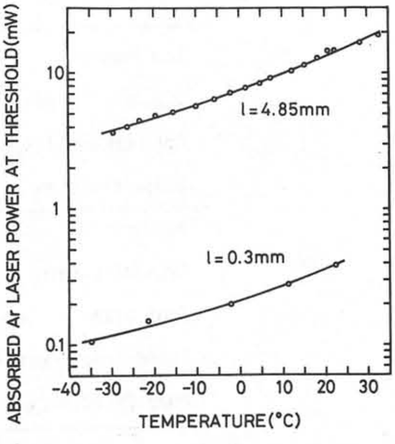

Fig. 2

at around -30°C at drive current of 290 mA for end-pump and 460 mA for side-pump. Threshold pump powers for end- and side-pump are 49 mW and 340 mW, respectively. From the estimations of the pump efficiencies η associated with the LED output and the power absorbed within the oscillating mode volume, the experimental threshold pump powers fairly agree with the theoretical threshold calculations, as are listed in Table 1.

In order to reduce the LED power required to oscillate the LNP laser, pump efficiency improvement and LNP crystal homogeneity will be discussed. From the above estimations, LED pump power densities required to oscillate the LNP laser at room temperature are 35 W/cm^2 and 8.5 W/cm^2, and the required power densities to obtain a 10 mW output are 990 W/cm^2 and 30 W/cm^2 for end- and side-pump, respectively. Table 2 summarizes the above results.

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Table 1

Threshold Comparison

		End-Pump		Side-Pump	
Sample Temperature	(°C)	22	-35	22	-30
Absorbed Threshold for Ar Laser Pump	(mW)	0.056	0.016	8.3	1.8
Absorbed Threshold for LED Pump	(mW)	-----	0.0092	----	2.1
Theoretical Threshold	(mW)	0.023	0.0067	9.2	2.0

Note:
Ar laser pump threshold data are multiplied by wavelength ratio 0.5145/0.80.

TABLE 2

LED Power Required to Obtain 10 mW Output at Room Temperature

		End Pump	Side Pump
LED Power	P_{in}	28 mW	88 mW
LED Power Density	I_{in}	990 W/cm^2	30 W/cm^2
Optimum Coupling Loss	L_{to}	8.5×10^{-3}	3.4×10^{-2}
Slope Efficiency	σ_s	0.40	0.19
Assumptions			
Crystal Length	ℓ	0.3 mm	4.85 mm
Spot Size	w_o	30 μm	30 μm
Round Trip Crystal Loss	L_i	5.0×10^{-4}	8.1×10^{-3}
Pump Efficiency	η	0.55	0.30