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## TUNABLE DIODE-PUMPED-LNA LASER

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**ABSTRACT** : Diode-pumped crystals provided recently new compact laser devices. We report the first end pumping of a  $\text{La}_x\text{Nd}_{1-x}\text{MgAl}_{11}\text{O}_{19}$  (LNA) crystal using a 200mW diode array (Spectra Diode Lab). We also report the first results obtained with a 1mW diode (SONY). This C.W. laser can be tuned from 1.048 $\mu\text{m}$  to 1.086 $\mu\text{m}$ .

Without selective elements in the cavity, the laser emits around 1.054 $\mu\text{m}$  with a threshold of 24mW and a slope efficiency of 4.4% (output mirror of transmission  $T = 1\%$ ) when pumped by the diode array. With the selective elements, the threshold increases to 100mW and we obtain a power of 4mW for a pump power of 200mW.

Diode-pumped solid laser materials provide highly efficient as well as compact and relatively low cost laser devices leading to a wide range of potential applications [1]. End pumping of Nd:YAG crystals can deliver over 100mW of continuous power at 1.06 $\mu\text{m}$  when pumped with diode arrays [2], the overall wall-plug efficiency being as large as 8% [1]. There is now a rapidly increasing number of neodymium doped material which has been shown to lase under diode excitation such as  $\text{LiNbO}_3$  [11] or silica fibers [4]. Here we report the diode pumping of  $\text{La}_x\text{Nd}_{1-x}\text{MgAl}_{11}\text{O}_{19}$  (LNA) [5,6] which is a crystal with laser characteristics similar to Nd:YAG or Nd:YAP [7] although with different crystalline symmetry. We also report the ability to tune the LNA laser output within the range 1.048 $\mu\text{m}$ -1.086 $\mu\text{m}$ .

An important difference between LNA and YAG is the Nd concentration, which can be higher in LNA than in YAG without quenching of the fluorescence [5]. This could be an advantage for future high-power lasers. LNA was recently found to be a slightly tunable infra-red laser with an efficiency comparable to YAG when excited by Ar or Kr lasers [8,9]. It oscillates at wavelengths significantly different from YAG, with a main peak around 1.054 $\mu\text{m}$  and two other weaker peaks around 1.065 $\mu\text{m}$  and 1.082 $\mu\text{m}$ . The laser band around 1.065 $\mu\text{m}$  had not been observed earlier. It corresponds to a weak fluorescence band actually observed in [5] and [9].

The LNA crystal is a cylinder, 5mm in diameter and 5mm in length, grown in LETI (Grenoble). The rod axis coincides with the crystalline c-axis. One of the two polished parallel faces is high reflectivity coated for the laser radiation and high transmission coated for the pump radiation. The other is antireflection coated for  $\lambda = 1.06\mu\text{m}$ . It is excited longitudinally by a C.W. diode focused on one end of the crystal. The set-up is shown in figure 1.

The diode emits at 800nm, wavelength within the absorption band of LNA [5,9]. The light emitted by the diode is collimated by corrected lenses of large aperture (Melles Griot 06 GLC 002).

To convert the diode output beam to a near-circular one, we use an amorphous

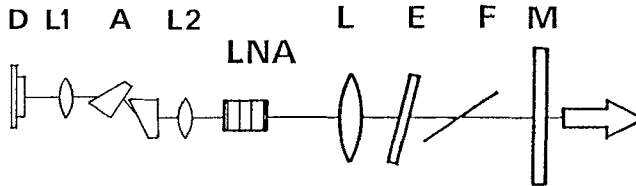


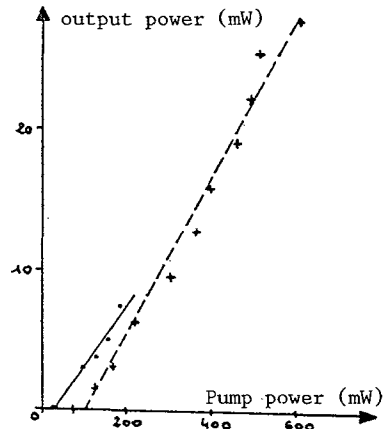
Fig. 1 : Cavity used for the LNA laser pumped by a laser diode

prism pair. Then we focus it on the crystal through a lens of focal length 10mm. The laser cavity consists of the high reflectivity coated face of the crystal and a plane output mirror M of low transmission  $T = 1\%$  associated with an AR coated lens L of focal length 25mm. The total cavity length is approximately 13cm. the transverse waist of the gaussian beam in this cavity is of the order of  $100\mu\text{m}$ , matching the pump spot size.

Fig. 2 : Output power of the LNA laser (at  $1.054\mu\text{m}$ ) as a function of the pump power on the crystal.

The two lines are for different laser diodes :

— SDL 2420 H1 diode array (200mW)  
 ---- SLD 304V diode (1W)



The results are shown in fig. 2 without selective elements in the cavity the LNA laser emits on the main fluorescence peak at  $1.054\mu\text{m}$ . The output power is plotted as function of the pump power on the crystal, which absorbs 80% of the incident light when pumped by a diode array (model 2420 H1 from Spectra diode lab) delivering 200mW. The threshold is 24mW and the slope efficiency 5,5% (emitted power/absorbed power).

Pumping by a demonstration diode SONY emitting 1W around  $80\text{nm}$  has been briefly tried [10] (model SLD 304V). The crystal absorbed 73% of this radiation. The threshold was 70mW and the slope efficiency 7,4% (emitted power/absorbed power). [The interfacing of the diode and the focusing optics was not optimized].

Tuning the frequency of the LNA laser was achieved by inserting a single plate birefringent Lyot filter F (a 1mm thick quartz plate) at Brewster angle in the cavity. Oscillation on the main peak at  $1.054\mu\text{m}$  could be suppressed and tuning around  $1.082\mu\text{m}$  was then possible. Fine tuning was accomplished with a thin, solid etalon E (a  $100\mu\text{m}$  non coated plate of fused silica). The observed laser emission when pumped with a 200mW diode array is shown in fig.3.

Pumped by two 200mW diode arrays coupled through a polarizing beam splitter or pumped by the 1W diode (SONY), we can tune the laser on any of the wavelengths within the range  $1.048\mu\text{m}$ - $1.086\mu\text{m}$ . The laser beam is linearly polarized according to the Lyot filter orientation.

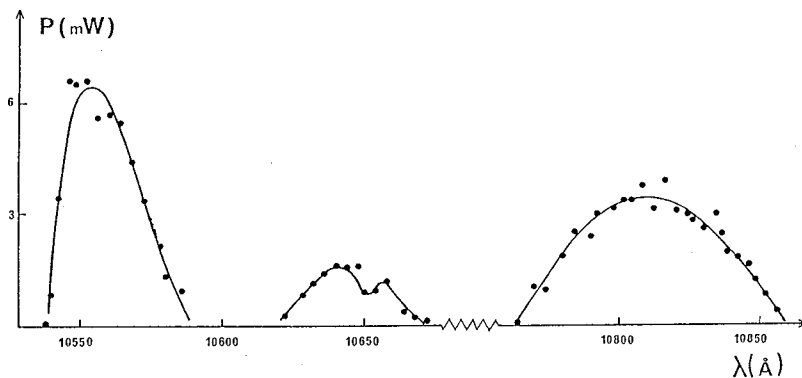


Fig. 3 : Output power of the LNA as a function of the wavelength. The pump power on the crystal is about 200mW.

In conclusion, LNA crystals can lase when pumped by diode, thus providing potentially a compact tunable source for atomic physics experiments.

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