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TUNABLE DIODE-PUMPED-LNA LASER

A. CASSIMI, V. HARDY, J. HAMEL and M. LEDUC*

Laboratoire de Spectroscopie Atomique, ISMRA-Université de Caen, F-14032 Caen Cedex, France
*Laboratoire de Spectroscopie Hertzienne de l’ENS, 24, Rue Lhomond, F-75231 Paris Cedex 05, France

ABSTRACT: Diode-pumped crystals provided recently new compact laser devices. We report the first end pumping of a LaNd$_{1-x}$MgAl$_{10}$O$_{17}$ (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 1.048µm to 1.086µm.

Without selective elements in the cavity, the laser emits around 1.054µm 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 1.06µm 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 LiNbO$_3$[3] or silica fibers [4]. Here we report the diode pumping of LaNd$_{1-x}$MgAl$_{10}$O$_{17}$ (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 1.048µm-1.086µm.

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$^+$ of Kr$^+$ lasers[8,9]. It oscillates at wavelengths significantly different from YAG, with a main peak around 1.054µm and two other weaker peaks around 1.065µm and 1.082µm. The laser band around 1.065µm had not been observed earlier. It corresponds to a weak fluorescence band actually observed in [8] 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 $\lambda$=1.06µm. It is excited longitudinally by a C.W. diode focused at 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 amorphic LNA 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 100μm, matching the pump spot size.

The results are shown in fig. 2 without selective elements in the cavity the LNA laser emits on the main fluorescence peak at 1.054μm. The output power is plotted 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)

Pumping by a demonstration diode SONY emitting 1W around 80mm has been briefly tried \cite{19} (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 1.054μm could be suppressed and tuning around 1.082μm was then possible. Fine tuning was accomplished with a thin, solid etalon E (a 100μm 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 1.048μm-1.086μm. 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 200 mW.

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

REFERENCES

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