High-reflectivity continuous-wave phase conjugation by four-wave mixing in a diode-pumped Nd:YVO₄ amplifier


The Blackett Laboratory, Imperial College,
London SW7 2BZ, U.K.
Tele. No.: (+44) 171 594 7783
Fax.: (+44) 171 594 7744
e-mail: m.damzen@ic.ac.uk

* Optoelectronics Research Centre
University of Southampton
Highfield, Southampton SO17 1BJ, U.K.

Abstract

We present the first demonstration of continuous-wave diode-pumped four-wave mixing in a Nd:YVO₄ amplifier and achieve phase conjugate reflectivity > 800%. Results for different amplifier gains and pump geometries are compared to numerical results.

Submitted to CLEO '99
Baltimore
High-reflectivity continuous-wave phase conjugation by four-wave mixing
in a diode-pumped Nd:YVO₄ amplifier

Mailis*, M. Trew and J. Hendricks*

The Blackett Laboratory, Imperial College,
London SW7 2BZ, U.K.
Tele. No.: (+44) 171 594 7733
Fax.: (+44) 171 594 7744
e-mail: m.damzen@ic.ac.uk

* Optoelectronics Research Centre
University of Southampton
Highfield, Southampton SO17 1BJ, U.K.

Summary

Self-adaptive laser resonators formed by diffraction from a gain grating have shown considerable promise for correction of distortions in high average power laser systems as well as for spectral and temporal control of the laser radiation [1-4]. In these systems, the gain grating is formed by spatial hole burning caused by interference of coherent beams in the laser amplifier and modulation of the population inversion. The gain grating formation can be used for phase conjugation by using the amplifier in a four-wave mixing geometry [2], for self-pumped phase conjugation by using an input beam in a self-intersecting loop geometry [3] and for formation of a self-starting adaptive oscillator by providing additional feedback from an output coupler and requiring no external optical input. Experimental demonstrations have been performed successfully in several laser systems including flashlamp-pumped and quasi-c.w. pumped neodymium-doped amplifiers [1,2], in laser-pumped titanium-doped sapphire [4] and CO₂ lasers.
We present, for the first time, demonstration of continuous-wave diode-pumped operation of four-wave mixing in a solid-state laser amplifier (Nd:YVO₄). Experiments have been performed in both a transversely-pumped Nd:YVO₄ amplifier (20x5x3mm³) using a 20W diode bar (see Figure 1a) and a longitudinally-pumped Nd:YVO₄ amplifier (3x3x1mm³) using a 2W broad-stripe diode laser (Figure 1b). The transversely-pumped amplifier, when run as a laser oscillator by placing it between a high reflectivity mirror and a partially-transmitting output coupler, produced 8.5W of output power for 18W of available diode pumping power. Very high small-signal gains >5,000 were also demonstrated in this amplifier system allowing the prospect of high efficiency four-wave mixing. Figure 2 shows results of phase conjugate reflectivity of a probe beam in a four-wave mixing geometry as a function of pump beam power in this side-pumped amplifier geometry (Figure 1a). A phase conjugate reflectivity > 800% has been achieved, and is the highest value obtained from a solid-state amplifier using a simple four-wave mixing geometry. Figure 3 shows corresponding numerical solutions for the continuous-wave four-wave mixing reflectivity versus pump intensity in a saturable amplifier. We compare the theoretical and experimental results including a discussion of the important issues of spatial overlap and thermal lensing in the amplifier system.

In conclusion, we have shown that high gain and high diffraction efficiency gain gratings are possible in a continuous-wave mode of operation from a diode-pumped solid-state (DPSS) laser amplifier, and this is the first such demonstration of a continuous-wave diode-pumped solid-state (DPSS) laser amplifier as a four-wave mixing medium. This result is of considerable importance since it now makes possible the operation of continuous-wave self-adaptive solid-state lasers and the compensation of thermal lensing when operating at high powers.

References

M. J. Damzen et al., "High reflectivity continuous-wave phase conjugation by FWM..."

**CAPTION FOR FIGURES**

Figure 1. Experimental four-wave mixing schemes in a c.w. diode-pumped Nd:YVO₄ amplifier in a) transversely-pumped and b) longitudinally-pumped geometries.

Figure 2. Experimental phase conjugate reflectivity versus four-wave mixing pump power in c.w. transversely-pumped Nd:YVO₄ amplifier at different small-signal amplifier gains.

Figure 3. Numerical results of continuous-wave four-wave mixing reflectivity versus pump intensity (normalised to saturation intensity) for different small-signal amplifier gains.
a) Transverse-pumping geometry

b) Longitudinal-pumping geometry