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Efficient adaptive self-starting Nd:YV04 gain-grating laser oscillator

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We present the results of a self-starting continuous-wave diode-pumped Nd:YVO4 laser oscillator based on an adaptive intracavity gain-grating technique. The laser produces 12W narrowband output in a TEM00 mode with 36W of diode-pumping.

Solid-state lasers with high average power and high beam quality are of great importance for many applications. However, the thermal load from high pumping levels results in problems such as thermal lensing or stress-induced birefringence [1]. In recent years, in addition to conventional techniques, self adaptive laser resonators based on laser induced gain gratings have successfully demonstrated correction of thermally induced aberrations in solid-state lasers [2]. This technique has recently been shown to produce distortion corrected beams in a diode pumped, injected seeded system in $Nd:YVO_4$ [3].

This paper describes the first characterization of a fully self-starting, high power $Nd:YVO_4$ self-adaptive laser without the requirement of an external seed source. Figure 1 shows a schematic of the self starting system in which a 1.1% at. $Nd:YVO_4$ slab (20mm $\times$ 5mm $\times$ 2mm) is used in a bounce geometry [4] and is transversely diode-pumped with a 36-W diode bar. Amplified spontaneous emission returning from the output coupler passes through the system to self intersect within the gain medium. The resulting interference pattern modulates the population inversion and forms a gain grating. The grating is then used for phase conjugation where phase information encoded in the gain grating is used to dynamically unravel intracavity aberrations experienced by the interfering beams. Inclusion of a Non-reciprocal transmission element (NRTE) optimizes the operation of the system and ensures unidirectional oscillation in the clockwise direction.

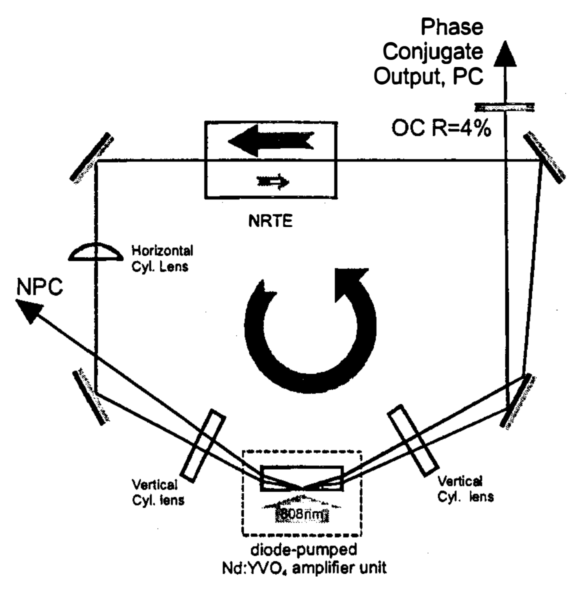

Fig. 1. Schematic diagram of the self-adaptive holographic loop resonator

For an efficient adaptive system, careful imaging of each beam is needed. This ensures the maximum available radiation is used to modulate the gain. Due to the novel nature of the bounce geometry used, the area in which the beams have to overlap is an ellipsoid. The use of cylindrical lenses allows for matching in the vertical and horizontal directions to give maximum overlap, and maximum modulation.

Figure 2 shows the power response curve for various pumping levels of the adaptive system. In the 24 to 29W pumping range the cavity is unstable and power levels drop due to thermal lensing within the amplifier. At this pumping level, thermal lensing becomes too strong to allow for the re-imaging of the original beam. Using this configuration, phase conjugate (PC) output of 12W at λ=1064nm has been achieved with 36W of diode pumping. M-squared factors of 1.7 and 1.6 in the x and y directions have been recorded, with a sample beam profile shown in figure 3. The oscillator output is SLM operation near threshold, and multimode at higher powers with a bandwidth of ~500MHz. The non-phase conjugate (NPC) beam has M-squared factors of 2.6 and 2.3 in the x and y directions with a power of 1W.

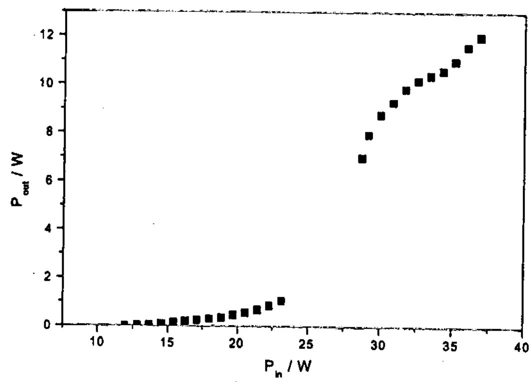

Fig. 2. Output vs. input power data for adaptive system

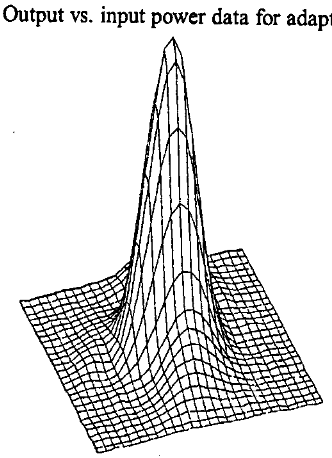

Fig. 3. Spatial properties of the self-adaptive laser output radiation

The route to power scaling these adaptive systems relies on the careful imaging of the gain medium back onto itself, to allow for maximum overlap, and interference, of the resonator beams. Current work has presented a stable, 12W distortion corrected adaptive system.

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