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Multi-watt continuous-wave diode-pumped $Nd:YVO_4$ adaptive laser resonator

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Abstract: We present for the first time, results of a continuous-wave diode-pumped $Nd:YVO_4$ adaptive laser resonator producing more than 6.5W output, in a single longitudinal-mode TEM_{00} beam with laser beam quality parameters, $M^2_x<1.3$ and $M^2_y<1.1$.

OCIS codes: (140.3480) Lasers, diode-pumped; (140.4780) Optical resonators; (190.0190) Nonlinear optics:

Diode-pumped solid-sate lasers are of growing technological importance as they increasingly replace existing lasers or indeed find new applications that require a compact, low maintenance laser source. However, scaling to higher power levels leads to problems arising from thermal heating of the laser medium such as thermally-induced lensing, pointing instability and stress-induced birefringence, and which are particularly pronounced in longitudinally-pumped amplifiers [1].

A solution to the thermally-induced problems, which uses a self-adaptive laser resonator architecture based on dynamic gain gratings, has been demonstrated in pulse-pumped solid-state lasers [2,3]. In this paper we present, for the first time, operation of a self-adaptive diode-pumped solid-state laser system capable of producing high power CW laser radiation with good beam quality, as shown in fig. 1. Both an injected and a self-starting version of the system will be presented.

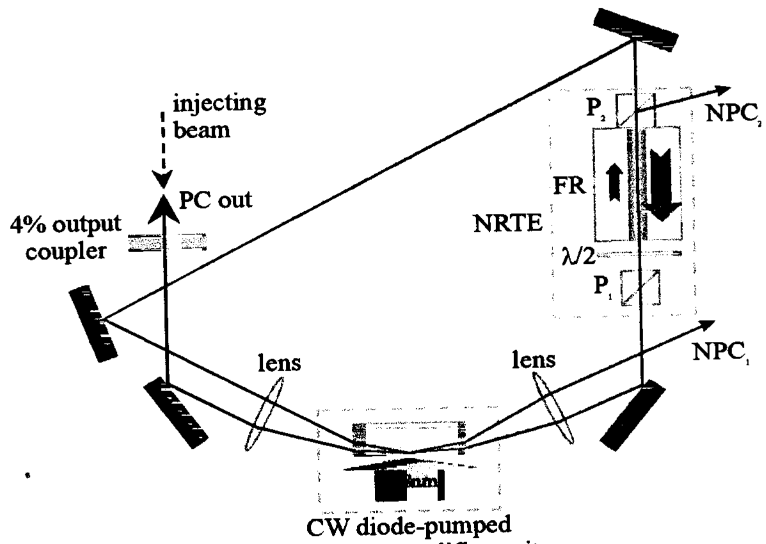

Fig. 1. Schematic diagram of the self-adaptive holographic loop resonator (with optional output coupler)

The core element is an amplifier unit comprising a thermoelectrically-cooled $Nd:YVO_4$ crystal pumped transversely by a 22W CW diode bar. In the injected version a single-frequency CW 1064nm beam is focussed with a lens into the crystal, and by employing a single internal reflection through the gain region, after Alcock *et al.* [4], a small-signal CW gain in excess of 24,000 has been obtained. After collimation by a second lens, the amplified beam is passed through a non-reciprocal transmission element (NRTE) [2] and is then looped back to self-intersect in the Nd:YVO_4 amplifier. The resulting interference pattern modulates the local inversion and leads to the formation of a volume gain hologram that can diffractively couple radiation back around the loop. As distortions experienced by the injected loop radiation are encoded in the hologram, the backward lasing mode can read out this phase information and thereby unravel these distortion on passing back around the system. A stable single-longitudinal mode CW output in excess of 6.5W was measured in a TEM_{00} beam with an M^2 <1.3 in the horizontal and <1.1 in the vertical, despite the presence of thermally-induced distortions. The self-adaptive nature of the resonator was further verified by the insertion of a severe phase aberrator into the loop which was observed to have very little effect on both the high output beam quality and the power level. The behaviour of the output power was also investigated as a function of both the injected power and the intracavity NRTE transmission. Figure 2 shows the high quality (elliptical) TEM_{00} spatial mode obtained from the system, and also a Fabry-Perot interferogram (FSR≈150MHz) illustrating the single-longitudinal mode frequency characteristics.

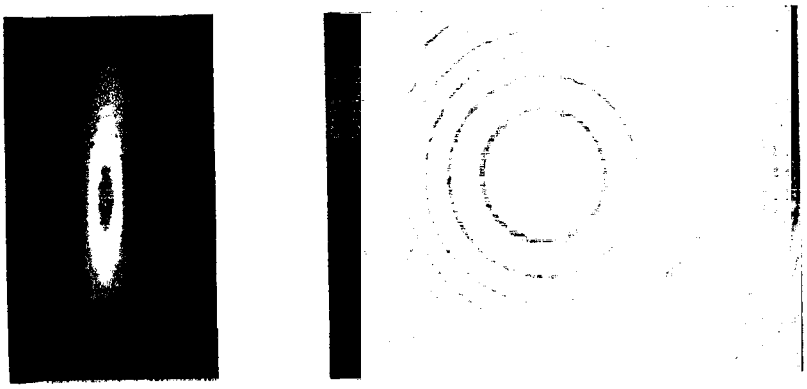

Fig. 2. Spatial and spectral properties of the self-adaptive laser output radiation

A self-starting version of the system was constructed by replacing the injecting beam by a 4% output coupler, as shown in fig. 1. Operating at a somewhat lower gain, the self-starting system yielded an output power of ≈3W in a TEM_{00} mode and was again shown to be insensitive to intracavity phase distortions.

In conclusion, we have demonstrated an efficient, high-power (>6.5W) CW diode-pumped solid-state laser which produces high TEM_{00} beam quality in the presence of thermal distortions by virtue of its spatial adaptability.

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