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Mode-hop-free tuning in high-power intracavity-frequency-doubled Nd:YAG and Nd:YLF ring lasers

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ABSTRACT

By simple cavity length adjustment, continuous, mode-hop-free tuning over many axial-mode spacings has been observed in efficient, intracavity-frequency-doubled, single-frequency Nd:YAG and Nd:YLF ring lasers generating multiwatt output powers at 532nm and 526.5nm

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SUMMARY

Mode-hopping is an undesirable feature in many lasers, occuring when there are small changes in the cavity length or a change in position of the gain peak. In addition to their obvious applications as efficient visible light sources [1],[2], a further attractive feature of intracavity-frequency-doubled, single-frequency lasers is that axial-mode-hopping is suppressed [3], enabling much more robust single-frequency operation and allowing for the possibility of continuous frequency tuning over many axial-mode-spacings by means of only a simple cavity length adjustment.

The explanation for this behaviour is based on the fact that adjacent (non-lasing) axial modes are

further suppressed by an additional loss due to sum-frequency generation [4] which is twice the loss due to second harmonic generation experienced by the lasing mode. In a low loss resonator with efficient intracavity-frequency-doubling this extra loss can more than offset any gain advantage of adjacent modes closer to the gain peak. The net result is that continuous (mode-hop-free) tuning is possible over many axial mode spacings.

To investigate this effect further we have conducted experiments on a intracavity-frequency-doubled Nd:YAG ring laser end-pumped by a 20W diode bar, and more recently on a Nd:YLF ring laser end-pumped by two 20W diode bars. In each case, a simple bow-tie cavity design was employed, similar to that described in [1], with a Brewster-angled LBO crystal. In the case of Nd:YAG for a non-optimised laser mode size in the LBO crystal the laser produced ~1400mW of single-frequency output in the green at 532nm. By varying the cavity length we obtained a single-frequency, continuous (mode-hop-free) tuning range of ~40GHz corresponding to ~80 axial mode spacings. This range is consistent with predictions of a simple model accounting for the effects of nonlinear loss due to sum frequency generation.

Suppression of axial-mode-hopping has also been observed in a Nd:YLF laser. This laser offers the potential of an extended tuning range through its broader linewidth. Furthermore Nd:YLF is attractive for operation at high powers due to its superior thermo-optical properties on the σ-polarisation compared to Nd:YAG, providing that appropriate steps are taken to avoid thermally-induced stress-fracture [5]. Thus, the expectation of improved conversion efficiencies should

allow for a further increase in the mode-hop-free tuning range. Preliminary results for this laser, end-pumped by two 20W diode-bars, include the generation of ~10.3W of single frequency 1053nm output in a TEM_{∞} beam (M^2<1.1), and ~6W of green output at 526.5nm (corresponding to ~7.8W generated internally in the LBO) and a conversion efficiency of ~5% with respect to intracavity power. So far, the mode-hop-free tuning range has been limited to only ~7 axial-mode spacings by etalon effects due to imperfect AR coatings on the Nd:YLF rod. However, with better antireflection coatings and further optimisation of the resonator configuration a significantly extended tuning range spanning a considerable fraction of the gain bandwidth is expected.

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