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SINGLE-FREQUENCY Nd:YLF MASTER-OSCILLATOR POWER AMPLIFIER WITH 15W OUTPUT AT 1053nm

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Power-scaling of diode-pumped single-frequency solid-state lasers has been hindered by strong thermal effects which can degrade beam quality, and often make the selection of a single-axial-mode difficult. A further problem is that changes in cavity length due to temperature fluctuations become more pronounced at high pump powers leading to mode-hopping. The latter problem can be eliminated by employing frequency selective components intracavity and by active stabilisation of the cavity length to an external reference cavity, but at the expense of considerable increase in complexity and cost.

Here we report an efficient diode-end-pumped Nd:YLF master oscillator and power amplifier (MOPA), with >15W of reliable single-frequency output in a beam with $M^2<1.1$ at 1.053μm. Our design exploits the weak thermal lensing behaviour on the lower gain σ-polarisation to avoid degradation in beam quality, and utilizes a simple passive technique to suppress axial-mode-hopping in the master oscillator. The master-oscillator employed a bow-tie ring cavity with a Faraday rotator and half-wave plates to enforce unidirectional and hence single-frequency operation. The cavity also included a Brewster-angle lithium triborate (LBO) frequency doubling crystal maintained at ~162°C for non-critical phase-matching at 1.053μm. The cavity was designed to efficiently out-couple the fundamental by using a mirror with 10% at 1.053μm, with only a small loss in efficiency due to intracavity second harmonic generation. The nonlinear loss experienced by adjacent (non-lasing) axial modes due to sum-frequency generation with the oscillating mode is approximately twice that experienced by the oscillating mode due to second harmonic generation. The net result is that that mode-hopping is suppressed and the lasing frequency can be tuned continuously (mode-hop-free) over many axial-mode-spacings by simply adjusting the cavity length. The master-oscillator was end-pumped by a beam-shaped diode-bar and produced 5W of single-frequency output at 1.053μm in a beam with $M^2<1$. By adjustment of the cavity length continuous mode-hop-free tuning of the fundamental by over 8GHz, corresponding to ~14 axial mode-spacings could be achieved. Thus, under free-running operation the laser could be operated single-frequency (mode-hop-free) for very long periods of time without the need of cavity length adjustment.

To increase the power further a dual rod diode-end-pumped Nd:YLF double-pass amplifier scheme was employed. The two Nd:YLF rods were rotated by 90° relative to each other to compensate for astigmatism, and had low Nd concentrations (~0.5%), to minimise energy-transfer-upconversion and its deleterious effects on gain and beam quality. With 45.5W of incident diode power the amplifier had a small signal gain of ~50 and produced 15.5W of output for ~5W input from the master-oscillator in a diffraction-limited beam with $M^2<1.1$. The relatively high optical-to-optical efficiency of this MOPA approach and the absence of any degradation in beam quality indicates that further power-scaling via the use of additional amplifiers should be easily achievable.