7.5W Alexandrite Ring Laser

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We report significant improvement in the performance of high-power Alexandrite ring lasers. In this work we demonstrate preliminary results for a red-diode-pumped Alexandrite laser with bidirectional output power of 7.5W with a near-diffraction limited output mode at 757nm.

Over the last decade, red-diode-pumped Alexandrite (Cr^{3+}:$BeAl_2O_4$) lasers have emerged as a highly promising laser material in the near-infrared due to its low-cost, small footprint, power scaling performance [1] as well as single-step second-harmonic-generation (SHG) to the UV-blue region. Single-longitudinal-mode (SLM) operation for applications including remote sensing and quantum technologies using diode-pumped solid-state lasers can be realised using a unidirectional ring resonator. SLM diode-pumped Alexandrite lasers have been demonstrated at the watt-level [2,3], however, for higher power operation, which is essential for efficient SHG conversion, multi-watt operation is necessary.

Fig. 1(a) shows the setup for the diode-pumped Alexandrite ring laser for bidirectional operation. Pumping is provided by a 200µm fibre-coupled red-diode at λ_p = 640nm. The pump was focused by an aspheric lens of focal length f_p = 79mm to a waist radius of w_p = 225µm. The 6mm long, 0.2 at.% Cr-doped Alexandrite crystal was mounted in a water-cooled copper mount at 20°C. The ring cavity was formed of four plane mirrors. Two dichroic mirrors (DM) were highly transmissive (HT) at λ_p and highly reflective at λ_l~755nm, a highly reflective mirror at λ_l (HR) and an output coupler (OC) with reflectivity R_{OC} = 98%. The cavity size was set to L_x = 30mm and L_y = 25mm. A convex-mirror (CM) and quarter-waveplate (QWP) were used to retro-reflect the residual pump.

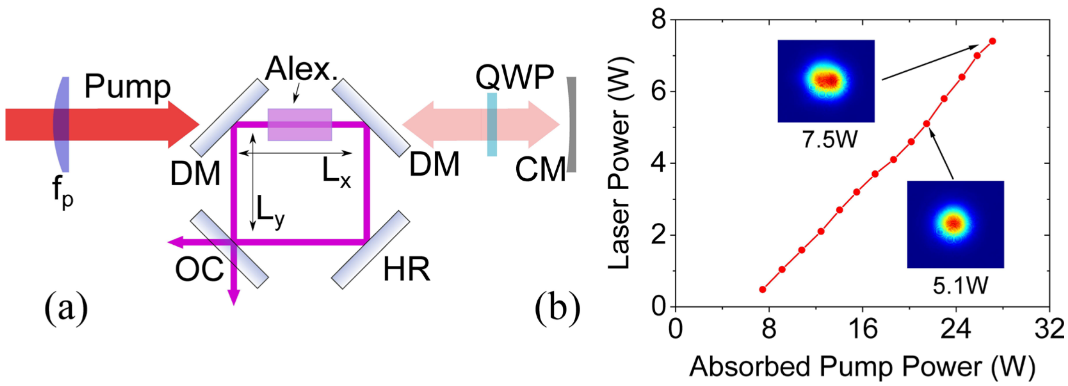

Fig. 1 (a) Diode-pumped Alexandrite ring laser with pump retro-reflection. (b) Laser power as a function of absorbed pump power for bidirectional ring cavity with mode profile at 5.1W and 7.5W of laser power.

Fig. 1(b) shows the total laser power as a function of the absorbed pump power. 7.5W was obtained at an absorbed pump power of 27.1W (28% optical efficiency) with a slope efficiency of 35%. At the maximum laser power, the beam quality was measured to be M^2 = 1.85 x 1.60, in the x-direction and y-direction, respectively. The laser wavelength was centred at 757nm with a linewidth (FWHM) of <1nm.

Better beam quality was achieved at lower pump power with M^2 < 1.1 in both directions at a laser power of 5.1W, as indicated in Fig. 1(b). The gradual degradation in beam quality above 21.5W is due to the increasing thermal lens strength reducing the TEM_{00} mode size at the gain medium. Optimal mode-matching is therefore obtained with a slightly higher-order mode. Improved beam quality should be possible with further optimisation of the cavity size.

These results show promising potential for a multi-watt wavelength tunable single-longitudinal-mode laser in the near-infrared and in the ultra-violet by means of second-harmonic-generation, which is currently in progress. Breakthrough in near-diffraction limited >10W Alexandrite lasers has also been recently demonstrated and will be presented in addition.

References

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