High Power Alexandrite Laser for Tunable UV-Blue Generation

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We present, to the best of our knowledge, the first ever demonstration of tunable UV-blue generation using a diode-pumped Alexandrite laser. A high-power and narrow-linewidth red-diode-pumped Alexandrite laser operating with diffraction limited output ($M^2 < 1.1$) is frequency doubled using a BBO crystal to generate 375-385nm continuously tunable light.

Advancements in Quantum Technologies have brought about an increased demand for laser sources in the UV-blue region (360-400nm) for applications including Doppler cooling and entangled photon pair generation. Diode-pumped solid-state lasers provide excellent mode quality, linewidth and stability but with limited direct emission in the UV-blue region. Red-diode-pumped Alexandrite lasers have undergone rapid development recently with compact systems achieving multi-watt TEM_{00} operation [1]. Their broad emission at 720-800nm matches the UV-blue region via second-harmonic-generation (SHG).

Fig. 1(a) shows the setup for the system. The Alexandrite laser is pumped by a 17W fibre-coupled red-diode at λ_p = 640nm focused to a waist radius of w_p = 225µm. The laser cavity is formed of: a dichroic curved mirror of curvature R = 300mm (convex) with high transmission (HT) coating at λ_p and highly reflective (HR) at the lasing wavelength λ_l =720-800nm; and an output coupler (OC) with reflectivity R_{OC} = 99%. The cavity length is around 60mm. The 4x4x6mm c-cut Alexandrite crystal with 0.2at.% Cr-doping was mounted in a water-cooled copper mount at 15°C. Wavelength tuning was obtained by rotating a 1mm thick intra-cavity birefringent filter (BiFi). SHG testing was performed by placing a BBO crystal (4x4x10mm) for Type I critical phase matching (θ = 30.8° and φ = 90°) at the laser output. The laser mode size at the OC was measured to be around 150µm.

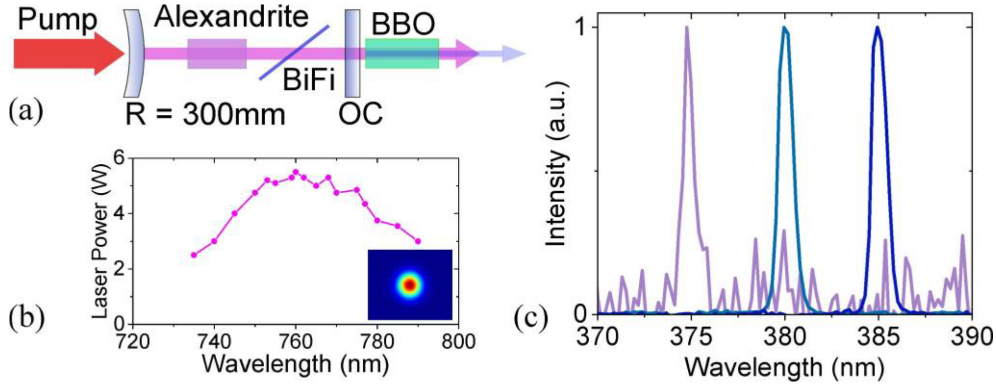

Fig. 1 (a) Wavelength tunable, diode-pumped Alexandrite laser and single-pass SHG generation using BBO. (b) Laser power as a function of wavelength. (c) SHG laser spectra at 375, 380 and 385nm.

Fig. 1(b) shows the laser power as a function of the wavelength. Continuous wavelength tuning at 735-790nm was obtained with >2.5W of laser power across the entire tuning range, and a maximum power of 5.5W at 760nm (17W absorbed pump power). The tuning was limited by the 57nm free-spectral-range of the BiFi. The beam quality was measured to be $M^2 < 1.1$ across the entire tuning range with a measured laser linewidth (FWHM), limited by the resolution of the spectrometer, of 0.2nm. SHG measurement were optimum at around 760nm with ~1mW of output power measured at 380nm. 375-385nm continuous tuning was obtained by rotating the BiFi and angular rotation of the BBO crystal. Fig. 1(c) shows the spectra at 375, 380 and 385nm.

Current work is aimed at improving the power levels and efficiency using a quasi-phase-matched material such as periodically poled lithium-niobate (PPLN) which has high nonlinearity and no spatial walk-off. PPLN waveguides have recently become highly favourable due to their high conversion efficiency, small size and low input power requirements [2]. The implementation of PPLN waveguides with red-diode-pumped Alexandrite lasers for a low-cost, compact and efficient UV-blue laser source is currently in progress and will be presented at the conference.

References

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