Wavelength-Tunable Internally-Frequency-Doubled Yb-doped Fiber Laser

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High power continuous-wave (cw) laser sources emitting in the visible spectral region have a diverse range of applications in areas such as laser processing of materials, projection displays, medicine and sensing. Fiber lasers using cladding-pumped architectures can yield very high power in the near-infrared wavelength regime [1], and hence offer the prospect of high power levels in the visible regime via nonlinear frequency conversion. High conversion efficiencies can be achieved using the technique of external resonant cavity second harmonic generation, but this approach is complicated by the need for a single frequency fiber source and by the need for active cavity length stabilisation [2]. In this paper we present a wavelength-tunable visible source based on a cladding-pumped fiber laser with a simple internal resonant enhancement cavity for efficient frequency doubling. The laser yields cw output at power levels >1 W in the wavelength range from 539 nm to 558 nm.

The experimental configuration (shown in Fig. 1) comprised a double-clad fiber with a polarization-maintaining single-mode Yb-doped core in a simple standing-wave resonator. Feedback for lasing was provided by a diffraction grating at one end of the fiber, and by an external cavity containing a resonant enhancement cavity at the opposite end of the fiber. The enhancement cavity comprised a Brewster-angled LiB_3O_5 (LBO) crystal placed in an oven and cut for type I non-critical phase-matching. In this scheme, the fiber laser automatically lases on axial modes that are resonant in the enhancement cavity avoiding the need for active stabilisation. The fundamental laser power is enhanced in the resonant cavity by virtue of its relatively low loss yielding high second harmonic conversion efficiency.

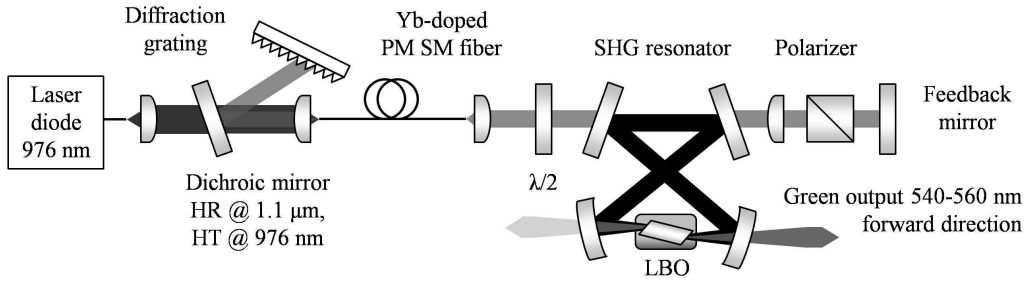

Fig. 1. Experimental set-up for internal frequency doubling in a fiber laser

Using this arrangement >30% of total fundamental laser power (10.6 W) was converted to green, yielding 2.3 W (i.e. 3.2 W inside the LBO crystal) of linearly-polarized cw output at 546.5 nm (1.5 nm linewidth) in the forward direction with very good spectral and temporal stability (Fig. 2a). The internal conversion efficiency with respect to fundamental power entering the enhancement cavity was >50%. The corresponding green power in the reverse direction was <100 mW. The laser could be tuned over the range of 539 -558 nm with >1 W output power by adjusting the grating angle and the LBO crystal temperature to maintain phase-matching (Fig 2b). The beam propagation factor (M^2) was measured to be <1.25. The prospects for further scaling of visible power via this approach will be discussed.

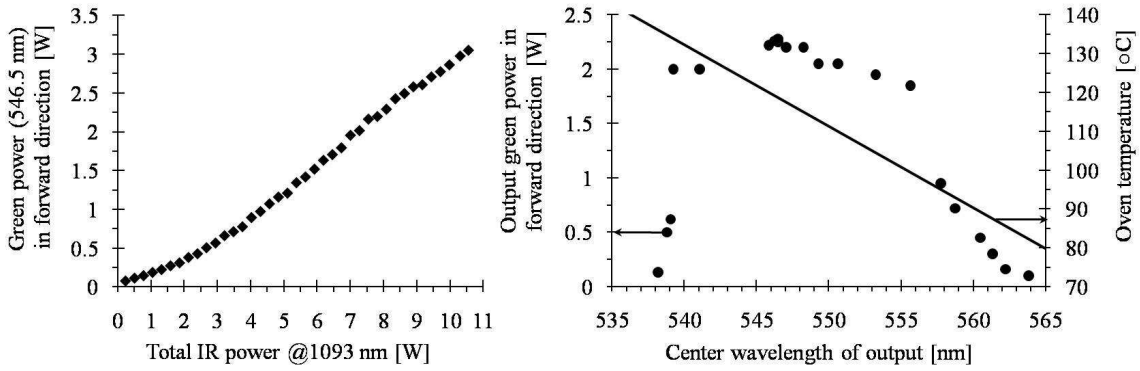

Fig. 2. a) Green power generated in forward direction vs. total fundamental power generated
b) Tuning curve of the frequency-doubled Yb-doped fiber laser

References

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[2] T. Sudmeyer et al., "Efficient 2nd and 4th harmonic generation of a single-frequency, continuous-wave fiber amplifier", Opt. Express **16**(3), 1546-1551 (2008).