236mW Average Second-Harmonic Power Generated from Periodically Poled Silica Fibres

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Thermally poled silica fibres are an attractive all-fibre solution to frequency conversion of high power fibre lasers. In comparison to nonlinear crystals, they offer inherently lower insertion losses, higher optical damage threshold, greater stability and ruggedness intrinsic to all-fibre solutions. Moreover, the relatively low second-order-nonlinearity (0.1-0.2pm/V) can be compensated by extending the length of the periodically poled fibre.

In this work, the generation of as much as 236mW single-mode second-harmonic (SH) light from a periodically poled fibre (PPSF) pumped by a high power fibre laser is demonstrated. The result shows the ability of the PPSF to handle high average pump powers (~1.6W) without any signs of decay of the second-order nonlinearity from day to day operation. The average power shows a 35-times improvement over the best results on PPSF to date and the corresponding average efficiency exceeding 15% was achieved with 20-times lower peak power [1]. The PPSF device was fabricated by the insertion of wire electrodes into the holes of a specialty twin-hole germanosilicate fibre (Figure 1(a) -inset). The device was subsequently poled at an optimum temperature of 210°C and the simultaneous application of 11kV DC within the electrodes over a 1 hour period. A uniform $\chi^{(2)}$ of ~0.12pm/V was measured after poling. Quasi phase matching (QPM) for second-harmonic-generation (SHG) was achieved through point-by-point periodic (Λ=66.5μm) UV erasure [2] at optimised conditions over a record length of 32cm. Splice losses to SMF28 fibre were measured to be 0.5dB at 1550nm and 1.0dB at 780nm. The device was initially characterised using a 9mW continuous-wave tunable external cavity diode laser. The acceptance bandwidth of the device was measured to be 0.46nm in agreement with theoretical predictions. The almost perfect sinc^2 profile of the tuning curve is a testament to the extremely good quality of the quasi-phase matched grating over the whole 32cm length (Figure 1(a)). From this measurement, the normalised conversion efficiency was estimated to be $7.34\text{x}10^{-2}$%/W, translating to a 3.3-fold improvement in comparison to the previously best reported value [2] and 14-fold over [1].

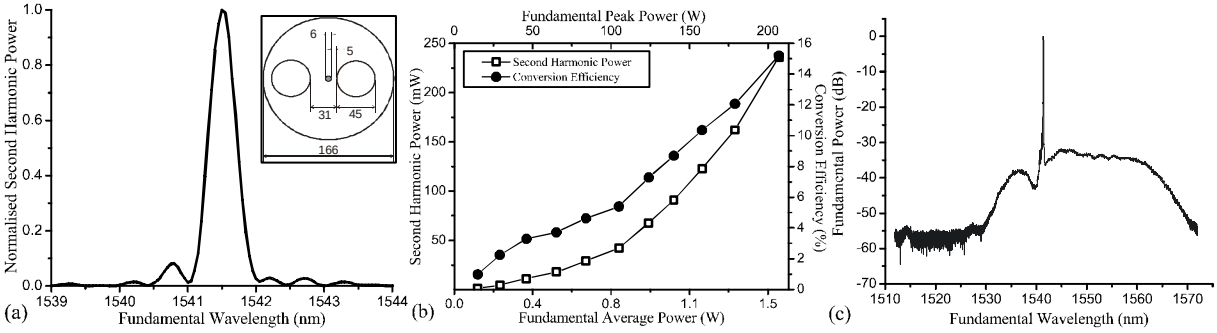

Figure 1 (a) Second-harmonic tuning curve of the PPSF device (inset) specialty twin-hole fibre, dimensions in μm (b) Average second-harmonic power and average conversion efficiency (c) Er/Yb fibre laser source spectrum (RBW 0.01nm)

A high power tunable Er/Yb fibre laser MOPA source of 3MHz repetition rate and 2.5ns pulse duration was employed to characterise the PPSF device. The quadratic dependence of the average SH power at the wavelength of 771.75nm against the fundamental source power operating at 1541.5nm is shown in Figure 1(b). The maximum average conversion efficiency was calculated to be 15.2% with just 207W of fundamental peak power (Figure 1(b)). The obtained average SH power was 236mW in a single-mode (LP_{01}). A further improvement of the conversion efficiency is theoretically possible by scaling to even longer lengths, through the enhancement of the effective nonlinearity or with higher peak power fibre laser sources [3].

References

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