

Mid-infrared-to-telecom wavelength conversion via four-wave mixing in a silicon core fibre

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The mid-infrared spectral region is of great interest for many applications in areas such as environmental sensing, free space communications, and medical diagnostics. However, accessing tuneable sources in the mid-infrared can be difficult due to the limited gain media in this region. An alternative approach is to make use of existing high power telecoms band pump lasers and couple them with highly nonlinear waveguides that offer efficient wavelength conversion via processes such as four-wave mixing (FWM) [1]. An advantage of this approach is that the signals can also be converted back to the telecom band where there are excellent diagnostic tools. In this regard, silicon core fibres (SCFs) have recently emerged as a promising platform for FWM processes due to their high damage threshold, strong nonlinear refractive index and extended infrared transmission (1.1 ~ 7 μm) [2]. Moreover, as they are clad in silica, the SCFs are directly compatible with the fiberized pump sources, opening a route for the development of robust all-fibre systems [3].

Here, we demonstrate broadband wavelength conversion from the mid-infrared to the telecom band via FWM in a SCF. The SCF used in this work was fabricated via a modified drawing tower method with a furnace constructed from a CO laser system [4]. The as-drawn SCF had a core diameter of 5.6 μm , and so a fibre tapering approach was applied to scale the core down to 1 μm , over a length of 7 cm, to optimise the dispersion for the FWM process [5]. The tapered SCF had a low loss of 0.2 dB/cm in the telecom band. The up- and down-taper transition regions were retained to facilitate more efficient optical coupling (inset of Fig. 1a). A continuous-wave (CW) pump laser at $\lambda=1.56 \mu\text{m}$ was mixed with a tuneable CW laser (2.1-2.4 μm) through a wavelength division multiplexer and coupled into the SCF with a lensed fibre, as shown in Fig. 1a. The output light was collected with a lens system and fibre coupled to the two optical spectrum analysers used to measure the spectra in the different bands. Fig. 1b shows the measured transmission spectra. A maximum conversion efficiency ($CE = P_{idler}/P_{signal}$) of ~ 37.6 dB was obtained with the signal wavelength set to 2265 nm. Thanks to the optimum phase-matching condition of this fibre, a broadband wavelength conversion of 1100 nm was achieved with a coupled-in pump power of only 35mW, significantly broader than our previous results with a pulsed laser pump [6]. By further optimising the fibre dispersion, the FWM wavelength conversion can be extended to longer wavelengths, opening a route to developing a compact all-fibre wavelength converter across the mid-infrared region.

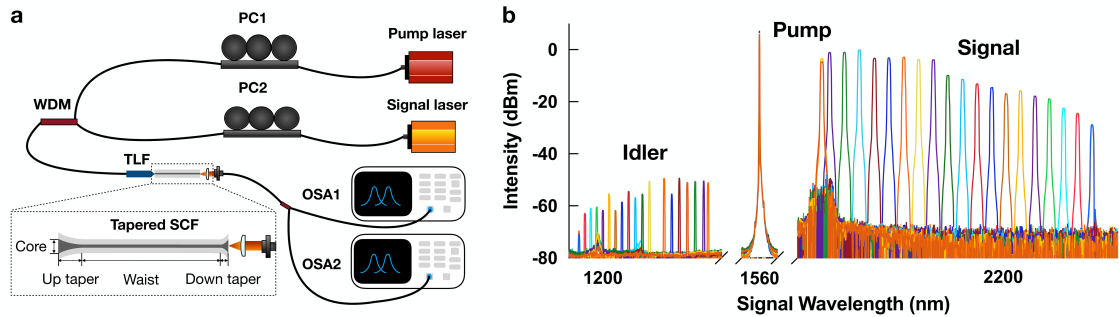


Fig. 1a Schematic of the experimental setup for FWM in a SCF fibre. Inset: symmetric tapered SCF profile. **b** Measured transmission spectra from the SCF output as the signal wavelength is tuned from 2 to 2.4 μm , pumping at 1.56 μm .

References

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