Semiconductor optical fibres for nonlinear applications in the mid-infrared

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Nonlinear silicon photonics in the mid-infrared (mid-IR) is attracting increased interest with applications ranging from broadband telecommunications to sensing and spectroscopy. Recent reports have shown that hydrogenated amorphous silicon (a-Si:H) can exhibit low transmission losses, a high refractive index similar to the crystalline material, an even higher Kerr nonlinearity, though is much cheaper to produce [1]. In this paper we extend the characterization of our a-Si:H core fibres beyond the telecommunications window of $\sim 1.5\,\mu$m and present the first measurements of the transmission properties up to the edge of the mid-infrared regime. The results show that the nonlinear figure of merit ($\mathrm{FOM_{NL}} = \mathrm{n_2}/\beta_{\mathrm{TPA}}\lambda$) increases dramatically over this region, with $\mathrm{FOM_{NL}} > 20$ around $2\,\mu$m and above in Fig. 1(a) which open up the possibility of these fibres for nonlinear applications in the mid-IR regime [2].

Our fibres are fabricated by depositing the a-Si:H material into silica capillaries with inner diameters that are micrometre sized via a high pressure chemical deposition technique. In the mid-IR region, the unwanted effects of two-photon absorption (β_{TPA}) in nonlinear silicon optical devices can be greatly reduced. However, the nonlinear refractive index (n_2) stays consistently large, and thus the $\mathrm{FOM_{NL}}$ increases significantly as shown in Fig. 1(a). Our initial nonlinear characterizations in a $5.7\,\mu$m diameter core only revealed fairly modest spectral broadening when pumping at $2.05\,\mu$m using a Ti:Sapphire based OPO with 200 fs pulses at 80 MHz in Fig. 1(b). By moving to a smaller $1.7\,\mu$m core size, not only is the effective fibre mode area reduced, but the zero dispersion wavelength is shifted closer to $\sim 2\,\mu$m, resulting in much larger broadening for lower input peak powers. The spectra plotted in Fig. 1(c) show that a 700 nm continuum can be generated over a 20 dB scale, similar to what has been measured in nanoscale a-Si:H waveguides on-chip [3]. In summary, these results suggest that a-Si:H core optical fibres are a viable platform for nonlinear applications extending beyond telecoms, and into the short wavelength end of the mid-IR regime where applications include supercontimuum source generation for gas detection and medical diagnostics.

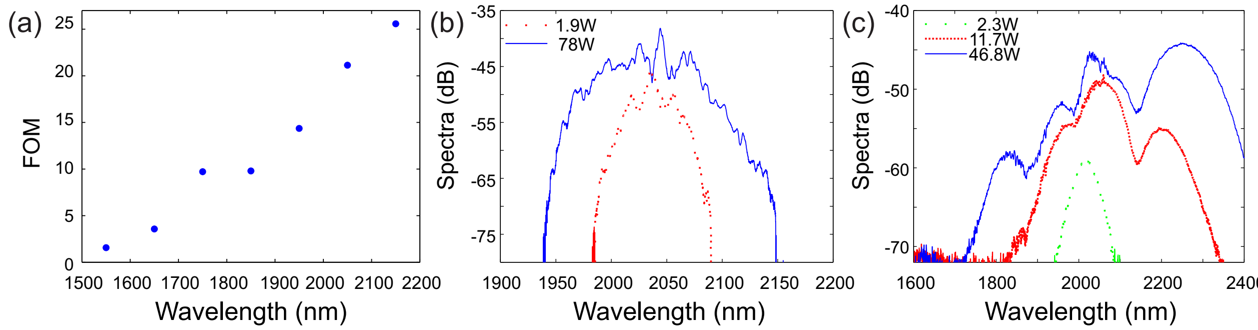

Fig. 1. (a) Wavelength dispersion of the FOM; Spectral evolutions of a-Si:H fibre when pumped at $2.05\,\mu$m with core size (b) $5.7\,\mu$m and (c) $1.7\,\mu$m. Coupled input peak powers given in the legend.

References

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