Mid-IR coherent supercontinuum generation in all-solid step-index soft glass fibers

Alexander M. Heidt, Francesco Poletti, Jonathan Price, and David J. Richardson
Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ, United Kingdom
Author e-mail address: A.Heidt@soton.ac.uk

Abstract: We numerically demonstrate that normal dispersion femtosecond pumping of tailored soft glass step-index fibers can generate highly coherent mid-IR supercontinuum light with two octaves bandwidth, suitable for recompression to few-cycle pulse durations.

OCIS codes: (060.2280) Fiber design and fabrication; (060.4370) Nonlinear optics, fibers.

Supercontinuum generation (SCG) in soft glass fibers is a promising approach to meet the growing demand for broadband coherent mid-IR radiation in various research areas such as metrology, few-cycle pulse generation and next-generation telecom systems. However, most current mid-IR SC sources are based on anomalous dispersion pumping and produce very broad but temporally incoherent radiation. Recent work in the visible and near-IR spectral region has shown that SCG in suitably designed all-normal dispersion (ANDi) fibers can produce highly coherent broadband spectra, which can be temporally recompressed to Fourier-limited single cycle pulses [1,2].

In this contribution we investigate the transfer of this concept to the mid-IR as an attractive way to create a versatile source of coherent broad bandwidth light in this wavelength region. While in the visible and near-IR complex small core silica microstructured fibers are mandatory to obtain the required flattened dispersion profiles [1], they can be realized in the mid-IR with simple step-index fibers (SIF) with relatively small refractive index contrast ($\Delta n \sim 0.05$-0.2) [3]. Such SIF can be based on glasses of the same family with tailored compositional variations. For example, Fig. 1 a) shows the dispersion profile for a tellurite based (TeO_2ZnO) SIF with core diameter d = 2.7 µm and index contrast Δn=0.13. It exhibits normal and flat near-zero dispersion in the range 2 – 4.5 µm and high nonlinearity γ, calculated to be around 500 $W^{-1}km^{-1}$ at 2 µm wavelength.

Fig. 1 b) shows the results of single-shot numerical SCG simulations for 200 fs pump pulses at λ_0 = 2µm central wavelength and 15 cm fiber length. Relatively smooth and flat spectral profiles with bandwidths of up to two octaves are achievable with moderate pump peak powers around 10 kW. Note that identical spectra can be generated with longer pump pulses for constant peak power and increased fiber length. These spectra are perfectly coherent over their entire bandwidth, Fig. 1 c) shows the first order coherence function $|g_{12}^{(1)}|$ exemplary for the broadest spectrum. Optimization of the fiber design and material to maximize bandwidth, spectral flatness and temporal compressibility will be discussed. In the temporal domain, a single pulse is conserved during the SCG process with smooth phase distribution, which is suitable for recompression to few-cycle durations.

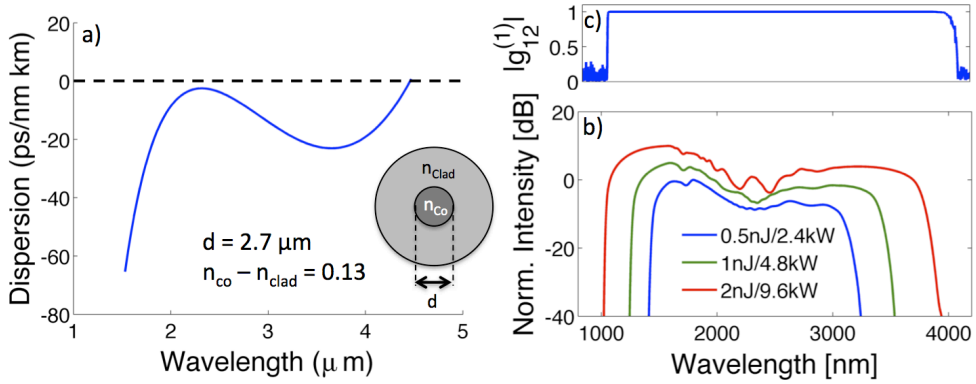

Fig.1. a) Dispersion profile of a dispersion-flattened tellurite step-index fiber. b) SCG simulation results for 200 fs pump pulses of varying energy at λ_0=2 µm and 15 cm fiber length. c) First order coherence function for the broadest simulated spectrum.

References

[1] A. M. Heidt, "Pulse preserving flat-top supercontinuum generation in all-normal dispersion photonic crystal fibers", J. Opt. Soc. Am. B **27,** 550-559 (2010).
[2] S. Demmler, J. Rothhardt, A. M. Heidt, A. Hartung, E. G. Rohwer, J. Limpert, and A. Tünnermann, "Generation of high quality, 1.3 cycle pulses by active phase control of an octave spanning supercontinuum," Opt. Express **19**, 20151 – 20158 (2011).
[3] F. Poletti, X. Feng, G. M. Ponzo, M. N. Petrovich, W. H. Loh, D. J. Richardson, "All-solid highly nonlinear singlemode fibers with a tailored dispersion profile," Opt. Express **19**, 66 – 80 (2011).