

Technical University of Denmark



Coherent multi-octave spanning supercontinuum in tapered sulphide fibres.

Kubat, Irnis; Mägi, Eric; Hu, Tomonori; Bang, Ole; Eggleton, Ben; Hudson, Darren

Publication date:
2015

Document Version
Peer reviewed version

[Link back to DTU Orbit](#)

Citation (APA):

Kubat, I., Mägi, E., Hu, T., Bang, O., Eggleton, B., & Hudson, D. (2015). Coherent multi-octave spanning supercontinuum in tapered sulphide fibres.. Paper presented at 14th annual CUDOS Workshop, New South Wales, Australia.

DTU Library

Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Coherent multi-octave spanning supercontinuum in tapered sulphide fibres

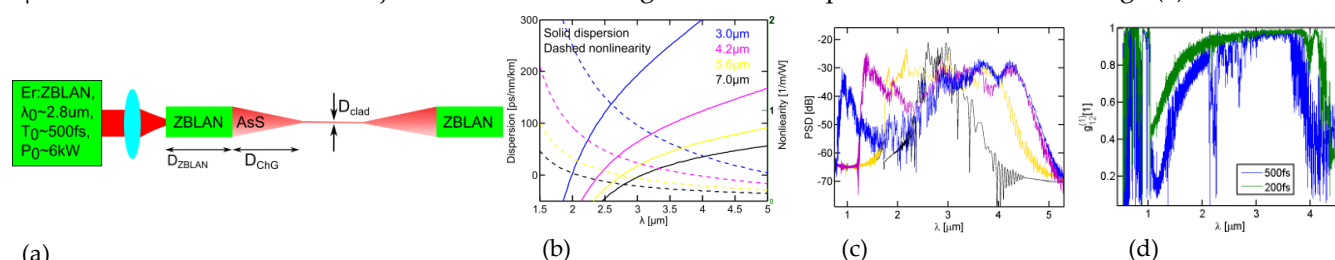
Irnis Kubat^{1,2}, Eric Mägi², Tomonori Hu², Ole Bang¹, Ben Eggleton², and Darren Hudson²
 Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS)

¹DTU Fotonik, ²University of Sydney

Phone: 0423735322, Email: ikub@fotonik.dtu.dk

A novel frequency comb design is proposed based on a newly developed ultrafast 3 μ m mid-infrared laser in conjunction with micro-taper chalcogenide fibre. The novel design allows for an all-fibre laser source yielding up to three octave coherent supercontinuum. The design is the first step in realising an all-fibre mid-infrared frequency comb.

Frequency combs are the new frontier in ultra-precise optical measurements utilised in applications such as optical clocks, ultra precise spectroscopy, etc. [1]. Especially, in the rapidly growing field of mid-IR photonics, mid-IR frequency combs have a great potential for delivering precise spectroscopic data in applications such as early stage cancer detection and food analysis [2,3]. Frequency combs consist typically of ultra-fast lasers such as mode-locked generating femto-second long pulses in conjunction with an appropriate nonlinear device that generates an octave spanning supercontinuum. The mode-locked laser in itself is almost a frequency comb as a single ultra-short pulse consists of many laser lines that are phase-locked with each other. However, for such short femto-second long pulses the pulse-to-pulse change in the so-called carrier envelope offset (CEO) needs to be stabilised. This has up to now been done through so-called self-referencing using the octave spanning supercontinua [1]. In this work we present a novel frequency comb laser design utilising a newly developed 3 μ m ultra-fast fibre laser in conjunction with a chalcogenide micro-taper such as seen in the Fig.1(a).



(a) Mid-infrared supercontinuum setup with a 2.8 μ m mode-locked laser, collimating lens and fluoride-chalc fibre taper. (b) Dispersion and nonlinearity at the taper waist for different cladding diameter. (c) Simulated supercontinuum. (d) Coherence for 200 and 500fs pulses durations supercontinuum in the 3 μ m taper.

The ZBLAN fibre laser pumped a chalcogenide fibre taper with ZBLAN fiber attached on either side. The fluoride fibre provided added handling and compensated the strong chalcogenide normal dispersion. This ensured that the pump pulse was transform limited at the taper waist. At the taper waist light was guided in the cladding allowing the pulse to undergo strong nonlinearity. This was due to the high chalc-air index allowing the fibre to be pulled down to very small dimensions as seen Fig. 1(b). The bandwidth of the supercontinuum was highly influenced by the dispersion and the nonlinearity at the taper waist. The widest continuum was achieved with a taper waist of 3 μ m. At smaller dimensions the dispersion increased further, which limited solitonic effects, and the mode cut-off moved to shorter wavelengths that also limited the achievable bandwidth of the continuum.

The 500fs pulses were short enough to provide a coherent continuum such as seen in Fig. 1(d). The temporal and spectral stability of the frequency combs are an important initial step in obtaining a stable comb structure. Reducing the temporal duration of the pump pulses from 500 to 200fs by compressing the pulses temporarily further reduced the pulse-to-pulse noise fluctuations and thereby improved the coherence of the supercontinuum [4].

[1] Jones *et al.*, Science **288**, 635-639, (2000)
 [2] Kubat *et al.*, Opt. Exp. **22**, 19169-19182, (2014)
 [3] Petersen *et al.*, Nat. Phot. Lett. **8**, 830-834, (2014)
 [4] Dudley *et al.*, Opt. Lett. **27**, 1180-1182, (2002)