Supercontinuum generation in an Yb3+ doped amplifier

Tobias Baselt[1,2,3], Christopher Taudt[1, 2], Andrés-Fabián Lasagni[2, 3], Peter Hartmann[1, 2]

1 West Saxon University of Applied Sciences Zwickau, Institute of Leupold-Institute for Applied Natural Sciences / Optical Technologies, D-08056 Zwickau
2 Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS, 01277 Dresden, Germany
3 Technische Universität Dresden, Institute of Manufacturing Technology, George-Bähr-Straße 3c, 01069 Dresden, Gemany

Motivation

- Coherent octave-spanning supercontinuum can be generated in photonic crystal fibers [1]
- For most applications, only a small part of the entire spectrum can be utilized [2]
- Techniques for spectral filtering which simultaneously enables an increase in the power spectral density, offer a clear advantage
- Biological transparency windows are defined by a local minimum in the absorption spectrum of biological tissue
- Higher spectral power density allow the investigation of deep structures
- The penetration depth of tissue can be greatly affected by the wavelength-dependent scattering

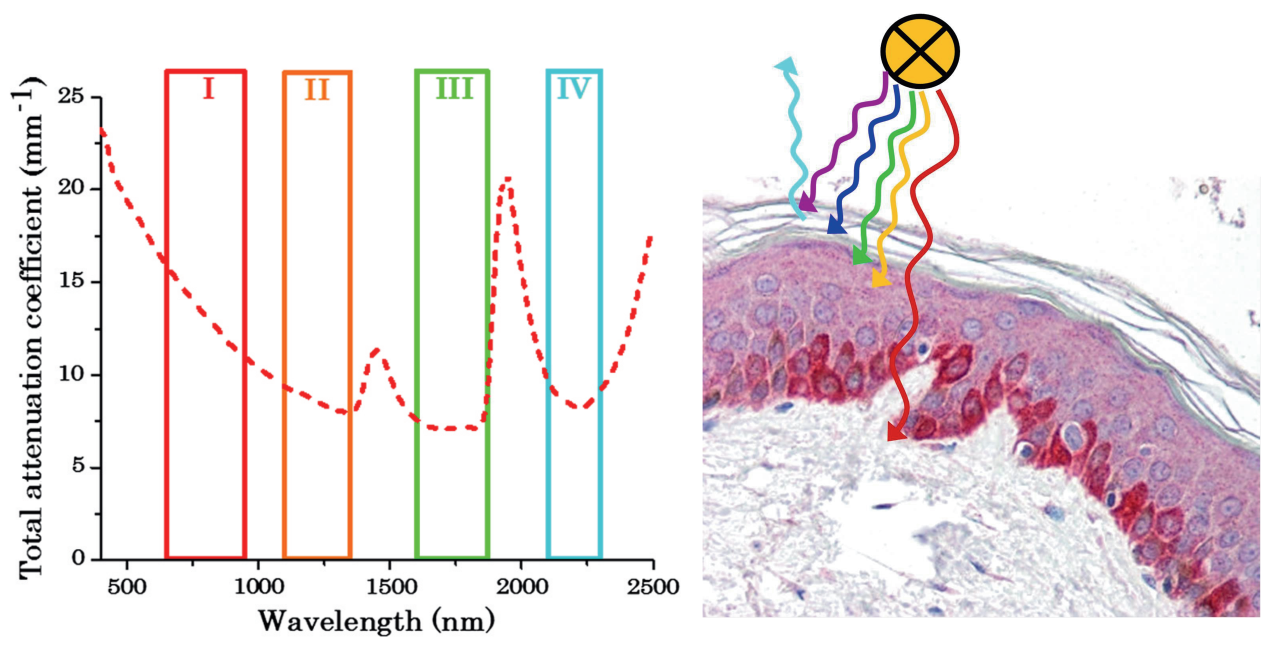


Figure 1. Biological transparency windows (a) and schematic representation of the wavelength-dependentpenetration depth (b) in biological tissue [3].

Experimental Setup

- The pump was free space coupled in the Yb^{3+} doped PCF
- The fiber was core pumped by a single mode diode laser (BL976- PAG700 / THORLABS) at 976 nm and pump power of up to 735 mW
- A notch filter is used as a dichroic mirror to launch the pump laser radiation at an angle of 20° (Fig.2)
- The microchip seed laser (1064-Q / Impex-hightech) has a peak power of 11 kW at a pulse length of 2.1 ns and a repetition rate of 12.5 kHz

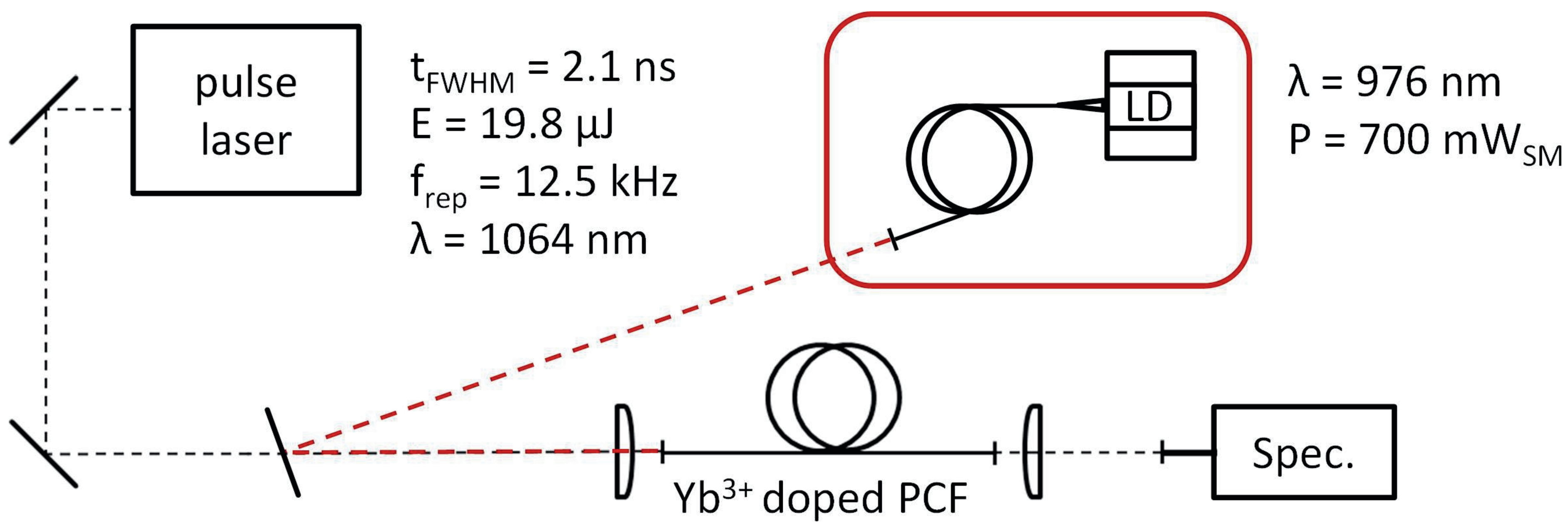


Figure 2. Schematic of the optical setup of the Yb3+ doped nonlinear photonic crystal fiber based amplifier. The nonlinear fiber medium enables the generation of supercontinuum at different levels of pump diode power. The setup used for the supercontinuum generation. MCL - Microchip Laser, LD – pump laser diode (λ = 976 nm), M - mirror, NM - notch mirror,Yb: doped PCF – fiber, LD - laser diode and Spec - spectrometer.

Fiber Desing

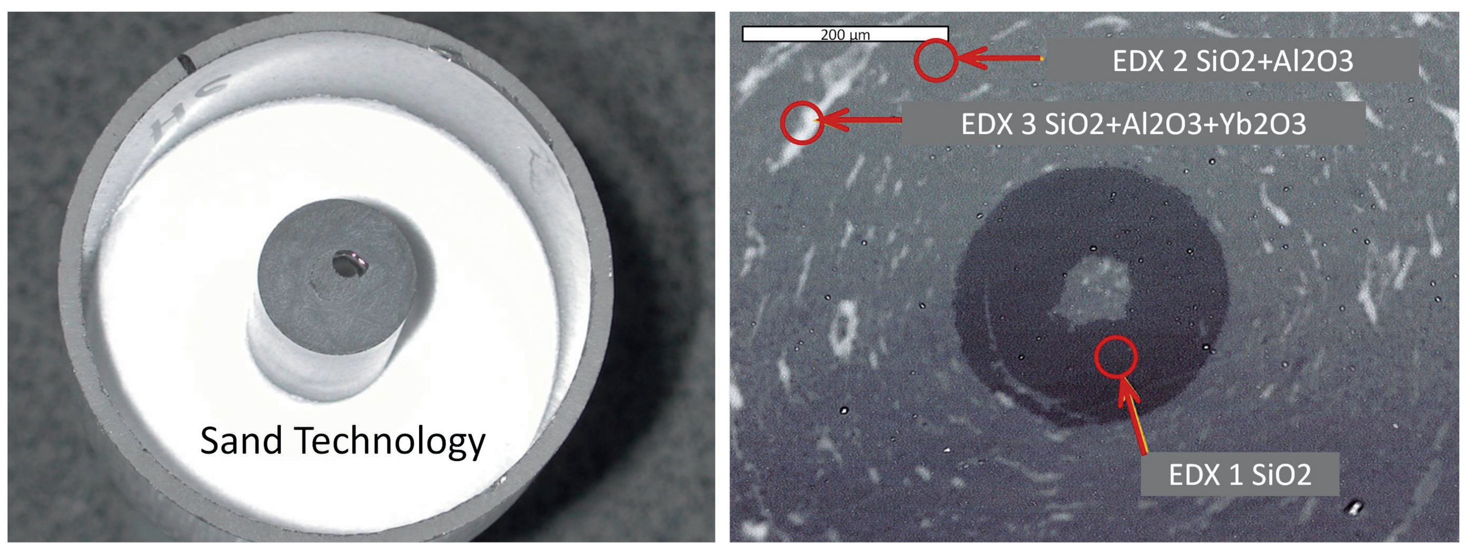


Figure 3. a)Sand technology based manufacturing of the doped core of the perform (silitec and fiberware) and b)Segregations in the doped core area and a technology-related symmetrical inhomogeneous material distribution. After the drawing process no segregations or symmetrical inhomogeneous material distribution were observed.

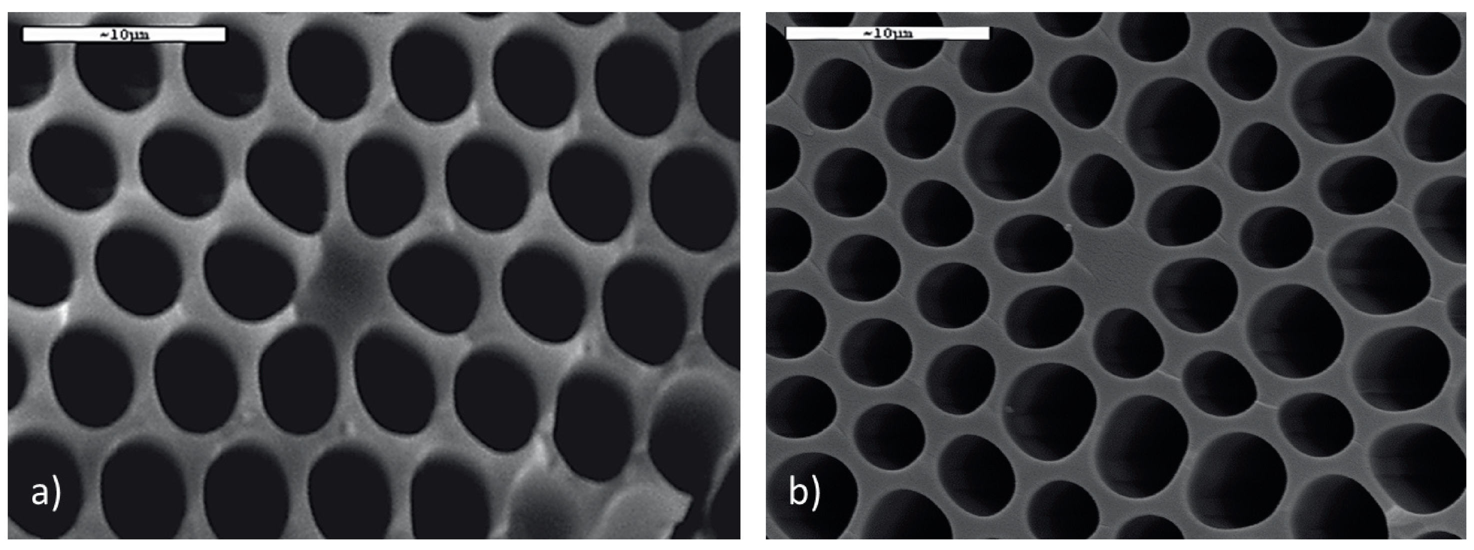


Figure 4. Scanning electron microscope image recording of the microstructured fiber geometry Yb3+ doped PCF (a) and without doping (b).

Table 1. Measured Parameters of the constituent fibers.

Item	PCF-1 Yb3+	PCF-2
core diameter [µm]	4.8 ± 0.1	4.5 ± 0.1
hole-to-hole distance [µm]	5.5 ± 0.1	5.1 ± 0.1
capillary diameter [µm]	4.5 ± 0.1	3.9 ± 0.5
V-parameter	5.8	5.8
zero-dispersion wavelength [nm]	1030 ± 3	1018 ± 3

Experimental Result

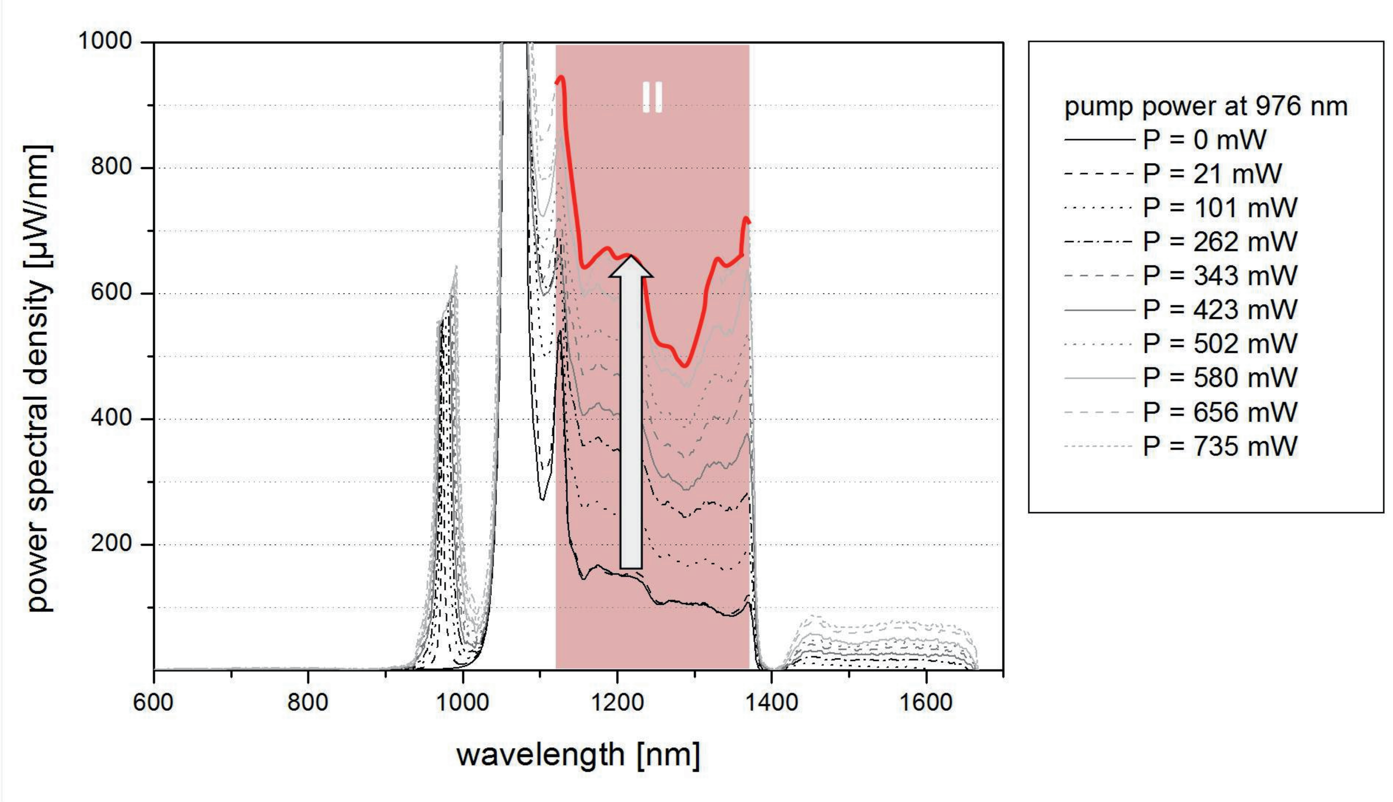
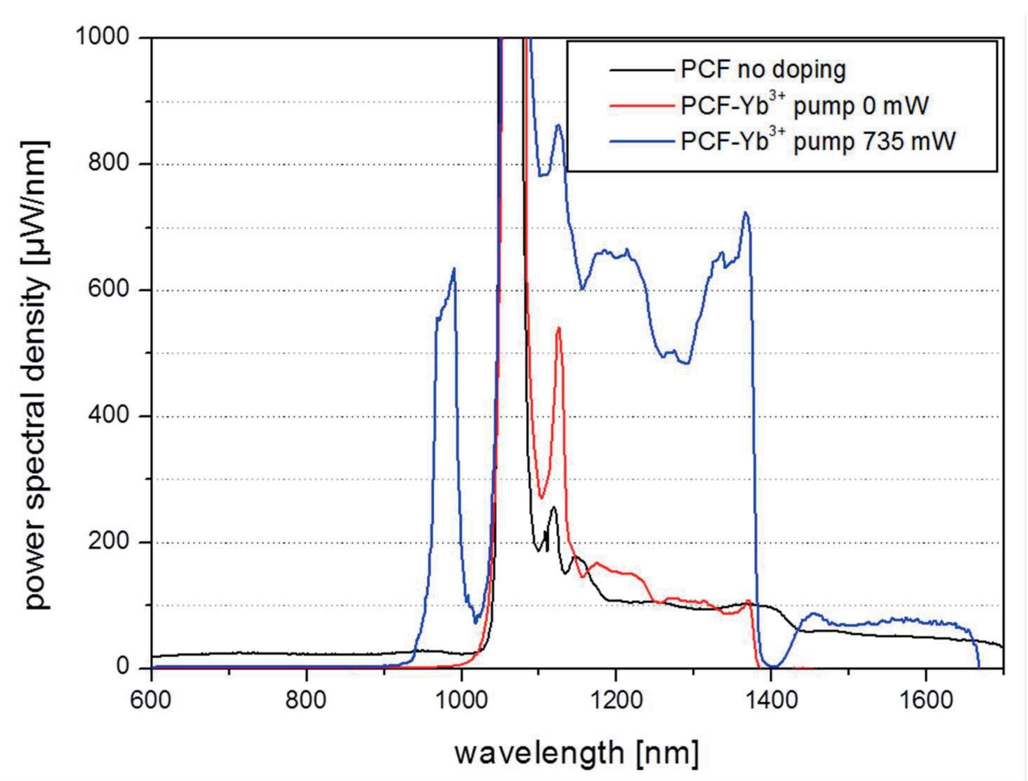


Figure 5. Power spectral density of the generated supercontinuum as function of the pumping power.



- the fiber offers the possibility to increase the spectral power density in the near infrared region
- the power spectral density increases by pumping at 976 nm by a factor of up to 7.2 (at 1365 nm) and averaged 4.3 times
- the shape of the spectrum can be significantly flattened from 7.8 dB variation without pumping to 2.9 dB variation at maximum pump power

Figure 6. Power spectral density of the generated supercontinuum in comparison to an undoped fiber.

Conclusion

- dispersions adapted Yb^{3+} doped PCF
- single mode operation
- zero-dispersion wavelength 1030 ± 3 nm
- increases power spectral density up to 7.2 times
- flattened from 7.8 dB variation without pumping to 2.9 dB
- higher performance in the second optical window

Acknowledgement

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