

Diode-Pumped MIR Supercontinuum Source

FOR APPLICATIONS WITHIN NON-DESTRUCTIVE TESTING

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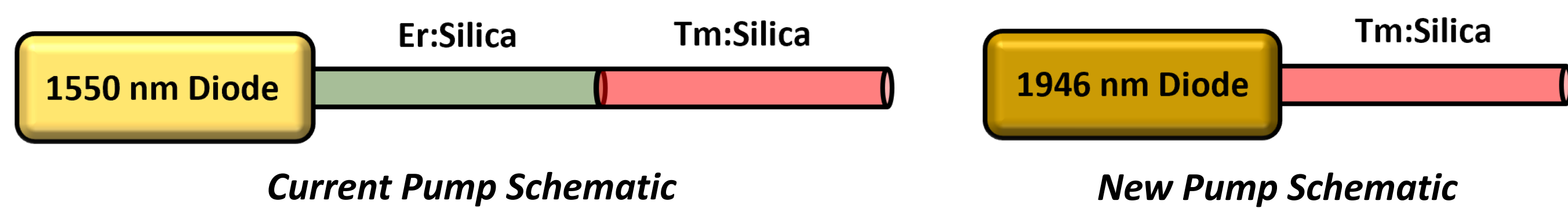


Motivation: Deeper Material Penetration for NDT

Optical coherence tomography (OCT) can be utilized as a non-destructive testing (NDT) technique within manufacturing, saving resources, time and money. MIR OCT systems (rather than NIR) are attractive since longer wavelengths scatter less and penetrate deeper¹. Here we present progress towards a compact, flexible, diode-pumped MIR supercontinuum source. An OCT system based on this source could be utilized for NDT of various components, including turbine blades and biological implants.

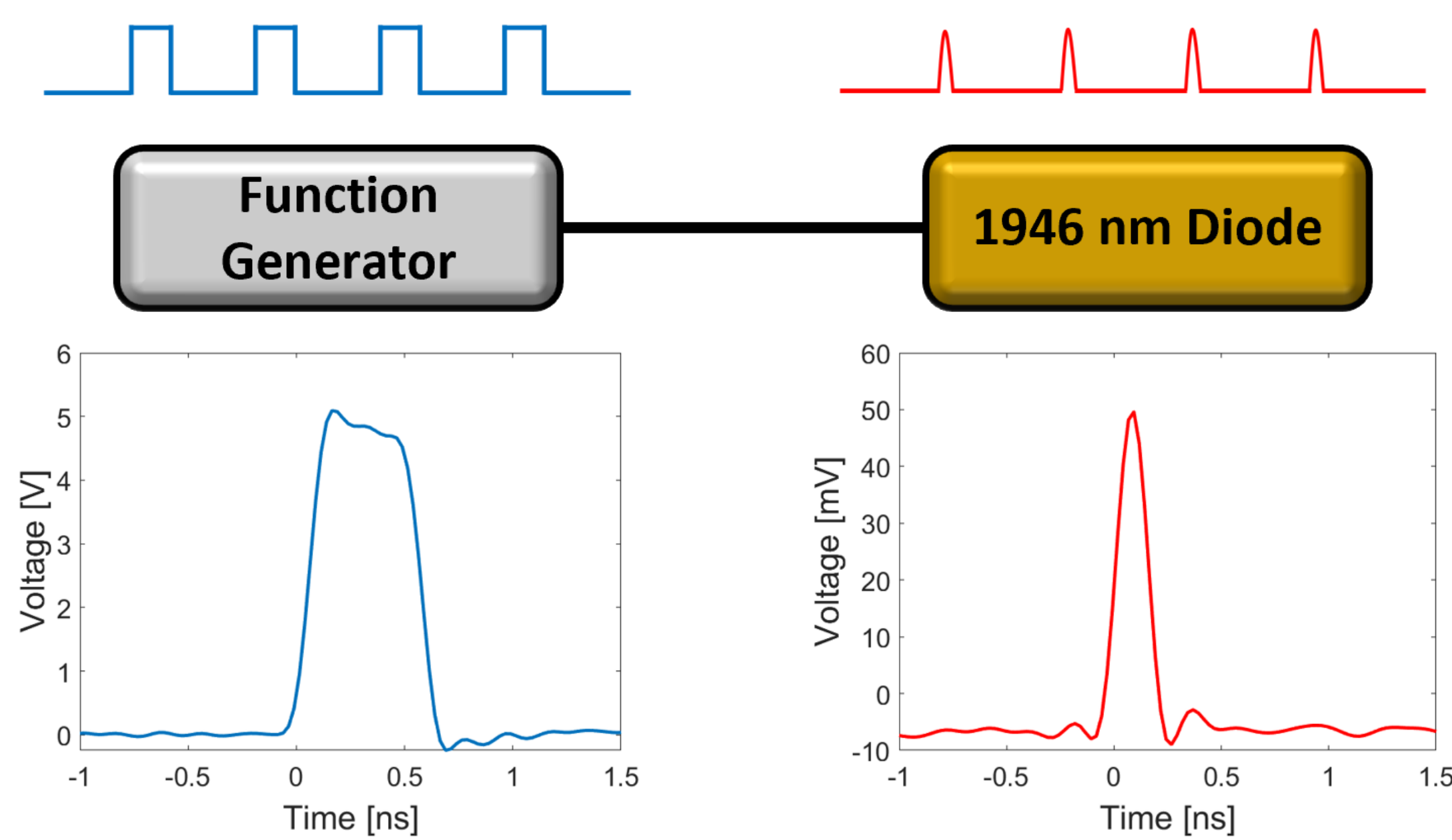
Supercontinuum Generation: Pump Source

MIR supercontinuum generation (SCG) can be realized by pumping the anomalous region of ZBLAN to initiate soliton dynamics. Currently the pump is based on an amplified 1550 nm diode followed by a redshifting Tm-doped fiber. To simplify the design we plan to replace the 1550 nm diode with a 1946 nm diode, which is already within the anomalous regime of the ZBLAN thus negates the need for additional Tm-doped fibers.



Starting Point: Gain-Switched Diode

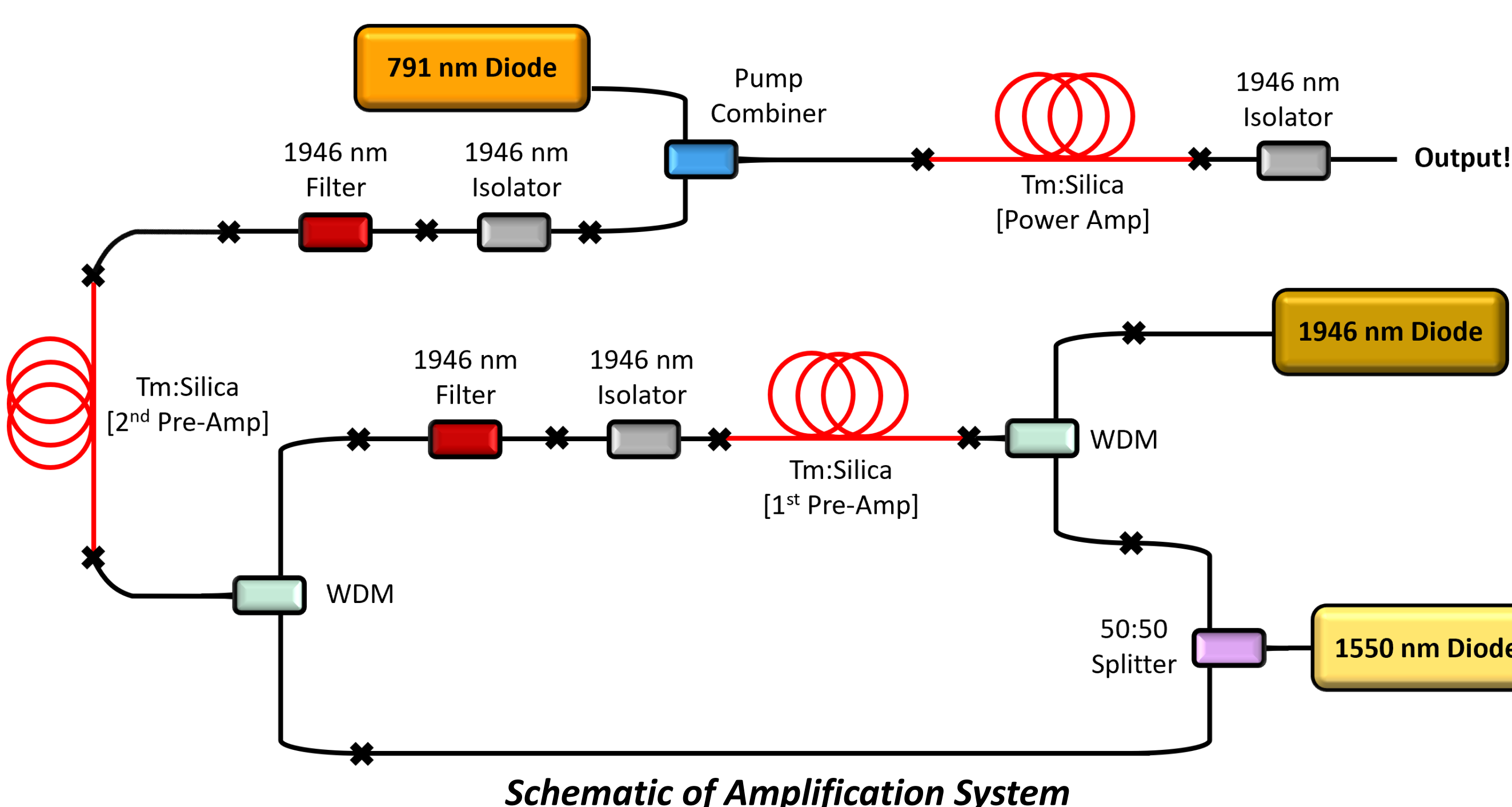
Gain-switched diodes allow simple control of the repetition rate. A short electrical pulse, ~ 500 ps, results in spiking dynamics. The first dominant spike, ~ 100 ps, can be isolated. A downside of this approach is low power.



Function Generator sends Square Electrical Pulse to Diode which Generates Short Optical Pulse

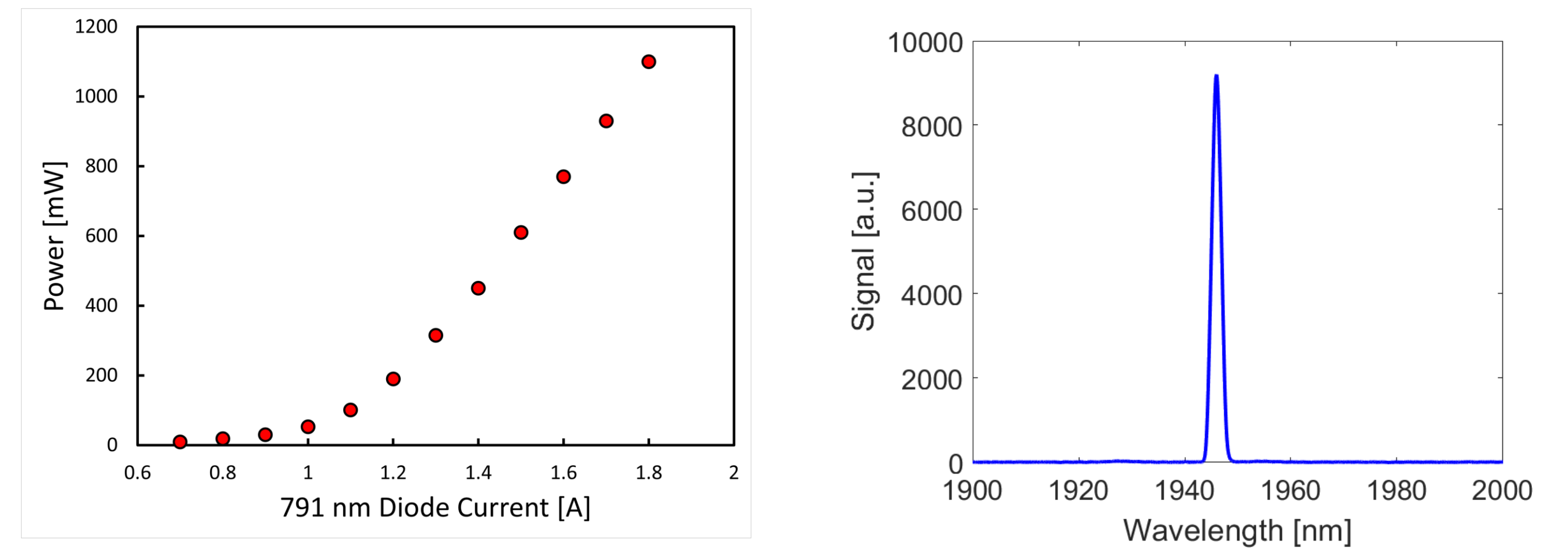
1950 nm Amplification: Layout

Amplification is required to obtain power suitable for SCG². The amplifier consists of two core-pumped (1550 nm) pre-amps and a cladding-pumped (791 nm) power amp. Spectral filters reduce ASE and maximise gain.



1950 nm Amplification: Performance

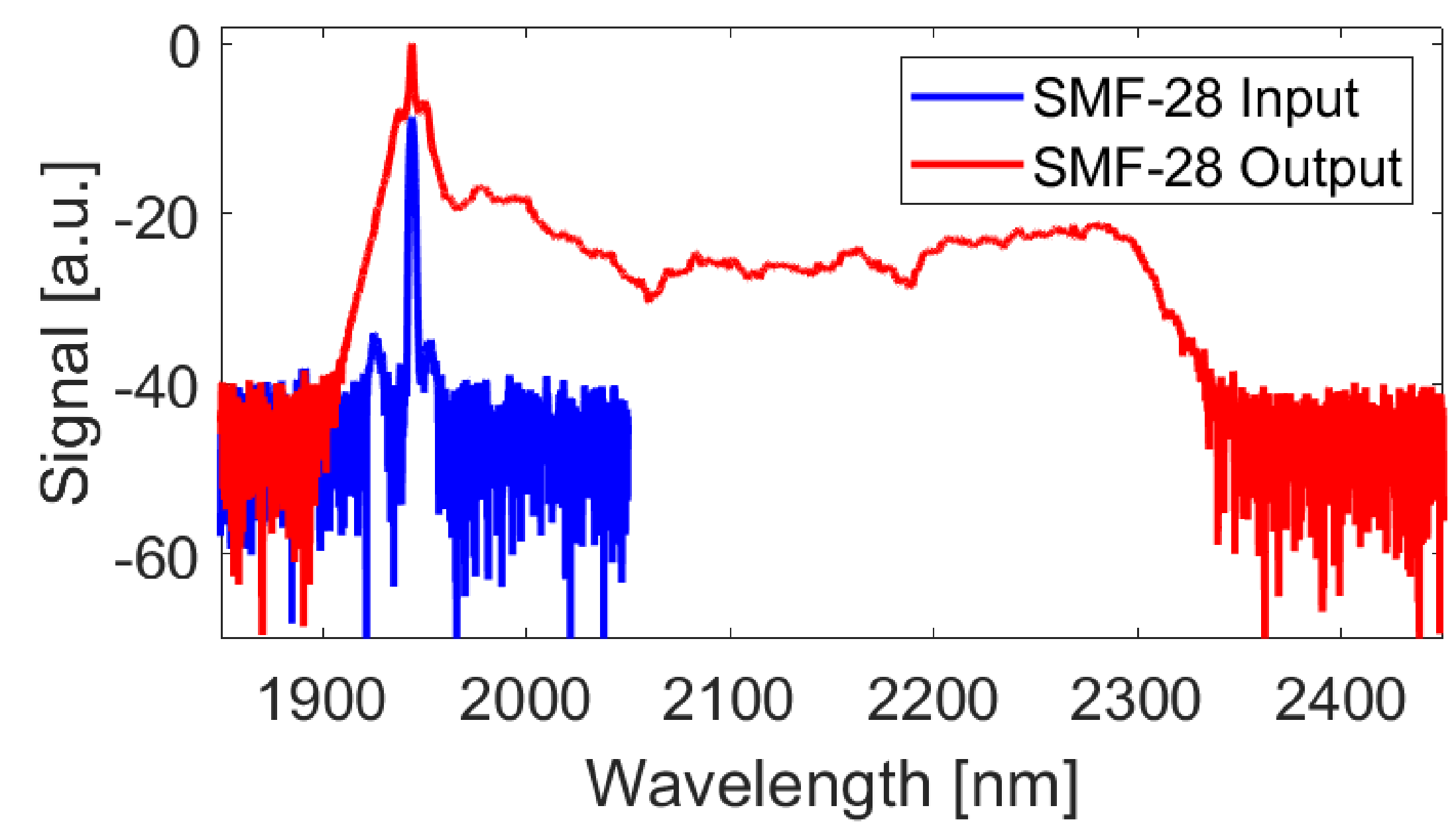
To ensure high SNR for OCT we operated at 10 MHz, achieving 1.1 W (> 55 dB gain), with a pulse duration < 200 ps (limited by detector bandwidth).



Amplifier Output Power with 791 nm Diode Current (left) and Output Spectrum (right)

Pulse Break-Up in Silica

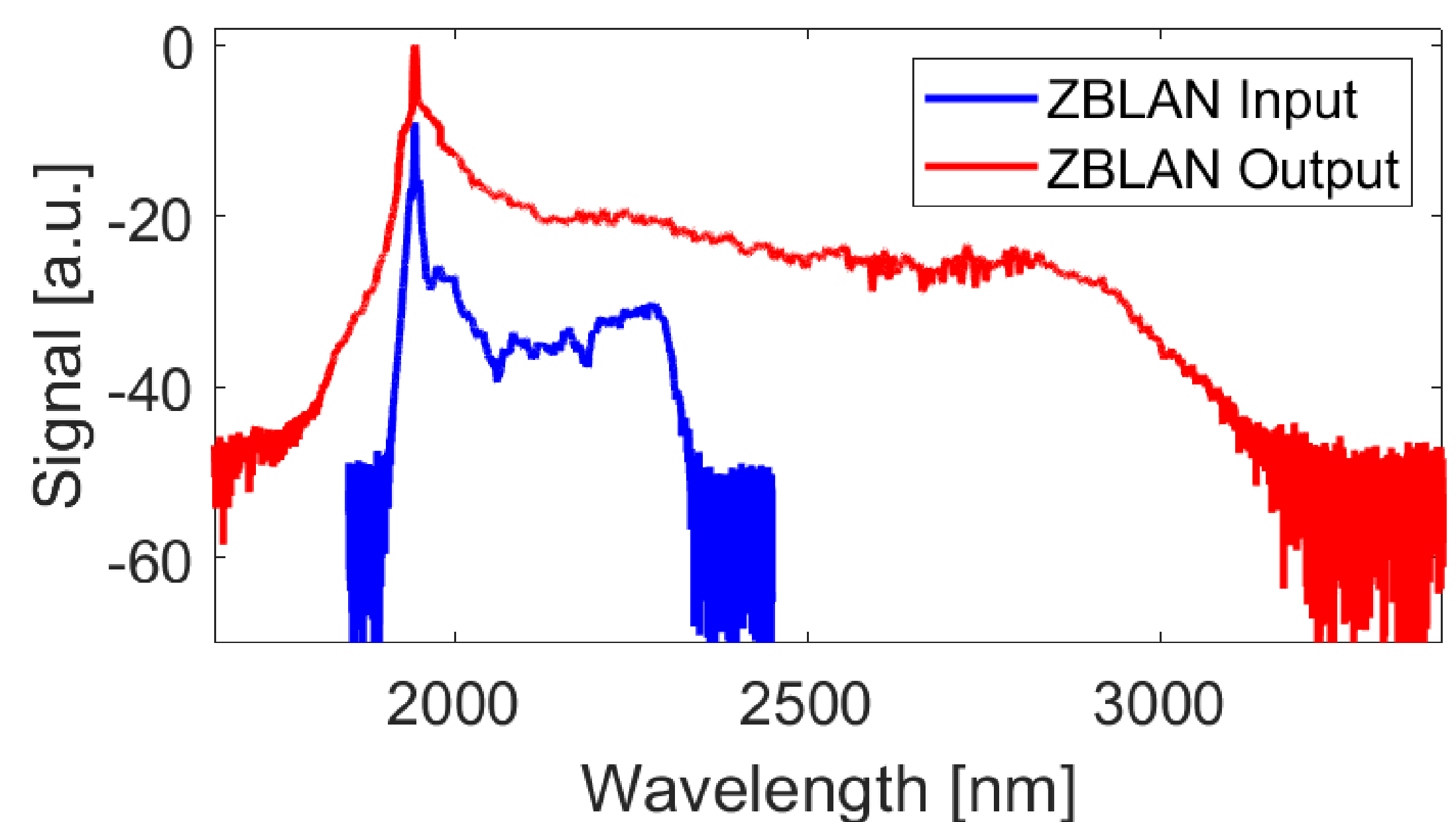
The peak power after amplification was not sufficient to directly generate supercontinuum in ZBLAN. Thus, the output was spliced to SMF-28 (30 m), initiating modulation instability and producing high peak power solitons.



Spectral Broadening in 30 meters of SMF-28 to Generate High Peak Power Solitons

Supercontinuum Generation in ZBLAN

The SMF-28 output was launched into 7 μ m core diameter ZBLAN fiber (4.5 m) generating a 40 dB supercontinuum spanning 1817 – 3070 nm.



Spectral Broadening in 4.5 meters of ZBLAN Fiber

Next Steps

To broaden the MIR to 4.5 μ m the SMF-28 will be exchanged for optimized SM1950, providing lower loss and increased long-edge transparency. Additionally, the amplifier will be optimized to increase peak pump power.

References

- [1] Israelsen, N.M., et al., Real-time high-resolution mid-infrared optical coherence tomography. Light: Science and Applications 8:11, (2019).
- [2] Liang, S., et al., 295-kW peak power picosecond pulses from a thulium-doped-fiber MOPA and the generation of watt-level > 2.5 -octave supercontinuum extending up to 5 μ m, Opt. Express 6, (2018).

Acknowledgements

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