10 MHz swept-source for optical coherence tomography at 1050 nm

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Optical Coherence Tomography (OCT) is a technology that allows non-invasive volume imaging with high resolution. The use of swept sources allowed a significant increase in imaging speed, shifting the speed limitation from the detector to the light source [1]. However, most of the current swept source designs use mechanical parts that have intrinsic speed and bandwidth limitations, translating to an axial resolution limitation for the OCT system. Therefore, the development of akinetic swept sources could lead to a further increase in speed and bandwidth. Most such sources have been demonstrated in the telecom band, due to the mature components that are low-cost and low-loss [2]. Due to the high absorption of water in this band that prevents biomedical applications, there is an interest in adapting such a swept source at 1060 nm central wavelength. We present a swept source with an 86 nm spectral bandwidth at full-width half maximum (FWHM), centered at 1050 nm, sweeping at 10 MHz. It is based on a combination of all-normal dispersion (ANDi) supercontinuum dynamics and optical time stretch to achieve a low-noise broadband high-speed swept source.

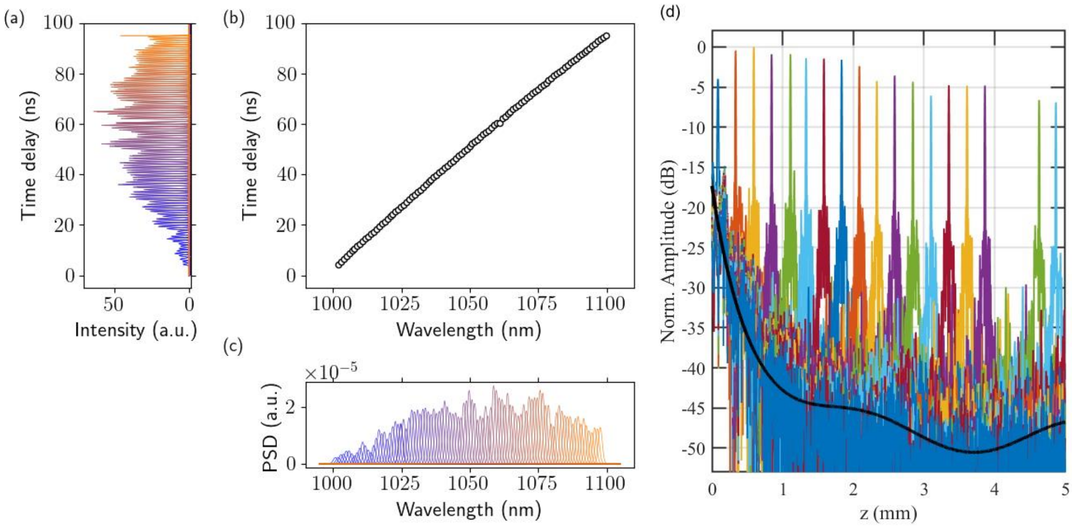

Fig. 1. Swept source output in the time domain (a), spectral domain (c), and the sweep mapping (b), measured with a monochromator; (d) Characterization with a silver mirror as a sample. The background noise is shown in black.

A 10 MHz low noise femtosecond laser produces pulses at 1050 nm central wavelength that are injected in 5 m of PM980 fiber. Self-phase modulation (SPM) and optical wave breaking occur in the fiber and broaden the spectrum to 100 nm bandwidth at -10 dB while preserving the low relative intensity noise (RIN) [3]. A broadband circulator directs the pulse toward a chirped fiber Bragg grating (cFBG) that has both a large reflection bandwidth from 1000 nm to 1100 nm and a large dispersion of 0.97 ns/nm. The pulse is stretched from a few ps to 97 ns measured a -10 dB, leading to a swept source duty cycle of 97%. The sweeping is highly linear, as presented in Fig.1(b), which eases the OCT processing.

Using this swept source, OCT measurements are performed with a silver mirror as a sample for characterization, as presented in Fig.1(d). An axial range of 4 mm is measured, enabling the measurement of thick samples. An axial resolution of 12 μm and a sensitivity of 41 dB are also measured.

The method presented here is limited in bandwidth by the stretcher, as broader supercontinuum pulses have been demonstrated. Therefore, we believe that this design will encourage future studies on broadband stretchers at this wavelength, which will open new possibilities for biomedical imaging.

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