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Development of a 850 nm Swept Source based on a Resonant Scanner Spectral Filter

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ABSTRACT

We present a swept source based on a semiconductor optical amplifier (SOA) as a light emitter as well as a gain medium at 850 nm, equipped with a diffraction grating and a 16 kHz resonant scanner. The developed swept source is bidirectional, capable of 32 kHz operation, with a linewidth of 0.08 nm and a tuning range of 12 nm.

1. INTRODUCTION

Swept source (SS) Optical coherence Tomography (OCT) is a modern modality of OCT that allows faster depth resolved information delivery than any other OCT methods. A SS operates by selecting a narrow linewidth from a broad spectral range which is continuously swept in time. A narrow linewidth and a broad spectral range are necessary to respectively achieve a long axial range and a high axial resolution in OCT [1]. Several principles have been reported to achieve tunable operation [2]; this paper focusses on a diffraction grating in combination with a resonant scanner. A semiconductor optical amplifier (SOA) is used as a light emitter as well as a gain medium in the SS. The grating angularly disperses the broad spectrum emitted by the SOA and based on the orientation of the scanner the wavelength is selected with a narrow linewidth. Such a configuration allows a simple implementation of tunable lasers for OCT. The only commercially available SS known (Superlum Broadsweeper) sweeps the spectrum at maximum 2 kHz.

2. EXPERIMENTAL SETUP

Fig.1 shows the experimental set-up for the swept source built in the wavelength range 850 nm. The set-up consists of a semiconductor optical amplifier (SOA-372-840-SM, Superlum) equipped with non-PM fibre ends, a grating (1200l/mm at 830 nm, Wasatch Photonics), a resonant scanner (16 kHz, EOPC) and a mirror.

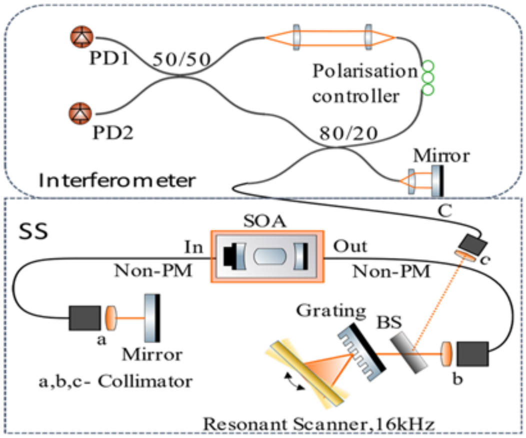

Fig. 1 Experimental set-up of the Swept Source

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The light from the output end of SOA travels to the resonant scanner (RS) through the grating. The RS, which is driven at a frequency of 16 kHz, reflects back the light, which then undergoes a second pass through the grating and recirculates through the SOA, reaching its opposite output. Here light emerges in free space and is reflected back by the mirror, closing the cavity. The amplified output is taken out using a beam splitter (BS). The output power was measured to be 3.6 mW at a drive current of 127 mA. For further characterisation of the SS, it is connected to an interferometer set-up with balanced detection, which enables us to quantify OCT imaging parameters.

3. RESULTS AND DISCUSSIONS

The performance of the swept source was analysed. Fig.2a) shows the narrowband spectrum obtained when the RS was at rest. An instantaneous linewidth of 0.08 nm was measured using an Optical Spectrum Analyser set to a 0.01 nm resolution. For a SOA drive current of 170 mA, a 12 nm tuning range (Fig. 2 b)) was measured when the resonant scanner was scanned continuously. It was observed that the tuning range is dependent on the SOA drive current, where the bandwidth increased with the increase in drive current.

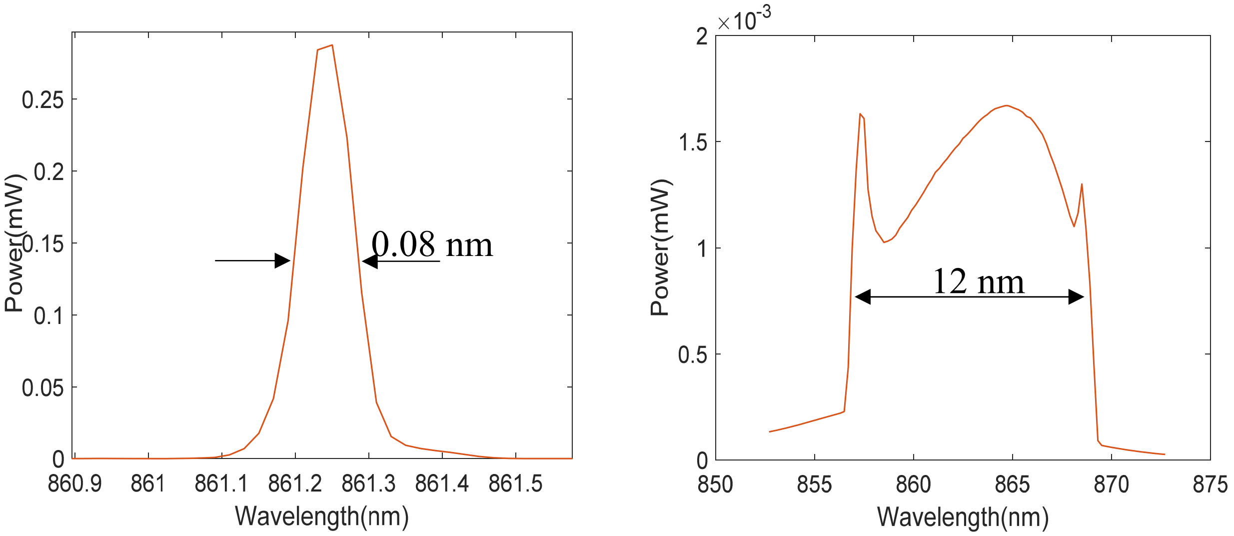

Fig. 2 a) shows a 0.08 nm instantaneous linewidth b) shows a tuning range of 12 nm

The resonant scanner is driven using a sinusoidal signal and therefore the tuning is bidirectional. This enables a sweep rate of 32 kHz. As the frequency of the RS is fixed, the parameter that allows a certain freedom of adjustment is the angular amplitude of the scanner.

It was observed that with an increase in the angular amplitude, the duration of the channeled spectrum reduces (increasing the fringe frequency) which in turn reduces the peak-to-peak amplitude of the spectrum as shown in Fig. 3.

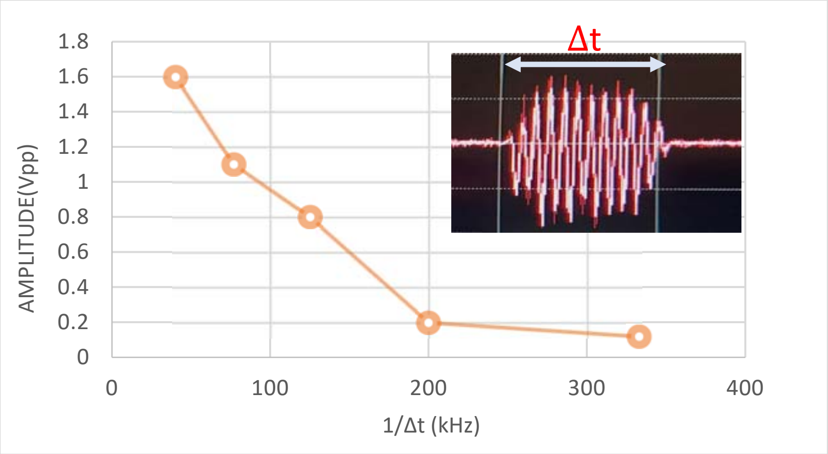

Fig 3. Drop in the amplitude of the channelled spectrum with increase in angular amplitude of resonant scanner

This drop can be explained using equation [1] below,

$$N = \frac{c\Delta t}{nL\pi}\frac{\delta\lambda}{\Delta\lambda} \tag{1}$$

where N = number of roundtrips, c = speed of light, Δt = duration of one sweep, $\delta\lambda$ = instantaneous linewidth, n = refractive index of the cavity, L = length of cavity, $\Delta\lambda$ = tuning bandwidth.

The equation shows that the number of roundtrips depends on the duration of the channelled spectrum fringe pattern. Consequently, when the pattern duration reduces, the number N of roundtrips for light of instantaneous linewidth $\delta\lambda$ centred at each conceptual wavelength λ reduces, potentially to a value that does not permit sufficient build-up of laser radiation at each wavelength. This suggests that the laser cavity is too long and further improve in speed is achievable by shortening the fibre leads and assembling the whole configuration more compact.

We optimise light amplification while maintaining the widest range of wavelengths that can be accommodated by our particular SOA and establish how different driving regimes in combination with our swept source geometry can turn our swept source into a tool for future imaging.

4. CONCLUSIONS

We demonstrate a 16 kHz swept source based on a resonant scanner spectral filter with a 0.08 nm instantaneous linewidth and 12 nm tuning range. The swept source can achieve a 32 kHz sweep rate as it is bidirectional. Further, we demonstrate the relationship between the angular scan amplitude and the intensity of the interference signal. We explore the suitability of the source for imaging applications, based on the constraints imposed by resonant scanner operation, as a precursor to the development of an OCT imaging capability at 850 nm.

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