Dual Amplification 850 nm FDML Laser

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Fourier domain mode locked (FDML) lasers have been widely used in optical coherence tomography (OCT) for many years at 1550 nm, 1310 nm and 1064 nm [1-4]. Developing a shorter wavelength FDML laser is interesting for eye imaging for instance, due to less water absorption and increased scattering which can improve the contrast of low scattering features.

In this work, we present an 850 nm FDML laser with a new cavity design enabling dual amplification of each sweep in a single round trip. Working at 850 nm becomes a challenge because of, for instance, high chromatic dispersion. In 780HP fiber at 850 nm the chromatic dispersion is three times larger than at 1064 nm, therefore for a dispersion compensation over 72 nm, several chirped Fiber Bragg Grating (cFBG) are necessary, together with the same number of circulators that leads to high losses. To compensate for the losses, a new design of an FDML laser was developed with the aim of performing dual amplification. In such a case the gain is higher, therefore it is expected that the relative intensity noise would improve to approach the value attainable by 1300 nm sources. In this new design the SOA is modulated in such a way that when the sweep from the inside ring is sent to the cFBG (on the right of the scheme, part 1 in Fig. 1 (A)), the SOA is switched on for initial amplification. Then the second amplification happens when the sweep is reflected back by the cFBG, the SOA is on again. Inversely, it is switched off when the sweep is circulating in the ring to prevent any parasitic lasing. The laser is sweeping over only 20 nm to avoid catastrophic optical damage (COD) threshold of the SOA as shown in Fig. 1 (B), we had to reduce the SOA current from 200 mA to 95 mA. Indeed, only one filter is present in the laser which imply that during the second amplification, not only the sweep is amplify but also the ASE which makes the inside power increasing near the COD. We will present different strategies to overcome this limitation.

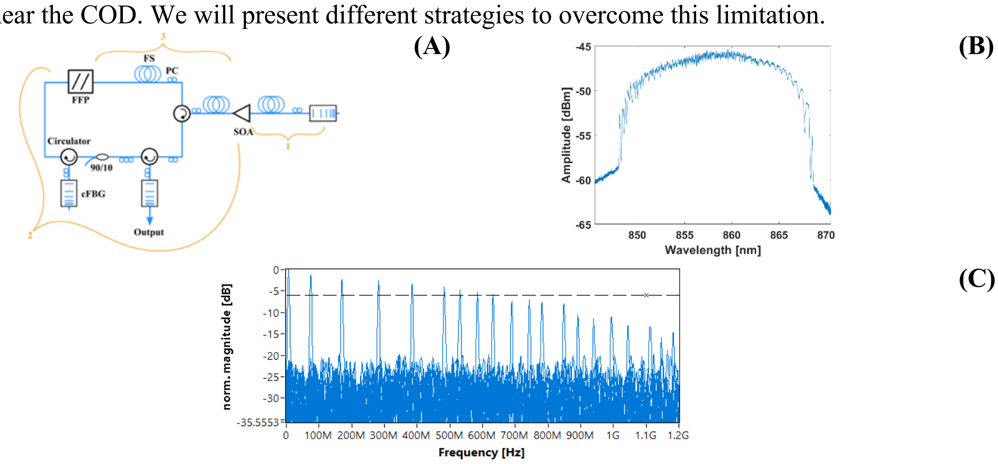

Fig. 1 Set-up (A) and spectrum (B) of the dual-pass SS FDML laser sweeping over 20 nm. (C) Sensitivity roll-off of more than 1.2 cm at -6 dB. SOA: semiconductor optical amplifier, PC: polarization controller, cFBG: chirped Fiber Bragg Grating, FFP: fiber Fabry-Pérot filter.

The remaining chromatic dispersion in the laser introduces noise in the laser which degrades its dynamic range to about 25 dB to 35 dB as shown in Figure 1 (C). Despite this, the dual-pass SOA FDML laser exhibits a 6 dB sensitivity roll-off of more than 1.2 cm delay, which is promising for current development steps. The roll-off was acquired using an Optilab 20 GHz balanced photodiode. In addition, based on the modulation of the SOA, with the FFP driven at 409 kHz, a sweep repetition rate of ~ 1.6 MHz is possible by applying optical buffering. We acknowledge the Innovative Training Networks NExt generation of Tunable LASer for OCT (ITN-NETLAS) program of the Marie Sklodowska-Curie actions (H2020- EU.1.3.1., grant agreement no. 860807).

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