18p-D5-5

Highly functional ultrashort pulse fiber laser sources and application for ultrahigh resolution optical coherence tomography

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Passively mode-locked fiber lasers are stable and practical ultrashort pulse sources. We have been investigating the highly functional wideband ultrashort pulse fiber laser sources using ultrafast fiber nonlinear effects. These novel light sources are useful in the fields of metrology. In this talk, the development of highly functional wideband fiber laser sources and their applications for ultrahigh resolution optical coherence tomography (OCT) are discussed.

Single wall carbon nanotube (SWNT) is useful saturable absorber with fast recovery time and wide bandwidth. We have been investigating SWNT fiber laser using SWNT dispersed in polyimide film. Recently, the highest power operation of 285 mW was achieved by dissipative soliton mode-locking operation[1] (Figs.1, 2).

The wavelength tuning operation is important factor for the application of metrology. In 1999, we demonstrated widely wavelength tunable soliton pulse generation[2]. Recently, we succeeded in the high quality spectral compression of wavelength tunable soliton pulses using comb profiled fiber technique shown in Fig. 3[3]. The fastest wavelength tunable operation can be achieved.

The widely broadened sources are also useful for metrology, such as UHR-OCT and optical frequency comb. Generally, the widely broadened supercontinuum has inherent noise and incoherent property. We succeeded in the generation of coherent, low-noise, almost fat, high quality supercontinuum as shown in Fig. 4[4].

Using the low noise supercontinuum, we can demonstrate highly sensitive ultrahigh resolution OCT. Figure 5 shows the 3D UHR-OCT images of pig trachea obtained with 800 and 1700 nm UHR-OCT systems. We can see the wavelength dependence of OCT images[5].

References [1] Y. Nozaki, et al, Opt. Lett. **37**, 5079 (2012). [2] N. Nishizawa and T. Goto, IEEE PTL **11**, 325 (1999). [3] N. Nishizawa, et al, Opt. Express **18**, 11700 (2010). [4] N. Nishizawa, Opt. Fiber Technol. **18**, 394 (2012) (invited). [5] S. Ishida and N. Nishizawa, Biomed. Opt. Express **3**, 282 (2012).

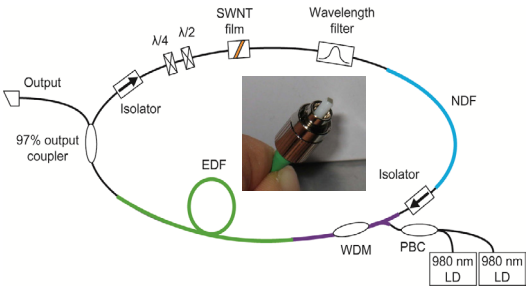

Fig.1. Dispersion managed SWNT fiber laser

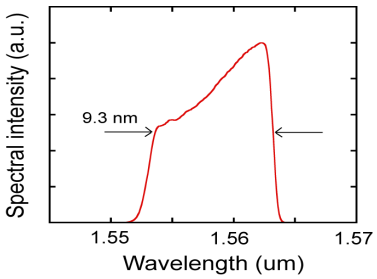

Fig.2. Spectrum of dissipative soliton pulse

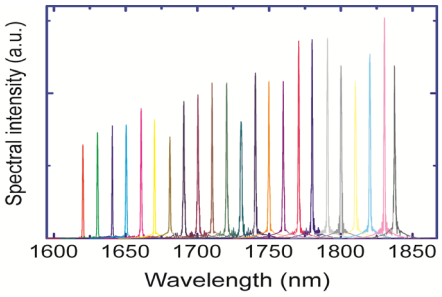

Fig.3. Spectra of wavelength tunable narrow linewidth source by comb-profile fiber

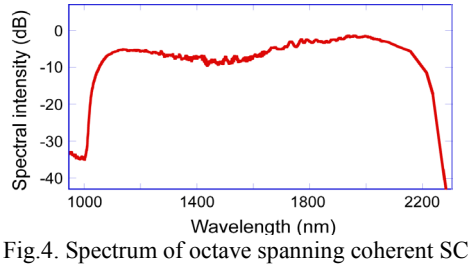

Fig.4. Spectrum of octave spanning coherent SC

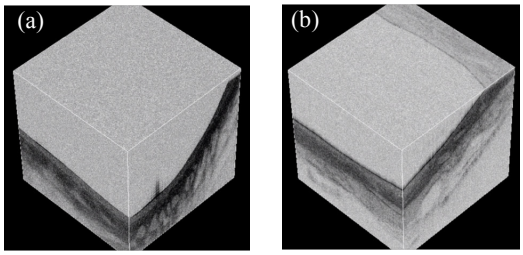

Fig.5. 3D-UHR-OCT images of pig trachea observed at wavelengths of (a) 800 nm and (b) 1700 nm