ソリトンポンピングを用いた中赤外光周波数コム光源の開発

Soliton pumping based mid-infrared optical frequency comb

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In our previous work, a wavelength tunable MIR comb driven by high power supercontinuum pulses have been reported [1]. The scheme can generate MIR pulses with high coherence, however, the spectra were so broad that mode-power was not high as expected. In this work, a coherent Raman soliton pulse and Yb-fiber laser output were used as the seed pulses of DFG, and the 4.4-5.2 um wavelength tunable, offset-free, coherent MIR comb was generated. For confirming the coherence, the RF beat signal between the MIR comb and quantum cascade laser (QCL) was observed directly in the MIR region.

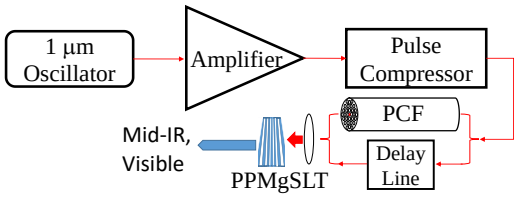

Fig. 1 Experimental setup of mid-IR generation.

The experimental setup is shown in Fig. 1. The seed source was an Yb-fiber oscillator with a repetition rate of 184 MHz. The chirped pulses centered at 1040 nm were amplified by an Yb-fiber amplifier pumped by two laser diodes, which could provide a pump power above 3 W. By a pair of transmission gratings, the pulses were compressed into 190 fs (FWHM). With a polarization beam splitter, the high power pulses were divided into two branches. One branch was injected into a photonic crystal fiber (PCF, NL-3.2-945, NKT Photonics Inc) to generate Raman solitons with wavelengths from 1300 nm to 1350 nm by changing the input power. The other one passed through an optical delay line and worked as the pump for DFG. The two branches were overlapped again at a dichroic mirror and focused into a 10-mm-long fan-out type periodically poled Mg-doped stoichiometric lithium tantalate (PPMgSLT) crystal. By carefully adjusting a delay line, the generated mid-IR could be changed from 4.4 μm to 5.2 μm, as shown in Fig. 2(a). The tunable wavelength range was limited by the crystal. To verify the coherence of the MIR comb, we measured the RF spectra and RF beat between the comb and a QCL working at 4.52 μm. Figure 2(b) shows the RF spectra from 0 to 1000 MHz, and the observed RF beats between QCL and MIR comb are shown in Fig. 3(c). Although the linewidth of the QCL was 30 MHz and the oscillation mode was not stabilized, the RF spectra of beat signal were observed clearly and stably, which confirmed the coherence of MIR comb.

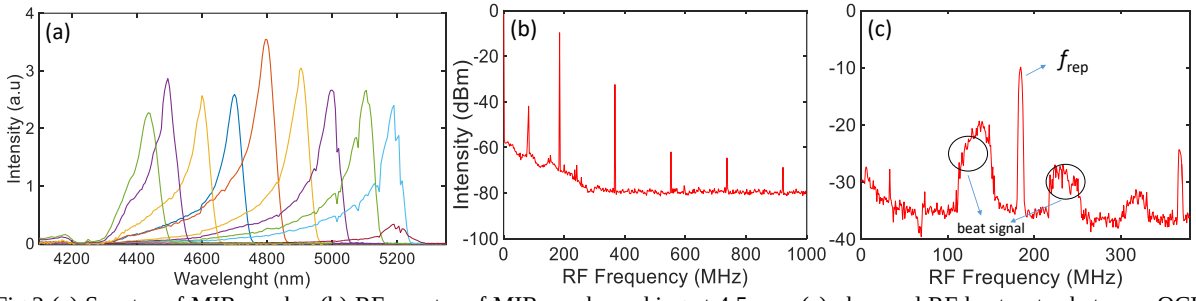

Fig.2 (a) Spectra of MIR combs, (b) RF spectra of MIR comb working at 4.5 μm, (c) observed RF beat notes between QCL and the MIR comb.

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