Waveform measurement of ultra-high repetition mode-locked pulses generated from a silica toroid microcavity

Zhelun Chen, Takuma Nagano, Yusuke Okabe, Tomoya Kobatake, and Takasumi Tanabe
Department of Electronics and Electrical Engineering, Faculty of Science and Technology, Keio University, Japan
takasumi@elec.keio.ac.jp

Abstract
Optical Kerr comb from a microcavity exhibits a high-repetition rate pulses in time domain. We measured the output in time-domain and demonstrated a 9.1-THz repetition rate pulse train generation. The large free-spectral range of the generated Kerr comb is due to the high Q and small V of the toroid microcavity, which is a unique feature compare to other systems. We also show that an add-drop configuration will allow us to have a better temporal profile.

Motivation
- Want to reveal the temporal dynamics of an optical Kerr comb in toroid microcavity by measuring the output waveform
- Want to demonstrate the generation of high repetition rate pulses.
- Want to investigate a method to obtaining clean output (i.e. investigate the effect of an add-drop configuration).

Some background
- **Silica toroid microcavity**

\[ P_{th} \propto \frac{v}{Q^2} \]

The threshold power of Kerr comb generation is proportional to the mode volume inversely proportional to \( Q^2 \).

Experiment and Result
- **Time domain measurement**

Temporal waveform and spectrum agrees well.

- **Generation of high-repetition rate pulses (theory)**

\[ \Omega_{\text{max}} = \frac{4\pi f_{\text{peak}}}{2 f_p} \] when a CW pump is applied, four-wave-mixing (FWM) gain is given as \( g(\Omega) \).

\[ Q_{\text{max}} \text{ is the frequency of the peak of } g(\Omega). \]

- **Kerr comb**

Four wave mixing (FWM) occurs in the cavity and Kerr-comb is obtained

- **Generation of high-repetition rate pulses (exp.)**

Successful generation of 9.1-THz repetition rate pulses

- **Add-drop system for better contrast pulses**

Flat spectrum is obtained at drop port

Conclusion
- Time domain measurement is performed to observe the pulsed output of a Kerr comb from silica toroid microcavity.
- Silica toroid microcavity allows 9.1-THz pulse train generation due to the high Q and small mode volume.
- Add-drop configuration is ideal to have high contrast output pulses.

Acknowledgement
Part of this work was supported by Ministry of Education, Culture, Sports, Science, and Technology (MEXT), Japan, KAKEN #15H05429