Improvement a Q-factor of Dispersion Engineered
Crystalline Microresonator towards Soliton Microcomb Generation

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Abstract

The development of optical frequency combs based on microresonators (Kerr combs, or microcombs) has attracted considerable attention since the experimental demonstration of soliton pulse formation. We fabricated an MgF2 microresonator by machine-shaping and hand-polishing. And with precise Q-factor or dispersion measurements, we revealed that the dispersion of the resonator changed little while the Q-factor improved by 10 times.

Whispering gallery mode microresonators (WGMs) & Kerr frequency comb (microcomb)

- WGM μ-resonator
  - GQ factor = 10^5 ~ 10^9
  - High Q-factor
  - Small mode volume
  - Material: SiNx
  - Crystalline
  - Ultrahigh-Q

- Resonator dispersion
  - Geometric + Material (MgF2)

- Kerr comb generation (soliton formation)
  - High fcomb (GHz-THz)
  - Compact
  - Low drive power

Microresonator fabrication methods

- Hand shaping & polishing
  - Brass
  - Hand shaping & polishing, and realize to generate soliton microcombs.

- Ultra-precision machining
  - Precise machining

Motivation

- Q-factor
  - Before polishing
    - Q-factor = 2.1 x 10^5
  - After polishing
    - Q-factor = 1.7 x 10^9
  - 10 Improvement

Dispersion

- Center wavelength
  - Mode number: + (reflected from pump)

Experimental results (microresonator characteristics, Q-factor and dispersion)

- Q-factor (ring-down, for high Q)
  - Exponential fitting
  - Voltage peak
  - Time to resonance

- Dispersion & Q (linewidth, for low Q)
  - Synchronous
  - Transmitted peak
  - Disappearance

Summary & Future work

We demonstrated that hand polishing improves only the Q factor without changing the dispersion for high-Q magnesium fluoride (MgF2) resonators. In other words, for machine-fabricated MgF2 resonators, hand polishing enables their characteristics (Q-factor and dispersion) to satisfy requirements for soliton microcomb formation. However, the Q-factor is still not sufficient for soliton generation. From now on, we need to improve the Q-factor to 10^9 by further hand polishing, and realize to generate soliton microcombs.

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