Direct Soliton comb generation in MgF_2 microresonator with an ultrahigh quality factor of 10 billion at ~mW level

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The emergence of soliton microcombs provides a reliable approach for the miniaturization of optical frequency combs (OFC), making them apt for use in optical clocks, frequency measurements, and precision spectroscopy within time and frequency metrology systems. However, most soliton experimental platforms inevitably require the introduction of an erbium doped fiber amplifier (EDFA), which seriously hinder the compact application of this technology. So, ultra-low-power direct pumping to generate soliton comb has always been the direction of efforts. Reducing the effective mode area and improving the quality factor of the resonator as much as possible are the fundamental solutions to achieve low power consumption.

In our experiment, MgF_2 crystalline Whispering-gallery-mode-resonator (WGMR) with a diameter of ~ 9mm (Fig.1(a), inset left) and a quality (Q) factor > 10^{10} were prepared using precision grinding and polishing techniques. The time-domain ringdown spectrum [1] of the resonance mode is shown in Fig.1(a), in which the exponential decay time is evaluated to τ=25us, yielding a loaded Q-factor $Q=\omega_0\tau/2=1.5\times10^{10}$ at λ=1550 nm. To the best of our knowledge, this is the highest quality factor reported for MgF_2 material within the communication band. Simulation results indicate tha the mode area is about 5×10^{-12} m^2 (Fig. 1(a), inset right). A C-band narrow linewidth laser was utilized to directly initiate the soliton comb with a standard frequency scanning method. Fig. 1(b) is the representative single soliton spectrum with a pumping power of 10 mW. Fig. 1(c) shows the relationship between the maximum existence range of the soliton (PDH method calibrated) [2] and the pumping power. More experimental detail and further investigation will be reported on the meeting.

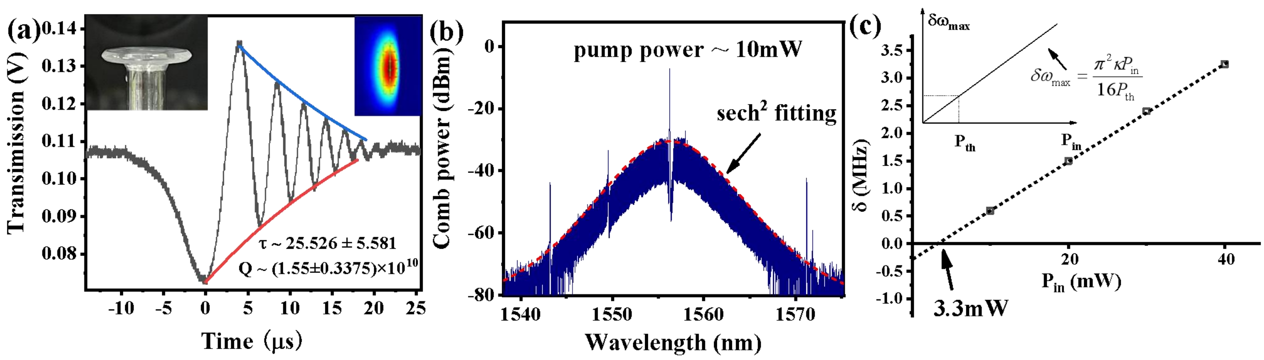

Figure 1. (a) Cavity ring-down signal from the MgF_2 WGM resonator. (b) Optical spectrum of the single soliton. (c) The relationship between the maximum existence range and the pumping power.

[1]Lecaplain, Caroline, et al. "Mid-infrared ultra-high-Q resonators based on fluoride crystalline materials." Nature communications, vol.7.1, 13383, 2016.

[2]Stone, Jordan R., et al. "Thermal and nonlinear dissipative-soliton dynamics in Kerr-microresonator frequency combs." Physical review letters, vol. 121.6, 063902, 2018.