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Soliton microcomb generation by cavity polygon modes

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Section 1: Device fabrication

The LN microdisk was fabricated from a thin-film lithium niobate (LN) on insulator wafer (NanoLN, Inc.) in which a 970 nm thick Z-cut thin-film LN layer sits on top of 2 μm thick silicon dioxide on an LN handle wafer[S1]. The disk-shaped pattern was first defined using femtosecond laser ablation with a chromium layer coated on the wafer. Then the pattern was transferred on the LN thin-film layer by etching the exposed LN region using chemo-mechanical polishing. The chromium layer was removed with chemical wet etching subsequently. Afterward, the LN microdisk endures secondary chemo-mechanical polishing to reduce the surface roughness and thin the microdisk to a thickness of ~950 nm by controlling the polishing time. Finally, the silicon dioxide layer underneath the LN microdisk was undercut into a small pillar to support the suspended LN microdisk.

Section 2: Experimental setup

The experimental setup for soliton comb generation is illustrated in Fig. S1. A tapered fiber with a waist of 2 μm was used to couple with the circular microdisk. The microdisk was fixed on the top surface of the 3-axis piezo-electric stage with a resolution of ~20 nm for controlling the coupled position. An optical microscope imaging system consisted of an objective lens with a numerical aperture of 0.28 and an infrared charge-coupled device camera (InGaAs camera, Hamamatsu Inc.) was mounted above the microdisk coupled with the tapered fiber to monitor and capture the polygon modes or the WGMs excited in the microdisk, which depend on the coupled condition. A tunable external cavity laser (Model: TLB-6728, New Focus Inc.) which was amplified with an Erbium doped fiber amplifier (EDFA) was used as the pump light. The input light was coupled into the microdisk with the tapered fiber, and the generated light signals in the microdisk was coupled out of the microdisk via the same tapered fiber. The pump light was adjusted to be transverse-electrically polarized which was controlled by an inline polarization controller (PC). The output signals were divided into two routes with 9：1 splitting ratio by a fiber splitter. The main part was sent to an optical spectrum analyzer (Model: AQ6370D, YOKOGAWA Inc.) for spectrum analysis. While the weak part was damped with a variable optical attenuation (VOA), and then sent to a photodetector (Model: 1611 FC-AC, New Focus Inc.). The photodetector (PD) was connected with an oscilloscope (Model: MDO3104, Tektronix Inc.) and an electrical spectrum analyzer (Model: RSA5126B, Tektronix Inc.) to record transmission spectrum during wavelength scanning and radio-frequency spectrum for noise analysis, respectively. The laser wavelength was calibrated by an unbalanced Mach-Zehnder interferometer with a 3 m long optical fiber.

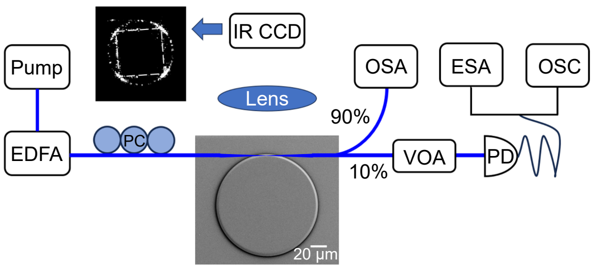

Fig. S1 | Experimental setup of soliton comb generation in the microresonator. Here, optical spectrum analyzer, electrical spectrum analyzer, infrared charge-coupled device, and oscilloscope are denoted as OSA, ESA, IR CCD, and OSC, respectively.

Section 3: Mode coherent recombination and excitation

The input laser was tuned as transverse-electrically polarized by the inline polarization controller. To form and excite the polygon mode around 1542.80 nm, the tapered fiber was placed in close contact with the top surface of the circular microdisk at the position which was ~60 μm far from the disk center, and the laser wavelength was tuned to 1542.80 nm. The polygon mode formation was monitored and confirmed by an optical microscope imaging system mounted above the microdisk and the transmission spectrum. The captured optical micrograph of the polygon mode is shown in the inset of Fig. S1, exhibiting a square pattern.

References

S1. Wu RB, Zhang JH, Yao N et al. Lithium niobate micro-disk resonators of quality factors above 10^7. *Opt Lett* **43**, 4116–4119 (2018).