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Citation for the original published paper (version of record):
Fülöp, A., Wang, P., Xuan, Y. et al (2017). Active feedback stabilization of normal-dispersion microresonator combs. Optics InfoBase Conference Papers, Part F82-CLEO_Europe 2017

Active Feedback Stabilization of Normal-Dispersion Microresonator Combs

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Silicon nitride microresonators provide a potentially CMOS-compatible platform for optical frequency comb generation [1]. As in any high-Q microcavity, thermal effects strongly affect the dynamics. This is particularly true considering that typical continuous wave pump powers for microresonator comb generation operate in the 20-35 dBm range. Temporal bright solitons for instance are generated when the pump is on the red side of a resonance, a situation that is challenging to attain owing to the thermo-optic coefficient of most microresonator materials [2]. Active stabilization has been successfully demonstrated by fixing the soliton power at a certain stage in the initialization process [3] or by careful power kicking and detuning of the pump laser [4].

Normal-dispersion combs aided by transverse mode interactions [5] can instead be pumped on the thermally stable blue side of the microresonator resonance and have recently been shown to provide unusually high conversion efficiency into the comb [6]. Nevertheless, thermal drifts on a long time scale remain. Here, we demonstrate active feedback stabilization of a normal-dispersion silicon nitride microresonator comb by using the comb power (excluding the pump) as the control parameter to tune the frequency of the pump laser (Toptica CTL) via a feedback loop. Hence, the comb output power can be kept stable over long term (<0.05 dB comb power variation over an eight-hour time period, see Figs. a) and b). Additionally, since the initialization process of normal-dispersion combs requires no pump-power changes, a chosen comb state can be accessed directly from an off-state by picking a comb power set point as the target for the regulator.

Since the pump power is kept constant, different set points represent different conversion efficiencies. We observe that as the set comb power increases, so does the comb bandwidth (Fig. c), while maintaining a low noise state (Figs. d and e). This situation is in sharp contrast to bright temporal solitons [7] and verifies that the bandwidth in normal-dispersion combs scales with the conversion efficiency [8]. In the next set of experiments, we plan to verify the pulse compression capabilities and measure the effective cavity detuning.

These results are important from an applications perspective, allowing a simpler start-up condition while at the same time permitting to run experiments over long term. They also demonstrate that the comb power-bandwidth relation is fundamentally different in combs operating in the normal-dispersion regime, - a crucial aspect for optical communication applications [9, 10].

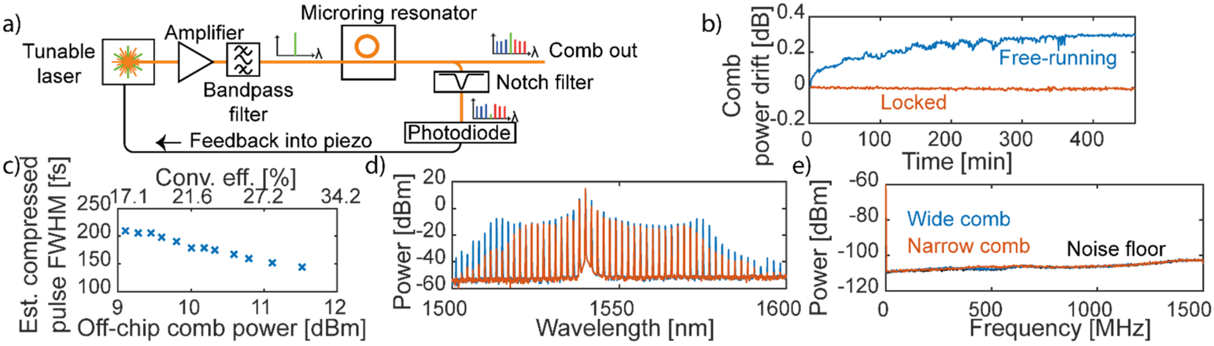

Fig. a) Schematic of setup showing the feedback loop used to control the pump laser wavelength ensuring the comb power stays constant. b) The comb output power stays stable over long timescales. If the pump laser is left free-running, slight environmental changes, such as temperature shifts in the lab, will cause the comb power to vary. c) As the comb power increases, the bandwidth follows. As a more representative indication of the increase in bandwidth, we calculated the full-width half-maximum of the corresponding transform-limited pulse duration assuming a flat spectral phase on the measured comb spectra. d) By locking the pump laser to slightly different comb positions, one can significantly change the comb's properties. Two comb spectra are shown highlighting the difference in bandwidth between two states. e) The electrical RF spectrum of the corresponding combs showing that they were both operating in a low-noise state.

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