Chip-Scale Self-Referenced Optical Frequency Comb Sources

Rapports

Informations projet

REFOCUS

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Résumé du contexte et des objectifs généraux du projet

Self-referenced frequency combs revolutionized metrology and enabled optical atomic clocks with unprecedented accuracy that benefit applications ranging from navigation and high-precision spectroscopy to telecommunications. Despite the outstanding performance, the application of such combs is limited to laboratories due to the prohibitively large size, weight, and power (SWaP) of a frequency comb system. Miniaturization of the comb systems will enable emerging applications such

as LIDAR, chemical sensing, and medical imaging. This project aims to develop a chip-scale optical frequency comb source that can be self-referenced.

Travail effectué depuis le début du projet jusqu’à la fin de la période considérée dans le rapport et principaux résultats atteints jusqu’à présent

Octave-spanning frequency combs are the key to the realization of self-referencing. Although on-chip frequency comb generation has been demonstrated in nonlinear waveguides and microresonators based on the Kerr effects, it is still challenging to drive a broadband (octave-spanning) frequency comb with microwave repetition frequencies using on-chip lasers with limited output power. This project targets achieving broadband frequency combs and increasing the efficiency of the nonlinear processes for comb generation to bridge the broadband frequency comb with on-chip lasers. In this project, we carefully engineered the dispersion of nonlinear waveguides for octave-spanning dispersive wave generation. We demonstrated different microresonator dispersion designs to suppress the avoided mode crossing for easier soliton generation. We realized high-Q AlGaAs and SiC microresonators, enabling sub-milli-watt-level threshold Kerr comb generation.

Turn-key operation is another critical element for chip-scale frequency comb source. In this context, deterministic single soliton generation is highly desired but still elusive for octave-spanning microcombs. A delicate thermal equilibrium is required to trigger soliton generation for broadband operation. This project investigated how to achieve the athermal operation of microresonators for deterministic soliton generation. We engineered the dispersion of multi-mode microresonators and utilized a modified laser cooling technique to demonstrate deterministic single-soliton generation.

Progrès au-delà de l’état des connaissances et impact potentiel prévu (y compris l’impact socio-économique et les conséquences sociétales plus larges du projet jusqu’à présent)

To bridge optical frequency and microwave frequencies, optical frequency combs should have octave-spanning bandwidths and microwave repetition rates. The required massive number of comb lines of such a broadband light source imposes a challenge in driving the combs and distributing sufficient power to the 1f and 2f comb lines for self-referencing using existing on-chip lasers (with state-of-the-art laser technologies). Therefore, a nonlinear process with extremely high efficiency needs to be developed. In this project, we also investigated a new method combining the AlGaAsOI waveguide's high nonlinearity and a seeded supercontinuum generation pump scheme. We demonstrated an octave-spanning comb with a microwave repetition rate using low-power picosecond pulses, which significantly relaxed the requirement for mode-locked lasers in supercontinuum generation and paved the way to the realization of chip-scale supercontinuum comb source.

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