Hybrid Integrated Nonlinear Photonics: From Chipscale frequency combs to cryogenic interconnects

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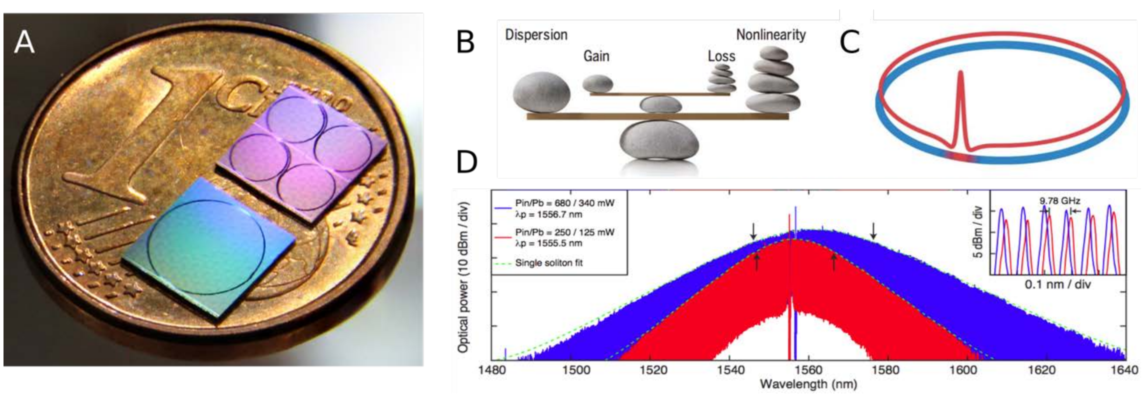
The development of optical frequency combs[1], and notably self-referencing, has revolutionized precision measurements over the past decade, and enabled counting of the cycles of light. Frequency combs, have enabled dramatic advances in timekeeping, metrology and spectroscopy. In 2007, it was discovered that such combs can also be generated using an optical microresonator[2] using parametric frequency conversion. Kerr combs also enable to generate dissipative temporal solitons (DKS)[3,4], which are formally solutions to a driven dissipative nonlinear Schrödinger equation, termed Lugiato-Lefever equation – first derived to describe spatial self-organization phenomena[5]. DKS have unlocked the full potential of Kerr combs enabling a deterministic route to broadband, and coherent optical frequency combs, whose bandwidth can be enhanced using soliton broadening phenomena, such as Soliton Cherenkov Radiation[6]. Such Solitons Kerr combs on a chip have enabled to realize counting of the cycles of light, realize dual comb spectrometers on a chip, enabled dual comb based ultrafast ranging[7], massively parallel coherent communication[8], and offered a novel approach to massively parallel FCMW LiDAR[9]. Recent advances in developing ultra low loss integrated photonics[10] based on silicon nitride (Si_3N_4), have enabled ultra-low propagation losses, enabling the direct integration with on chip pump lasers[11]. On the fundamental side, new and theoretically not previously predicted dynamics has been observed ranging from formation of soliton crystals[12], soliton switching[13], and new type of breather solitons[14], and emergent nonlinear dynamics in arrays of coupled resonators[15]. Nonlinear driven integrated photonics circuits are thereby providing a highly fruitful new playground for fundamental nonlinear science and applications alike. Beyond this, ultra-low loss integrated photonics are giving rise to novel applications: for realizing traveling wave optical parametric amplifiers to heterogeneous integration with Lithium Niobate to create ultra low voltage modulators for that can serve as cryogenic interconnects for superconducting quantum computing.



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