Docket #: S20-031

Improved Nonlinear Optical Devices

Researchers at Stanford are advancing a new class of nonlinear optical devices that operate with significantly lower energy requirements than previous platforms. Commercial applications include various photonic applications; sensors; telecom (fast modulators); analytical instruments, and spectrometers. Specifically, the researchers have developed devices that combine quasi-phase-matching with nanophotonic waveguides to achieve efficient nonlinear interactions of femtosecond pulses over length scales an **order of magnitude larger than the current state of the art**. The crucial breakthrough is the change in dispersion due to sub-wavelength confinement; light propagates with a different velocity in nanophotonic waveguides, and the waveguide geometry can be chosen to achieve simultaneous group-velocity matching between multiple interacting waves and reduced higher-order dispersion. Using these methods, the researchers have developed and experimentally demonstrated several devices that achieve efficient spectral broadening and harmonic generation with **the lowest energy requirements demonstrated to date**.

Stage of Development

Recent demonstrations include second-harmonic generation using ~50x less pulse energy than the previous state of the art, and multi-octave supercontinuum generation with ~500x less pulse energy than previous demonstrations in ion-exchanged waveguides with quadratic nonlinearities.

Applications

- Near- and mid-infrared light generation
- Ultra-short pulse compression
- Supercontinuum generation
- Frequency comb stabilization
- Upconversion detection
- Quantum frequency conversion

- All-optical signal processing
- Coherent Ising machines
- Generation of nonclassical states of light such as Fock states, heralded photons, squeezed states and cat states

Advantages

- Combines two key techniques: (i) quasi-phase-matching and (ii) dispersion engineering in nanophotonic devices
- Resulting interactions allow many typically used nonlinear interactions to be scaled to radically lower pulse energies
- Enables new class of nonlinear devices that operate with significantly lower energy requirements than previous platforms

Publications

- Marc Jankowski, Carsten Langrock, Boris Desiatov, Alireza Marandi, Cheng Wang, Mian Zhang, Christopher R. Phillips, Marko Lon?ar, and M. M. Fejer, "**Ultrabroadband nonlinear optics in nanophotonic periodically poled lithium niobate waveguides**," Optica 7, 40-46 (2020) https://doi.org/10.1364/OPTICA.7.000040

Patents

- Published Application: 20220252958
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