Integrated Nonlinear Nanophotonics in Silicon

Alexander L. Gaeta
School of Applied and Engineering
Cornell University
Ithaca, NY USA
a.gaeta@cornell.edu

***Abstract*—We describe our recent work on the creation of nonlinear optical devices in silicon-based nanowaveguides for a wide variety of applications including ultrafast optical processing and frequency metrology.**

Keywords-component; nonlinear optics; four-wave mixing; frequency combs; all-optical processing.

A highly promising research area that recently has emerged is nonlinear optics using silicon photonics. Since the birth of nonlinear optics, researchers have continually focused on developing efficient nonlinear optical devices that require low optical powers. The strong light confinement in silicon waveguides results in a high effective nonlinearity and enables tuning of the waveguide dispersion, which is essential for phase matching of parametric nonlinear optical processes such as four-wave-mixing (FWM). We have demonstrated FWM-based frequency conversion in Si waveguides using as little as 1 mW of pump power in a ring-resonator geometry and over bandwidths exceeding 800 nm in a straight-waveguide device with 100 mW of power. In addition, by using the concept of time-space duality on a silicon chip we have show temporal stretching, compression, and characterization of optical waveforms which allows for seamless transformation between the GHz and THz regimes. Lastly, we are able to produce broadband frequency combs by using FWM parametric oscillation in ring resonators which offers the possibility of CMOS-compatible multiple-wavelength sources and all-optical clocks.

.