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Parametric Phase-sensitive and Phase-insensitive All-optical Signal Processing on Multiple Nonlinear Platforms

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Parametric processes in materials presenting a second- or third-order nonlinearity have been widely used to demonstrate a wide range of all-optical signal processing functionalities, including amplification, wavelength conversion, regeneration, sampling, switching, modulation format conversion, optical phase conjugation, etc. The recent evolution of optical fiber communication systems towards advanced modulation formats making use of the phase dimension, as well as polarization- and, more recently, space-multiplexing, has created new requirements, as well as new opportunities, for parametric all-optical signal processing.

In this presentation, we will review our recent results on the demonstration of all-optical parametric signal processing using different nonlinear platforms, including highly nonlinear optical fibers (HNLFs), silicon nanowires, and periodically-poled lithium niobate (PPLN) waveguides. In particular, we will show how phase-sensitive processes can be engineered to demonstrate phase-quadrature separation, which we have recently demonstrated in HNLFs [1] and PPLN waveguides [2]. Silicon nanowires are particularly attractive for signal processing thanks to their compact size, CMOS-compatible fabrication process, degrees of freedom in dispersion engineering, and high nonlinear coefficient. However, the detrimental effect of free-carrier absorption induced by two-photon absorption has so far prevented them from being used for the demonstration of phase-sensitive processing. Thanks to the introduction of p-i-n junctions across silicon waveguides, we have recently been able to demonstrate phase-sensitive extinction ratios as high as 20 dB, allowing the phase regeneration of phase-modulated signals under continuous wave pumping operation [3]. One of the well-known limitations of planar waveguide devices for all-optical signal processing is their inherent polarization-sensitivity. We will show how the introduction of polarization-diversity circuits relying on efficient and wideband polarization splitters and rotators [4] can overcome this limitation. Finally, we will also discuss the introduction of signal processing functionalities that are compatible with the novel dimension of space multiplexing. More specifically, we will show how mode-selective wavelength conversion based on four-wave mixing can be realized in a multimode silicon waveguide [5].

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