Integrated or disordered nonlinear optical generator for information processing

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Nonlinear devices are present in our daily life with many applications: light sources for microsurgery, green laser pointers, or modulators for telecommunication. Most of them use bulk materials such as glass fibres or high-quality crystals, hardly integrable or scalable. Even the fast developments of thin film lithium niobate face the challenging etching of metal-oxides. Therefore, the quest for a non-centrosymmetric material system, easy to fabricate and to scale up while maintaining its functionality is still ongoing. Here I will present our recent advances in top-down fabrication of lithium niobate devices and bottom-up assemblies of randomly oriented nanocrystals to produce electro-optic, nonlinear and parametric down conversion signals for information processing.

In a first application, we use a 14-mm waveguide in lithium niobate on an insulator as an optical processor to validate the benefit of optical nonlinearity for reservoir computing. Data are encoded on the spectrum of a femtosecond pulse, which is launched into the waveguide [1]. A second approach is based on a disordered polycrystalline slab composed of lithium niobate nanocrystals. Mediated by random quasi-phase-matching and multiple scattering, linear and nonlinear optical speckle features are generated defining a complex neural network in which the second-order nonlinearity acts as internal nonlinear activation functions [2]. Both cases show improved performance across a large collection of machine learning tasks in image classification, regression, and graph classification with varying complexity.

References

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