Optical Materials EXPRESS

Nonlinear Nanophotonics: feature issue introduction

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Abstract: We introduce the feature issue of *Optical Materials Express* on Nonlinear Nanophotonics. This collection highlights recent advances in the design, fabrication, and application of nanophotonic systems that exploit nonlinear optical phenomena, spanning topics from high-harmonic generation and soliton microcombs to plasmon-enhanced emission and mid-infrared nonlinear optics.

The field of nonlinear nanophotonics is driving the next generation of optical technologies by leveraging strong light-matter interactions at the nanoscale. Recent breakthroughs in novel material platforms, dispersion engineering, and advanced fabrication techniques have paved the way for ultrafast signal processing, enhanced frequency conversion, and integrated quantum photonics. This feature issue presents a selection of research contributions that push the boundaries of our understanding and technological capabilities in this rapidly evolving domain.

Our feature issue highlights plasmonics as a powerful material platform for nonlinear photonics. Szenes et al. offer a fresh perspective on carrier-envelope phase (CEP) sensitivity by optimizing the design of gold nanoantennas, providing new strategies for on-chip CEP diagnostics in ultrafast optics [1]. Wang et al. investigate the enhancement of bismuth-doped silica glass luminescence using metal nanoparticles, demonstrating a remarkable 72% increase in surface emission through localized surface plasmon resonance effects [2].

Integrated photonics remains at the forefront of fundamental and applied research in nonlinear optics. Lv et al. explore dispersion-engineered InGaAsP/InP waveguides, achieving efficient all-optical wavelength conversion and demonstrating a 22 dB improvement in conversion efficiency over conventional designs [3]. Soliton microcombs, with their potential for optical frequency metrology and high-speed communications, are explored in Sun et al.'s work, where they establish a universal scaling law for accessing single-soliton states in Kerr microresonators [4]. Younesi et al. present a wafer-scale fabrication method for low-loss lithium niobate-on-insulator waveguides, achieving record-low propagation losses, a crucial step toward scalable nonlinear photonic circuits [5].

Novel and exotic nonlinear materials shine in two contributions. In the realm of mid-infrared nonlinear optics, Li et al. investigate layered vanadium diselenide (VSe_2) as a broadband

#560262
Journal © 2025
https://doi.org/10.1364/OME.560262
Received 20 Feb 2025; published 25 Feb 2025

Optical Materials EXPRESS

saturable absorber, demonstrating its viability for deep mid-infrared optical modulation [6]. In nonlinear superconducting optics, Niedzielski and Berakdar reveal how curvature in type-II superconductors enables highly nonlinear THz high-harmonic generation, offering new pathways for nonlinear light-matter interactions in quantum materials [7].

Koutserimpas et al. explore the fundamental constraints on harmonic generation in nonlinear and time-varying materials, deriving new sum rules that link quantum mechanics and causality principles [8]. The latter contribution charts important connections between the nonlinear and time-varying materials, offering to fill the gap in understanding the two media classes.

Finally, as photonics emerges as a viable route to low-power and low-latency computing, Arregui Leon et al. introduce an innovative THz-based event detection system using flat nonlinear optics, showcasing new possibilities for ultrafast analog computation [9].

While this collection is a small fraction of many ongoing activities in this field, we hope it will become a valuable resource for researchers working in Nonlinear Nanophotonics and beyond, providing insights into emerging trends and inspiring innovation. We thank all the authors, reviewers, and the *Optical Materials Express* editorial team for making this issue a success.

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