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Classical and Quantum Light Generation in Silicon Nitride Photonics via Photoinduced Second-Order Nonlinearities

Silicon nitride (Si_3N_4) is a widely used platform for integrated nonlinear and quantum photonics, yet its amorphous nature prevents access to second-order processes such as second-harmonic generation (SHG) and spontaneous parametric down-conversion (SPDC). We show that an all-optical poling mechanism can permanently inscribe a photo-induced $\chi(2)$ response within SiN microresonators, breaking the symmetry of the material and enabling quasi-phase-matched frequency conversion without modifying fabrication.
Using this approach, we demonstrate efficient and reconfigurable SHG across a broad spectral range, extending into the visible and near-UV. Leveraging coupled-resonator architectures, we enhance control over nonlinear interactions and enable functionalities such as ultrabroadband frequency-comb upconversion with milliwatt-level output power, and investigate the suitability of this approach for quantum light generation through SPDC. These results expand the capabilities of SiN photonics, bridging classical nonlinear optics and quantum light generation and offering a scalable, CMOS-compatible route toward integrated sources for communication, sensing, and emerging quantum technologies.

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