High-Performance Broadband Nonlinear Photonic Platform Based on Thin-Film $LiNbO_3$

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Highly tunable $LiNbO_3$ (LN) frequency conversion platforms are gaining interest due to their potential in quantum computing, spectroscopy, neuromorphic networks, or aerospace technologies. Conventional nonlinear LN platforms, based on type 0 Quasi-Phase-Matching and combined with sub-micrometer LNOI waveguides, offer high conversion efficiencies (2500 %/W/cm²)[1]. However, they suffer from limited spectral tunability and short interaction lengths of a few millimeters. This also correlates with stringent waveguide dimension geometric tolerances such as sub-2 nm thickness precision for a 5 mm interaction length[2].

To address these challenges, we propose a new frequency-conversion platform based on a rib waveguide suspended in air and type I birefringent phase matching between fundamental modes. This approach extends the tunability bandwidth up to 900 nm and relaxes 5 times the manufacturing tolerance. The required LN film thickness must be around 2 µm, which is unfortunately beyond the thickness range of LNOI technology. To achieve this specific thickness, we developed a new manufacturing process at the MIMENTO technology center, with facilities provided by the Renatech network, based on precision saw thinning followed by a more precise Reactive Ion Etching (RIE) thinning sequence. We can then achieve a good thickness control in the range of 700 nm to 500 µm from a monolithic LN wafer. Moreover, the rib waveguide, inscribed via standard dry RIE process, is adiabatically coupled to titanium-diffused waveguides at both input and output, enabling low coupling loss (0.8 dB/facet) and single-mode operation. This platform paves the way for a new generation of compact, broadband, and energy-efficient thin-film technologies, suitable for integrated frequency converters.

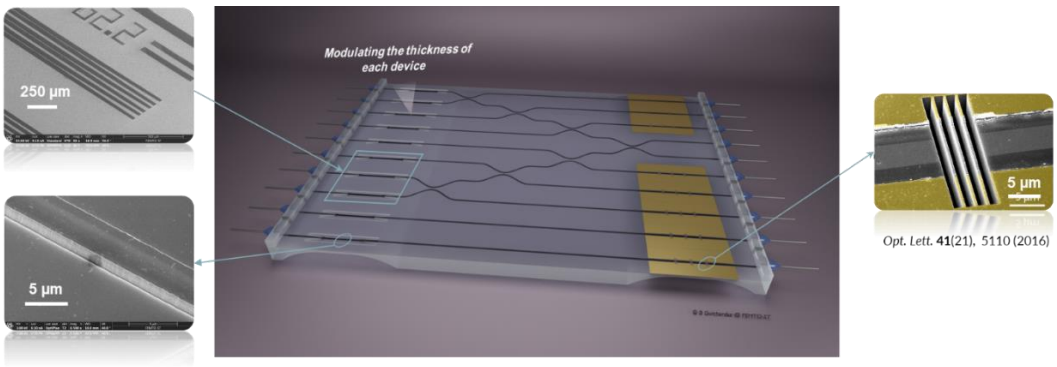

Figure 1: Multi-scale integrated nonlinear photonic platform based on lithium niobate for enhanced frequency conversion and broadband tunability.

Bibliography:

[1] C. Wang, C. Langrock, A. Marandi, M. Jankowski, M. Zhang, B. Desiatov, M. M. Fejer, and M. Loncar, "Ultrahigh-efficiency wavelength conversion in nanophotonic periodically poled lithium niobate waveguides," Optica 5, 1438 (2018).

[2] P. S. Kuo, "Noncritical phasematching behavior in thin-film lithium niobate frequency converters," Opt. Lett. 47, 54 (2022).

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