Editorial for special issue on lithium niobate based photonic devices

Lithium niobate ($LiNbO_3$), so-called “Silicon in Photonics,” is a multifunctional crystal with a combination of a number of excellent physical properties. In optics and photonics, the $LiNbO_3$-based devices, such as modulators, wavelength converters, waveguide amplifiers, and quantum photonic chips, have been realized and widely applied in various areas. In addition to the traditional waveguides, the $LiNbO_3$ on insulators (LNOI) technology enables fabrication of large-scale, high-quality $LiNbO_3$ thin film wafers, boosting the development of thin film $LiNbO_3$-based devices; consequently, versatile applications have been realized to satisfy the small footprint for photonic integrated circuits (PICs). Aiming to present the impressive progresses in this field, *Chinese Optics Letters* publishes this special issue focusing on the fabrication of new LNOI wafers, new design of LNOI-based structures, and the intriguing applications of LNOI-based devices in selected active topics.

This special issue includes 11 invited and 5 contributed papers by the active groups on $LiNbO_3$-based photonic devices. The fabrication of new LNOI wafers is the base of high-performance functional devices. Hu *et al.* reported on the fabrication of new hybrid $Si/LiNbO_3$ thin film platforms and investigated their properties. Zhao *et al.* studied the ridge waveguide fabrication in $LiNbO_3$ by oxygen ion implantation and precise diamond dicing, which is helpful to understand the ion–lattice interaction process (also being a fundamental of LNOI wafer fabrication). The experimental techniques for characterization of LNOI-based devices are crucial for their applications. Luo *et al.* demonstrated the polarization diversity of a two-dimensional grating coupler on x-cut LNOI.

One of the major applications of LNOI-based photonic devices is to realize nonlinear frequency conversion, for example, second harmonic generation (SHG). In this special issue, nonlinear LNOI devices have been presented as follows. Lu *et al.* reviewed the advances of SHG based on the thin film $LiNbO_3$ platform, summarizing the up-to-date progress of nonlinear LNOI devices for integrated photonic applications. Xie *et al.* studied the effect of dimension variation for LNOI waveguides towards SHG, indicating that the SHG profile and efficiency can be greatly affected by the waveguide cross-section dimension variations. Li *et al.* theoretically proposed a Si-covered LNOI waveguide structure for highly efficient SHG, which may be useful to design new types of LNOI wafers. Hu *et al.* reported on local periodically poled LNOI ridge waveguides for SHG, and up to normalized conversion efficiency of $435.5\%\ W^{-1}\cdot cm^{-2}$ was obtained. In addition to the typical nonlinear optical effects, Sheng *et al.* investigated nonlinear Talbot self-healing in periodically poled $LiNbO_3$ crystals, opening up new possibilities for defect-tolerant optical lithography and printing. Li *et al.* reported on the direct generation of vortex beams in the second harmonic by a spirally structured fundamental wave.

Modulators are typical photonic devices. The configurations of the LNOI-based modulators are multiple. In this special issue, Cai *et al.* reported on an integrated thin film $LiNbO_3$ modulator based on Fabry–Perot geometry, and Liu *et al.* realized a wideband thin film $LiNbO_3$ modulator with low half-wave-voltage length product of only 1.7 V·cm based on the Mach–Zehnder configuration. Moreover, Fang *et al.* produced high-quality-factor optical racetrack micro-resonators (intrinsic Q factor $\sim 2.8 \times 10^6$) based on LNOIs with an electro-optical tuning range spanning over one free spectral range of 86 pm. Wang *et al.* demonstrated $LiNbO_3$ microring resonators with intrinsic Q factors over 10^5 using standard lift-off metallic masks and dry etching, which was considered as a fully compatible process with wafer-scale production.

In addition to the above devices, Bo *et al.* reported on the fabrication of on-chip erbium-doped LNOI waveguide amplifiers, and a net internal gain of ~ 30 dB/cm in the telecommunication band was achieved. Jia *et al.* proposed LNOI-based dielectric metasurfaces to realize surface lattice resonances for enhanced light–matter interaction, offering valuable information for the design and optimization of high-quality-factor optical $LiNbO_3$ metasurfaces. Ge *et al.* theoretically constructed a broadband and lossless valley photonic crystal waveguide robust against sharp bend and chirality in $LiNbO_3$ valley photonic crystals. This work can provide guidance on the design of the high-performance topological waveguides with a lossless edge state for low refractive index materials.

It is noted that the commercialization of the LNOI wafer has sparked significant on-chip photonic integration requirements in the past five years. To provide a common platform compatible with Si photonics, Hu *et al.* explored and fabricated the heterogeneous integration of Si and $LiNbO_3$ thin films of 3 inch wafers, which combines the advantages of excellent electric properties and mature semiconductor processing technology of Si, as well as the remarkable photonic, acousto-optic, electro-optic, and piezoelectric nature of $LiNbO_3$. The Si-LNOI wafer will drive new promising devices and potential applications for PICs.

This special issue is expected to provide a glance to the rapidly growing topics in $LiNbO_3$-based photonics, covering selected branches of recent theoretical and experimental research related to $LiNbO_3$-based photonic structures and devices (particularly on thin film $LiNbO_3$ platforms). We strongly encourage our colleagues working in this area to pay attention to this special issue and submit their excellent works to *Chinese Optics Letters* in the future.

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