Periodic Poling of Thin-Film Lithium Niobate for Quasi-Phase Matching

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Lithium niobate on insulator (LNOI) is an emerging photonic integrated circuit (PIC) platform that offers strong second order nonlinear optical and electro optical interaction. The high refractive index contrast in this platform can be used to tightly confine the optical modes, resulting in high intensities with low optical powers, ideal for high nonlinear optical conversion efficiencies. Efficient frequency conversion in LNOI waveguides can be achieved by quasi-phase matching the wavelengths, using periodic inverted crystal structures [1], often called periodically poled LN. However, the fabrication process of the period poled LNOI is highly dynamic due to the semi-random domain nucleation and growth process, posing a significant challenge to achieve uniform poling patterns with a duty cycle of 50%, which is desired for achieving the high conversion efficiencies. Hence, there is a need to study and improve the domain engineering process of LNOI waveguides.

In this contribution, we investigate periodic poling of 300nm thin-film X-cut LNOI. We investigate the correlation between applied voltage pulses and domain evolution. The comb like electrodes are patterned using standard lithography (Fig. 1(a)), while several high voltage (HV) pulses with varying magnitude and pulse duration are applied to invert the domains. After the poling, the inverted domains are visualized by HF etching the LN thin film cross-section and scanning electron microscopy (SEM) imaging (Fig. 1(b)). Fig. 1(c) presents the domain width as a function of voltage for three pulse durations and two cycles. The results show that the domain width increases with pulse duration and magnitude, which suggests further promotion of nucleation sites. This indicates that the domain width can be controlled by these parameters, providing the means to improve the poling process for high efficient second-order nonlinear optical frequency conversion processes.

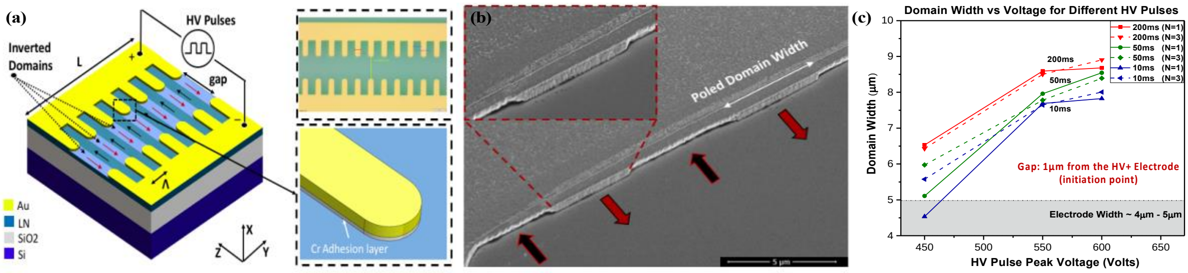

Fig. 1. (a) Schematic of poling electrodes on 300nm thin-film X-cut LNOI. (b) SEM image showing the inverted domains after HF etching. (c) Domain width as a function of applied HV pulses.

[1] A. Boes, et al. "Efficient second harmonic generation in lithium niobate on insulator waveguides and its pitfalls," *Journal of Physics: Photonics*, vol. 3, no. 1, p. 012008, 2021.