Fraunhofer IPM

Maskless poling of lithium niobate crystals

A fast and versatile tool for rapid prototyping and small-volume production

A high-voltage writing head while »writing« domains into a chromium-coated 3-inch lithium niobate (LN) wafer

Periodically-poled lithium niobate (PPLN) crystals are key components of many nonlinear-optical frequency converters, ranging from the visible spectral range up to the THz range. Fraunhofer IPM has developed a maskless poling technique, which combines short turnaround times, full flexibility in poling-pattern design with high quality poling results.

Cost-effective fabrication

Periodically-poled lithium niobate (PPLN) crystals can make nonlinear-optical frequency conversion very efficient. Periodic modulation of the spontaneous polarization allows to quasi-phase match processes. By designing the poling pattern, the desired nonlinear-optical process can be chosen at will. This gives rise to tailor-made light sources, emitting at any desired wavelength within the transparency range of lithium niobate.

For mass-production of identical PPLN crystals, a cleanroom process has become the dominating fabrication technique: Using photolithographically structured mask-electrodes, a whole wafer can be processed within seconds.

However, when it comes to one-of-a-kind samples for R&D projects or small-volume production, mask-poling shows some serious drawbacks: Any new poling-pattern requires the fabrication of a specific photomask, making the overall process time-consuming and costly.

To address the need for a cost-effective fabrication technique for small-volume and one-of-a-kind production at short turnaround times, Fraunhofer IPM together with Freiburg University have developed a maskless poling technique, which does not demand cleanroom processes.

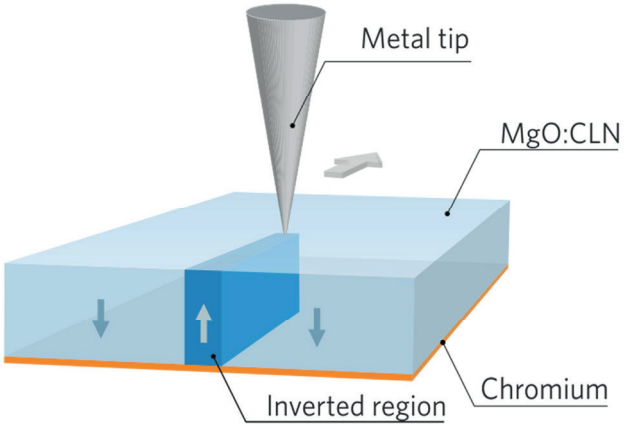
The poling results are equivalent to the established fabrication techniques. The effective nonlinear-optical coefficient does not exhibit any degradation and the long-range order can be guaranteed on the sub-µm level.

Key specifications

- Short turnaround times
- One-of-a-kind to small-volume production
- Cleanroom- and mask-free process
- Periodic, aperiodic, chirped, fan-out, and other patterns
- Min. periodicity: ~6 µm
- Sub-mm to multi-mm thick LN-crystals
- Single-chip to 3”-wafer sizes
- Compatible to stoichiometric, MgO-doped, and congruently melting LN

The working principle

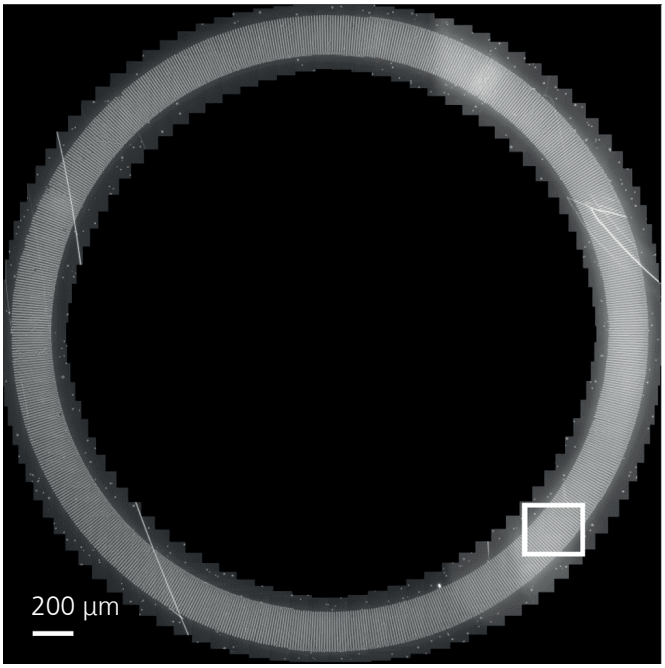
We achieve maskless domain inversion by moving a metal tip over the surface of an unpoled lithium niobate crystal. A high voltage between the tip and a planar metallic bottom electrode leads to a well localized µm-sized domain inversion, right below the tip. By coordinately displacing the charged tip, we are able to serially write domain lines into a lithium niobate crystal. To ensure high-quality poling results, the electrical poling current is monitored and controlled.

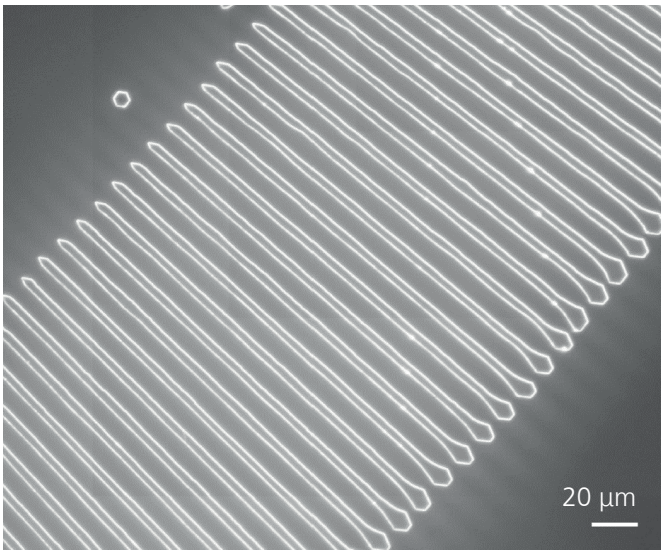


The technique delivers high-quality poling results independent of the LN crystal's crystallographic x- and y-axes. With this, any structure (e. g. fan-out, or radial patterns) can be written – even in MgO-doped, congruently melting lithium niobate (MgO:CLN). The quality of the poling pattern can be checked via bi-sided domain selective etching.

Your benefit

Fraunhofer IPM offers maskless poling as a service, ranging from one-of-a-kind to small-volume production. You will benefit from short turnaround times, which gives you a temporal advance for your research or product development. If requested, dicing and polishing can be offered as well. Besides »poling-as-a-service«, Fraunhofer IPM offers turn-key poling machines for your own in-house maskless poling production, without the need for clean-room facilities.





Radial poling pattern in MgO-doped congruently melting lithium niobate after domain selective etching under dark-field illumination

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