

All Optical Network Thrust:

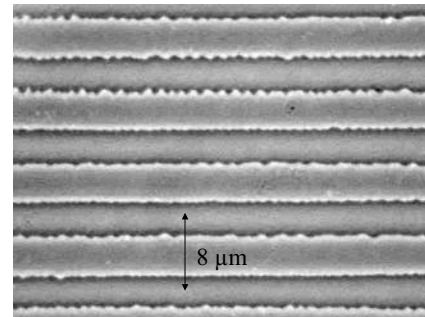
Light-aided domain engineering and in-situ control of the poling process in LiNbO_3

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Motivation

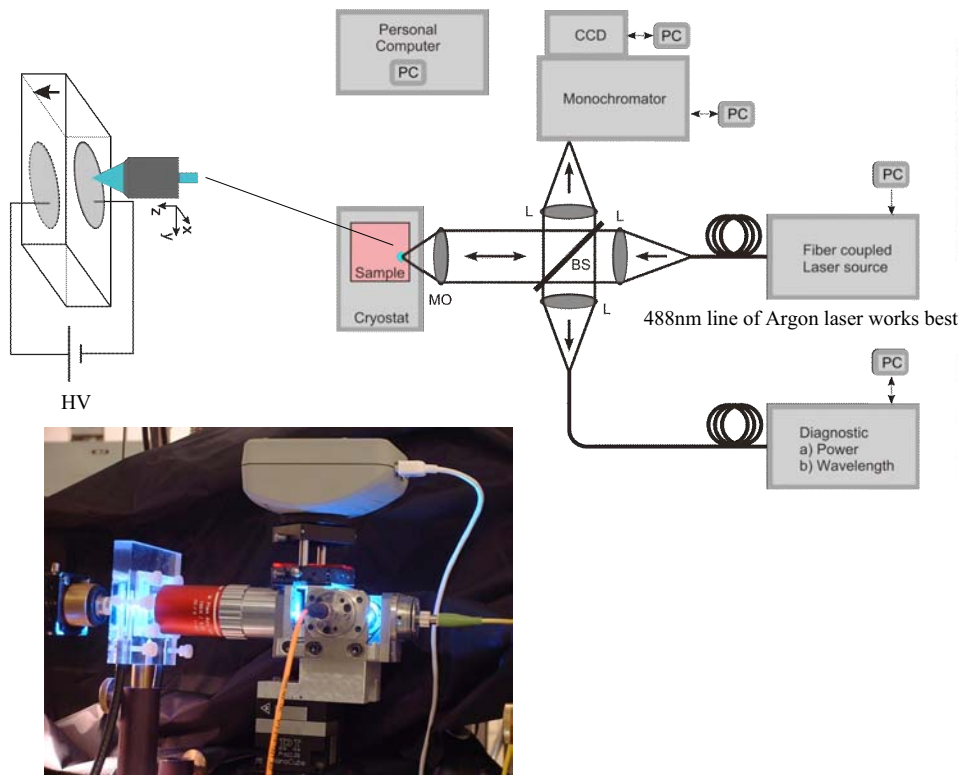
The ferroelectric, lithium niobate is a mature material which is widely used because of its acousto-optical, electro-optical and nonlinear optical properties. In many applications, such as nonlinear frequency converters, photonic band-gap devices, electro-optic Bragg switches, and data storage, it is crucial to create precise ferroelectric domain patterns. Smaller structures, however, are difficult to achieve with the present electric field poling techniques, and thus alternative methods are needed. Light induced poling effects, have good potential to reduce feature sizes. We concentrate on methods in which visible light reduces the coercive fields allowing to directly write domain patterns onto the crystals.

Etched domain pattern in undoped LiNbO_3

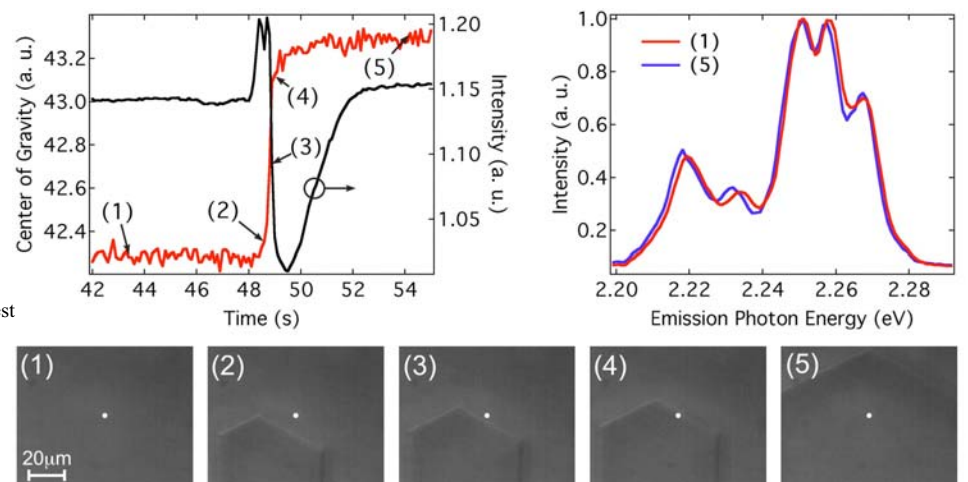


- Er doping does not play a role
- 8 μm period can be obtained very reliably
- Reduction of coercive fields due to heating can be excluded by Raman measurements

Experimental Technique



In-situ observation of domain inversion

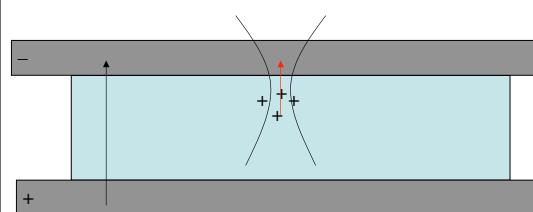


- Changes in the emission and Raman spectra can be monitored up to 100Hz
- The changes occurring in the vicinity of the Er defect ions are faster than the induced birefringence
- The rearrangement around the Er ions occurs on a time scale of about 500ms.

Summary

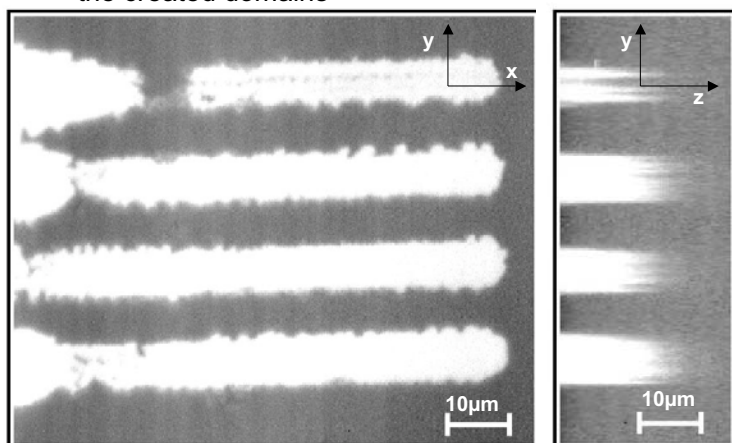
We have developed a technique to directly write stable ferroelectric domain patterns into lithium niobate crystals using visible light from an argon laser tightly focused to a diffraction limited spot in a confocal luminescence microscope. The patterns produced exhibit feature sizes down to 2 μm and show very little strain. The coercive field was reduced by as much as 30%. From the dynamics of the process, we attribute the reduction in coercive field to space charge fields produced by photoionization of defects. The precision of the method is obtained through in-situ monitoring of the domain inversion process

Results



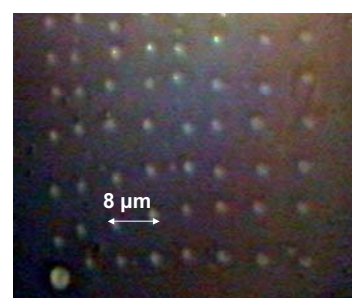
- Creation of space charge fields at the laser spot
- Writing at 25% below the usual coercive field
- Initialization at 130 micron below surface
- Actual writing 5 micron below surface

- Er-doped LiNbO_3 sample
- Emission of the Erbium ions is used for 3D imaging of the created domains



Extension of the Approach to E-beam writing

Similar as for light induced domain inversion, the possibility to invert domains using an electron beam will profit from the direct feedback through in-situ monitoring.



- Using an E-beam small domain structures can be obtained but shapes are irregular.
- Under E-beam bombardment we expect to find cathodo-luminescence (CL) that change as the domain inversion occurs. This CL change would than be used for feedback