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Optical Control of Domain Structures in Lithium Tantalate.

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The patterning of domain structures in ferroelectric crystals continues to attract great interest for numerous non linear optical and photonic applications, including blue light generation from semi-conductor diode lasers, via quasi phase matching.
Other future possibilities include manipulation of the material properties at sub-micron scale lengths for two dimensional photonic band gap devices.
The work reported here concentrates on the fabrication of gratings within ferroelectric lithium tantalate, for periods ranging from 10 - 100 μm (1) and considers extending the technique down to a UV wavelength imposed fundamental limit of 80 nm.
The domain patterning process involves a combination of electric field poling and simultaneous illumination to invert domains within specific areas of the crystal. In our experiments an electric field was applied along the crystallographic z axis of 200 μm thick lithium tantalate.
Switching of ferroelectric domains occurs within un-illuminated regions, while domain switching is inhibited within illuminated regions. A periodic illuminated pattern is thereby translated into a corresponding periodic domain grating within the material. The increase in coercive field under illumination is a consequence of internal field relaxation within the crystal, (2). Optical illumination was provided by UV (351 nm) and visible (488 nm) light from an Ar ion laser.

We report on the crystal orientation, wavelength and intensity dependance for periodic domain inversion via this technique. Optical poling experiments have involved z face illumination at 488 nm and x, y face illumination using 351 nm. Periodic domain patterning was realised via binary mask shadowing, two beam interference and standing wave configuration experiments. Repeated domain switching by cycling the electric field during illumination resulted in well defined domain structures with periodicities of 30 μm.
We discuss further uses of this technique for other ferroelectrics including lithium niobate.

References.

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