Abstract

Nonlinear optical effects play a major roll in the field of integrated optics. A typical example for commercial application of such phenomena in nonlinear devices is frequency conversion. Here a critical parameter would be phase matching which determines the magnitude of the constructive interaction of involved optical fields. Thus to achieve high efficiency of such processes the dispersion for the involved frequencies has to be compensated. For nonlinear components based on optical waveguides one uses the principle of quasi-phase matching that micro domain inversion takes advantage of. Here in average rapid phase-changes arising at domain boundaries compensate the various phase velocities. The area of application for such periodic structures mainly depends on sharpness, homogeneity, depth expansion and periodicity of the domain structure. In this context the nonlinear confocal laser scanning microscopy (CLSM) allows imaging of this transferred ferroelectric domain structure. The main aim of this thesis is the characterization and imaging of the transferred ferroelectric domain structures on lithium niobate (LN). Here a modular confocal microscope allows for nonlinear analysis in reflection and transmission geometry. Regarding important process parameters systematic investigations have been performed on differently processed PPLN specimens in both geometries. It was shown that due to the larger nonlinear coherence length in transmission mode the SHG primarily occurs in forward direction. Depth-resolved analyses on Z-Cut PPLN structures reveal a varied SHG behavior for the surface area and bulk crystal. Here an inversion of the SH contrast was observed; whereby domain walls inside “as poled” crystals appear considerably broadened. A similar SH signature could also be found on LN samples with circular poling structure, whereas this then was merged to a hexagonal domain structure inside the crystal. Within Ti:PPLN a strong and distinct enhancement of the nonlinear signal from the domain walls was found. Here solely the common SH-contrast of surface-signals from the domains and the domain walls is inverted.

In addition differently processed planar and ridge structures in X- and Y-Cut LN with periodically arranged micro domains were investigated. In both cases a strong second harmonic contrast between inverted and non-inverted domain areas could be found which remains in the entire depth of inversion. Here, for example, a successful poling beyond the ridge area could be verified to a depth of up to 5 µm. Further examinations and a cross section analysis of the micro domain structures stand to reason that this specific nonlinear signature arises from embedded domain filaments of the inverted regions.

Furthermore the µ-Raman spectroscopy was performed as an archetype imaging method to study the ferroelectric domain structure of PPLN. Here a specific modulation of the Raman lines by the local variation of polarity and a non-symmetric measuring-signal across the domain structure were found, which allows for imaging of domain boundaries as well as oppositely orientated domains.