Abstract

This thesis presents the results of research centered on the topic of improvement of dynamic range and sensitivity in volume holographic recording using photorefractive lithium niobate crystals. In general, there are two approaches to improving the dynamic range. One is at system level, the other approach is at material level. The second chapter compares the system performances of two holographic recording geometries (the 90-degree and transmission geometries) using iron-doped lithium niobate. The comparison is based on dynamic range, sensitivity, scattering noise, inter-pixel noise, and storage capacity. The third chapter investigates dark decay mechanisms in lithium niobate crystals. Two mechanisms of the dark decay, proton compensation and electron tunneling with activation energies of 1.0 eV and 0.28 eV, respectively, are identified. In crystals with low doping levels, proton compensation dominates the dark decay and extrapolation of lifetimes by an Arrhenius law to room temperature is valid. The time constant of this type of dark decay is inversely proportional to the proton concentration. For crystals with high doping levels, electron tunneling dominates the dark decay. This type of dark decay also limits the highest practical doping level in $LiNbO_3$ crystals. For crystals with medium doping levels, both proton compensation and electron tunneling contribute significantly to the dark decay, and the single Arrhenius law does not hold with a single activation energy. In the fourth chapter, holographic data storage experiments are performed using manganese-doped lithium niobate crystals. The idea to use manganese-doped lithium niobate crystals for holographic storage is the direct result of the understanding of dark decay mechanisms discussed in Chapter 3. The experimental results of dark decay, M/#, sensitivity, multiplexing, thermal fixing, and holographic scattering for $LiNbO_3:0.2$ atomic% Mn and $LiNbO_3:0.5$ wt% $MnCO_3$ are presented. The experimental results show that manganese-doped lithium niobate crystals are well suited for holographic storage. In the final chapter attention is focused on photorefractive properties of manganese-doped lithium niobate crystals. Material parameters, such as the distribution coefficient, are determined. Absorption measurements are used to obtain some information about several charge transport parameters. The dynamic range(M/#) and sensitivity for crystals of different doping levels, different oxidation states, and for different light polarizations have been measured