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Sehr geehrte Damen und Herren,
im Rahmen des SFB/TRR39 PT-PIESA Projekts laden wir Sie recht herzlich zu einem Gastvortrag von Frau MSc Uliana Yakhnevych von der TU Lemberg (Ukraine) ein.

Der Vortrag zum Thema:

“Diffusion of dopants in piezoelectric $LiNbO_3$ crystal during high-temperature treatment in the presence of metal ions”

findet am 10.08.2017 um 09:00 Uhr im Beratungsraum des Institutes für Festkörperelektronik der TU Dresden, Günther-Landgraf-Bau, Raum 7-E02, Mommsenstraße 15, statt.

Abstract

The development of modern functional electronics devices requires both research on new materials and the modification of the properties of already existing ones.

Single crystals of complex oxides play an important role in functional electronics. They easily change their properties under the influence of various physical fields. On the other hand, they possess a high temperature stability of their properties and resistance to chemical aggressive environments. Lithium niobate is one of the most frequently used oxide crystals. Its attractiveness is attributed to a unique set of physical properties. Particularly, lithium niobate single crystals exhibit outstanding pyroelectric, electrooptic, and non-linear optical effects, high photorefractive sensitivity, etc. The annealing of lithium niobate in the presence of metal ions allows to increase photorefractive sensitivity, to form the integral optics structures, etc. Due to the peculiarities of their "soft" structure, the crystals can be doped by large number of impurities allowing crystal property modification. Usually, doping is carried out during the crystal growth. After-growth diffusion is also practiced. Here, the dopants are incorporated into the crystal during a high-temperature treatment in an appropriate environment containing metal ions. So far, doping of $LiNbO_3$ by Cr, Cu, Fe, Ga, Hf, In, Mg, Nd, Sc, Sn, Ti, Tm, Zn and Zr has been investigated. However, results were obtained only for relatively thin samples. The main investigation methods were SIMS and optical methods. Measurements were carried out in the direction of diffusion, so that information on the spatial impurity ion distribution was missing. As a consequence, the anisotropy of diffusion processes in $LiNbO_3$ was not evaluated.

In this work, we study the optical absorption spectra of bulk doped $LiNbO_3$ crystals (7 × 15 × 32 mm, X, Y, Z cuts) doped with Cu, Fe, Co, Ti and Cr ions along the main crystallographic axes perpendicular to the direction of diffusion. Doping was performed by a solid state source (metal oxide powders or sputtered onto the crystal face metal thin films). A specially designed device was used for the registration of absorption spectra consistently at points separated by a distance of 20 μm. This approach is very effective when the ions are incorporated into the crystal with different valence states.

Our investigations revealed that the ions diffuse surprisingly up to depths of more than 700 μm. The spatial distributions of the absorption had maxima for all crystallographic directions and for all investigated dopants. The absorption maxima were located at distances of about 170…700 μm from the crystal edge. They depend on type of the ion and the conditions of heat treatment, i.e. the duration and the temperature of annealing. The ion diffusion was anisotropic with the largest diffusion length in the Z-direction. In the case of copper diffusion, it was shown that both Cu^{+} and Cu^{2+} ions were incorporated into the crystal. The diffusion depth of these ions was different. The spatial distribution of the copper ions in different crystallographic directions of $LiNbO_3$ was calculated using the Smakula-Dexter formula based on the oscillator strength of the corresponding optical transitions.

The nature of processes occurring during annealing is much more complex than the one predicted by conventional diffusion models. Such a behavior suggests that quasi-chemical reactions take place during annealing and that chemical compounds consisting of niobium and dopant ions are probably formed.