Application potential of nonlinear ferroelectric crystals $KTiOPO_4$, $KTiOAsO_4$, and $KNbO_3$ in the millimeter waves

N. A. Nikolaev[1,*], A. A. Mamrashev[1], G. V. Lanskii[2], V. D. Antsygin[1], Yu. M. Andreev[2,3]

[1] *Institute of Automation and Electrometry SB RAS, Novosibirsk, Russia;*
[2] *Institute of Monitoring of Climatic and Ecological Systems SB RAS, Tomsk, Russia;*
[3] *Tomsk State University, Tomsk, Russia*
[*] *E-mail: Nazar@iae.nsk.su*

Today's progress in radio and radio-photonic technologies shows the growth of carrier frequencies of optical and wireless transmission channels up to hundreds of gigahertz. Many experts note that this trend will lead to an excess of channel capacity of more than 100 Gbps in recent years [1]. Realization of these expectations requires the development of millimeter-waves (100-300 GHz) and terahertz (0.3-10 THz) technologies and techniques where a search for new materials and study of their properties is important. Not only new dielectric materials for substrates and waveguides are required but also nonlinear-optical materials serving as efficient optical-to-THz and THz-to-optical converters are needed. Since "classical" electronic devices have limited performance in the designated ranges a new approach based on the optical-to-optical conversion of laser radiation into the millimeter-waves range was proposed.

Ferroelectrics like lithium niobate $LiNbO_3$ [2] and titanyl potassium phosphate $KTiOPO_4$ [3] are shown to be efficient optical-THz converters. In the case of integrated photonics devices, ferroelectrics allow designing waveguides and periodic structures by poling. Such structures show a sufficient increase in the efficiency of laser frequencies downconversion [4] and upconversion [5]. Recent studies show an efficient detection of terahertz waves using two-stage upconversion in a lithium niobate crystal [6]. Moreover, according to the old works of Yu. V. Shaldin [7] the nonlinear components of the dielectric tensor responsible for the conversion processes within the millimeter-wave range are 4 orders of magnitude higher than the values of the components in the optical range. Thus, ferroelectrics are positioned as potentially promising nonlinear media for millimeter-wave and terahertz photonics, including radio-photonics.

Here we present the dielectric properties of three common nonlinear ferroelectric crystals $KTiOPO_4$, $KTiOAsO_4$, and $KNbO_3$ in the millimeter-wave range. The dispersion of the measured refractive index is approximated in the form of Sellmeier equations. Collinear phase matching for fiber lasers frequencies (wavelengths in the vicinity of 1 μm and 1.5 μm) down-conversion into the millimeter-wave range was estimated. Additionally, phase-matching curves of the second harmonic generation process within the millimeter-wave range are presented.

References

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