

METHOD FOR GROWING HIGH-QUALITY KTaO_3

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Potassium tantalate, KTaO_3 , has a unique combination of characteristics. It is an all-inorganic perovskite known for its high dielectric constant values and is suitable for voltage-tunable microwave devices for low-loss tunable filters, dielectric resonators for radio-spectroscopic measurements, field-effect transistors, etc. It is also a high-quality optical material with a refractive index of 2.381 at 405 nm and a transparency window from 345 to 3000 nm. The bulk material demonstrates perfect processability which implies that in many ways KTaO_3 can be used instead of isotropic optical glass due to almost isotropic hardness and stability against cleavage.

As to its most intriguing feature, KTaO_3 demonstrates the behavior of incipient ferroelectric. It means that, being cooled to low temperatures, this material never achieves a phase transition and retains paraelectric properties down to the lowest temperatures achieved. The electric properties of KTaO_3 are known as the so-called behavior of “quantum paraelectric”.

Due to its fascinating features single-crystalline KTaO_3 is very attractive both for fundamental research and multiple applications. Especially, bulk single crystals of KTaO_3 are requested for production of laser modulators, digital deflectors and, particularly, for ferroelectric resonators used in EPR spectrometers that ensure the improvement of signal-to-noise ratio at least by a factor of 10. For all the above applications the quality of KTaO_3 single crystals is a crucial issue. Therefore the methods to achieve the desired quality of crystals cause the unfadable interest.

The present study is devoted to the optimization of the growth method of KTaO_3 single crystals aimed to improve the efficiency of raw material utilization and to make growth conditions more controllable with no loss in quality of single crystals. The starting method of growing, which was subjected to optimization, is the top-seeded solution growth that in its turn is the modified Czochralski method. Both methods imply pulling an ingot from a melt, however, Czochralski method in its pure form cannot be used for growing KTaO_3 . Indeed, KTaO_3 is the substance with very high melting temperature. In the special case of growing infusible single crystals one uses the melted solution instead of the traditionally used pure melt of the targeted material. Procedure of growing from the melted solution instead of melt provides lowering of the growing temperature as compared to the growing from the melt. In our case, when the targeted material is KTaO_3 , K_2O is used as a solvent. The right choice of the composition of the melted solution is crucial for obtaining high-quality crystals. Besides the adjusting of melted solution composition other issues are very important, such as, control of temperature gradients inside the furnace, proper convection in the melted solution inside the crucible, pulling rate optimization,

right choice of the shape of the seed, and so on. Therefore, in the present paper we introduced the improvements beyond the present status of the top-seeded solution-growth method.

We modified the growth set-up by securing more homogeneous heating of the crucible bottom. This was achieved by adding a movable ferrite bar that could be inserted into the inductor. By adjusting the vertical position of the ferrite bar inside the radio-frequency-powered inductor, we controlled the extra currents in the conducting bottom of the crucible. As a result, the bottom was heated additionally and the temperature of the crucible bottom was tuned. By this we managed to lower thermal gradients within the crucible and to suppress spontaneous formation of unwanted crystallization seeds at the bottom of the crucible.

Bulk potassium tantalate single crystals were grown using this modified set-up. The crystals were studied by X-ray diffraction, Raman scattering, and magnetic resonance spectroscopy methods. All the characterization techniques have proven the high crystal quality and purity of the samples. Thus, the proposed modification of the growth set-up ensures production of KTaO_3 single crystals with properties in demand in multiple fields including electronic and optical industries as well as for the development of highly sensitive and compact radio-spectroscopic instruments.

REFRACTIVE, NONLINEAR OPTICAL, AND VIBRATIONAL PROPERTIES OF Na_2SO_4 CRYSTAL

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Dielectric crystals find wide practical application in various electronic devices as their active and passive elements. Important properties characterizing these materials include their transparency in a wide spectral range, a large value of the band gap, the possibility of modifying properties by changing the composition, the possibility of using them as a matrix for various kinds of impurities, etc. Crystals of the A_2BX_4 group are promising representatives of dielectric materials that are actively studied. Previously, a number of studies have been conducted on the study of refractive [1], birefringent [2], piezo-optical properties [3] and band-energy structure [4] of crystals of this group.

An interesting and little-studied representative of this group of crystals is Na_2SO_4 . It is known that the crystal can exist in four phases, which, with decreasing temperature, undergo the following phase transitions: $\text{I} \rightarrow \text{II} \rightarrow \text{III} \rightarrow \text{V}$ [5]. At a temperature of 1156 K, the crystal melts.

The aim of this study is to elucidate the refractive, nonlinear optical, and vibrational properties of the Na_2SO_4 crystal using theoretical and experimental methods. The Na_2SO_4 crystal was synthesized by the method of slow solvent evaporation. The structure and composition of the