Applied Innovative Research
Vol. 2, September 2020, pp. 184-187

Study of sodium potassium tantalate mixed system

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Received 7 September 2020

Ceramic pellets of $Na_{1-x}K_xTaO_3$ (x= 0 & 0.5) system have been prepared by solid state reaction method and sintering process. The prepared samples are characterized by XRD and SEM techniques. Lattice parameters have been calculated by XRD pattern and grain size has been calculated by SEM. It has been observed that the prepared samples show orthorhombic structure at room temperature.

Keywords: Dielectrics, Ceramics, X-Ray diffraction, Scanning electron micrographs

Introduction

The ABO_3 type tantalate perovskite compounds constitute an important group of oxide crystals with broad ranges of scientifically and technologically important dielectric, piezoelectric, ferroelectric and electro-optic properties[1]. Sodium tantalate ($NaTaO_3$) is a member of the perovskite family. The dielectric properties of sodium tantalate were studied by Matthias[2] and showed that it's Curie point is T_c = 475 °C. Vousden[3] studied the tantalate by X-ray diffraction at room temperature and showed that $NaTaO_3$ belongs to the rhombic syngony with parameters a = 5.5239 Å, b = 3.881 Å and c = 5.4778 Å. $NaTaO_3$ is a orthorhombic structure with space group Pbnm below 720 K, and belongs to another orthorhombic space group C_mC_m between 720 and 853 K. At 835 K, it is transformed into a tetragonal structure with space group Pm3m[4-6]. At room temperature and above, it is anti-ferroelectric with a Curie point 475 ºC.

Because of the recent developments in piezoelectric applications and optoelectronic devices viz. high speed electro-optic switches, modulators and frequency doublers, perovskite tantalate have been considered as functional materials for future technologies. For studies of fundamental properties of materials, large homogeneous single crystals are usually desirable to minimize the effects of surfaces and imperfections, however, single crystal are very expensive and difficult to grow, wheareas ceramics have the advantage of being easier to prepare than their single crystal counterparts[1]. Preparation of amorphous and nano crystalline Sodium Tantalate Oxide photocatalysts with porous matrix structure for overall water has been investigated by Harun Tuysuz *et al.*[7]. Microstructure of Sodium – Potassium niobate ceramics sintered under high alkaline vapour pressure atmosphere has been studied by Jerome Acker *et al.*[8]. Fast synthesis of $NaNbO_3$ and $Na_{0.5}K_{0.5}NbO_3$ by microwave hydrothermal method was performed by Rigoberto Lopez-Juarez *et al.*[9]. Synthesis, photo-physical properties, and photocatalytic applications of Bi doped $NaTaO_3$ and Bi doped Na_2TaO_3 nanoparticles were studied by Pushkar Kanhere *et al.*[10]. Theoretical & experimental studies on Ceramic Samples of different ferroelectric material have been done to understand the salient features as these materials[11-15]. Scott *et al.*[16] reviewed the properties and technological potential of ferroelectric memories of $Na_{1-x}K_xTaO_3$. A great deal of interest has developed in the utilization of ferroelectric thin films for opto-electronic integrated circuits[17]. Birefringence is induced in ferroelectric materials following exposures to a constant or varying electric field. There are a number of prerequisite conditions that the ferroelectric layer must meet in order to successfully be integrated within an opto-electronic devices[18]. Previously we have studies different properties of Sodium potassium niobate, lead Magnesium niobate, ultrasonic properties and electrical properties of ferrofluids[19-28]

Purpose of the Present Work

The purpose of the present work is to prepare, characterize and measurement properties of material of different compositions, to enable researchers to select the material for device applications by keeping in view the specific requirement. These materials may

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be used for second harmonic generation, delay line applications & optoelectronic applications.

Experimental Procedures

The raw materials used for preparing the compositions from this system were sodium carbonate, Potassium carbonate and tantalate pentaoxide. The two carbonates were both reagent-grade products of the Qualigens Fine chemicals and tantalum penta-oxide was of 99.9 % purity from Fluka Chemie AG CH-9471 Buschs. The starting material was dried at 200°C for one hour to remove the absorbed moisture. Different compositions of $K_{1-x}Na_xTaO_3$ for (x= 0, 0.5) were prepared by weighing the sodium carbonate, potassium carbonate and tantalum pentaoxide (Starting materials) in proper stoichiometric proportions. The mixture was calcined in the platinum crucible, in air, at 950ºC for 2 h for carbonate removal. After cooling, in dry air, the calcined mixtures were weighed to ensure complete carbonate removal.

The presintered mixture was ground and pressed into pellets of 10 mm diameter. The pellets were placed on a platinum crucible and sintered, in air, at 1050ºC for 26 h.

Characterization

X-Ray diffraction (XRD)

To characterize the material in the present study, X-ray diffraction pattern of the samples at room temperature were obtained on a SEIFERT X-ray diffractometer made by Bruker, using Cu-K filter radiation of 1.540598 Å wavelength. The instrument is well calibrated with the silicon standard sample. Peak indexing was done by using Joint Committee on power diffraction standards (JCPDS) data cards. From the observed diffraction pattern, lattice spacing d was determined, which was used to determining the perovskite lattice parameters. The unit cell parameters were determined using the Auto-X computer software, which includes CRYSFIRE and FULLPROF software.

X-ray diffraction patterns obtained for the prepared samples show characteristic lines corresponding to the orthorhombic and cubic structure along with some impurity and are shown in Figs. 1 & 2, respectively. The peaks related to impurities for $NaTaO_3$ and $Na_{0.5}K_{0.5}TaO_3$ ceramic system have been marked. The lattice parameters for all the prepared compositions have been presented in Table 1.

Scanning electron micrographs (SEM)

Surface topology of the prepared samples were studied by Scanning Electron Micrographs (SEM) using LEO 440 scanning electron microscope. The (SEM) of prepared samples for $Na_{1-x}K_xTaO_3$ system are shown in Figs. 3 & 4. The estimated grain size have been tabulated in Table 2.

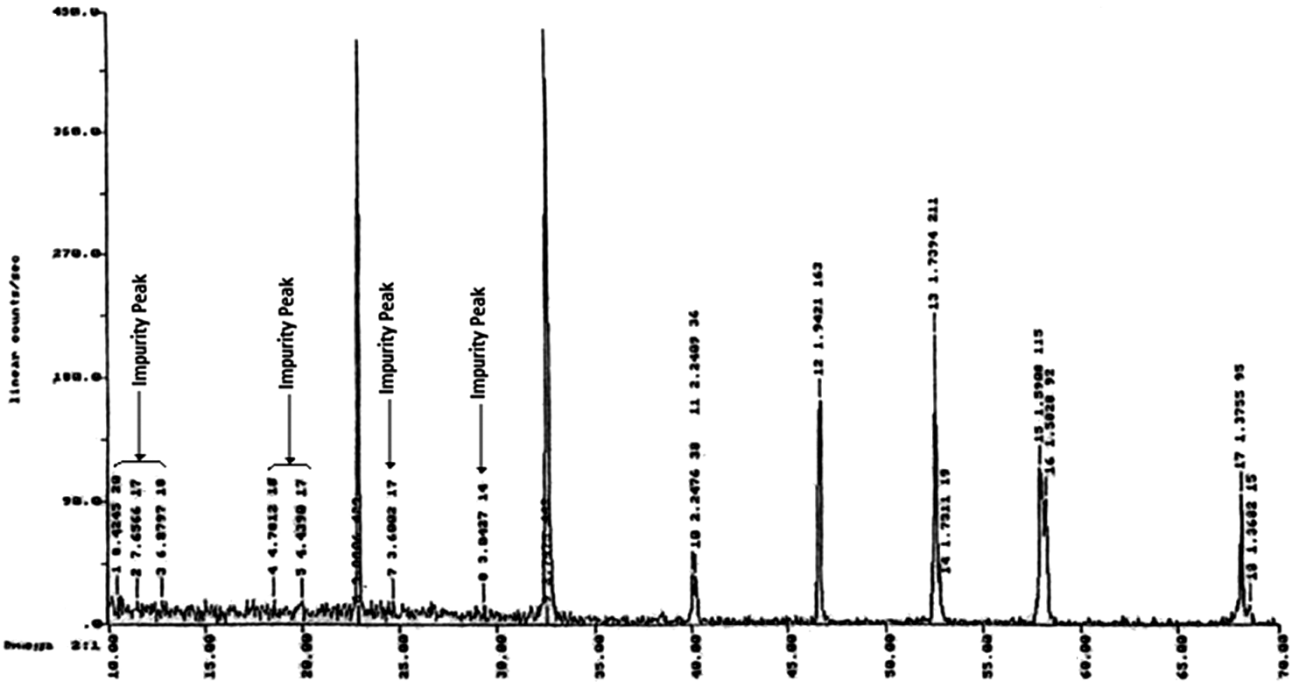

Fig.1 — X-ray diffraction pattern of $NaTaO_3$.

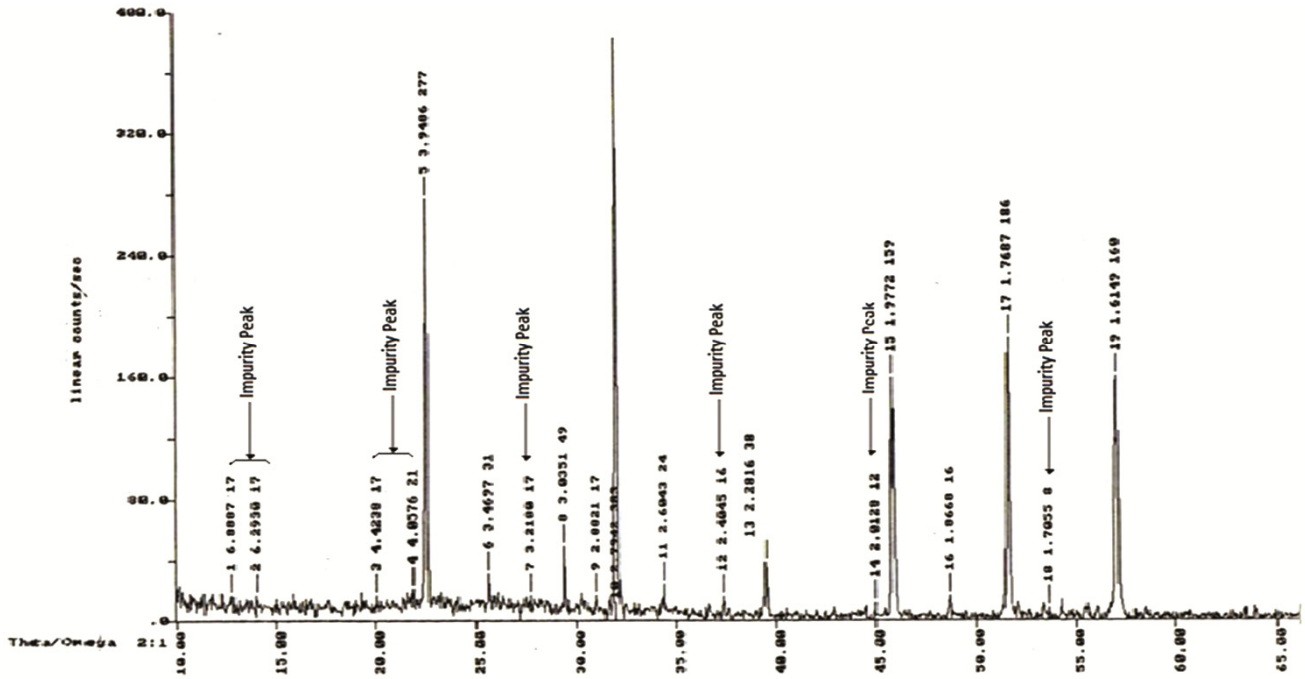

Fig. 2 — X-ray diffraction pattern of $Na_{0.5}K_{0.5}TaO_3$.

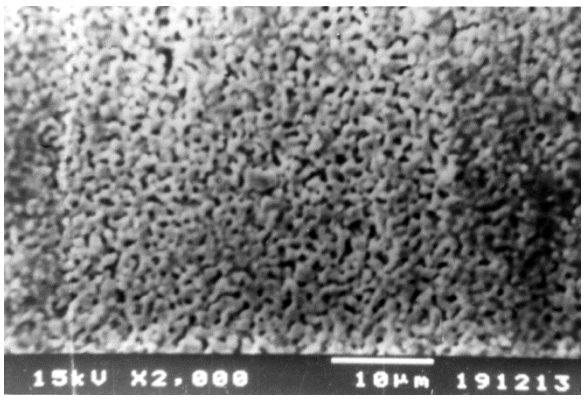

Fig. 3 — Scanning Electron Micrograph of $NaTaO_3$.

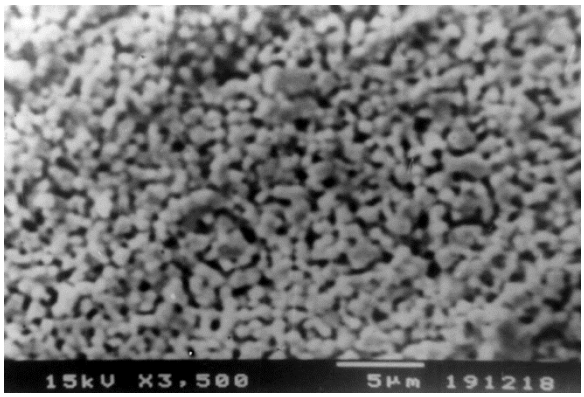

Fig. 4 — Scanning Electron micrograph of $Na_{0.5}K_{0.5}TaO_3$.

X-ray diffraction patterns obtained for the prepared samples show characteristic lines corresponding to the orthorhombic and cubic structure along with some impurities are shown in the Figs .1 & 2. From X-ray patterns, it was found that the structure of $NaTaO_3$ showing orthorhombic in nature while $Na_{0.5}K_{0.5}TaO_3$ is cubic, which is in agreement with the previously reported results[29]. Lattice parameters (Table 1) also reveal the structures of the present systems. The SEM pictures of $Na_{1-x}K_xTaO_3$ sample have been shown in Figs. 3 & 4.

Table 1 — Variation of lattice parameters by mixing K on $NaTaO_3$ in replacement of Na.

Composition	Lattice parameters		
	a (Å)	b (Å)	c (Å)
NaTaO3	5.525	7.419	5.49
$Na_{0.5}K_{0.5}TaO_3$	5.588	5.581	5.585

Table 2 — Estimated grain size for $NaTaO_3$ & $Na_{0.5}K_{0.5}TaO_3$ systems are as follows

Composition	Grain Size (µm)
$NaTaO_3$	5.568
$Na_{0.5}K_{0.5}TaO_3$	6.874

Conclusions

It is observed that when potassium is added in Sodium Tantalate ($NaTaO_3$), the lattice parameters get elongated and also from the SEM patterns it is observed that the grain size of the composition also increases with increase of Potassium (K) in $NaTaO_3$.

Acknowledgement

The Authors are thankful to University Science Instrumentation Centre (USIC), HNB Garhwal University, Srinagar (Garhwal), Uttarakhand for providing XRD and SEM.

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