Effect of Emission Slits and Laser Powers on Up-conversion emission Intensity of $Ba_{.995}Er_{.005}(Sn_{.06}Ti_{.94})O_3$ ceramics

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Abstract.

BSnT and 5Er-BSnT ceramics compositions were prepared by solid-state reaction method. Single phase formation is confirmed by X-ray diffraction at room temperature, with the increasing of Er^{3+} content at A-site the (b/a) values are increases by 1.41445 to 1.42048 respectively. Grain size and Room temperature Dielectrics analysis. The visible up-conversion photoluminescence (UC) emission spectra analysis under the excitation of 980 nm from a diode laser, a strong UC emission is observed at room temperature. The prepared Er^{3+} doped 5Er-BSnT compositions exhibit one red emission band at 662 nm and two strong green emission bands at 527 nm and 550 nm, which are attribute to the transitions $^4F_{9/2} \rightarrow {}^4I_{15/2}$ and $^4H_{11/2} \rightarrow {}^4I_{15/2}$, $^4S_{3/2} \rightarrow {}^4I_{15/2}$ respectively and effect of the slit widths (1-5 nm) and laser powers (50-130 mW) on up-conversion emission intensity analysis .

Key words: Up-conversion spectra, Slit widths, Laser Powers**, X**-ray diffraction, Solid state reaction

INTRODUCTION

In these days Researchers are showing special interest in the combination of Barium Titanate ($BaTiO_3$), Stannate (Sn) and suitable rare earth materials such as Nd^{3+}, Ho^{3+}, Tm^{3+} Pr^{3+} and Er^{3+} [1]. Because $BaTio_3$ is a more useful for various applications due to its excellent dielectric, low loss, ferroelectric and piezoelectric properties such as capacitors, multilayer capacitors (MLCs) and energy storage devices [2]. Doped barium titanate has found wide application in positive temperature coefficient resistors, ultrasonic transducer, and piezoelectric device [3]. The temperature region in which its phase transfers from tetragonal to cubic structure is around 120 -130 ^oC. When appropriately doped with tin (Sn) at the B-site, barium titanate, exhibits a lowering of the transition temperature to near about room temperature, and this makes it more useful for low temperature applications. Sn doped barium is known to enhance the dielectrics and piezoelectric properties significantly [4], Among the lanthanide ions, Er^{3+} is found to be the most effective dopants for Up-conversion emission, and its metastable state levels $^4I_{9/2}$ and $^4I_{11/2}$ of Er^{3+} can be easily populated using low cost, low power laser diodes operating at 800 and 980 nm [5]. In the present study the investigation of effect of slit width and laser power on upconversion spectra intensity.

EXPERIMENTAL

$Ba(Sn_{.04}Ti_{0.96})O_3$ (BSnT) and $Ba_{.995}Er_{.005}(Sn_{.04}Ti_{0.96})O_3$ (5Er-BSnT) compositions were prepared by solid-state reaction method, and the precursor powders Er_2O_3, SnO_2, $BaCO_3$, (purity > 99.9%) TiO_2 (purity > 99.5%) from Fisher Scientific were used. The powders were weighed in stoichiometric amount and High energy boll milled for 4 hours in iso-propyl alcohol (IPA) with 5 minutes interval per hour. The milled powder was dry at 100^oC for 2 h and calcined at 1200 ^oC for 3 h. The powder was mixed with 1 *wt. %* polyvinyl alcohol (PVA) binder after calcination. The dry powder was pressed into circular discs of about 1.5 mm thickness and 10 mm diameter using a hydraulic press (500 MPa). Pellets were finally sintered in air at 1300 ^oC for 5h. The phase formation was evaluated by analyzing the X-ray diffraction spectra collected with Cu-Kα radiation on a Bruker D-8 Advance X-ray diffractometer. For the up-conversion spectra analysis, Horiba Canada (Model No. PTI QM-8450-11-C), for the Grain size Gemini SEM500 made in Germany and Dielectric properties analysis using Nova dielectric-impedance analyser were used.

RESULTS AND DISCUSSION

The X-ray diffraction (XRD) of BSnT and 5Er-BSnT ceramics at room temperature shown in fig.1a. all ceramics exhibit a pure perovskite structure without any trace of impurity, Indicating that Er^{3+} has completely diffused into The host lattice to form a single solution. Enlarged fitted XRD pattern show one broad peak at 45^0 . This result is also similar to Kalyani's report [7] in which O-phase and T- phase coexisted in the same compositions $Ba(Ti_{0.94}\ Sn_{0.06})O_3$ at RT. The peak intensity (002) is higher than (200) ranging from 45^0 to 47^0 in fig.1b its confirming the O-phase in all the compositions and also observed that the peak intensity of (200) is increasing with increasing the Er^{3+} content at A-site.

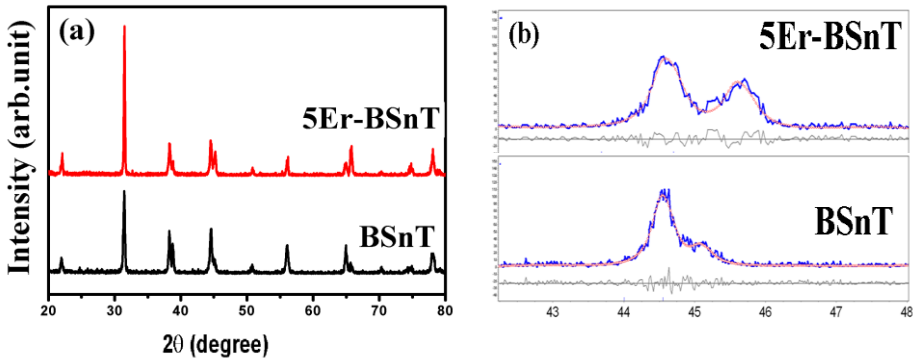

FIGURE 1.(a) The XRD patterns of BSnT and 5Er-BSnT. **1.(b).** Enlarged XRD fitted pattern of 2θ (angle) between (44-47^0)

The rietveld refinement parameters (space group- Amm2 , GOF ~ 1.09) for BSnT- (a=4.05190 Å, b= 5.73122 Å, c=5.84678 Å, V=135.77585 Å^3) , and 5Er-BSnT (a=4.05172 Å, b= 5.75540 Å, c=5.85994 Å, V=136.64951 Å^3), and there (b/a) values are 1.41445, 1.42048, respectively, its indicating the effect of Er^{3+} content at A-site, with the increasing of Er^{3+} content at A-site the (b/a) values are increased , Intensity (I) $I_{(200)0} < I_{(200)5}$ which is clearly seen in fig.1b. The density of pellets were measured by Archimedes method ~ 5.79 g/cm^3. We observed that dielectric constant of BSnT (~3800) higher than 5Er-BSnT (~1600) at 1kHz and Average grain size of BSnT (~30µm) are lower than 5Er-BSnT (~50µm).

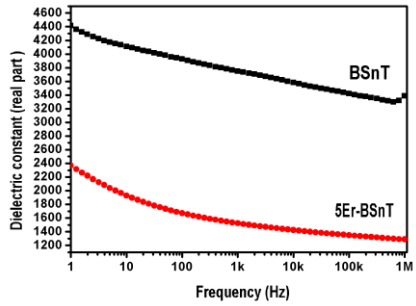

FIGURE 2. Room Temp. Dielectrics constant.

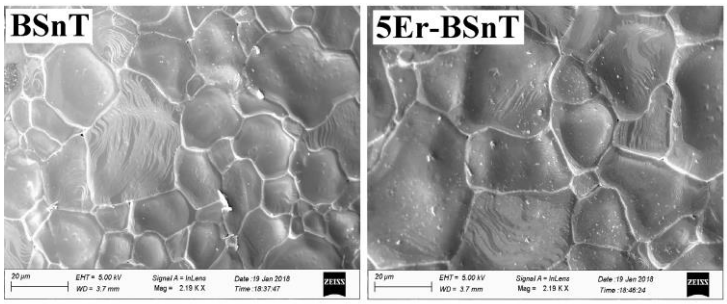

FIGURE 2. FESEM analysis

Up conversion emission spectra analysis:

The visible up-conversion photoluminescence (UC) emission spectra of BSnT and 5Er-BSnT ceramics is shown in Fig. 2a. Under the excitation of 980 nm from a diode laser, a strong UC emission is observed visibly to the naked eye. The prepared Er^{3+} doped BSnT compositions exhibit one red emission band at 662 nm and two strong green emission bands at 527 nm and 550 nm, which are attribute to the transitions $^4F_{9/2} \rightarrow {}^4I_{15/2}$ and $^4H_{11/2} \rightarrow {}^4I_{15/2}$, $^4S_{3/2} \rightarrow {}^4I_{15/2}$ respectively[6], and UC emission peaks do not shift with increasing erbium content. Several mechanisms have been proposed to describe the process of up-conversion in Er^{3+} doped materials [5].

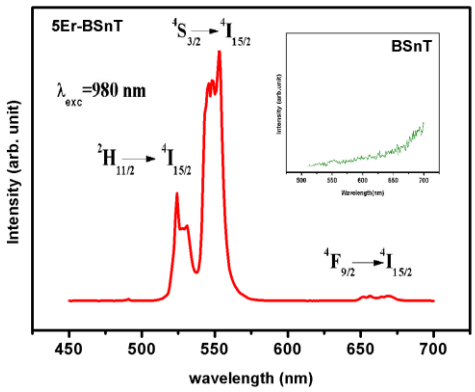

FIGURE (2a). Up conversion emission spectra of 5Er-BSnT and BSnT ceramics.

Effect of slit widths and laser powers on up conversion emission intensity:

Laser powers are increases the intensity of up conversion emission due to its multiphoton process, the number of photons required to populate the upper emitting levels can be well described as follows I_{up} (P) directly proportional to P^n. where I_{up} is the up-conversion emission intensity , n is the number of IR photons required for the up-conversion process and P is the input laser power. At higher pump power, phonon density increases resulting in increase in non-radiative relaxation rate, and thereby the internal temperature of the sample rises and the thermalization effect comes into play which results in no further increase in the UC emission intensity [8]. At the fixed emission slit widths (1nm) , excitation slit width (1nm) and Integration time (1 sec.) when increase the laser powers 50, 70, 90, 110, and 130 mW Intensity (I_{520})- 0.4, 15, 60, 100,150 k and (I_{550})- 0.5, 25, 160, 350, 500 k were increased respectively which is seen in fig.3a. and mentioned in table.1.

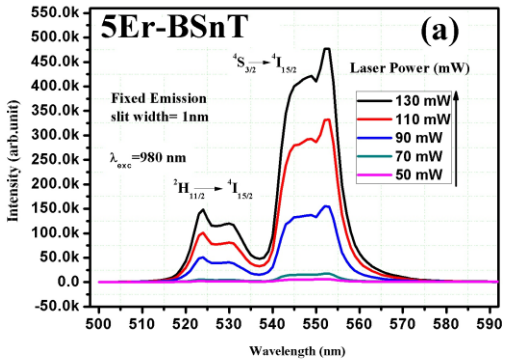

FIGURE (3). Up conversion emission spectra intensity of $Ba_{.995}Er_{.005}(Sn_{.06}Ti_{.94})O_3$ with increasing laser powers.

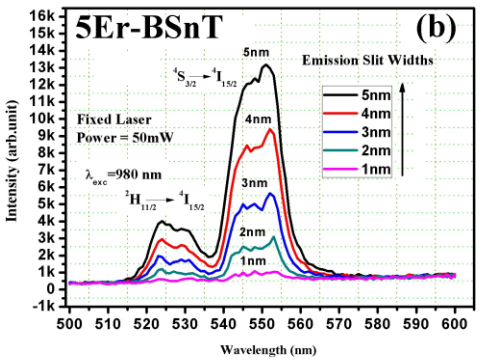

FIGURE (4). Up conversion emission spectra intensity of $Ba_{.995}Er_{.005}(Sn_{.06}Ti_{.94})O_3$ with increasing slit width

Similarly at fixed laser power (50 mW), Excitation slit width (1nm) and integration time (1sec.) when increase the slit widths 1, 2, 3, 4 and 5 nm intensity (I_{520})-0.4, 1, 2, 3.5, 4.5k and (I_{550})-0.5, 3, 5.5, 9.5, 13.5k were increased which is seen in fig.3b. and mentioned in table.1. its clear that with the increasing of both slit widths and laser powers increases the intensity of up-conversion emission,

Table (1). Up-conversion spectra intensity of 5Er-BSnT ceramics with slit widths and laser powers

S. No.	Fixed laser power = 50 mW			Fixed emission Slit width = 1nm		
	Slit width	(I_{520}) - Intensity - (I_{550}) $^2H_{11/2}$-$^4I_{15/2}$	$^4S_{3/2}$-$^4I_{15/2}$	Laser power	(I_{520}) – Intensity - (I_{550}) $^2H_{11/2}$-$^4I_{15/2}$	$^4S_{3/2}$-$^4I_{15/2}$
1	1 nm	0.4k	0.5k	50 mW	0.4k	0.5k
2	2 nm	1k	3k	70 mW	15k	25k
3	3 nm	2k	5.5k	90 mW	60k	160k
4	4 nm	3.5k	9.5k	110 mW	100k	350k
5	5 nm	4.5k	13.5k	130 mW	150k	500k

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CONCLUSION

The X-ray diffraction of BSnT and 5Er-BSnT ceramics at room temperature, all ceramics exhibit a pure perovskite structure without any trace of impurity, Indicating that Er^{3+} has completely diffused into The host lattice to form a single solution, with the increasing Er^{3+} content intensity peak also increases Intensity (I) $I_{(200)0} < I_{(200)5}$. The visible up-conversion photoluminescence (UC) emission spectra Under the excitation of 980 nm from a diode laser, a strong UC emission is observed visibly to the naked eye at room temperature . The prepared Er^{3+} doped 5Er-BSnT compositions exhibit one red emission band at 662 nm and two strong green emission bands at 527 nm and 550 nm, which are attribute to the transitions $^4F_{9/2} \rightarrow {}^4I_{15/2}$ and $^4H_{11/2} \rightarrow {}^4I_{15/2}$, $^4S_{3/2} \rightarrow {}^4I_{15/2}$ respectively. At the fixed emission slit widths (1nm), excitation slit width (1nm) and Integration time (1 sec.) when increase the laser powers 50-130 mW Intensity I_{520}- (0.4-150k) and I_{550}- (0.5- 500k) were increased respectively, Similarly at fixed laser power (50 mW), Excitation slit width (1nm) and integration time (1sec.) when increase the slit widths 1- 5 nm intensity I_{520} (0.4-4.5k) and I_{550}- (0.5-13.5k) were increased. We observed that Average grain size increased 30-40 μm and Room temperature dielectrics constant decreased 3860- 1600 at 1kHz.

ACKNOWLEDGEMENT

The authors wish to thank University of Delhi for R&D grant (2015-2017) and the central facilities at the University Science Instrumentation Center (USIC). One of the authors (Mohd Azaj Ansari) is thankful to University Grant Commission, India for providing financial assistance through Junior Research Fellowship (Ref. No. Ref: FOS-1/114/PhD/4805).

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