

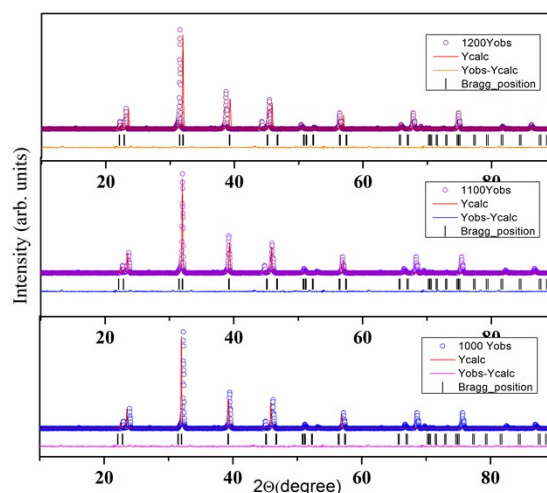
## Electronic Supplementary Information:

### Synthesis of $\text{Er}^{3+}/\text{Yb}^{3+}$ : BCZT ceramic phosphor

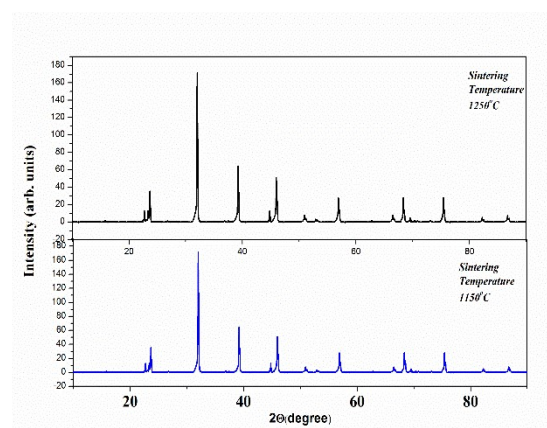
Reagent grade pure raw powders of  $\text{BaCO}_3$ ,  $\text{CaCO}_3$ ,  $\text{TiO}_2$ ,  $\text{ZrO}_2$ ,  $\text{Er}_2\text{O}_3$  and  $\text{Yb}_2\text{O}_3$  from Sigma Aldrich (Germany) were used for sample preparation. The RE ion concentrations of  $\text{Er}^{3+}$  and  $\text{Yb}^{3+}$  were taken as 0.5 mol% and 2.0 mol% respectively to get the optimum luminescence output from the sample. After weighing in stoichiometric quantities, the starting materials were mixed with zirconia in isopropanol for 10 h in an agate mortar. Followed by the wet and dry mixing process, the prepared slurry was then put in an oven for 8 hours at 100 °C. After drying, the mixed batch was calcined at 980 °C for 4 hours to obtain a pure phase. In the next step, the resultant sample was again mixed carefully with the polyvinyl alcohol (PVA) binder and subsequently pressed into a pellet form. At the final stage the pellets were sintered at various temperatures ranging from 1000-1300 °C for 10 hours. The sintered pellets were used for further characterization.

### Thin Film deposition Techniques

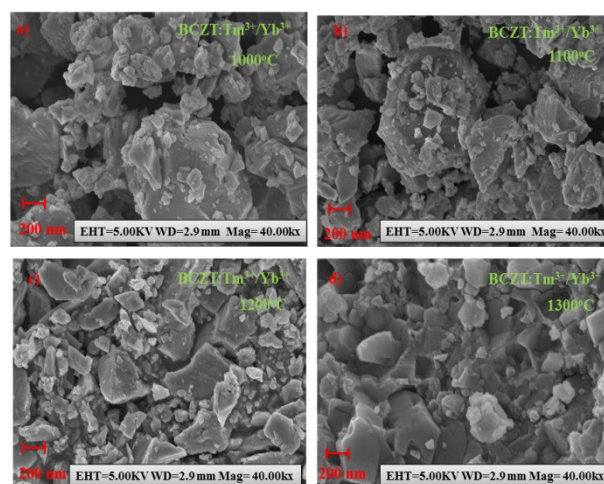
The MW assisted multistage solid state reaction was used for the synthesis of the  $\text{Tm}^{3+}/\text{Yb}^{3+}$ : BCZT ceramic powder. Thereafter, the calcined powder was mixed with a Polyvinylidene Fluoride (PVDF) binding agent and subsequently pressed into the pellet form (into a disk) with 25 mm diameter and 2 mm thickness, and then sintered at 1300°C for 12 h in the Ar ambient. The films were grown by pulsed laser deposition method using an Nd-YAG laser with a wavelength of 260 nm. The distance between the target and the substrate was kept constant at 35 millimeters. The laser beam fluence was around 3.5  $\text{J}/\text{cm}^2$  with a 5 Hz repetition rate. On a p-type Si (1 0 0),  $\text{Tm}^{3+}/\text{Yb}^{3+}$ : BCZT thin film phosphors were deposited.



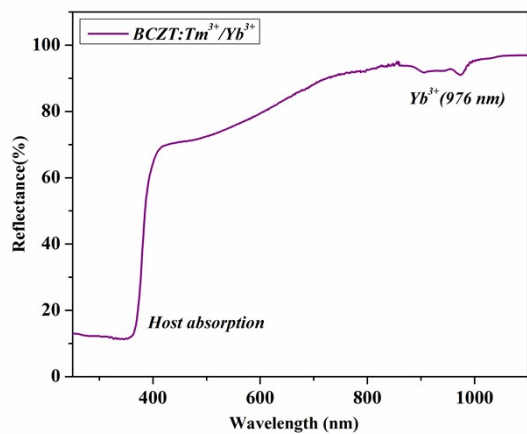
ESI 1: Rietveld refinement results for the  $\text{Tm}^{3+}/\text{Yb}^{3+}$  doped BCZT samples sintered at 1000°C, 1100°C and 1200 °C.



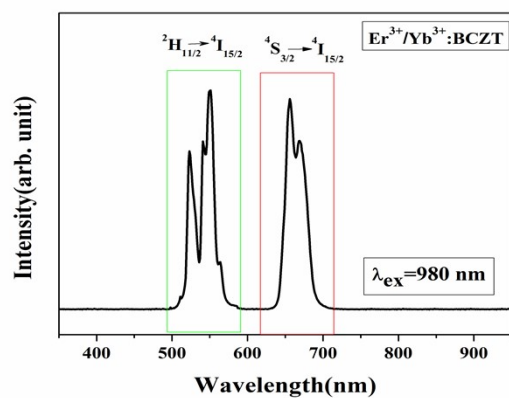
ESI 2: XRD pattern of the samples  $\text{Tm}^{3+}/\text{Yb}^{3+}$  doped BCZT samples sintered at 1150°C and 1250 °C.



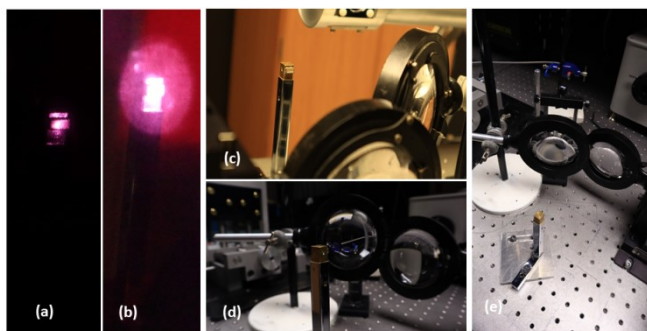
ESI 3: Field emission scanning electron microscopy images of  $\text{Tm}^{3+}/\text{Yb}^{3+}$  doped BCZT ceramics sintered at 1000 °C, 1100 °C, 1200 °C, 1300 °C.



ESI 4: The absorption spectra in the diffuse reflectance mode of the  $Tm^{3+}/Yb^{3+}$ : BCZT ceramic phosphor at 1000 °C.



ESI 5: UC emission spectra of  $Er^{3+}/Yb^{3+}$ : BCZT ceramic phosphor sintered at 1300 °C under 980 nm excitations



ESI 6: (a) Biphasic sample emission image with longer NIR exposure (laser heating), (b) Emission image from the sample without NIR filter, (c) Top view of sample holder, (d) horizontal view of sample holder in normal light (e) Full 980 laser setup.