Supporting Information

A wide temperature range dual-mode luminescence thermometer based on Pr^{3+} doped $Ba(Zr_{0.16}Mg_{0.28}Ta_{0.56})O_3$ transparent ceramics

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S1. *Material morphology*

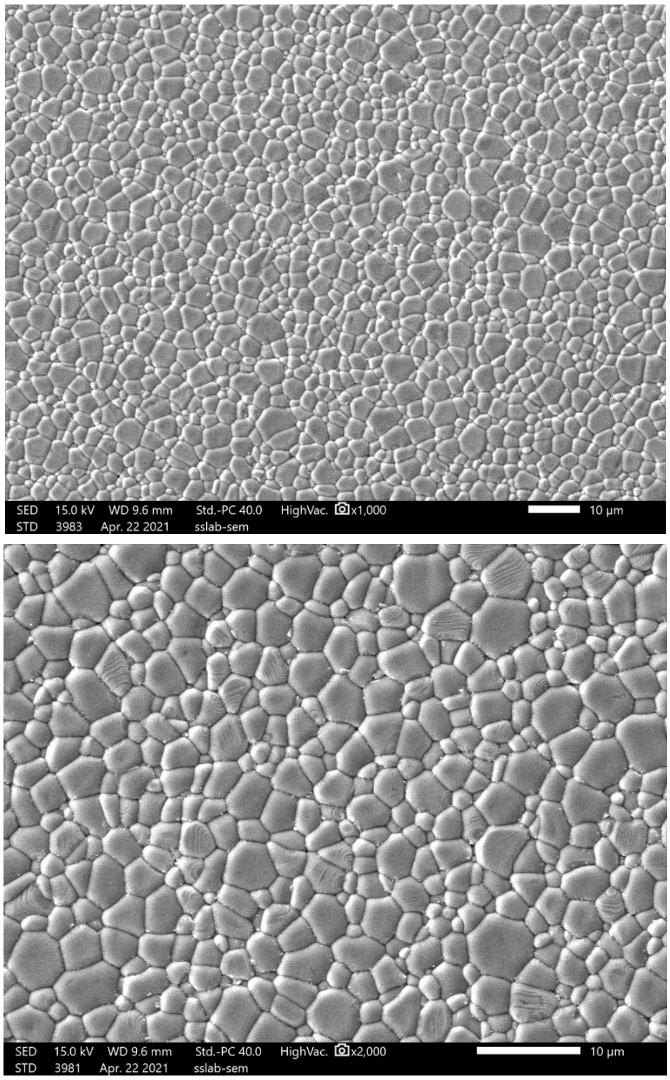

Fig. S1. The microstructure of the 0.6% Pr^{3+}:BZMT transparent ceramic upon two different magnifications: 1000 x (top) and 2000 x (bottom). Very efficient densification is proved and no voids or pores can be seen within the material body. This results in a very low loss of in-line transmittance as presented in Fig. 1. The material was sintered at 1450 °C. Hence, there is no fear that its microstructure will undergo any changes at temperatures at which its thermometric properties are tested in this work.

S2. ***The excitation and emission spectrum of 0.6% Pr^{3+}:BZMT TCs***

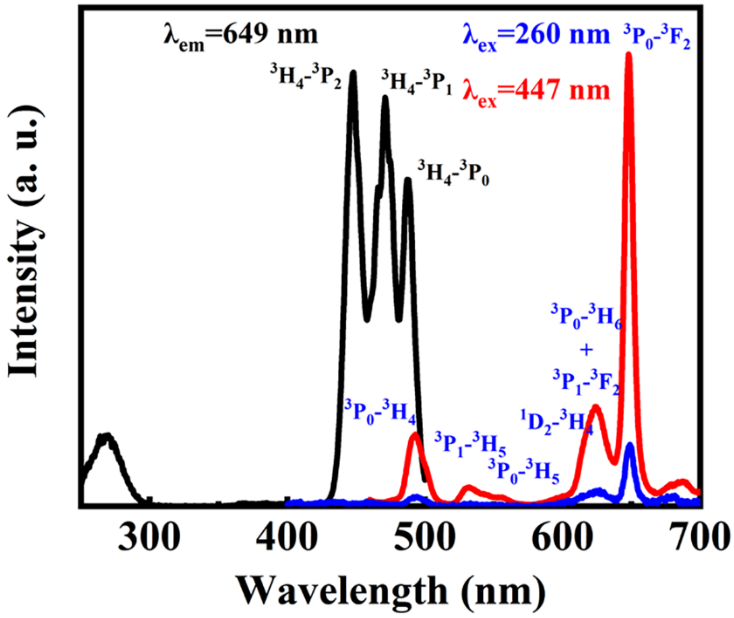

Fig. S2 Excitation and emission spectrum of 0.6% Pr^{3+}:BZMT TCs. In the UV part a broad band representing the 4f-5d transition and coinciding with the absorption of the material is present. From emission spectrum, it is clear that the Pr^{3+} luminescence can be effectively excited either by the intra-configurational 4f-5d transition in UV or by the $^3H_4$-$^3P_2$ blue band. Choosing the former poses a problem of low fluorescence efficiency especially at higher temperatures. Therefore, we have chosen excitation into the $^3H_4$-$^3P_2$ band.

S3. ***The PL spectra of different Pr^{3} concentration doped BZMT***

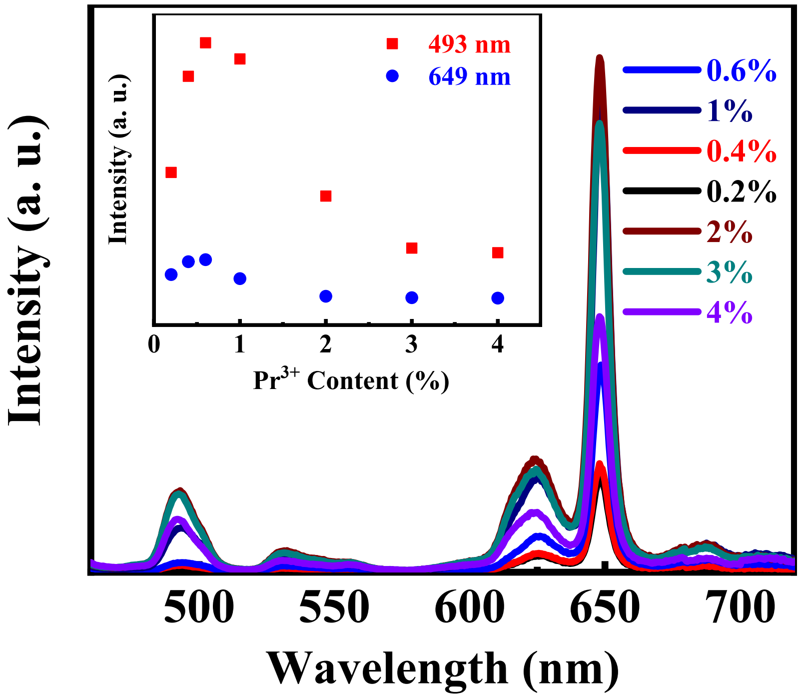

Fig. S3 PL spectra of Pr^{3+}:BZMT phosphor at room temperature with different Pr^{3+} contents (range from 0.2% to 4.0%). The inset shows the intensity of I_{493} and I_{649}.

S4. *The index of refraction of BZMT*

The refractive index was measured by the spectroscopic ellipsometry (ES) wavelength rank from 400 to 900 nm (Nanofilm-EP4SE). Using the Cauchy's equation, given as below (1), the refraction index n was calculated.

$$n=\frac{A}{\lambda^4}+\frac{B}{\lambda^2}+C \tag{1}$$

Here, the constants A=2.110, B=23793, C=0.

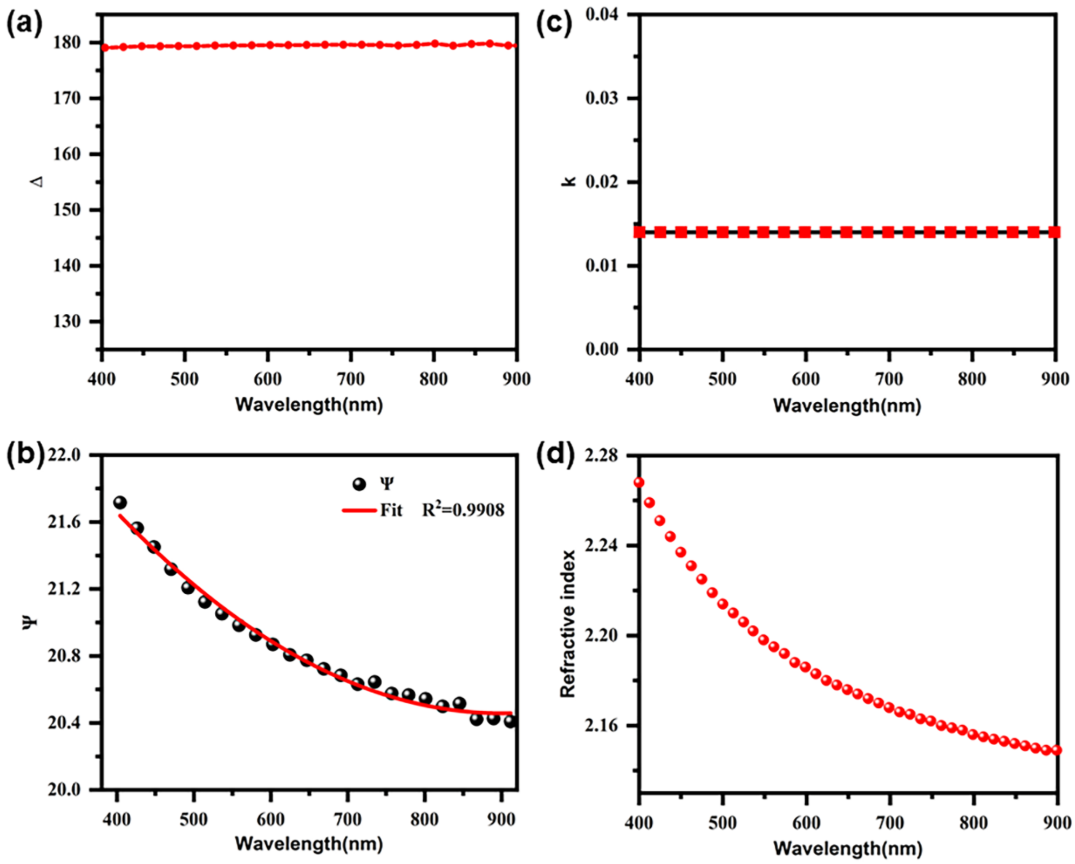

Fig. S4 (a) and (b) is measured value of Δ and Ψ; (c) Optical constants k; (d) The refraction index of BZMT. It can be found that the refractive index value decays from 2.27 to 2.15 in the range of 400 to 900 nm, which is a relatively large value over all wavelength ranges.

S5. *The fluorescence decay curves of 0.6% Pr^{3+}:BZMT TCs*

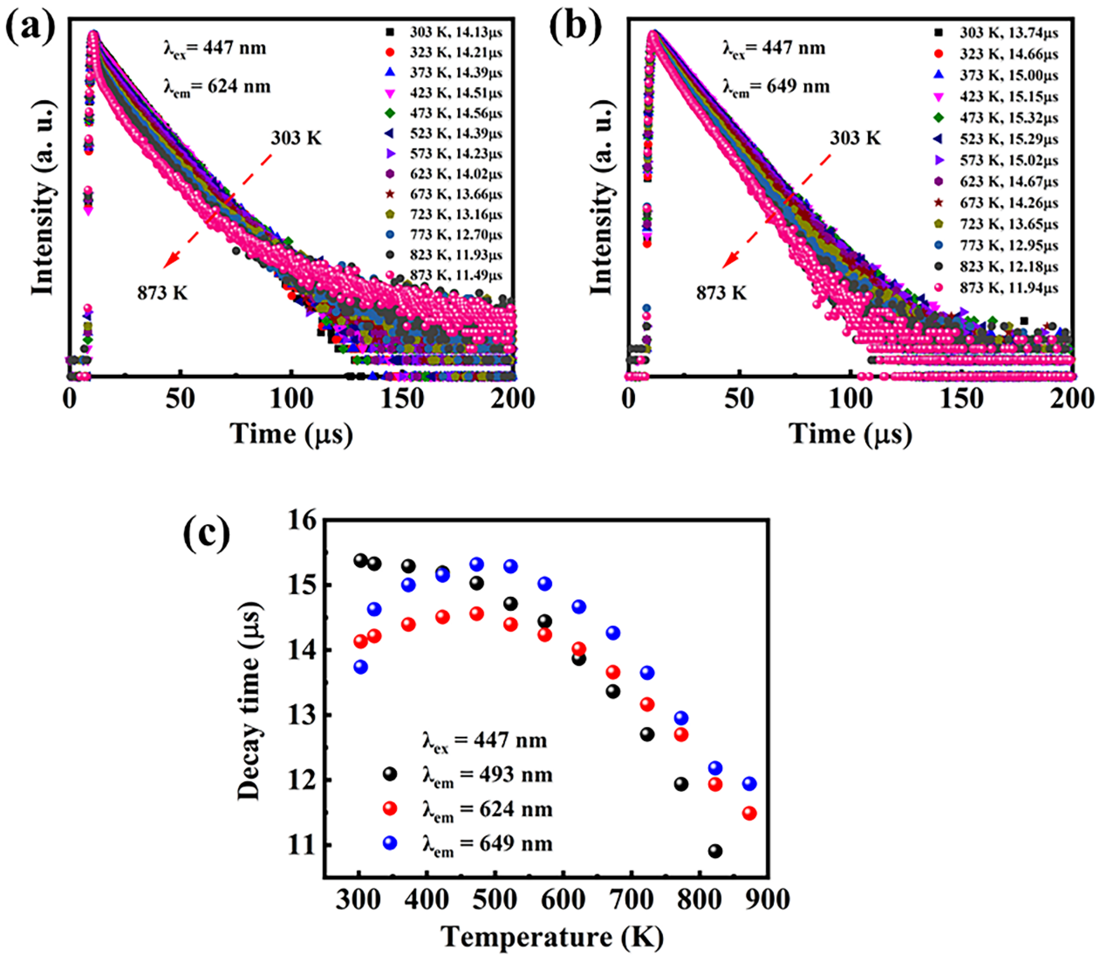

Fig. S5 Fluorescence decay curves of (a) 624 nm emission and (b) 649 nm emission from 303 to 873 K. (c) Lifetime of 493 nm, 624 nm and 649 nm emission versus temperature.

S6. *The Raman spectrum of 0.6% Pr^{3+}:BZMT TCs*

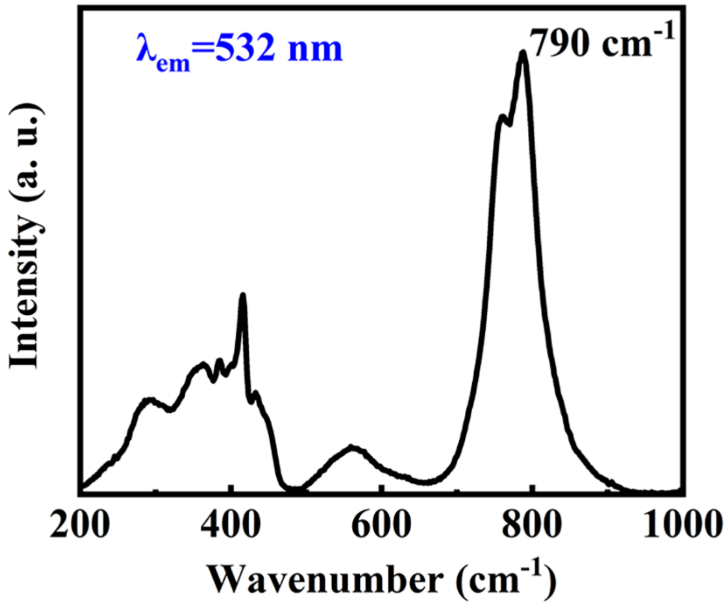

Fig. S6 Raman spectrum at room temperature under 532 nm excitation. The band centered at 790 cm^{-1} is accordance with the maximum phonon energy of the host material.

S7. *The thermal imaging of 0.6% Pr^{3+}:BZMT TCs*

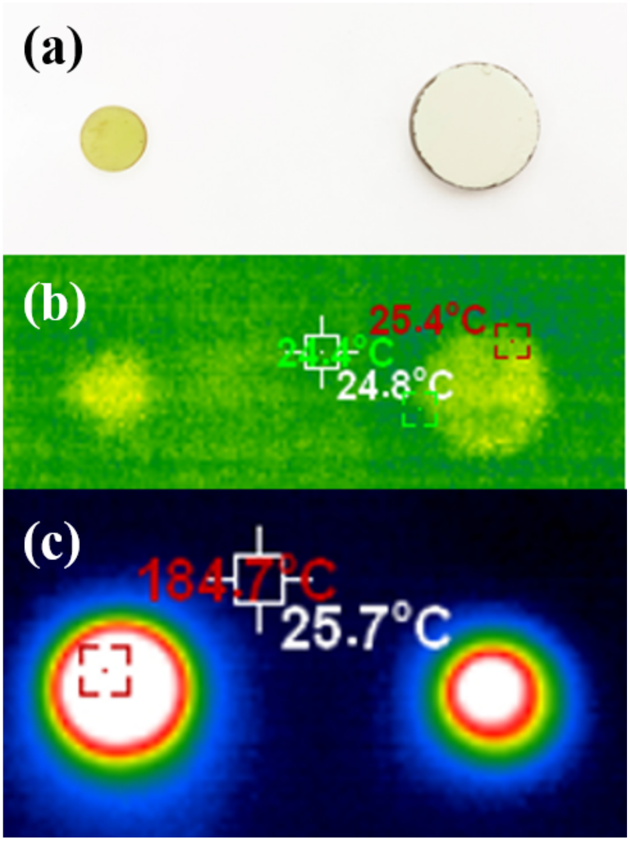

Fig. S7 (a) Physical view of 0.6% Pr^{3+}:BZMT transparent ceramic and powder at room temperature. (b) thermal imaging of 0.6% Pr^{3+}:BZMT transparent ceramic and powder at room temperature. (c) thermal imaging of 0.6% Pr^{3+}:BZMT transparent ceramic and powder exposed to a 450 nm laser for 30 seconds.