

## Supplementary Material

### Origin of dielectric relaxation behavior in TiO<sub>2</sub> based ceramics co-doped by Zn<sup>2+</sup>, W<sup>6+</sup> ions

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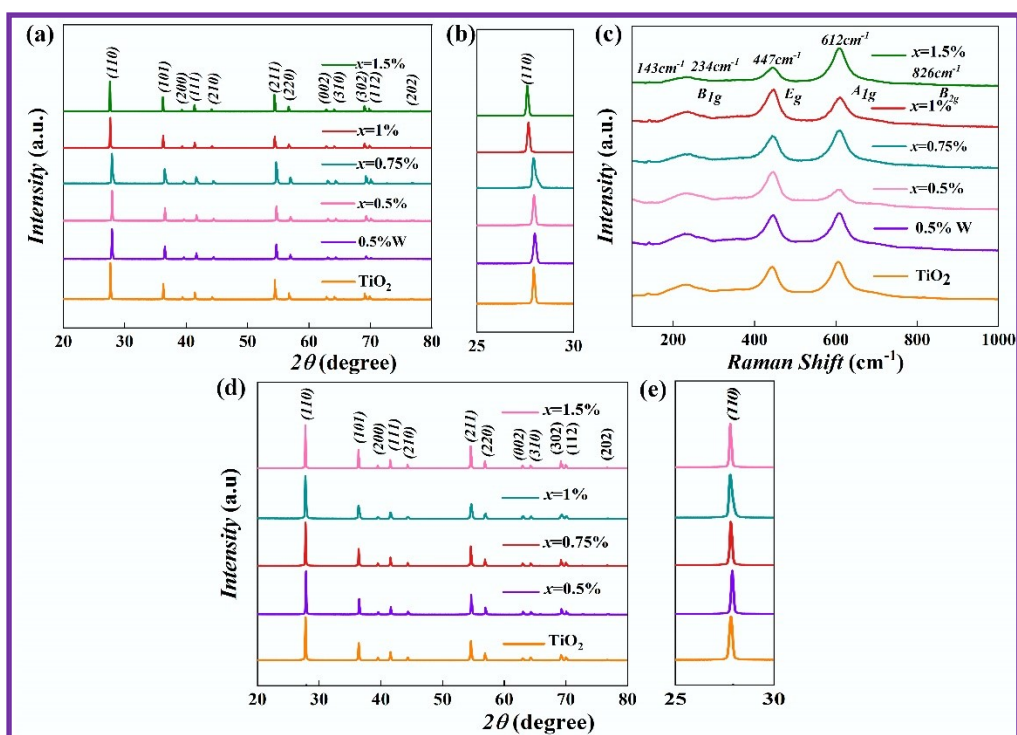


Fig. S1 (a) XRD patterns of ZWTO<sub>x</sub>-N<sub>2</sub> ceramics. (b) Enlarging local detail in range of 25°~30° in XRD patterns of ZWTO<sub>x</sub>-N<sub>2</sub> ceramics. (c) The Raman spectra of ZWTO<sub>x</sub>-N<sub>2</sub> ceramics. (d) XRD patterns of ZWTO<sub>x</sub>-O<sub>2</sub> ceramics. (e) Enlarging local detail in range of 25°~30° in XRD patterns of ZWTO<sub>x</sub>-O<sub>2</sub> ceramics.

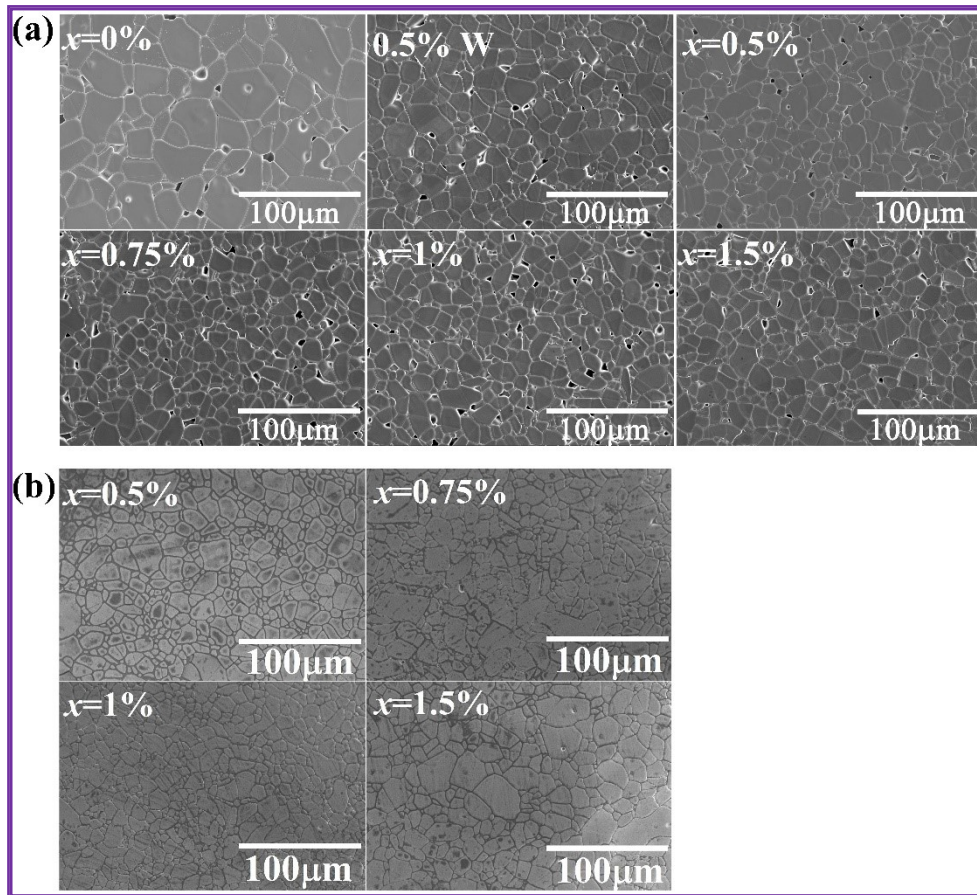


Fig. S2 SEM images of ceramics after thermally etched surface: (a) ZWTO<sub>x</sub>-N<sub>2</sub> ceramics, (b) ZWTO<sub>x</sub>-O<sub>2</sub> ceramics.

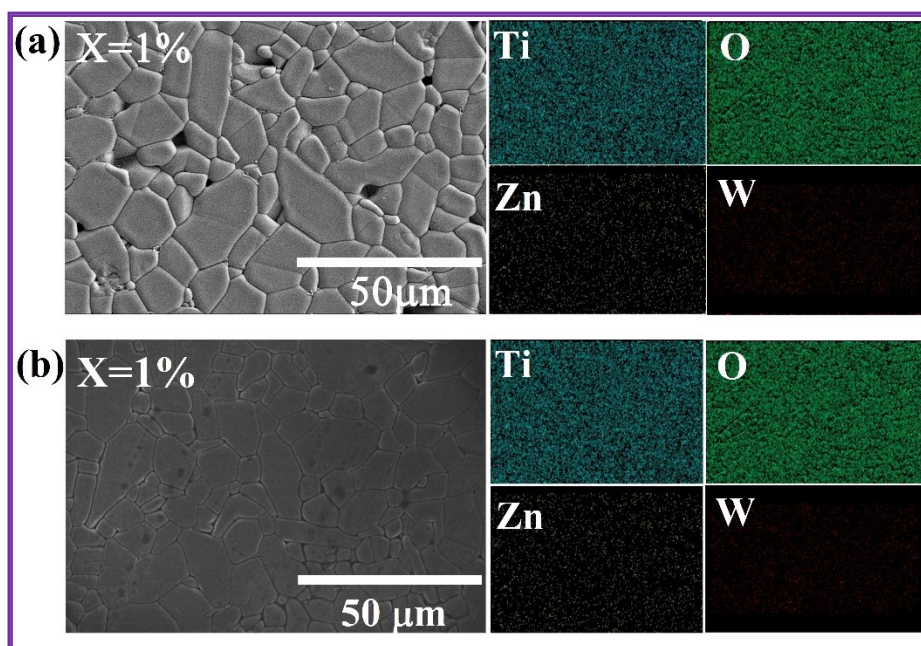


Fig. S3 SEM mapping of ceramics (Ti, O, W, Zn elements): (a) ZWTO<sub>x</sub>-N<sub>2</sub> ceramics, (b) ZWTO<sub>x</sub>-O<sub>2</sub> ceramics.

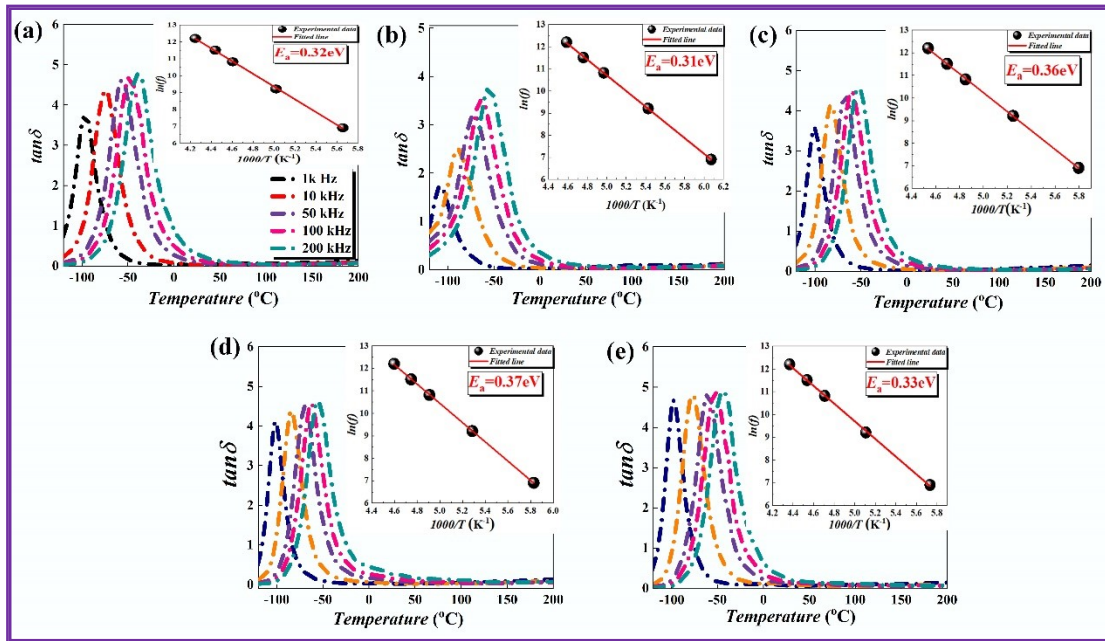


Fig. S4 Temperature dependence of  $\tan \delta$  for ZWTO $_x$ -N $_2$  ceramics at different frequency: (a) 0.5% W, (b)  $x=0.5\%$ , (c)  $x=0.75\%$ , (d)  $x=1\%$ , (e)  $x=1.5\%$ . The inset is activation energies fitted by Arrhenius law.

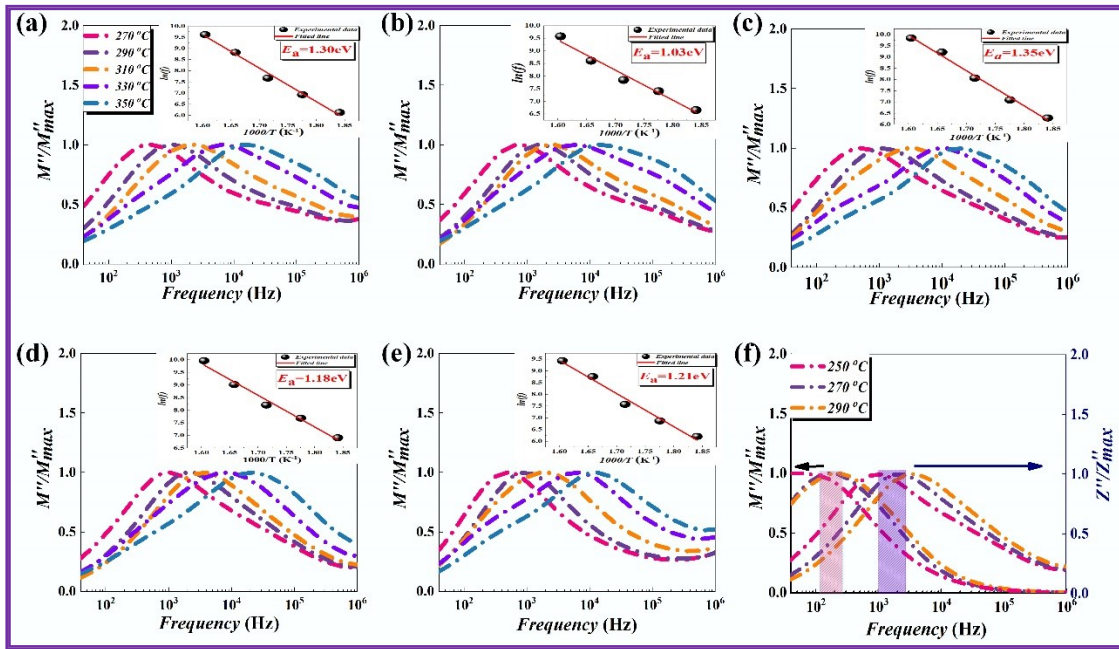


Fig. S5 Frequency dependence of imaginary part of electrical modulus for  $ZWTO_x-N_2$  ceramics: (a) 0.5% W, (b)  $x=0.5\%$ , (c)  $x=0.75\%$ , (d)  $x=1\%$ , (e)  $x=1.5\%$ . The inset is activation energies fitted by Arrhenius law. (f) Frequency dependence of imaginary part of complex impedance and electrical modulus for  $ZWTO_{0.01}-N_2$  ceramics at 250 °C, 270 °C and 290 °C.