# Supplementary information

# High- $\kappa$ dielectric $\epsilon$ -Ga<sub>2</sub>O<sub>3</sub> stabilized in a transparent heteroepitaxial structure grown by mist CVD at atmospheric pressure

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### **Supplementary Table**

**Table S1.** Thickness of  $\varepsilon$ -Ga<sub>2</sub>O<sub>3</sub> and ITO epitaxial thin films, roughness of top surface and bottom interface, and dielectric parameters of the  $\varepsilon$ -Ga<sub>2</sub>O<sub>3</sub> epitaxial thin films. Thicknesses and roughnesses were determined by x-ray reflection shown in Figure S1 and a stylus profilometer for samples A–C and D, respectively. The errors of  $\kappa$  were calculated from the total roughness of the top surface and bottom interface of the  $\varepsilon$ -Ga<sub>2</sub>O<sub>3</sub> epitaxial thin films for Samples B and C, while the error of thickness was reflected in that of  $\kappa$  for Sample D.

	Thickness of ε-Ga <sub>2</sub> O <sub>3</sub> (nm)	Roughness of top surface of ɛ-Ga <sub>2</sub> O <sub>3</sub> (nm)	Roughness of bottom interface of ε-Ga <sub>2</sub> O <sub>3</sub> (nm)	Thickness of ITO (nm)	κ at 10 kHz	Error of <i>κ</i> at 10 kHz
Sample A (on Al <sub>2</sub> O <sub>3</sub> )	79	0.9	1.2	-	-	-
Sample B (on ITO/YSZ)	136	2.0	0.2	42	32.1	0.5
Sample C (on ITO/YSZ)	156	2.3	0.9	44	22.9	0.5
Sample D (on ITO/YSZ)	89(±14)	-	-	-	14	2

### **Supplementary Figures**



**Figure S1.** X-ray reflection patterns for  $\varepsilon$ -Ga<sub>2</sub>O<sub>3</sub> epitaxial thin films. Red curves denote the fitting results to evaluate each layer thickness shown in Table S1.



**Figure S2.** XRD  $\theta$ -2 $\theta$  patterns for  $\epsilon$ -Ga<sub>2</sub>O<sub>3</sub> thin films on  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> and ITO/YSZ substrates around  $\epsilon$ -Ga<sub>2</sub>O<sub>3</sub> 006 diffraction. Vertical dashed lines denote peak positions for  $\epsilon$ -Ga<sub>2</sub>O<sub>3</sub> and  $\beta$ -Ga<sub>2</sub>O<sub>3</sub> as references.<sup>S1</sup>



Figure S3. A plane view SEM image for bare YSZ substrate.

## Reference

S1 H. Y. Playford, A. C. Hannon, E. R. Barney and R. I. Walton, *Chem. Eur. J.*, 2013, **19**, 2803–2813.