

Supporting Information

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ULTCC Glass Composites Based on Rutile and Anatase with Co-firing at 400 °C for High Frequency Applications

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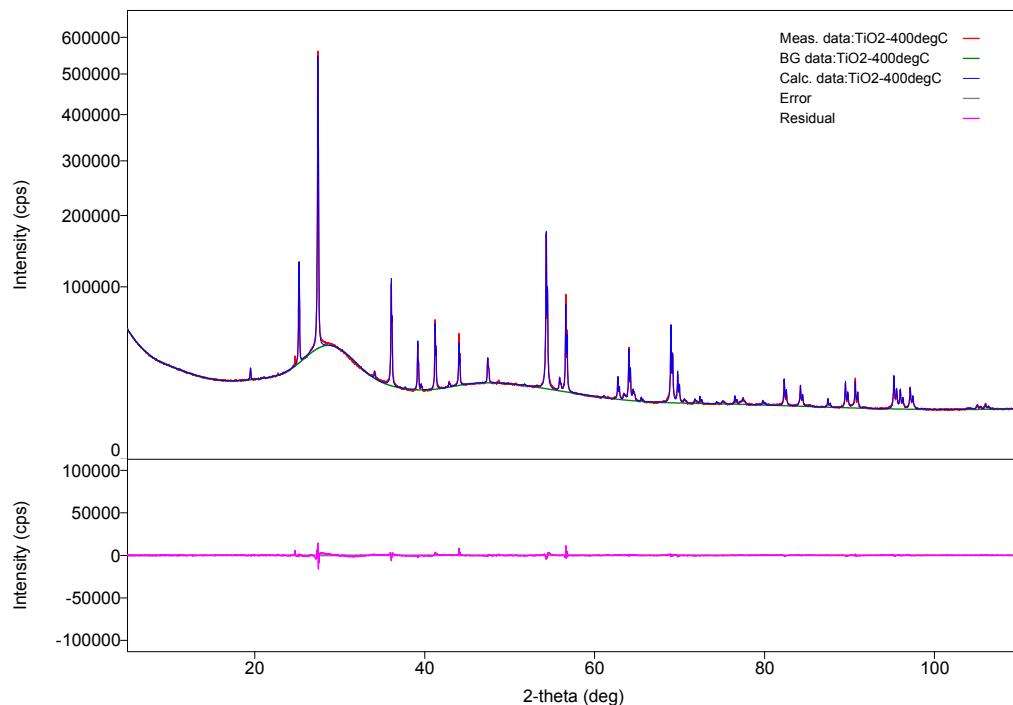


Figure S1. Rietveld refined XRD pattern of $\text{TiO}_2\text{R}-40\text{GO}17$ sintered at 400 °C.

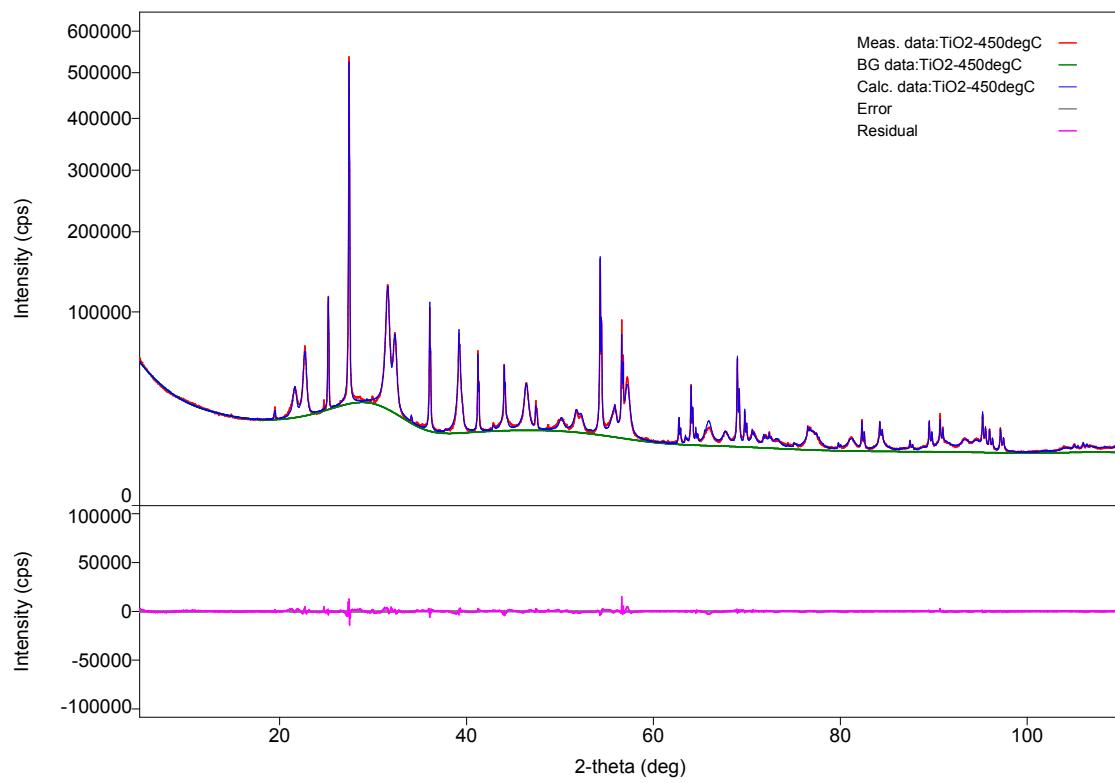


Figure S2. Rietveld refined XRD pattern of $\text{TiO}_2\text{R-40GO17}$ sintered at 450°C

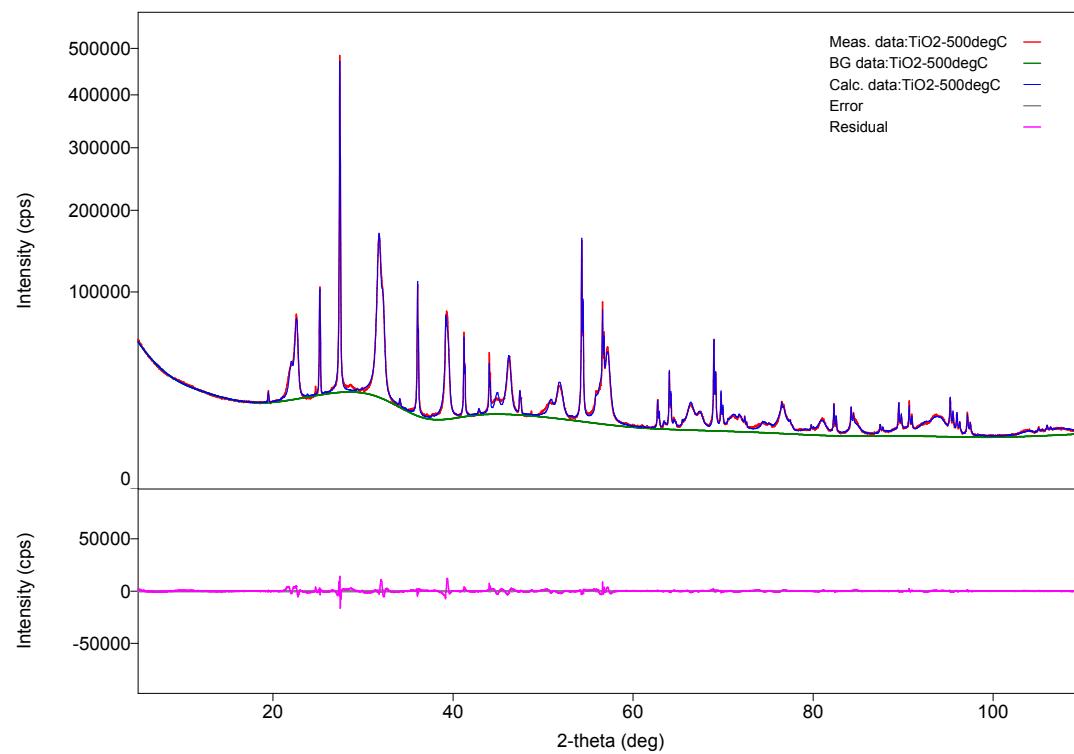


Figure S3. Rietveld refined XRD pattern of TiO₂R-40GO17 sintered at 500 °C

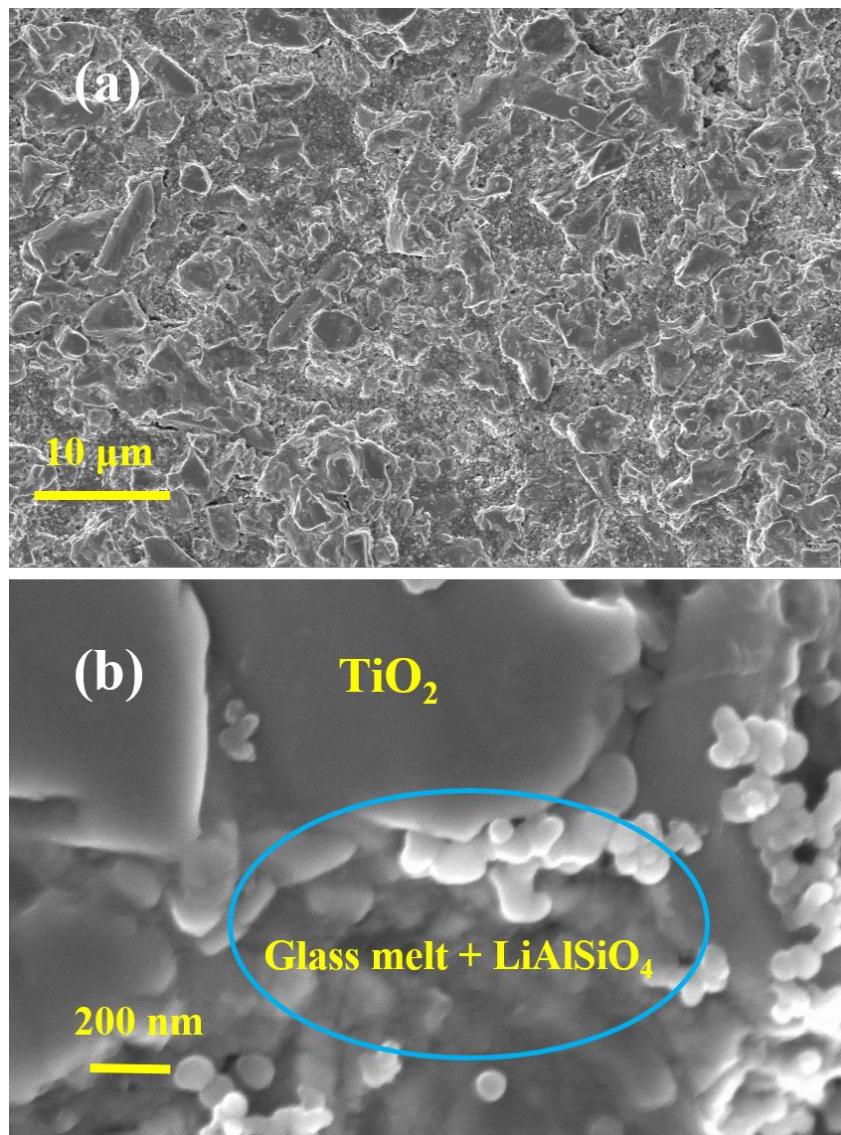


Figure S4. (a) Cross-section microstructure of $\text{TiO}_2\text{R-40GO17}$ and (b) higher magnification grain boundary view after sintering at 400°C .

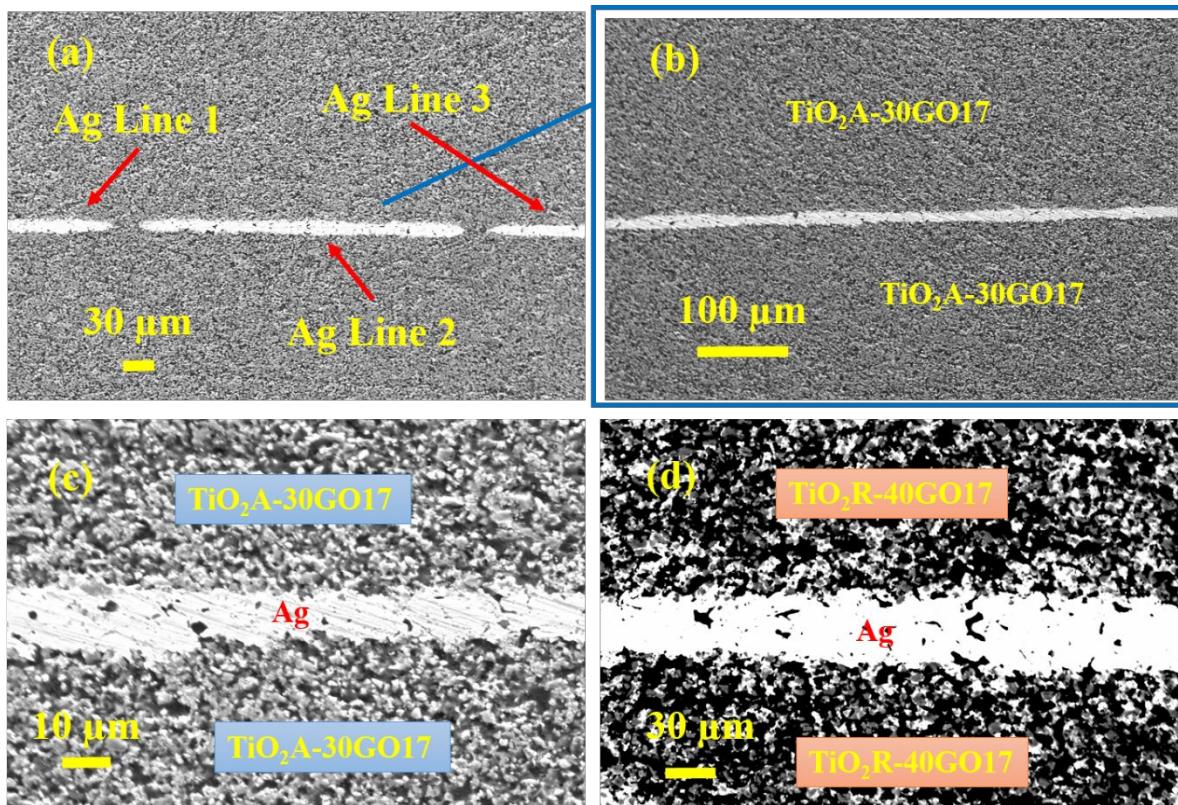


Figure S5. (a & b) Cross-section microstructure of co-firing of Ag electrode lines with separation of TiO₂A-30GO17 at 400 °C, (c & d) shows the cross-section SEM images of TiO₂A-30GO17 and TiO₂R-40GO17 with Ag electrode co-firing at 400 °C.

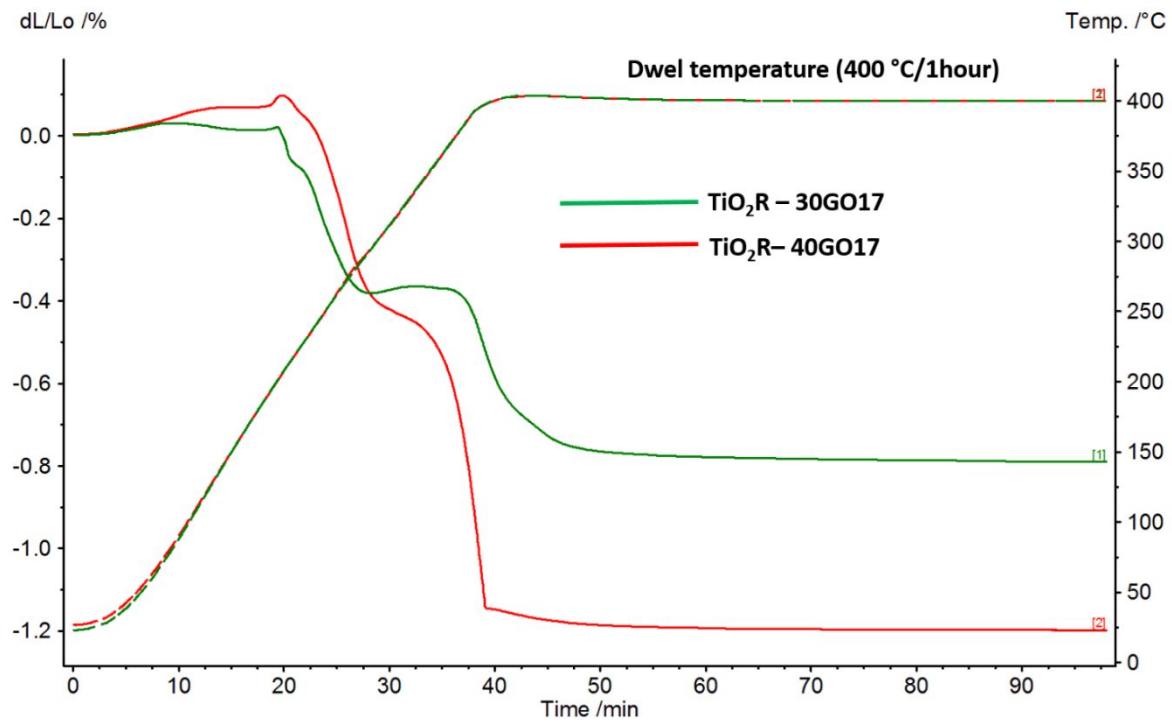


Figure S6. Dilatometry Z-axis shrinkage of $\text{TiO}_2\text{R}-30\text{GO}17$ and $\text{TiO}_2\text{R}-40\text{GO}17$ bulk tape samples.

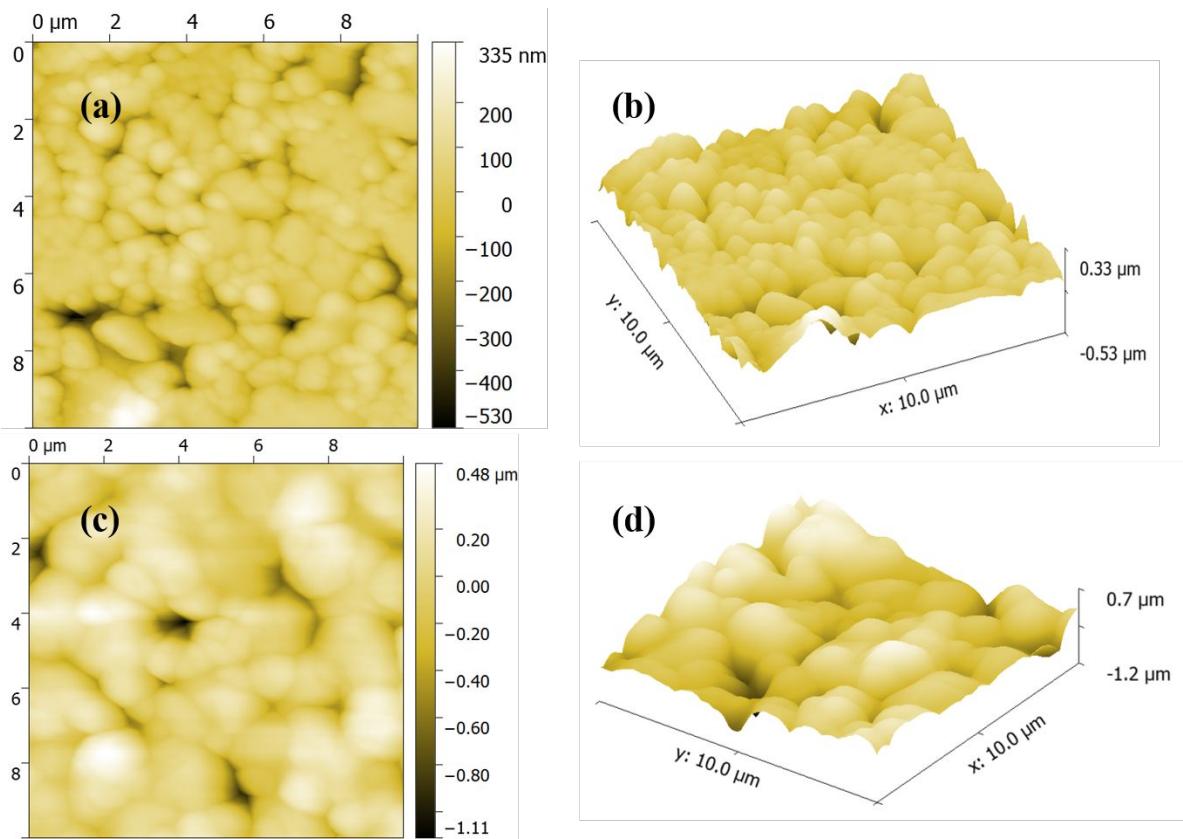


Figure S7. AFM surface roughness analysis of (a) 2D and (b) 3D surfaces of dried screen-printed Ag electrode, (c) 2D and (d) 3D surface of co-fired Ag at 400 °C.

Table S1. Refinement details of TiO₂R-40GO17 sintered at 400 °C using PDXL software.

Phase name	Formula	Content (%)	Figure of merit refinement	Phase reg. detail	DB card number
Rutile, syn	TiO ₂	81.1 (4)	0.494	ICDD (PDF-4+ RDB)	2018 01-079-5859
eucryptite, syn	LiAl(SiO ₄)	18.9 (5)	0.311	ICDD (PDF-4+ RDB)	2018 04-012-5822

Table S2. Refinement details of TiO₂R-40GO17 sintered at 450 °C using PDXL software.

Phase name	Formula	Content (%)	Figure of merit refinement	Phase reg. detail	DB card number
Rutile, syn	TiO ₂	64.5(5)	0.395	ICDD (PDF-4+ 2018 RDB)	01-079-5859
eucryptite, syn	LiAl (Si O ₄)	11.56(2)	0.534	ICDD (PDF-4+ 2018 RDB)	04-012-5822
Titanium Lead Oxide	PbTiO ₃	23.94(4)	0.395	ICDD (PDF-4+ 2018 RDB)	04-006-5631

Table S3. Refinement details of TiO₂R-40GO17 sintered at 500 °C using PDXL software.

Phase name	Formula	Content (%)	Figure of merit refinement	Phase reg. detail	DB card number
Rutile, syn	TiO ₂	58.6(6)	0.749	ICDD (PDF-4+ 2018 RDB)	01-079-5859
eucryptite, syn	LiAl(SiO ₄)	12.0 (6)	0.726	ICDD (PDF-4+ 2018 RDB)	04-012-5822
Titanium Lead Oxide	PbTiO ₃	29.42(11)	0.727	ICDD (PDF-4+ 2018 RDB)	04-006-5631