SUPPLEMENTARY INFORMATION

Circular membrane for nano thin film micro solid oxide fuel cells with enhanced mechanical stability

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1. Fabrication process for a circular thin film μ-SOFC

The fabrication procedure for circular thin film electrolyte membranes is described as follows: 1) Low-stress Si_3N_4 with a thickness of 200 nm was deposited on both sides of the 400 μm-thick <100> silicon wafer by low-pressure chemical vapor deposition (LPCVD). Next, square windows were lithographically patterned to define the surface for KOH etching on the bottom side and Si_3N_4 was removed by reactive ion etching (RIE) with CF_4 and O_2. The window sizes (*b*) are varied from 1 mm to 4 mm. 2) The bottom side of a silicon substrate was lithographically patterned for additional etching by deep reactive ion etching (DRIE) process (ICP-RIE, Surface Technology Systems). DRIE was performed with coil power of 800 W for 10 s etching cycles by SF_6 and coil power of 800 W for 6 s passivation cycles by C_4F_8, correspondingly etching depth of 30 μm with various diameters (0.5 mm~3 mm, *a*). This additional silicon etching was not only to effectively remove silicon residues which can remain underneath Si_3N_4 layer, but also to predefine circles in advance. The circular shape was still retained even after KOH etching to release a free-standing membrane due to etching rate differences according to silicon crystallinity. 3) The opened silicon windows were chemically etched by 30 *wt.*% KOH solution at 80 ºC and free-standing circular electrolyte membranes with tapered edge support were released. The dimension of the tapered edge support can be controllable according to KOH etching time (450 μm in width and 30 μm in thickness in this study). 4) Silicon wafer was diced as 10 mm × 10 mm silicon chips, and 100 nm-thick electrolytes were deposited by PLD or ALD. 5) Si_3N_4 layer underneath an electrolyte was then removed by RIE and 6) 100 nm-thick porous Pt on the both sides was deposited by radio-frequency (RF) sputtering under 30 mTorr Ar pressure and 100 W RF power without substrate heating. Afterwards, free-standing circular thin film μ-SOFCs were obtained with diameters between 0.5 mm and 3 mm.

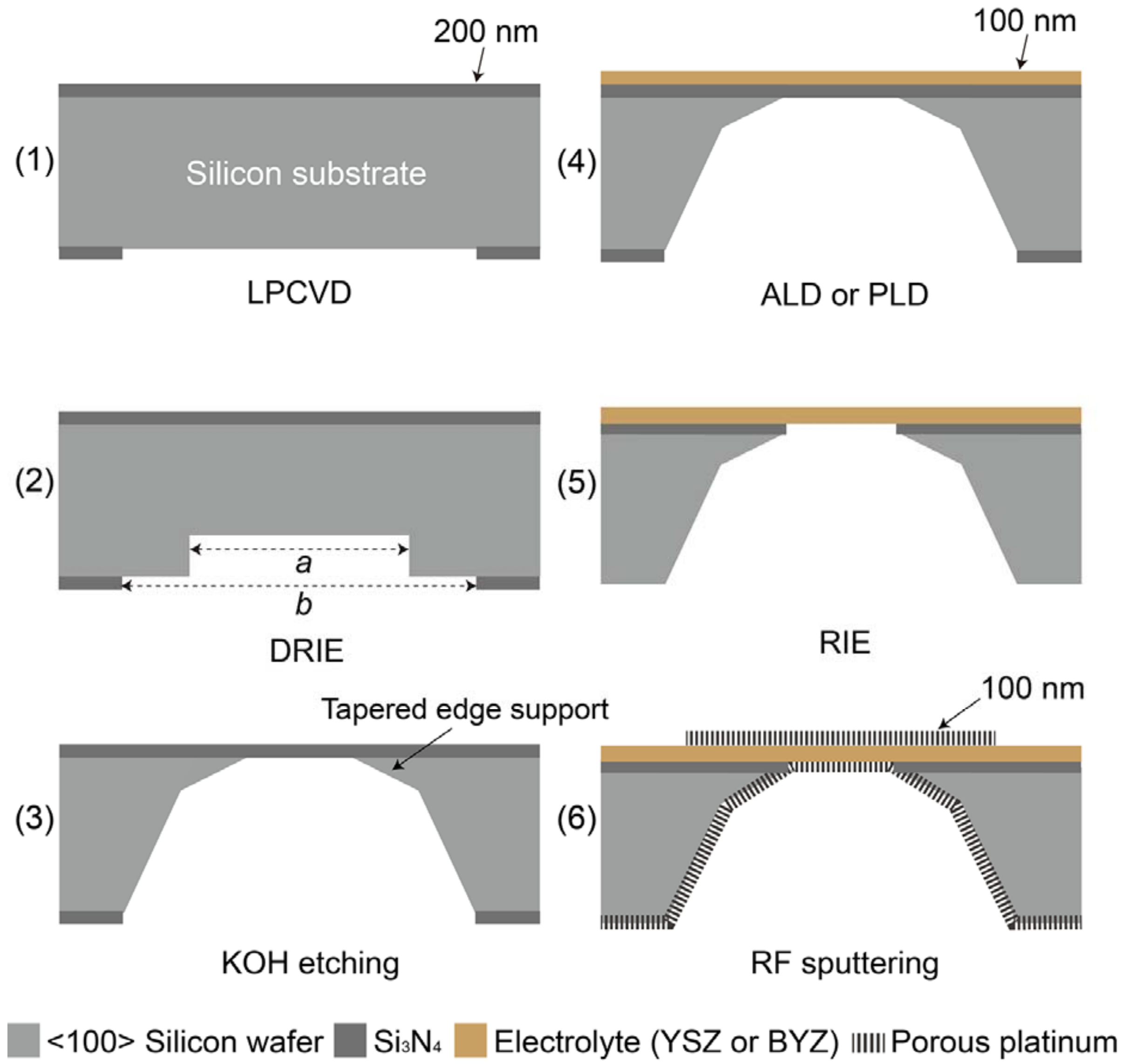

Figure S1. Schematic of fabrication process for a circular thin film μ-SOFC on a silicon substrate

2. The tapered silicon edge support

Figure S2 shows the cross-sectional etched profile of silicon supporting structure evolved with increasing KOH etching time. The additional anisotropic DRIE before the KOH etching predefined the circle on a silicon substrate. This circular trench with the etching depth of 30 μm is evolved to the circular opening after KOH etching (Figures S2 (a) and (b)). As the KOH etching proceeds, the (100) planes exposed to KOH were etched at much higher rate and a tapered structure is appeared along the circular boundary as shown in Figure S2 (c). As the front (100) plane etched by DRIE reached the bottom of Si_3N_4 etch stop layer, an annular-shaped and tapered edge support is completed (Figure S2 (d)). This support is likely to be evolved from the corner of the DRIE trench, and as it has a taper angle of 3.4-3.9 degree with (100) plane, it could be related to the (110) plane.

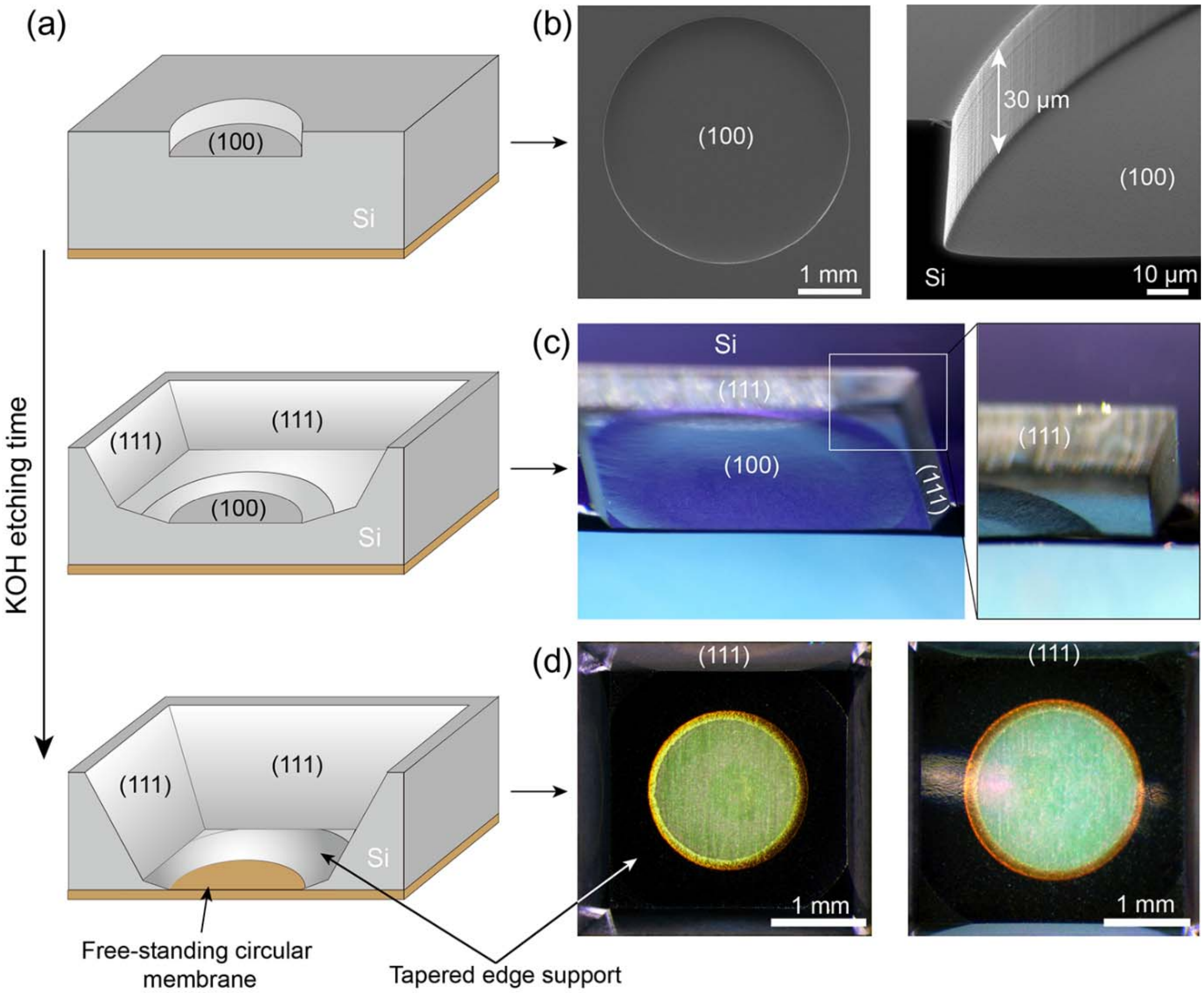

Figure S2. (a) Progression of cross-sectional etched profile during KOH etching. (b) SEM views after DRIE on silicon substrate. (c) OM views during KOH etching. (d) OM views after completing KOH etching.