Supporting material

Hydrogel assisted GDC chemical diffusion barrier for durable solid oxide fuel cells

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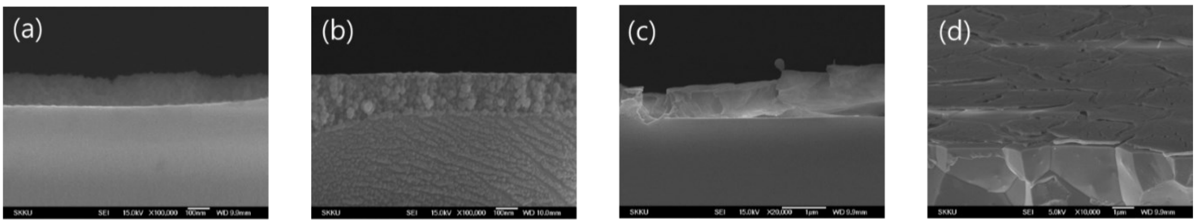

Figure S1. The cross-sectional film morphology according to gelatin concentration. (a) 1.5, (b) 3, (c) 10, (d) 20 wt%.

At the lowest gelatin concentration, the film was not uniform and discontinuous because of the small amount organic material, which is necessary for preventing agglomeration of metallic materials at the early stage of heating. In contrast, with higher gelatin concentration as shown in Figure S1. (c and d), in some places the gelatin-GDC formed dense film but mostly the film had defects such as delamination and crack. The non-uniform morphology was the result of insufficient connection among metallic components due to the excessive organic material interrupts the merging. At the moderate concentration ratio shown in Figure S1. (b), relatively smooth film was achieved, and the ratio was applied for the further optimization.

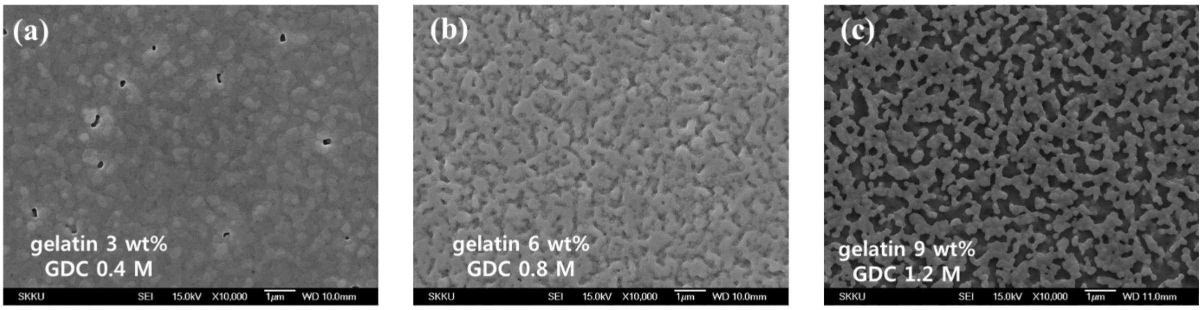

Figure S2. Surface morphology of GDC films annealed at 1200 °C.

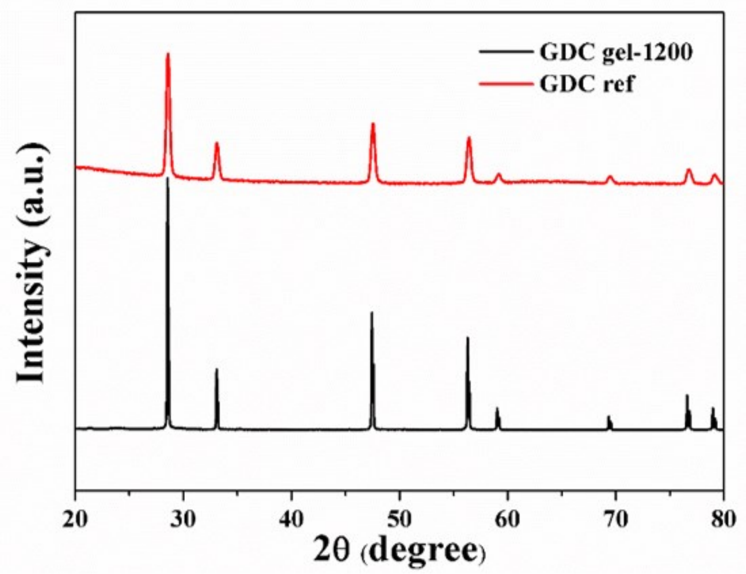

Figure S3. X-ray diffraction pattern of GDC nano-powder and dense film GDC.

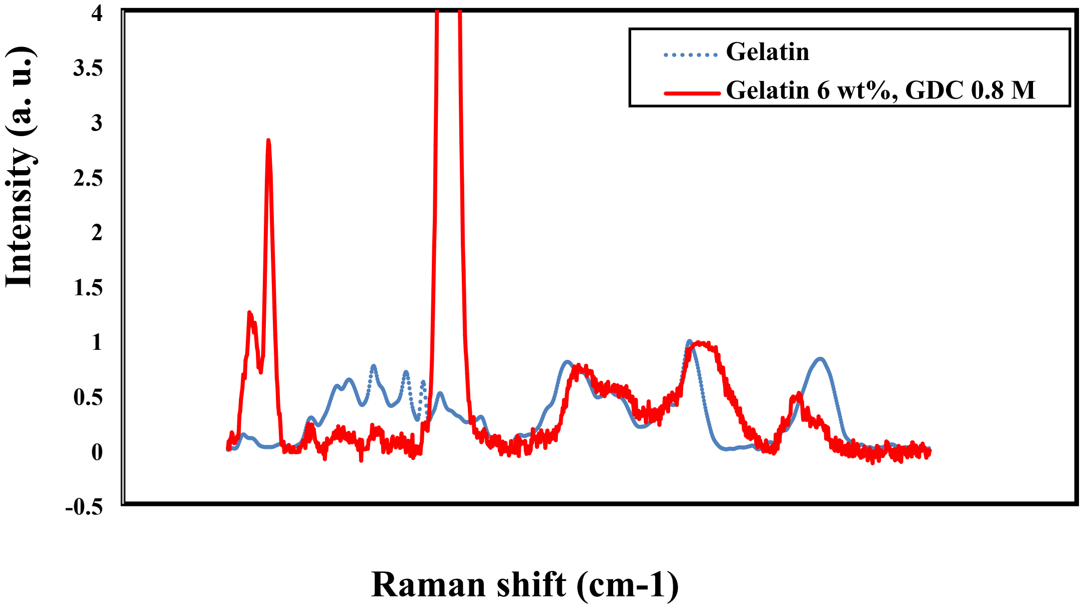

Figure S4. Raman spectrum of gelatin film and gelatin-GDC film.

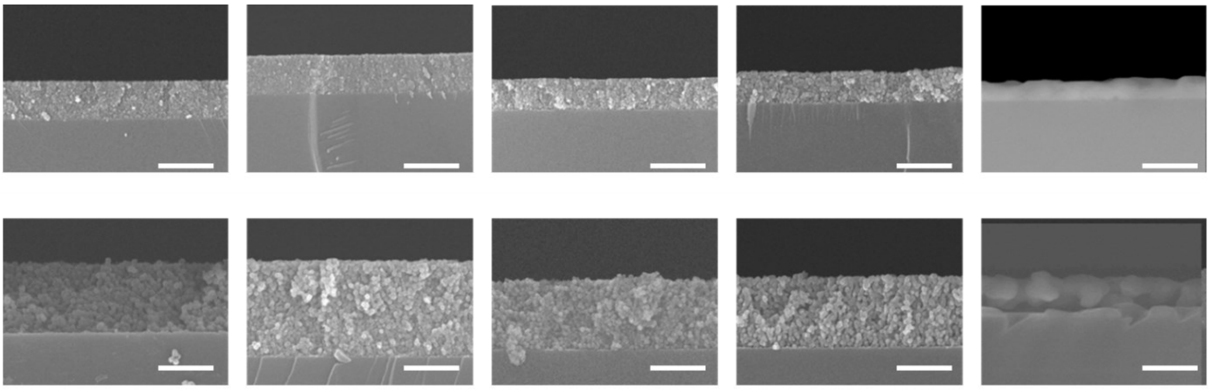

Figure S5. The effect of sintering temperature with gelatin for the 1st row and PVP for the 2nd row. (from left) 300, 400, 800, 1000, 1200 °C. Scale bars are 500 nm for all images.

The film morphology and density were investigated by changing sintering temperature from 300 to 1200 °C. To demonstrate the effect of gelatin scaffold on the dense film formation, a common polymer for film coating (PVP) was compared with gelatin. The lowest temperature was selected to ensure completely dried structures and the highest temperature was selected for phase formation. The GDC nanoparticles from gelatin solution was much smaller than those from PVP solution. The small particle formation with several nanometers was the reason for the dense film since the more porous PVP-based structure gets coarser as increasing temperature. After sintering at 1200 °C, PVP based film showed porous layer in the cross-sectional view, unlikely to the result of gelatin-based film.

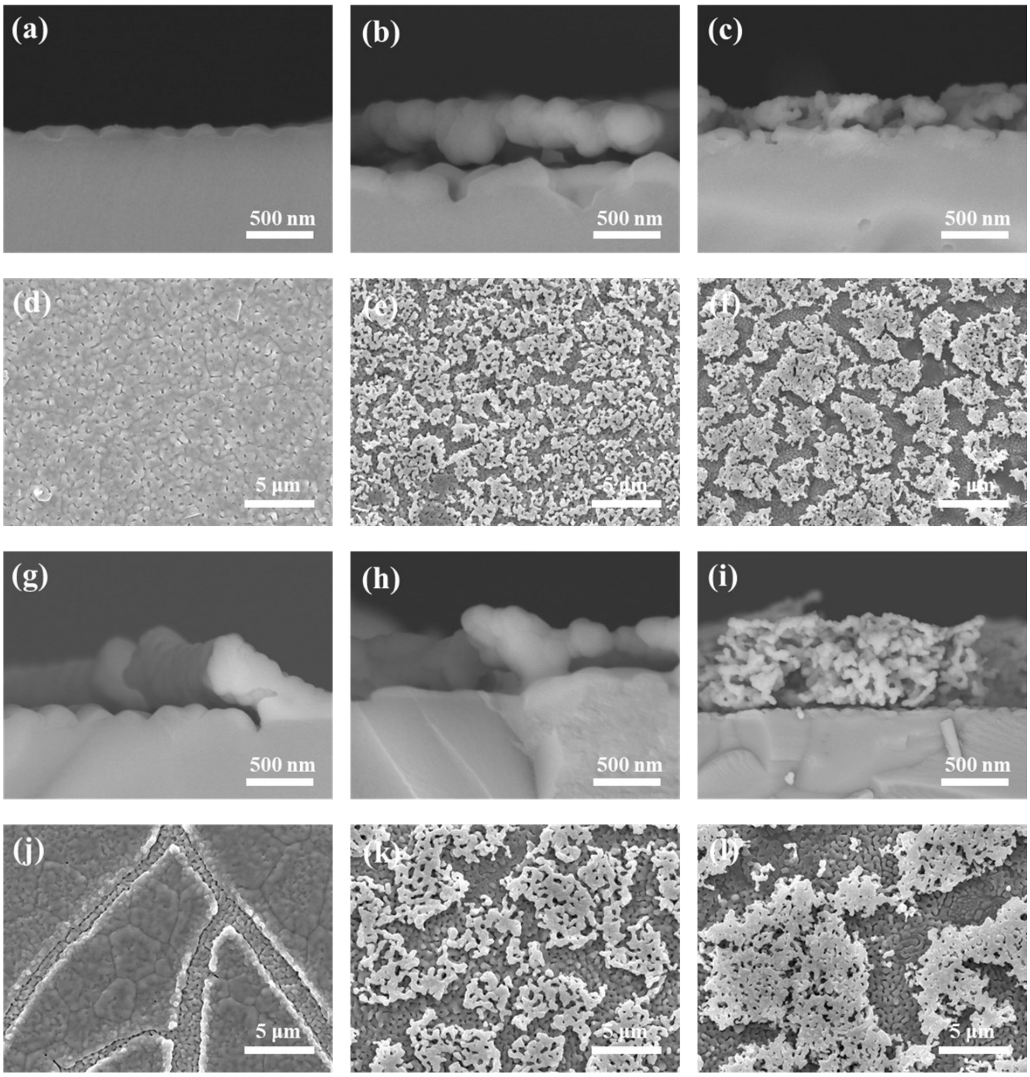

Figure S6. Cross-sectional view and top view of film morphology after annealing at 1200 °C. PVP concentration of (a-f) 3 and (g-l) 6 wt%. The metal ion concentration of (a, d, g, j) 0.2 M, (b, e, h, k) 0.4 M, and (c, f, i ,l) 0.6 M.

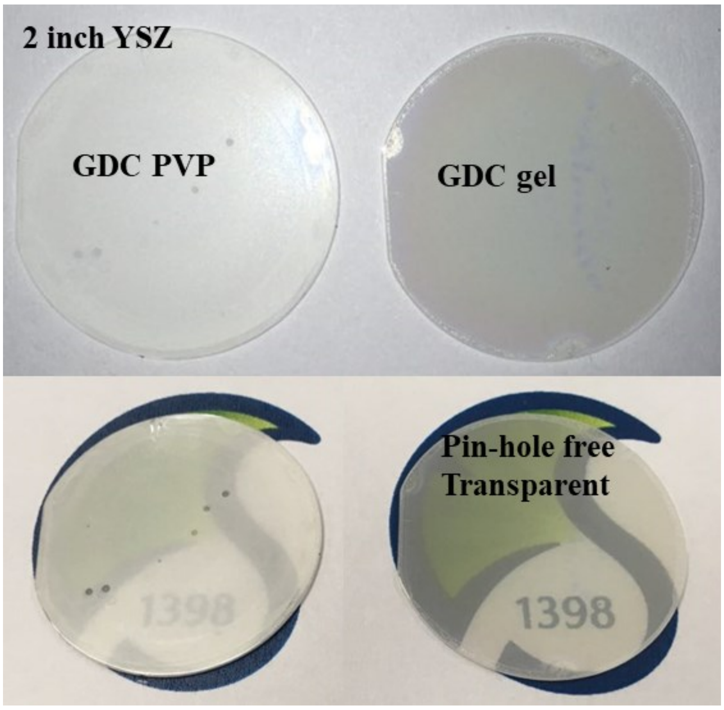

Figure S7. Large area demonstration and comparison of hydrogel assisted spin coating on single crystal YSZ substrate size of 2 inch.

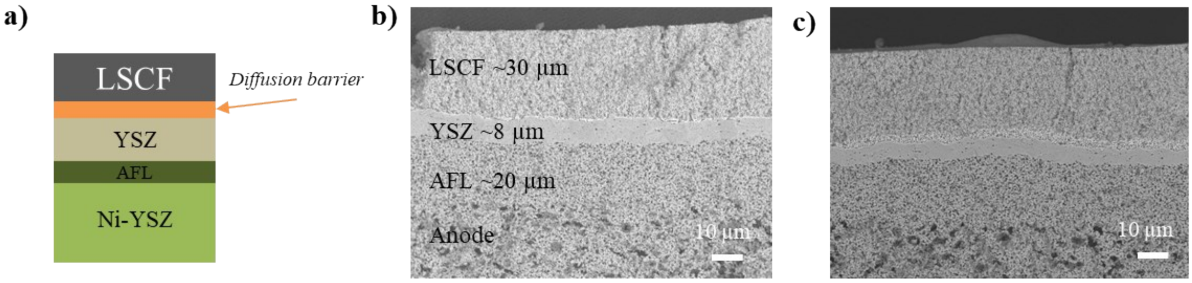

Figure S8. Single cell configuration and SEM images.

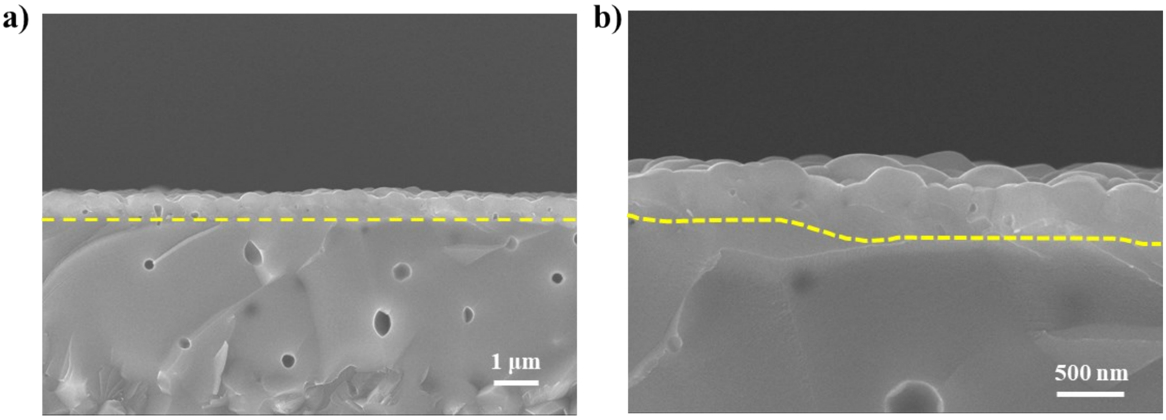

Figure S9. The spin coated images on the single cell with SEM. a) 1 cycle spin coated and b) 2 cycle spin coated.

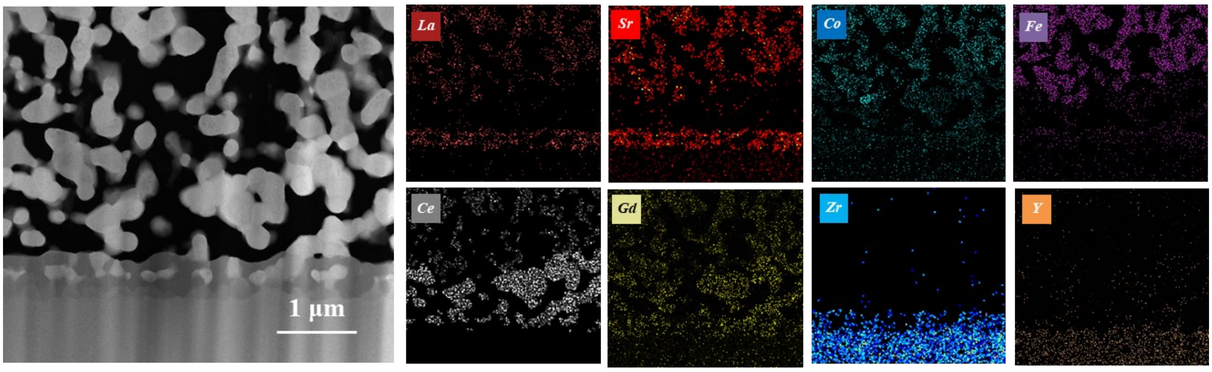

Figure S10. TEM mapping images for the all elements for the porous GDC

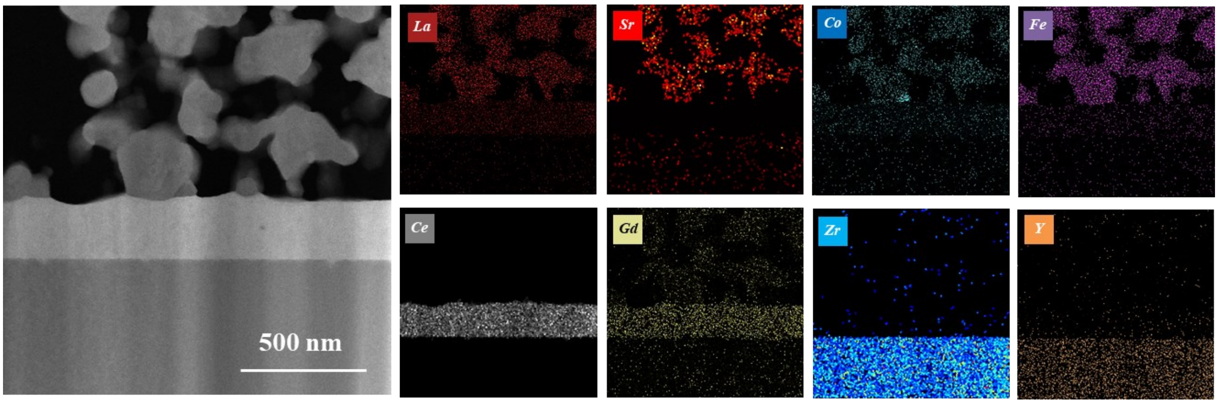

Figure S11. TEM mapping images for the all elements for the dense film GDC.

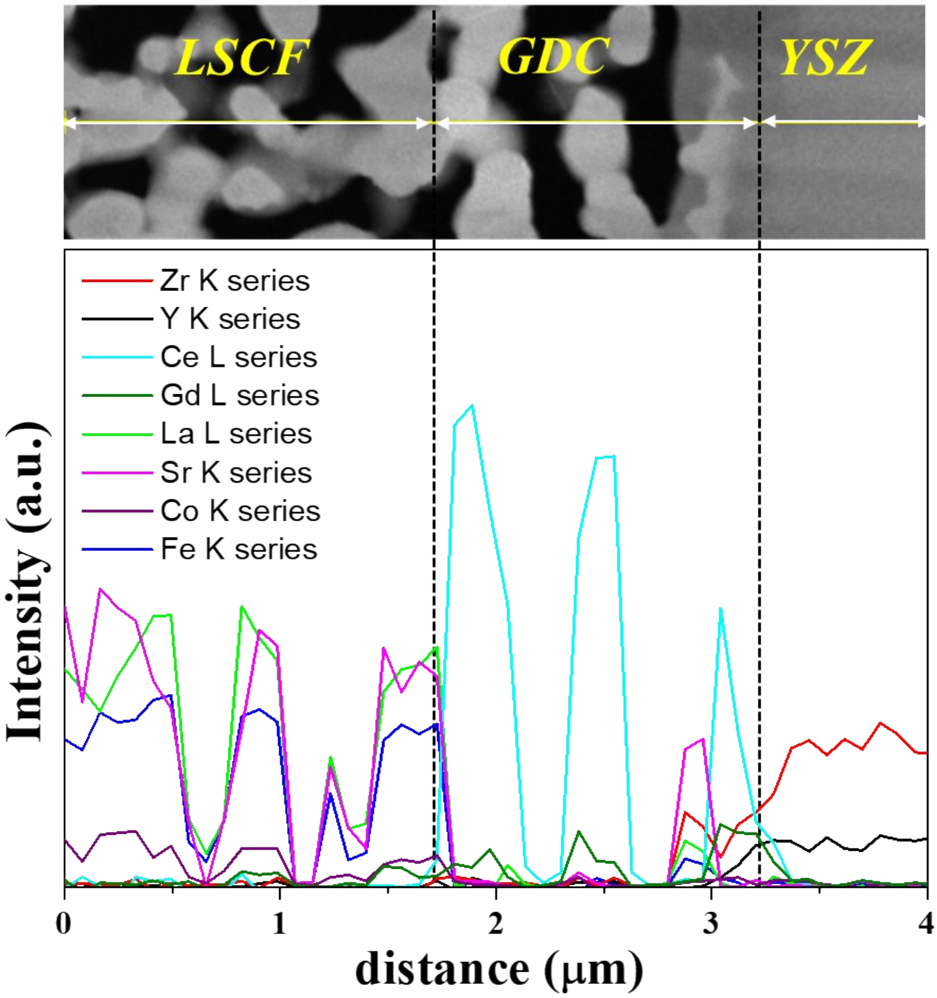

Figure S12. line scanning of porous GDC.

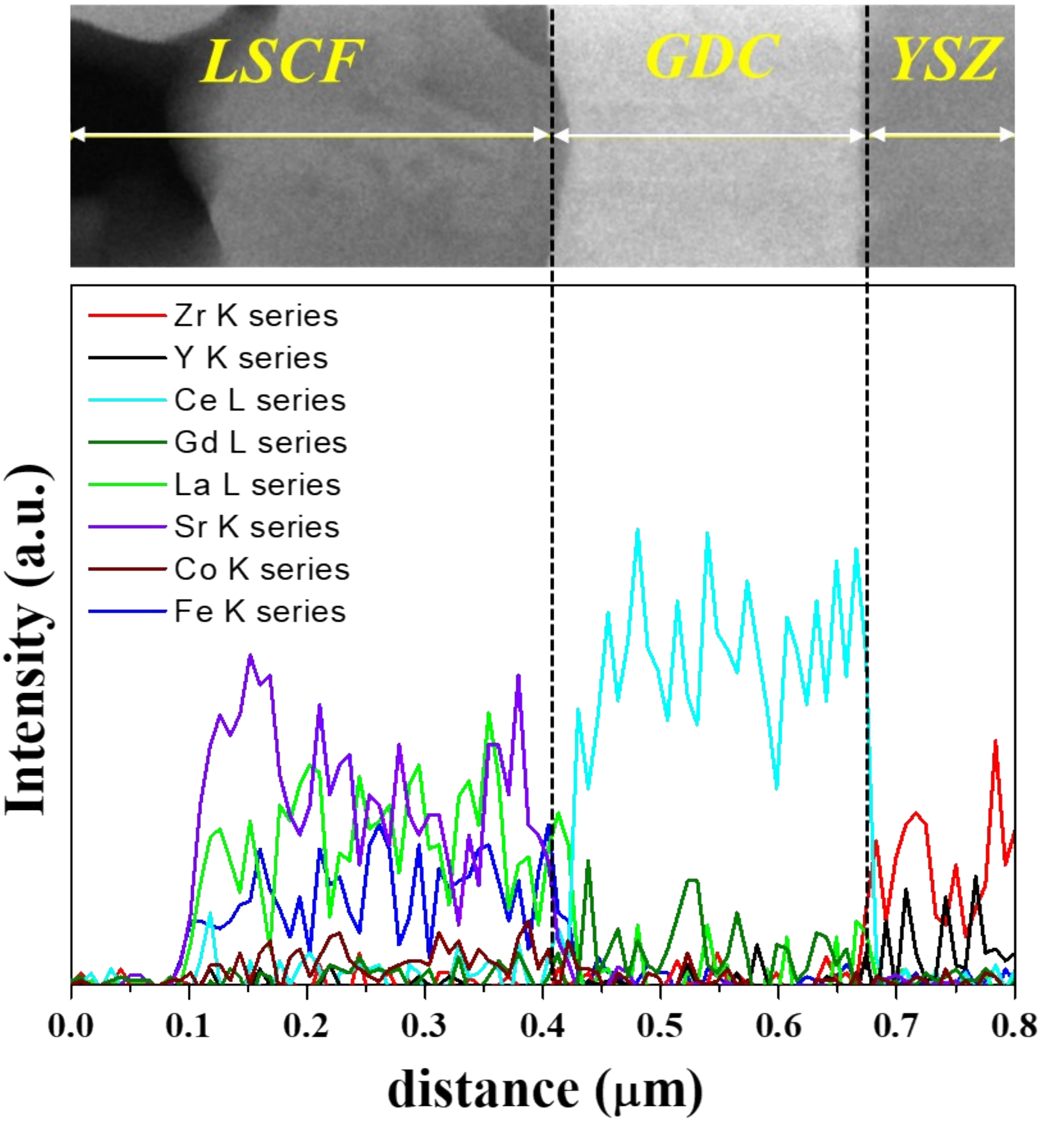

Figure S13. line scanning of dense film GDC.