# Electrical Properties of YSZ Thin Films Deposited on Nanoporous Substrates

Yong-il Park, Yuji Saito, Rojana Pornprasertsuk, Jeremy Cheng, Suk-won Cha, Fritz B. Prinz

*Rapid Prototyping Laboratory, Department of Mechanical Engineering, Stanford University, Stanford, CA94305, USA*

Gas-tight thin film deposition has been a key technique in the fields of gas sensors, gas-separating membranes and solid oxide fuel cells (SOFCs). Especially for SOFC, a lot of effort has been dedicated for reducing electrolyte thickness which should result in a large decrease of ohmic resistance of the electrolyte layer and a decrease of working temperature in fuel cell devices.

Recently, high-tech processing such as PVD, CVD, PLD and sol-gel deposition has been tested to reduce electrolyte thickness and increase film density. However, the oxide thin film deposition technologies that have been developed for decades are mainly for highly flattened substrates, especially silicon wafers [1~4], not for rough and porous substrates. Since the electrolyte layer in SOFC should be deposited on porous electrodes to maintain high fuel-gas diffusion, it is not suitable to use the same deposition process for silicon wafers.

A successful deposition of continuous ‘submicron’ yttria stabilized zirconia (YSZ) thin films on anodic nanoporous alumina was reported [5-7]. A viscous alkoxide-derived Y-Zr solution was deposited on the substrates having highly ordered nanoholes with uniform diameters. However, the sol-gel derived thin films have several demerits, specifically, a large shrinkage during heat-treatment and low density from inherent high organic content that may cause local defects resulting in serious gas leakage. Therefore, these demerits may increase the attainable minimum film-thickness needed to evade gas leakage.

In present study, we demonstrate a simple but effective process for gas-tight YSZ thin film deposition on anodic nanoporous alumina substrates for low-temperature SOFCs application. The key ideas are as follows: *i*) Providing nanoporous alumina substrates with pore sizes varying from 20nm to 200nm to support electrolyte thin film. *ii*) Depositing a metal film directly on the nanoporous alumina substrate in Ar atmosphere, and then oxidizing it at 400$^o$C ~ 700$^o$C. *iii*) Preventing gas leakage through thin films using the compressive stress from the volume expansion of the oxidized metal layer.

By oxidation of DC-sputtered metal thin films deposited onto anodic nanoporous alumina substrates with pore sizes of 20nm and 200nm, YSZ thin films with thickness of about 30nm~300nm could be obtained. During oxidation at high temperature, the metal films were successfully transformed into defect-free oxide films, and volume expansion induced from oxidation of metal resulted in dense thin films that are free from hydrogen permeation. Hydrogen permeance and conductivity of YSZ thin films at different temperature were measured. Activation energy of the YSZ thin films was also obtained and compared with the reported values of YSZ ceramics.

## References

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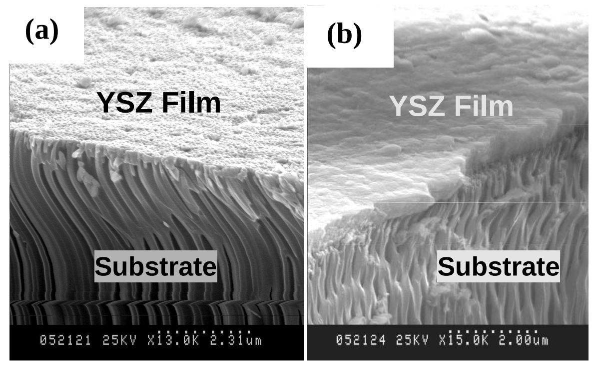


*Fig. 1. SEM images of YSZ thin films with a thickness of (a)30nm and (b)250nm on nanoporous anodic alumina substrates.*

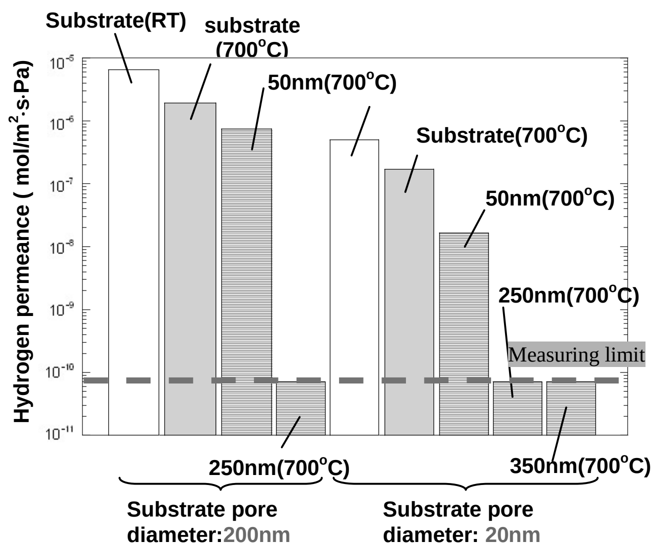


*Fig. 2. Gas permeance of the deposited YSZ thin films. (Numbers on graph indicatefilm thickness and heat-temperature)*

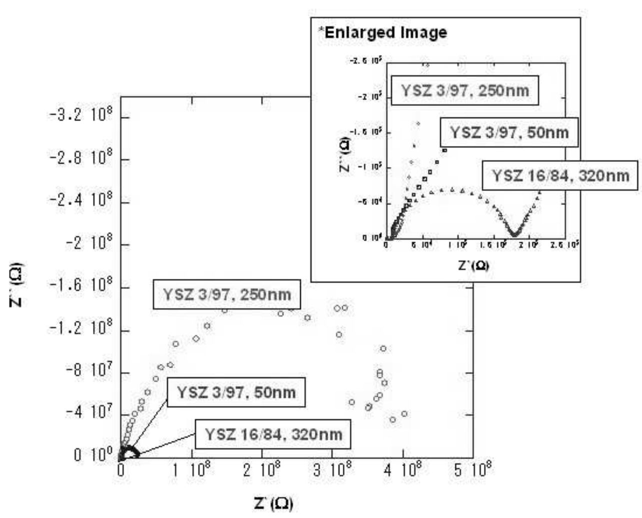


*Fig. 3. Nyquist plots of YSZ thin film with different composition.*