YSZ Interconnect Barriers via ALD

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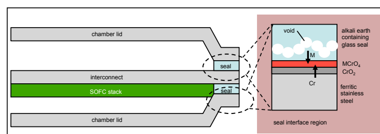
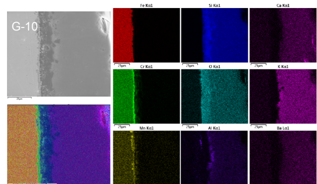
Need for Interconnect Barrier



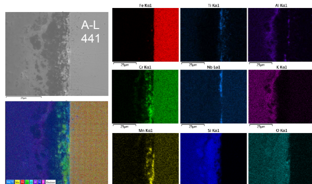
Improved barriers are needed to extend operating lifetime of glass sealed interconnects in SOFC stacks

- Alkali-earth (M=Mg, Ca, Sr, Ba) cations in seal glass react with Cr in stainless steel
- Form $MCrO_4$ chromites; other alumino silicates and Mn-Cr-O due to segregation effects
- Leave vacancies that coalesce to voids
- Voids lead to leaks in seals
- YSZ has shown promise as an effective barrier material*



Reaction of ferritic stainless steels with SEM-CON SCN-01

850°C
260 hr.

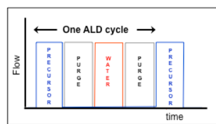


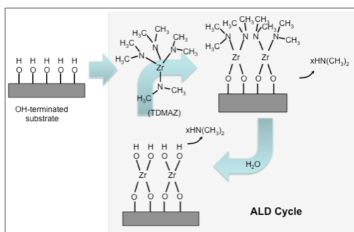
*R.N. Singh, "Innovative Self Healing Seals for Solid Oxide Fuel Cells," 12th Annual SECA Workshop, Pittsburgh, PA, July 28, 2011

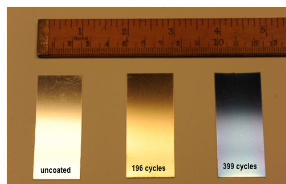
Novel Interconnect Barrier Approach: ALD YSZ

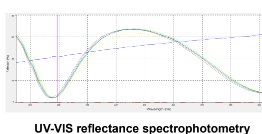
ALD is a simple, highly self-regulating process that uses precursors and reactants separated by an inert gas (N_2)

- Surface saturation limiting of precursor dose
- Reactants fed into reactor in a pulse train









UV-VIS reflectance spectrophotometry

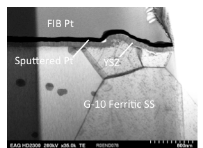
λ at 5 QWOT

λ (nm)	Distance from end (mm)
277	5
274	15
275	25
275	35
276	45
278	55
279	65
Mean 276	
StDev 1.80	
StDev (%) 0.65%	

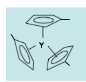
76 mm

- Highly uniform thickness achieved (<1% 1 sigma)
- Uniformity observed over length scale of full sized interconnects

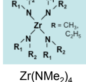
TEM
800 cycle YSZ film



YSZ ALD Process



$Y[MeCp]_3$



$Zr(NMe_2)_4$

Precursor chemistry:

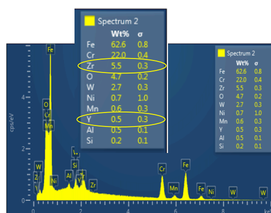
- Volatile
- Thermally stable
- Zr source widely used for DRAM manufacturing
- Highly reactive with water as oxidizing agent

Process conditions:

- Deposition temperatre 230°C
- Deposition pressure 1 Torr

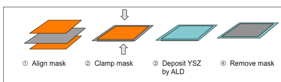
Process recipe:

- 9:1 ratio of Zr to Y cycles
- Film composition ~ 11.5:1 (Zr:Y)

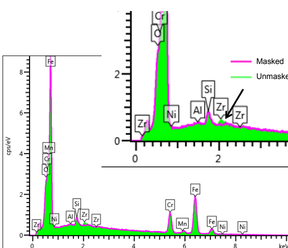


Masking

Barrier coating must be limited to perimeter of interconnect

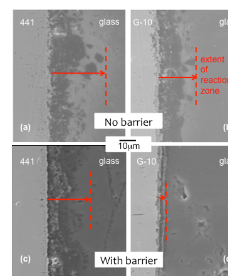


- Novel, reusable mask strategy identified
- Stackable for high volume manufacturing

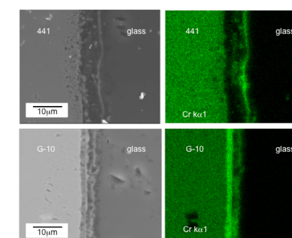


- Silicone mask
- High thermal stability

Barrier Perfomance



- Significant reduction in reaction with YSZ barrier
- (800 cycles)
- Surface of stainless steel has an effect

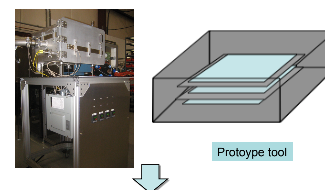


- 441 sample showed evidence of spallation
- Hitachi G-10 had robust Cr_2O_3 layer
- Phase II will examine effects of surface condition in combination with barrier optimization

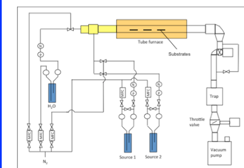
From Research to Manufacturing

R&D ALD tool uses a 50mm tube furnace

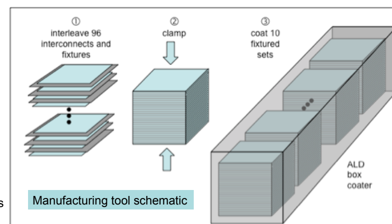
Prototype tool will allow coating of full size interconnects



Protoype tool



Manufacturing tool takes advantage of highly scalable batch processing of ALD ➔
Current systems coat very large area (thousands of m²) in high volume manufacturing environments



Manufacturing tool schematic

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