IMPROVING THE CORROSIVE DURABILITY OF THERMAL BARRIER COATINGS

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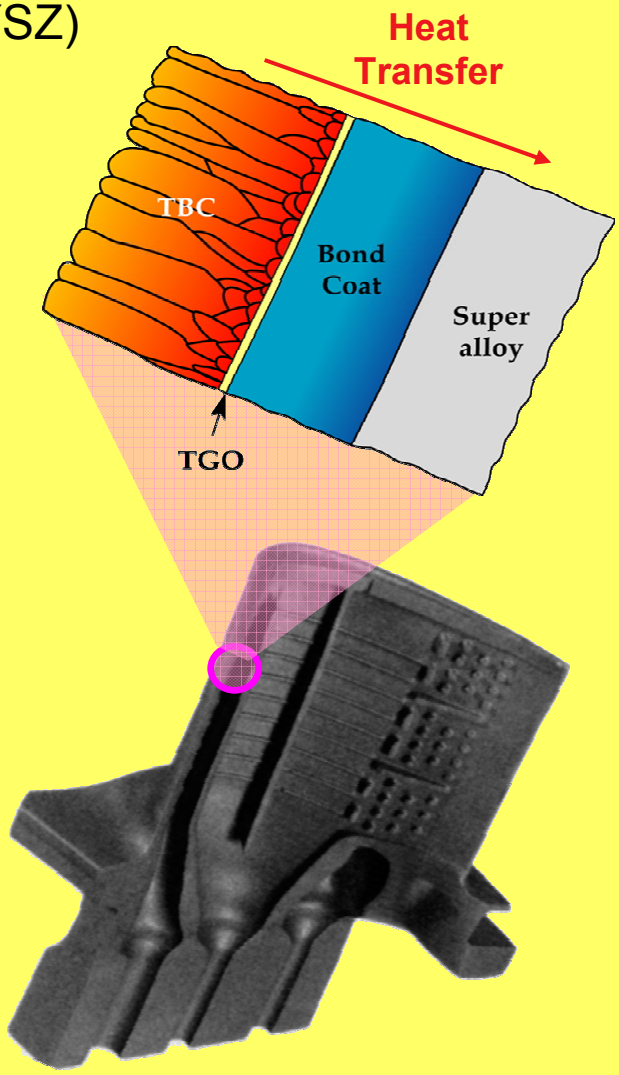
Funded by:

Overview of Thermal Barrier Coatings (TBCs)

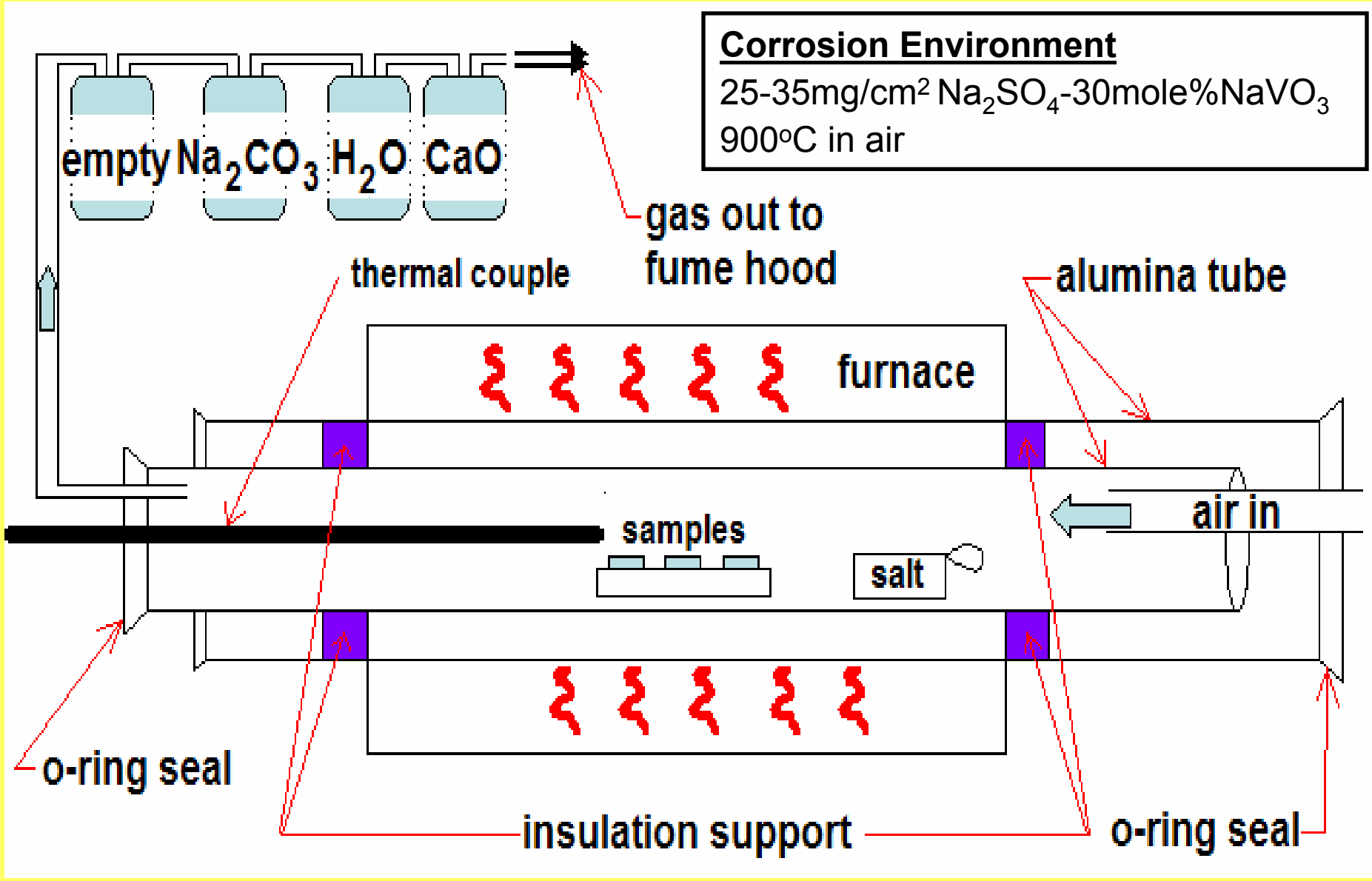
- **What are TBCs?**
  - Thermal and corrosion resistant ceramic shields to underlying alloy components
  - Conventional TBCs are made of yttria stabilized zirconia (7YSZ)
- **Applications of TBCs**
  - Propulsion
  - Power generation
- **Failures of current TBCs**
  - Being corroded by dirty fuels and other contaminates such as V, S, Na---reducing TBC life
- **The need for improved TBCs**

GOAL: Gain understanding of how to make a better TBC

1. Production of 5 different yttria stabilized zirconia (YSZ) through reverse co-precipitation
   - Doped with yttrium and/or tantalum
2. Producing Powders
   - Pyrolization
   - Grinding solid into powder form
3. Pressing the compositions into pellets
4. Analysis before corrosion testing using
   - X-Ray Diffraction (XRD)
5. Corrosion Testing
   - Putting vanadate/sulfate corrodant on pellets
   - Heat Treatment of pellets
6. Analysis after corrosion testing looking for phase stability using
   - X-Ray Diffraction (XRD)
   - Transmission electron microscope (TEM)
   - Scanning electron microscope (SEM) with electron dispersive spectroscopy (EDS)

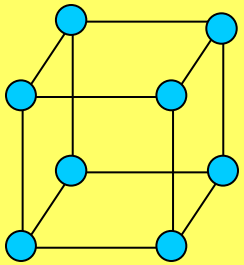


Hot Corrosion Testing Device and Setup

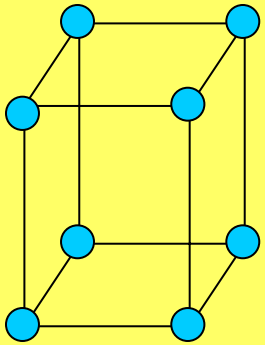


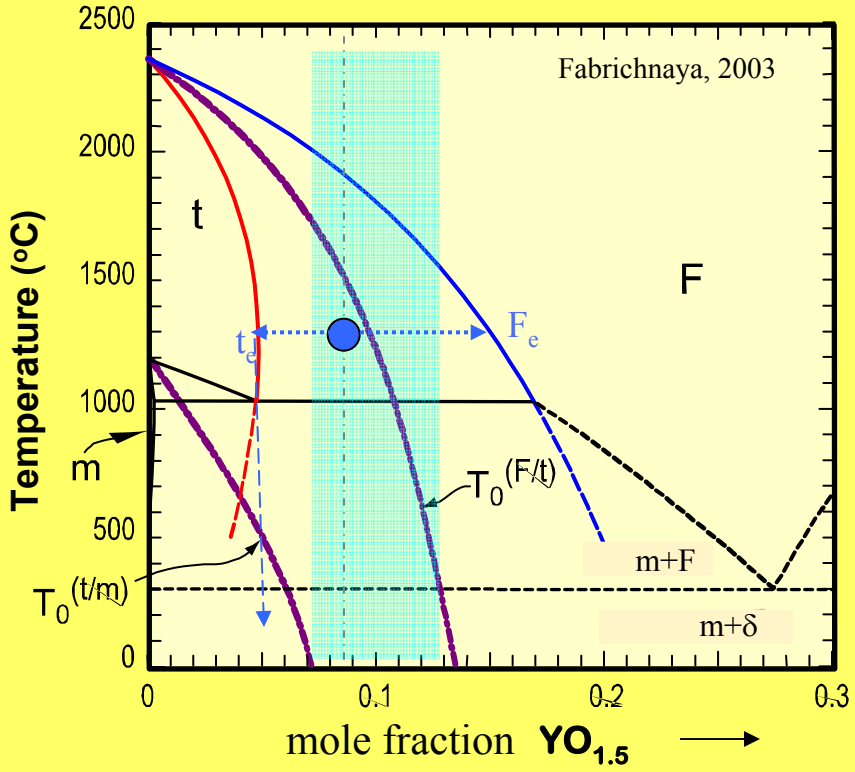
Phase Stability of Yttria Stabilized Zirconia (YSZ)

cubic (c) crystal structure



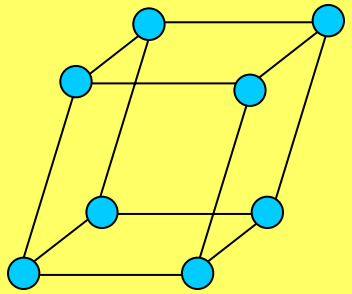
tetragonal (t) crystal structure





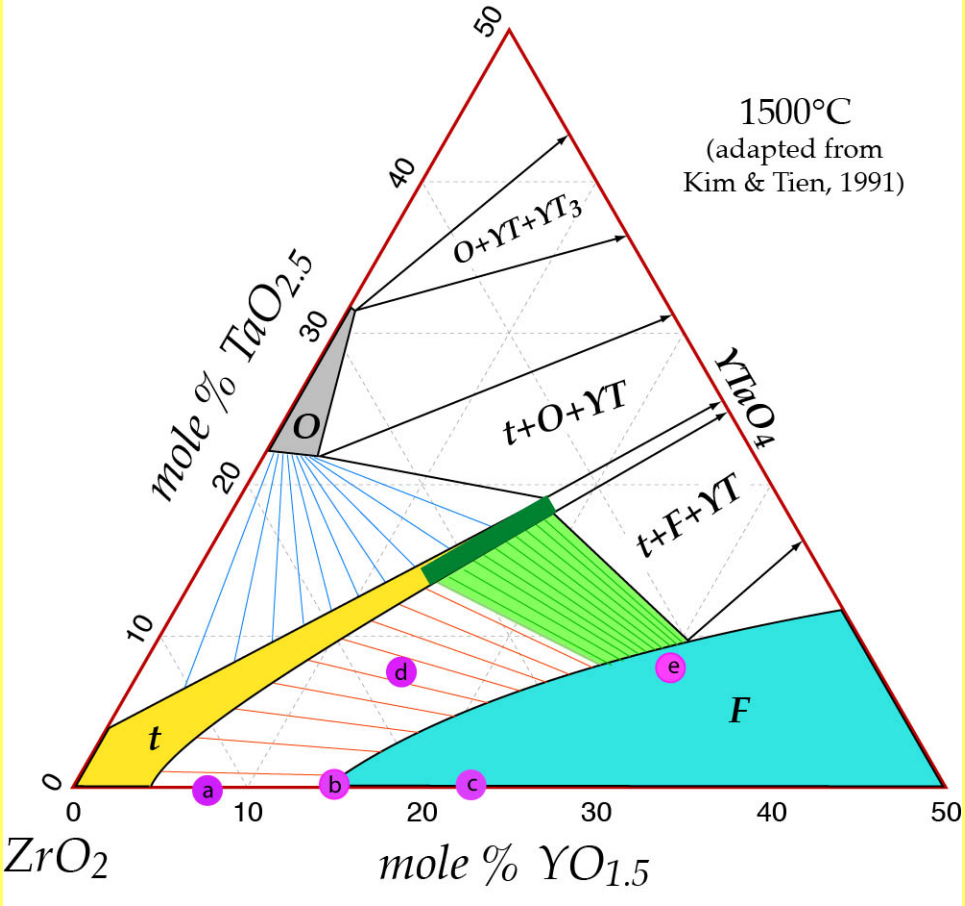
fluorite (F) is a particular structure of cubic

monoclinic (m) crystal structure



$$Y_2O_3(\text{in t-}ZrO_2) + V_2O_5(\text{melt}) = 2YVO_4 + \text{m-}ZrO_2$$

ZrO_2-$YO_{1.5}$-$TaO_{2.5}$ Ternary Phase Diagram

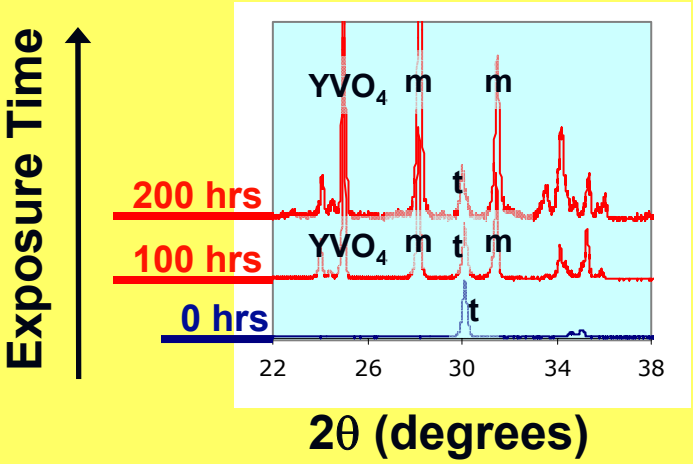


Sample Compositions

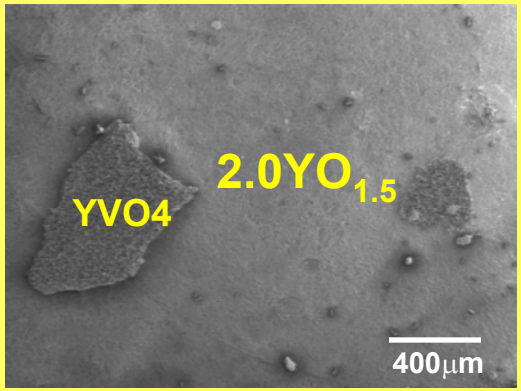
- Sample A (a)---7.6mole% $YO_{1.5}$
- Sample B (b)---15.2mole% $YO_{1.5}$
- Sample C (c)---22.8mole% $YO_{1.5}$
- Sample D (d)---15.2mole% YO1.5 + 7.6mole%TaO2.5
- Sample E (e)---30.0mole% YO1.5 + 7.6mole%TaO2.5

XRD and SEM Analysis of the Microstructure and Phase Changes

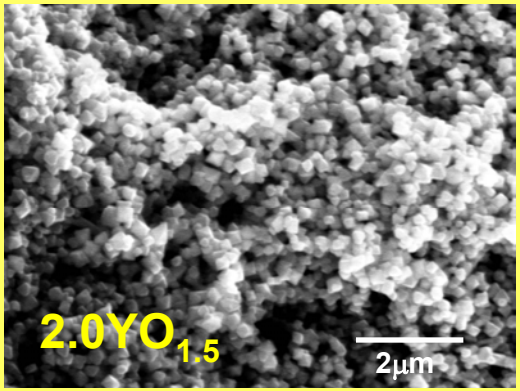
$7.6YO_{1.5}$



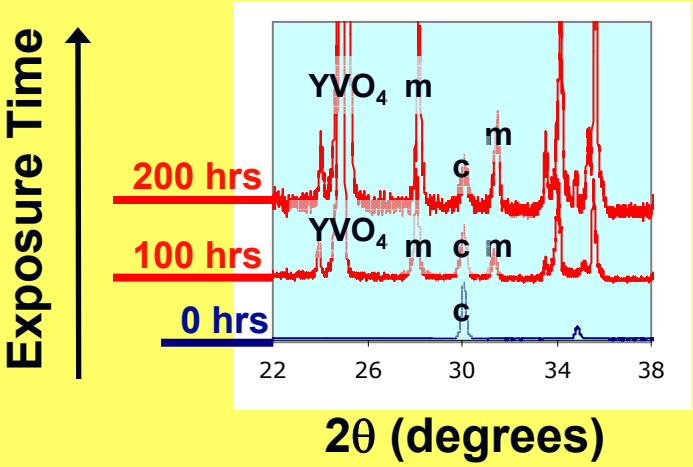
Spalled Area



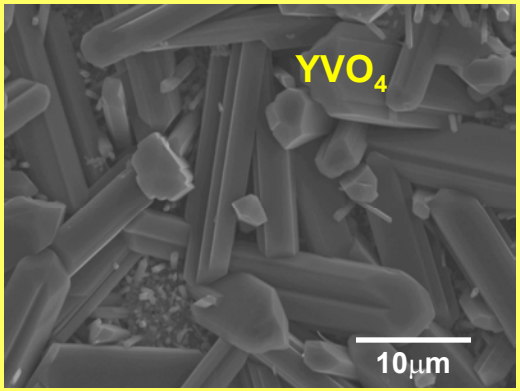
Spalled Area



$15.2YO_{1.5}$

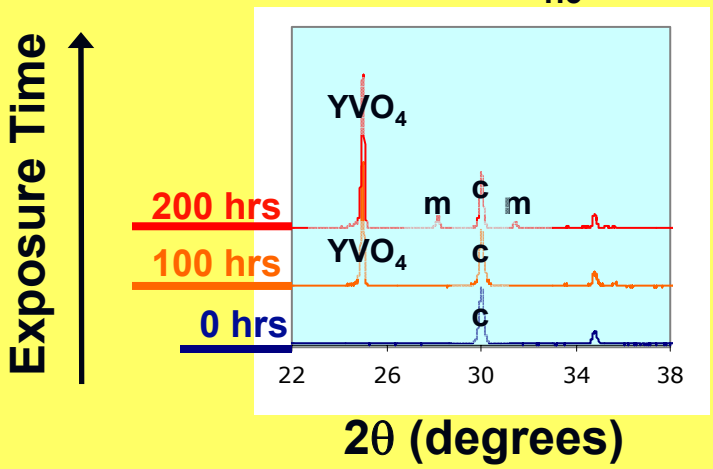


Crystal Product Formation

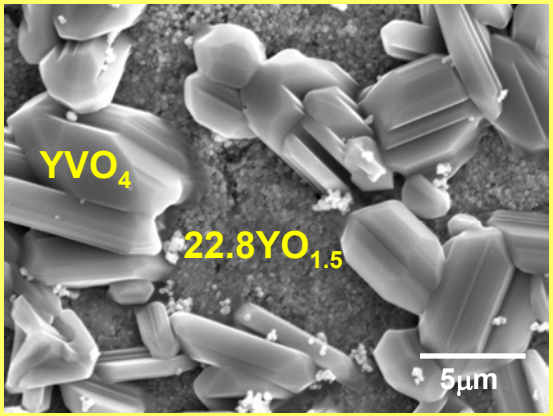


XRD and SEM Analysis of the Microstructure and Phase Changes

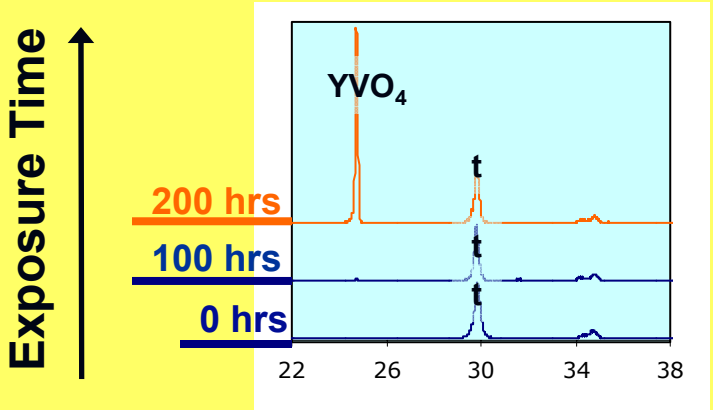
$22.8YO_{1.5}$



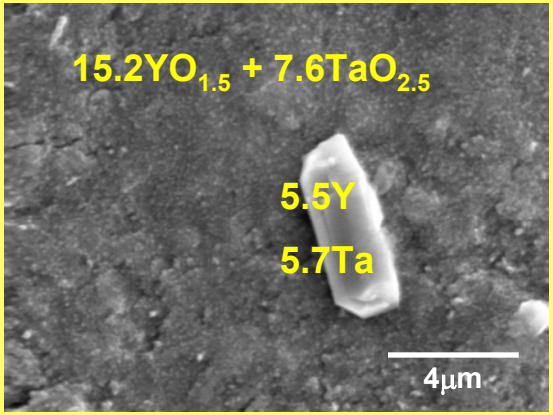
Representative Surface



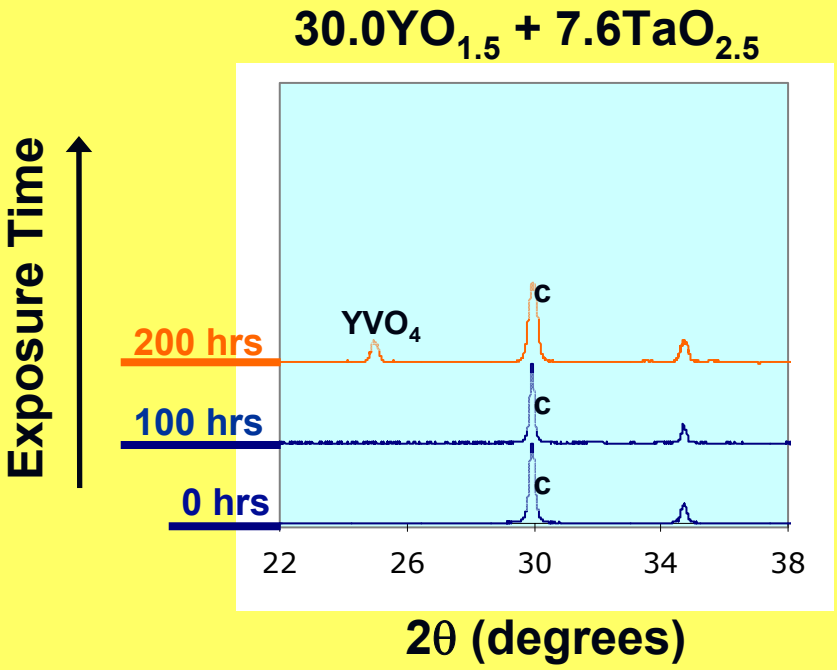
$15.2YO_{1.5} + 7.6TaO_{2.5}$

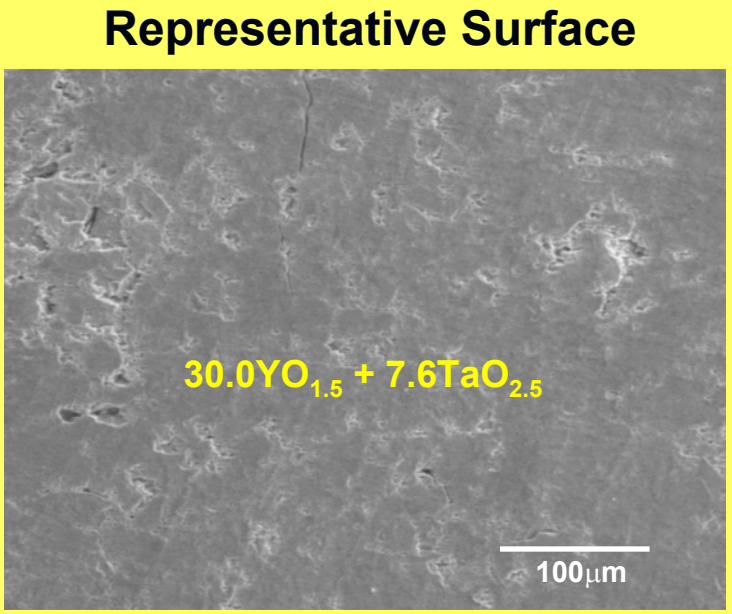


Representative Surface



XRD and SEM Analysis of the Microstructure and Phase Changes





Summary of Analysis

- Hot corrosion tests on all 5 compositions for 200 hours
- $7.6YO_{1.5}$ and $15.2YO_{1.5}$ samples
  - Formation of product YVO_4 after 100 hours
  - Phase Change from tetragonal to monoclinic after 100 hours
  - Spalled areas (where product breaks away from sample) found only on $7.6YO_{1.5}$ sample
- $22.8YO_{1.5}$ sample
  - Formation of product YVO_4 after 100 hours
  - Phase Change (small amounts) from tetragonal to monoclinic after 200 hours
- $15.2YO_{1.5} + 7.6TaO_{2.5}$ and $30.0YO_{1.5} + 7.6TaO_{2.5}$ samples
  - Small amounts of product YVO_4 formed after 200 hours
    - Considerably less found on $30.0YO_{1.5} + 7.6TaO_{2.5}$ than on $15.2YO_{1.5} + 7.6TaO_{2.5}$
  - No phase change from tetragonal to monoclinic
  - Best performance among samples

Future Plans

- Continue hot corrosion tests on all 5 compositions for up to 500 hours
- Conduct analysis on the phase changes and microstructure of the samples after each 100 hours of testing
- Comparison of compositions with baseline 7YSZ to determine the effect of increasing yttria content and co-doping with $TaO_{2.5}$

Acknowledgements

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