Thermal Properties of Novel Thermal Barrier Coatings (TBCs)

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What is a TBC?

Thermal Barrier Coatings (TBCs)

- Are a system of oxides grown atop a super alloy bond coat providing a protective layer.
- TBCs increase the efficiency and life of the components of gas powered turbine engines.

Why is 7YSZ unsuitable for the next generation of gas turbine engines?

- The components of a gas turbine engine begin to deform at high temperatures. By selecting a coating with lower thermal conductivity, the engine can run hotter without damaging the components

- The focus of the research is to select oxides with lower thermal conductivity than 7YSZ

A look at thermal conductivity

Minimal thermal conductivity can be approximated using known constants in the following expression:

$$\kappa_{\min} \longrightarrow 0.87 k_B N_A^{2/3} \rho^{1/6} E^{1/2} * \frac{\boldsymbol{m^{2/3}}}{\boldsymbol{M^{2/3}}}$$

Clarke, David R. Materials selection guidelines for low thermal conductivity thermal barrier coatings. [Conference Paper] *Elsevier. Surface & Coatings Technology, vol.163-164, 30 January, 2003, pp.67-74*

Minimum thermal conductivity approximation

How can thermal conductivity be minimized?

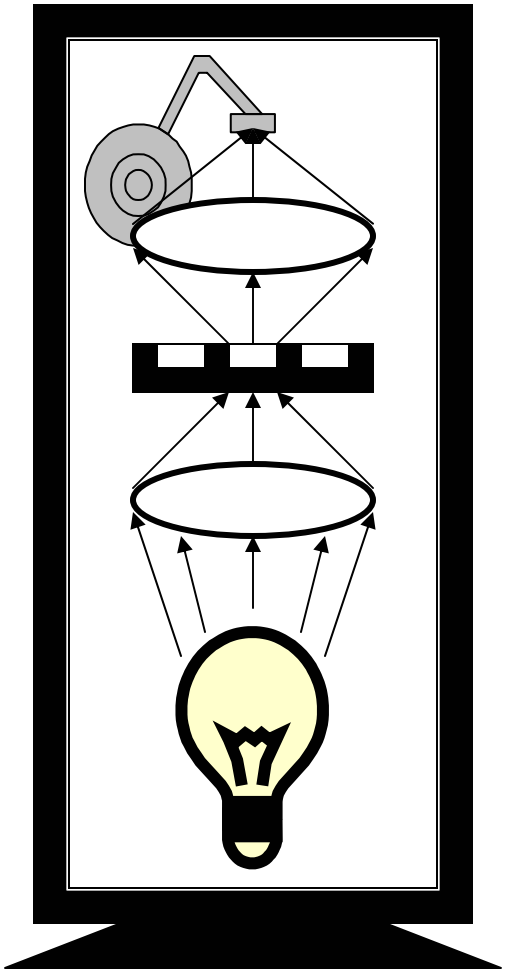
Based upon the minimum thermal conductivity approximation:

$$\kappa_{\min} \; is \; proportion al \; to \quad \frac{1}{Mean \; Atomic \; Mass \, (m/M)}$$

By adding hafnia in with the zirconia, the effect of raising the mean atomic mass will be explored.

Determining thermal conductivity

- Flash Lamp 3000 measures infrared intensity
- Device measures diffusivity (α) used in thermal conductivity equation



Flashline 3000 data to solve for κ

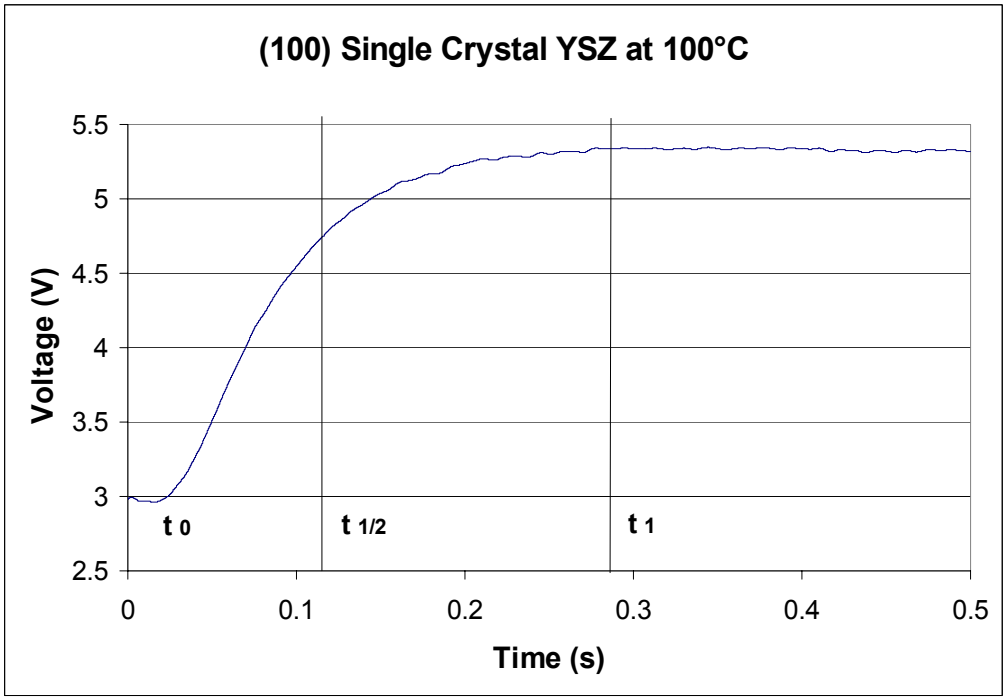
Thermal Conductivity:

$$\kappa = \alpha \rho C_p$$

ρ = Density of sample

C_p = Heat capacity

$$\alpha = 0.48 \frac{L^2}{\pi^2 t_{1/2}}$$



Flash Method of Determining Thermal Diffusivity, Heat Capacity, and Thermal Conductivity, WJ Parker et al. Journal of Applied Physics, Volume 32, Number 9, September 1961

Current project YSZr/Hf mixed at two levels

7 mole percent Y_2O_3	14 mole percent Y_2O_3
Mix Percent Hf/Zr Composition	Mix Percent Hf/Zr Composition
10/90 C1	10/90 C6
20/80 C2	20/80 C7
50/50 C3	50/50 C8
80/20 C4	80/20 C9
90/10 C5	90/10 C10

Comparison of values

YSZ vs YSZr/Hf (Composition 1)