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HIGH TEMPERATURE UNIQUE LOW THERMAL CONDUCTIVITY THERMAL BARRIER COATING (TBC) ARCHITECTURES

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FUTURE NEEDS AND REQUIREMENTS

Increased efficiency of power plants (current pulverized coal technologies and future IGCC plants) is needed for less fuel consumption and reduction in toxic (CO_2. NO_x and SO_x) emissions.

Inlet temperature of involved gas turbines needs to be higher (>1300F). Better protection of the metal components is required. Thermal barrier coatings (TBC) should have the following attributes:

- Lower thermal conductivity
- Higher temperature phase stability
- Strain compliance at higher temperature

CURRENT STATE-OF-THE-ART (SOA) TBC TECHNOLOGY

TBC system (top coat, bond coat) is used to protect the metallic components of gas turbine engines.

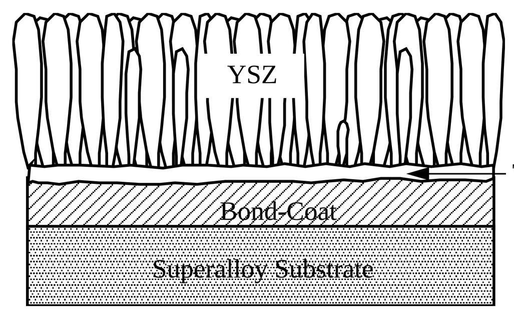
Current state-of-the-art TBC System
- Top Coat : 6-8% Yttria Stabilized Zirconia (YSZ)
- Bond Coat : Single Phase (Ni,Pt)Al, Two Phase MCrAlY

LIMITATIONS OF SOA TBC TECHNOLOGY

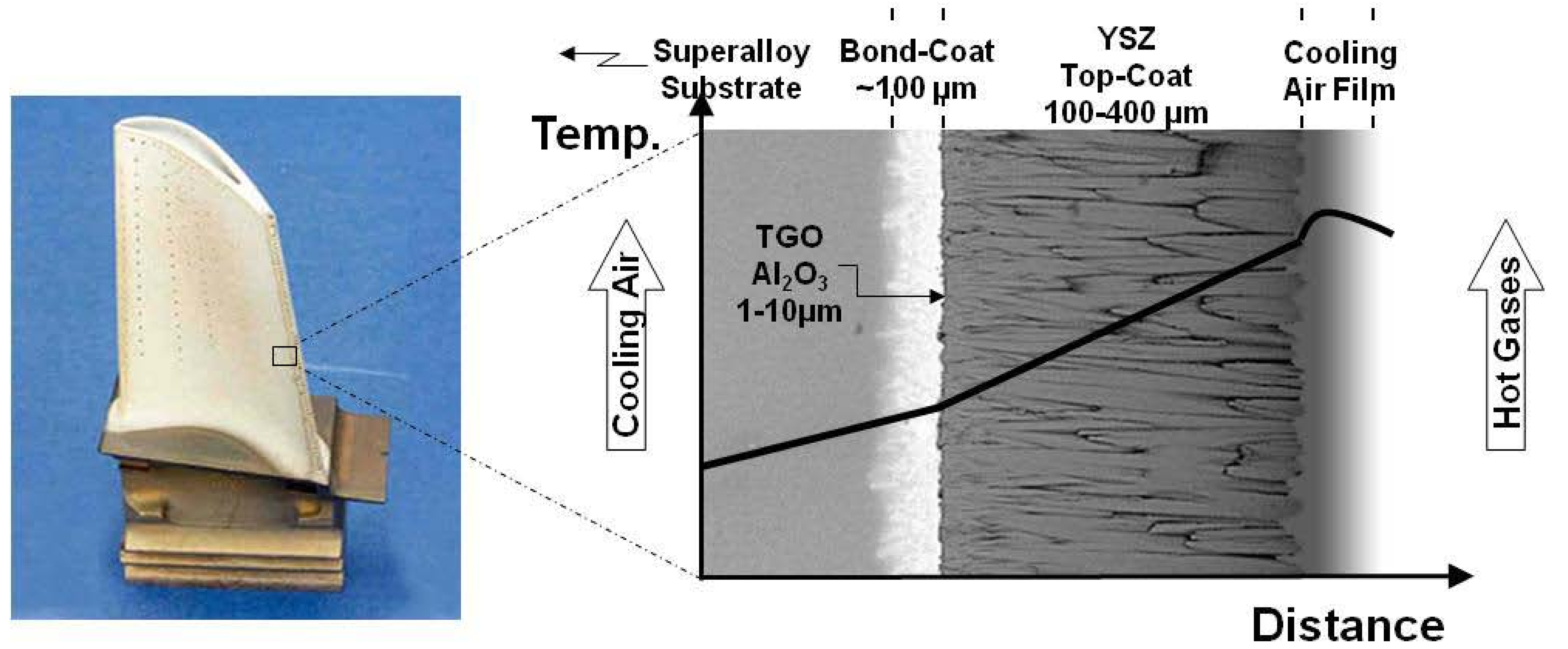
At higher (>1100°C) gas temperature YSZ undergoes
- Increased sintering: Higher thermal conductivity (k), Increased elastic modulus, Lower strain compliance
- SOA TBC is unlikely to be usable at elevated temperatures

OBJECTIVE

Development of high temperature TBC coating architectures having low thermal conductivity and high strain tolerance



Sketch of a TBC system



TBC MATERIALS FOR HIGH TEMPERATURE APPLICATIONS

1. Low k YSZ: YSZ doped with divalent rare earth oxide
2. Pyrochlore oxides: Stable at higher temperature, Sluggish sintering kinetics, Lower thermal conductivity

Examples: $Gd_2Zr_2O_7$ (1500°C), $Sm_2Zr_2O_7$ (1700°C)

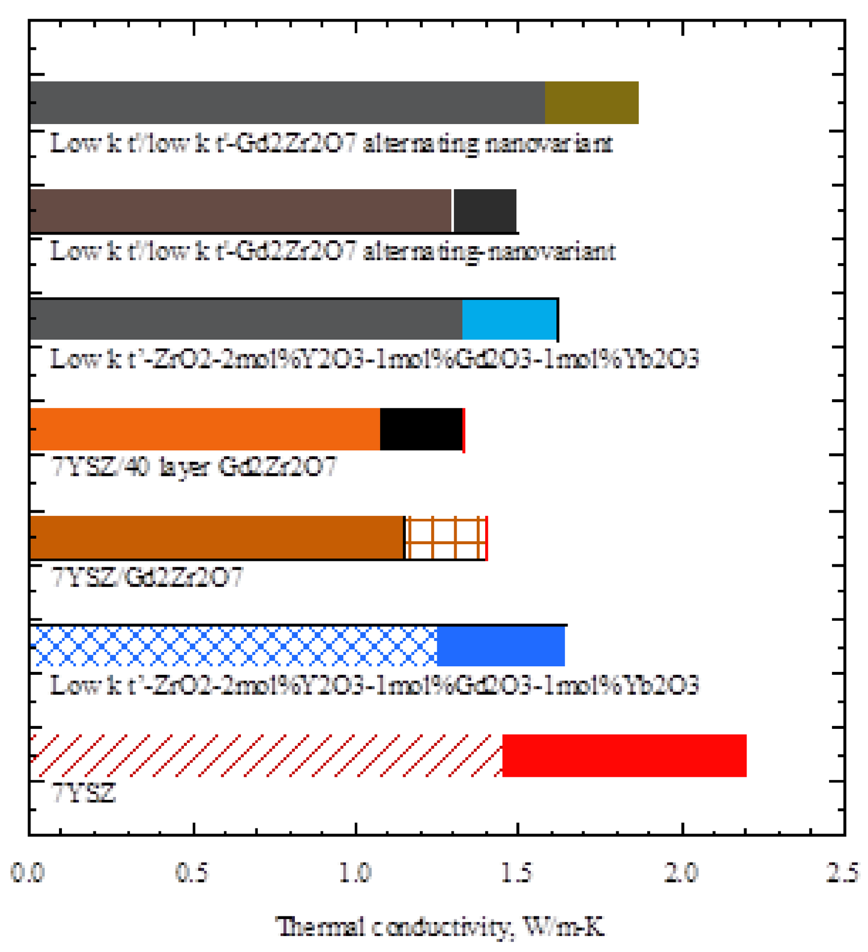
SELECTED HIGH TEMPERATURE TBC MATERIALS/DESIGN WITH LOWER THERMAL CONDUCTIVITY

1. Materials: Low k YSZ, Doped YSZ, $Gd_2Zr_2O_7$
2. Design: Monolayer, Multilayer (Shuttered, Alternating, Low k YSZ/$Gd_2Zr_2O_7$)

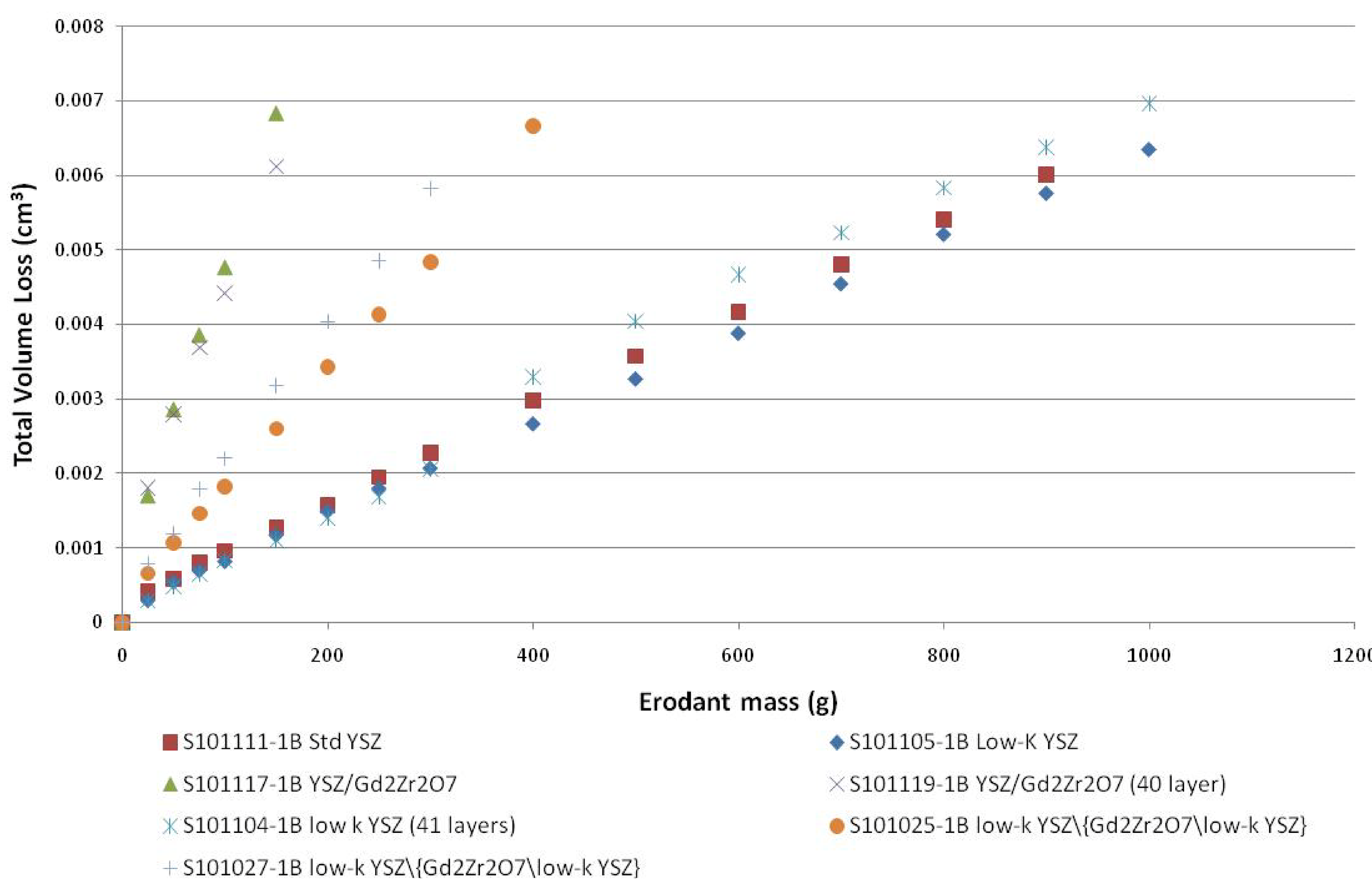
PHASE I ACCOMPLISHMENTS

1. Successfully fabricated monolayered and multilayered TBCs of selected materials.
2. Demonstrated lower thermal conductivity (TC) of monolayered $Gd_2Zr_2O_7$ and low k YSZ TBC compared to SOA YSZ TBC. Shuttered multilayered $Gd_2Zr_2O_7$ exhibited even lower TC. TC data also demonstrated lower sinterability of the $Gd_2Zr_2O_7$ and low k YSZ compared to the SOA YSZ.
3. Low k/$Gd_2Zr_2O_7$ multilayered TBC exhibited higher TC than monolayered and shuttered multilayered TBC. This could be related with unoptimized microstructure.
4. Demonstrated that the intrinsically higher erosion rate of $Gd_2Zr_2O_7$ can be lowered by multilayered (low k YSZ/$Gd_2Zr_2O_7$) coating architecture.

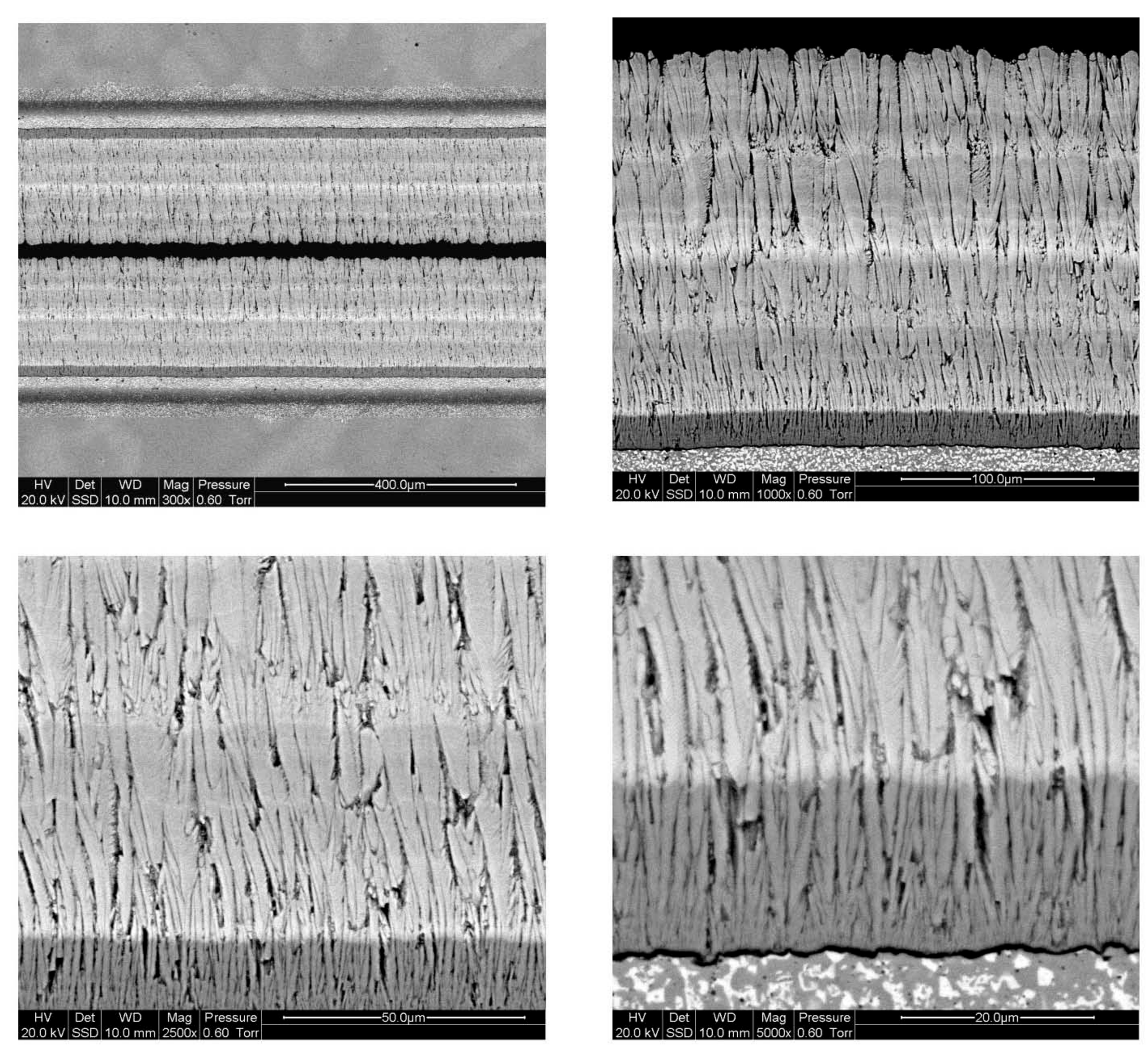
TC Data of TBCs



30° Volume Loss vs Erodent Mass



Composite TBC Structure



PHASE II PROGRAM

1. Optimization of TBC in relation to microstructure, and design for lower TC and erosion rate.
2. Evaluation of thermal cycle life of optimized TBCs.
3. Develop customer base for commercialization of the proposed technology.
4. Develop cost effective thermal spray process for the optimized TBCs.

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