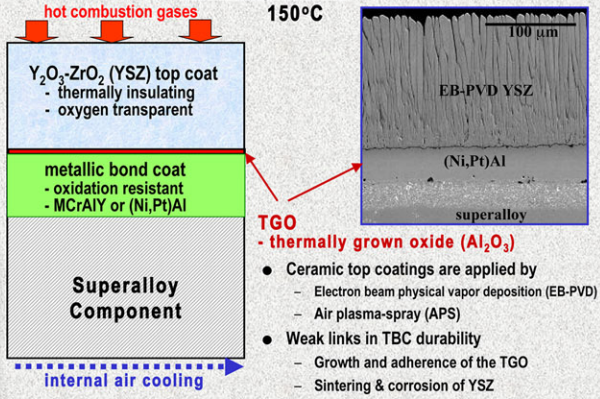
# TBCs for Industrial Gas Turbines

*Thermal barrier coatings (TBCs) are a critical materials technology that reduces the operating temperature of internally air-cooled hot-section superalloy hardware. TBCs allow increased turbine inlet temperatures resulting in dramatic improvements in **engine performance**, **efficiency** and/or **durability**.*

## Key Issues in TBCs for IGTs

- Coating Manufacturing
- TBC Durability/Reliability
- Alloy/Coating Compatibility

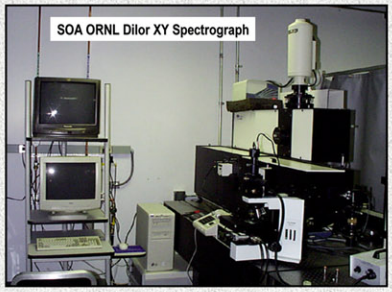
### Thermal barrier coatings (TBCs) can reduce the temperature of internally cooled components by up to 150°C




- Ceramic top coatings are applied by
  - Electron beam physical vapor deposition (EB-PVD)
  - Air plasma-spray (APS)
- Weak links in TBC durability
  - Growth and adherence of the TGO
  - Sintering & corrosion of YSZ

### TBC Durability and Reliability: Residual Stress

Round-Robin Testing with industrial and university collaborators is being conducted to determine the reproducibility of photo-stimulated luminescence spectroscopy for non-destructively analyzing stress & oxide phase content within TBCs.




**Collaborators:**

- GE Aircraft Engines
- Howmet Research Corporation
- Siemens-Westinghouse
- Honeywell
- Solar Turbines
- UC- Santa Barbara
- University of Connecticut

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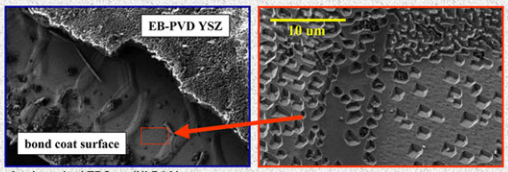
### TBC Manufacturing: Bond Coat Surface Finishing

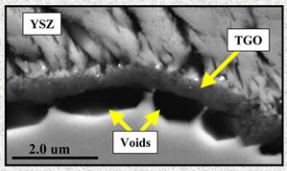
Problem: Grit-blasting of (Ni,Pt)Al bond coat surfaces prior to deposition of EB-PVD YSZ alleviates TBC "infant mortality", but also decreases ultimate TBC life.




*Bond coat surfaces that are not grit-blasted form voids beneath the $Al_2O_3$ scales. These voids can result in premature TBC spallation.*

*As-deposited TBC on (Ni,Pt)Al with no grit-blasting.*

Result: Sulfur impurities in the (Ni,Pt)Al surface stabilized void formation – CVD process improvements & heat treatments are being developed to remove sulfur.




*TBC cross-section, showing voids beneath $Al_2O_3$ on non-grit-blasted (Ni,Pt)Al.*

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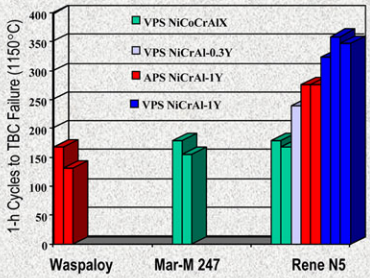
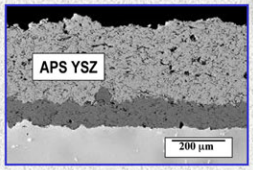
### Alloy/Coating Compatibility: Influence on TBC Life

Proper combination of the superalloy and bond coat is important, since TBC durability can be reduced by some alloy compositions. However, the existing database of information on coating/alloy compatibility is currently very limited.




Plasma-sprayed TBC

Lifetimes of APS TBCs on Mar-M 247 and Rene N5 superalloys were not influenced by superalloy composition, whereas TBCs lifetimes were reduced on Waspaloy substrates.

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## Summary

Progress has been made in understanding relationships between manufacturing and TBC lifetime, but much additional work is needed in order to guide the design of advanced TBC systems for industrial gas turbines. There is a particular need for improved understanding of TBC failure mechanisms in order to identify practical routes to improved coating durability, reliability and life prediction.

*Office of Power Technologies*

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