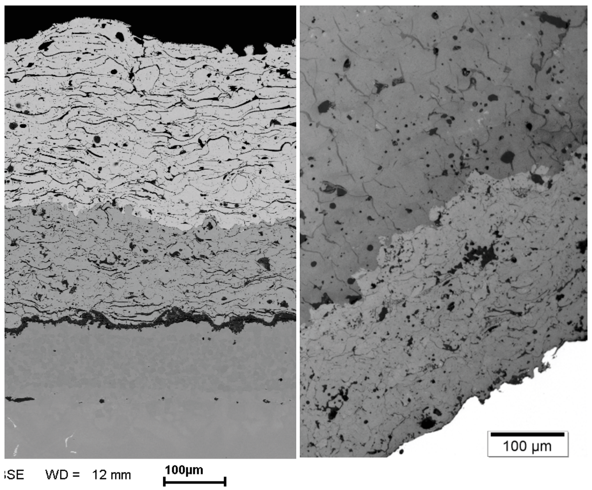
New TBC concepts

Multilayer and graded coatings

Increasingly demanding requirements for TBC´s could hardly be met by a single material. Therefore combinations of materials in the form of multi-layer systems and concentration graded coatings are currently under development at IEK-1.
Thus, it is possible to apply the optimal material for all needed conditions. Especially, double layers of YSZ with rare earth zirconates or aluminates present promising results for TBC applications.
Moreover, the control of microstructure and local compositions offers the possibility to develop multifunctional TBC systems with optimized thermal barrier and process sensing properties.



Micrographs of a $La_2Zr_2O_7$ (left) or $Y_3Al_5O_{12}$ (right) on top of an YSZ layer in an advanced TBC system.

TBCs resistant to molten deposits

Different concepts are developed against attack by molten deposits as they can occur at increased operation temperatures from imperfectly filtered air or fuel intakes or even turbine wear especially in flexible fuel environments (often addressed as "CMAS" being Ca-Mg-Al-Si-oxides).

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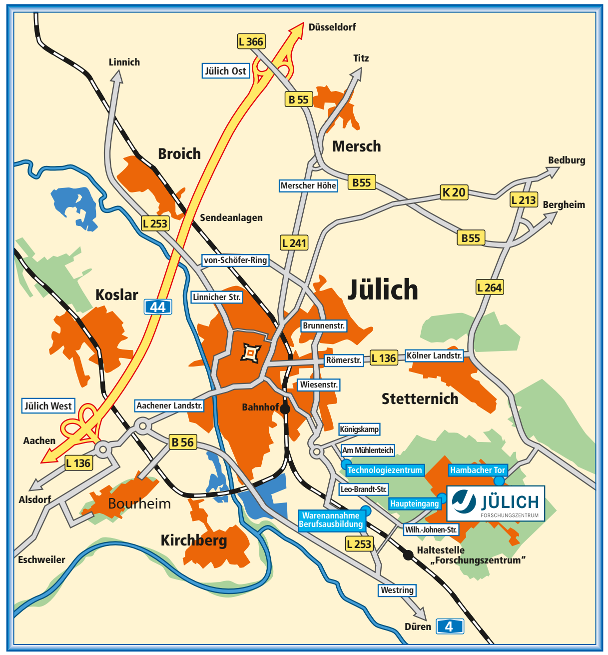

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Advanced Thermal Barrier Coatings (TBCs)

Institute of Energy and Climate Research (IEK)
Materials Synthesis and Processing IEK-1
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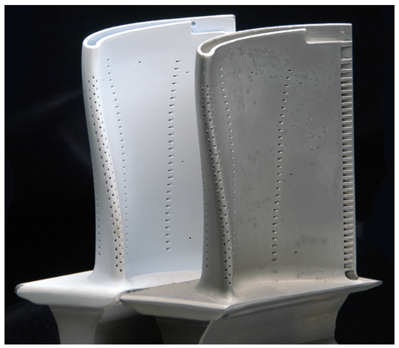
FORSCHUNGSZENTRUM

Application of Thermal Barrier Coatings (TBCs)

Thermal Barrier Coatings (TBC) find a large application as a protection shield against high temperature for the structural components in stationary and aerospace gas turbines. State of the art TBC´s based on yttria stabilized zirconia (YSZ) may be used at temperatures in long-term operation up to 1200°C. Higher temperatures lead to earlier failure of the coating because of phase transformation and sintering processes. However, for a higher efficiency of power engines, increasing the operation temperature is obligatory.

Requirementsfor new TBCs

At the Institute for Materials and Processes in Energy Systems (IEK-1) new concepts and materials for TBC systems are developed, which are intended to replace YSZ.



Turbine blades

In general, TBC materials have to fulfill most of the following requirements:

- a stable phase and microstructure from room temperature up to the operation temperature
- low thermal conductivity (< 2 $Wm^{-1}K^{-1}$)
- high thermal expansion coefficient (> $9 \cdot 10^{-6}$ K^{-1})
- chemical resistance against high-temperature corrosion caused by aggressive media as e.g. CMAS
- a low sintering rate
- a high fracture toughness

Spray-drying facility

Development of new TBC materials

One focal point of research is the development of new ceramic TBC materials (e.g. pyrochlores, perovskites, garnets or hexaaluminates). In comparison to YSZ, some of these candidates show a lower thermal conductivity, better high temperature stability and a comparable level for the thermal expansion coefficient.

Synthesis of materials & powders

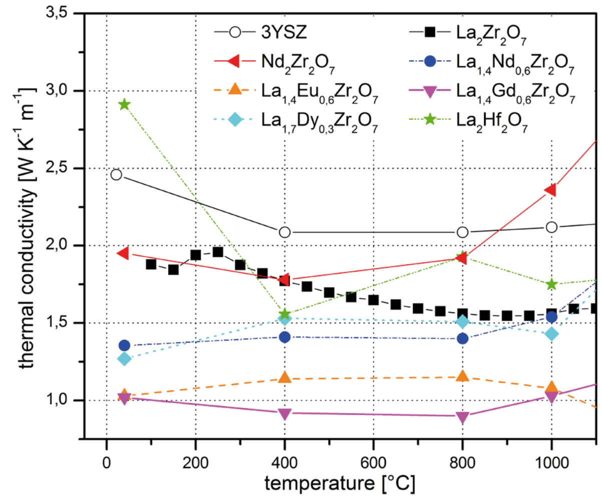
At the IEK-1 new materials are synthesized by precipitation or solid state reaction, as well as spray drying with subsequent calcination and sintering. Free-flowing, spray-able powders or slurries of nanosized powders are tailored for the use in various thermal spray pro-cesses.

Fabrication of coatings

New TBCs as well as metallic bondcoats are manufactured via thermal spraying routes. Available processes are

- APS
- HVOF
- VPS
- SPS
- LPPS-TF (< 10 mbar)

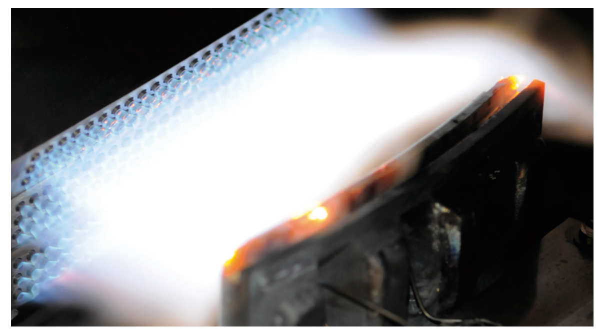
One out of three thermal spray facilities



Thermal conductivity of some rare earth zirconates ($RE_2Zr_2O_7$) with pyrochlore structure in comparison to YSZ.

Characterisation of the TBC

- Microstructural investigations (e.g. optical & electron microscopy, mercury porosimetry, specific surface area, X-ray diffraction)
- Measurement of thermal and mechanical properties (e.g. hardness, thermal expansion, sintering, 3 point bending, thermal conductivity)
- Thermal cycling for testing the thermal shock resistance with options for simultaneous corrosive attack



Burner rig setup for thermal cycling tests of large scale TBC specimen and components with multi segment burner .
A setup for flat geometries with simultaneous injection of corrosive agent is shown on the front side of this flyer.