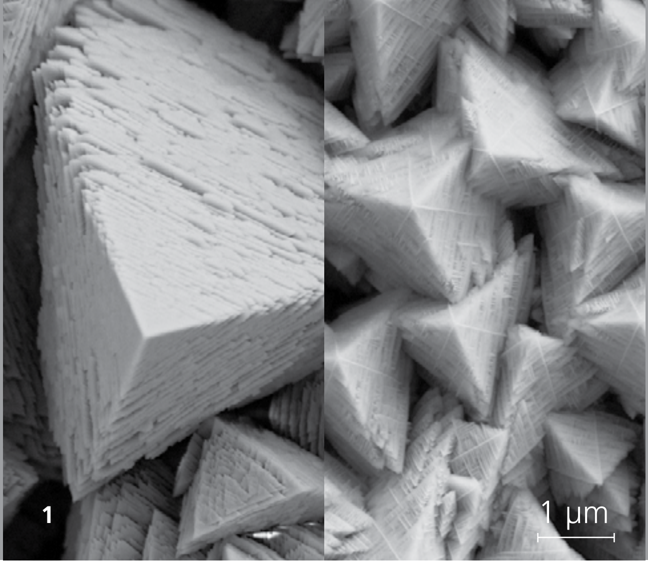
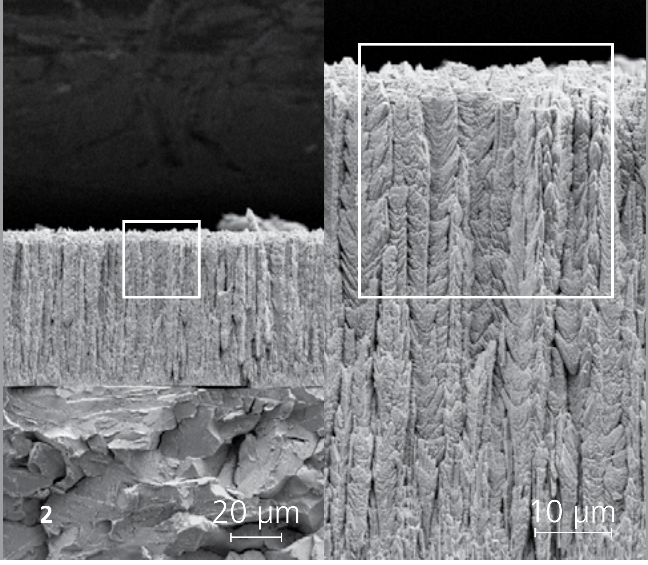




GAS-FLOW SPUTTERED THERMAL BARRIER COATINGS

For a more efficient operation of gas turbines at high temperatures, the metallic materials used must be protected against hot-gas corrosion and overheating. Nowadays the ceramic thermal barrier coatings employed as protection in such cases are produced by electron beam evaporation. However, novel and promising ceramic thermal barrier coatings for highly stressed components can also be produced with the gas-flow sputtering technique (GFS) developed at the Fraunhofer IST.

Thermal barrier coatings for use in gas turbines

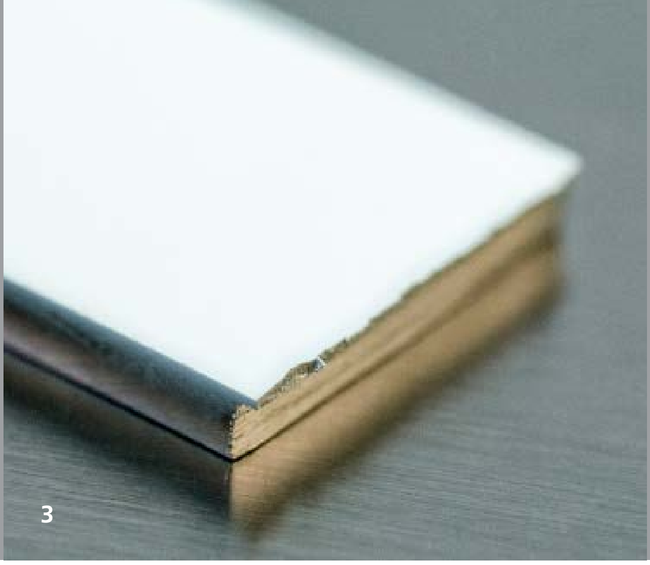
The efficiency of a gas turbine can be significantly increased by having a high gas inlet temperature. Components in the combustion chamber of a turbine are therefore exposed to very high temperatures which even high-quality materials cannot withstand. However, with the aid of a combination of active film cooling and thermal barrier coatings, high gas temperatures of approximately 1400 °C are possible without compromising the service life.

Thermal barrier coatings usually consist of partially yttria-stabilized zirconia (PYSZ). These coatings are normally produced by thermal spraying processes such as atmospheric plasma spraying (APS) or electron beam evaporation (EB-PVD), with each method creating different microstructures. So-called columnar microstructures, as produced by electron beam evaporation, have a longer life under cyclic loading than the lamellar microstructures of plasma-sprayed coatings. An alternative production method is gas-flow sputtering, a high-rate sputtering technique developed at the Fraunhofer IST which also creates columnar microstructures with a high internal porosity.

Heat transfer through such thermal barrier coatings depends on the one hand on the material and on the other on photon and phonon conductivities. The latter are further reduced by internal interfaces which is why a specific setting for the porosity can have a positive influence on the heat resistance.

Gas-flow sputtered thermal barrier coatings

At the Fraunhofer IST, deposition parameters, which have a major influence on the resulting microstructure of the zirconia coating, were determined and investigated. With the gas-flow sputtering method, fully and partially stabilized zirconia coatings of the most diverse structures were successfully deposited on a high-temperature resistant FeCrAlY alloy. These oxide coatings, deposited at substrate temperatures in the 500 °C to 800 °C range, were characterized and tested for their suitability as a thermal barrier coating. A total of four different microstructures with different intercolumnar porosities were identified. The column diameters can be influenced by an applied bias voltage. In addition, a sufficiently high bias compresses the sputtered layer and thereby influences the mechanical stiffness of the coating and its internal stress. Another process parameter in addition to the bias voltage is the flow of



oxygen that is provided during growth, which can change the density and the preferred orientation of the resulting coating structure.

Thermal cycling tests up to a temperature of 1050 °C and up to 1300 cycles proved that the life of gas-flow sputtered coatings depends very markedly on layer stiffness and the tendency to sinter. Sintering tests with highly feather-like columns continued to reveal a high coating porosity even after a sintering temperature of 1200 °C, thus promising a low heat transfer. In addition, investigations of highly rigid layers indicated sintering tendencies between the individual columns which result in segmentation cracking. On the other hand, coatings of low rigidity do not form cracks of this kind but are rather less resistant to buckling and a subsequent spallation of the coating.

Outlook

Further investigations into the mechanisms described which limit service life are currently in progress. Depending on the selection of parameters, many of the analyzed coatings have already shown a promising durability in the tests and thus appear suitable for use as thermal barrier coatings. Assuming a rational parameter selection a balance of stiffness and the sintering tendency should be found in future so as to deliver the longest possible service life for the coatings coupled with good thermal insulation.

1 *The structures of the GFS thermal barrier coatings differ according to the deposition temperature (top view).*

2 *Columnar microstructure of the GFS thermal barrier coatings (side view, fracture).*

3 *Fracture edge of the thermal barrier coating on a FeCrAlY alloy prepared for examination of the microscopic structure.*

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