Key areas of work

- Thermo-mechanical testing of ceramic matrix composites at temperatures up to 2200 K
- Determination of the resistance to thermal shock of monolithic ceramic using Nd-YAG laser
- Characterization of the mechanical behaviour of monolithic ceramic, functional ceramic and porous ceramic
- Development of new testing procedures in mechanical testing
- Cooperation in the development of technical rules and standards (DIN NMP 291, CEN/TC 184)
- Customized mechanical testing

BAM, division 5.2 (old V.2) is approved by DGA Deutsche Gesellschaft für Akkreditierung mbH according to DIN EN ISO/IEC 17025:2005 as an accredited testing laboratory.	Deutscher Akkreditierungs Rat DAR DGA-PL-2614.16

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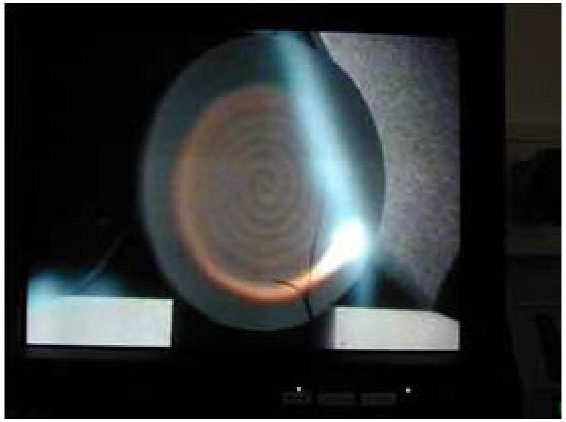
Laser thermal shock experiments on ceramic materials



Failure of a ceramic specimen after exceeding the critical thermal stress

Working Group „Composite Materials“

Basic principles

Most ceramic materials are sensitive to thermal shock [ΔT] and thermal fatigue due to their poor thermal conductivity [λ], low coefficient of thermal expansion [α] and poor plasticity [ε_{pl}]. A bar with fixed ends suppressed thermal expansion undergoing a thermal shock develops thermal stresses:

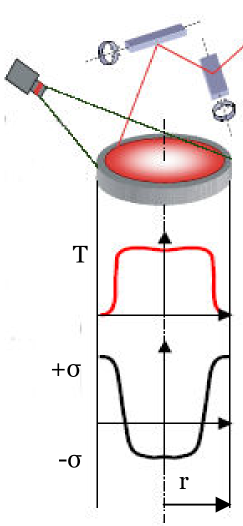
$$\sigma_{th} = E\varepsilon_{el} = -E\varepsilon_{th} = -E\alpha\Delta T$$

The equipment available in the divison permits the repeatable setting of well-defined profiles of temperature distribution in thin circular specimens. Therewith it is possible both to create targeted stress gradients which cause failure and to undertake thermal fatigue tests.

Setup of the equipment

High-speed IR-camera

- InSb—Focal Plane Array with 256 x 256 Pixel
- Exposure time 2 µs —> max. 1400 Hz



Nd : YAG—Laser

- 1064 nm
- cw, max 1500 W

Laser—Scanner

variable:

- diameter
- distance of paths
- velocity

Temp.-distribution

T = f(r,t)

Tangential stressdistribution

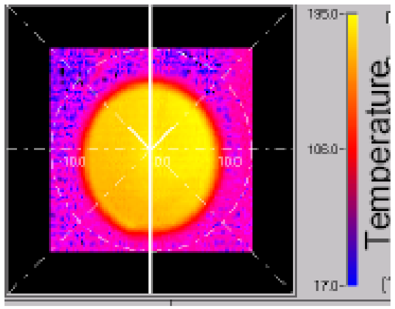
σ = f (r,t)

Procedure

The laser beam is moved spirally from the center of the specimen to the outside margin. This happens so quickly that thermal conduction can be neglected.

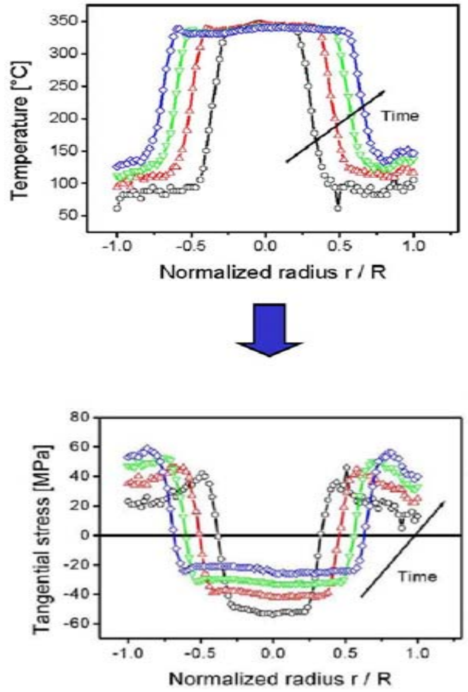
Experimental equipment

The local temperature is recorded with a high-speed IR-camera. The temperature is transformed into a false color representation.



Distribution of temperature in a tested specimen

Out of these data, as well as from further material characteristics the critical stress before failure is calculated.



Typical radial temperature and stress distribution during thermal shock testing

Potential of the thermal shock equipment

- Test of the resistance to thermal shock of ceramics and ceramic coated substrates with Nd-YAG Laser up to 1.5 kW
- Determination of thermal shock parameters that enable a comparison of thermal shock sensitivity of different materials
- Testing of thermal fatigue (repeated moderate thermal shocks) up to 10^4 cycles
- Realization of different environment media during the test