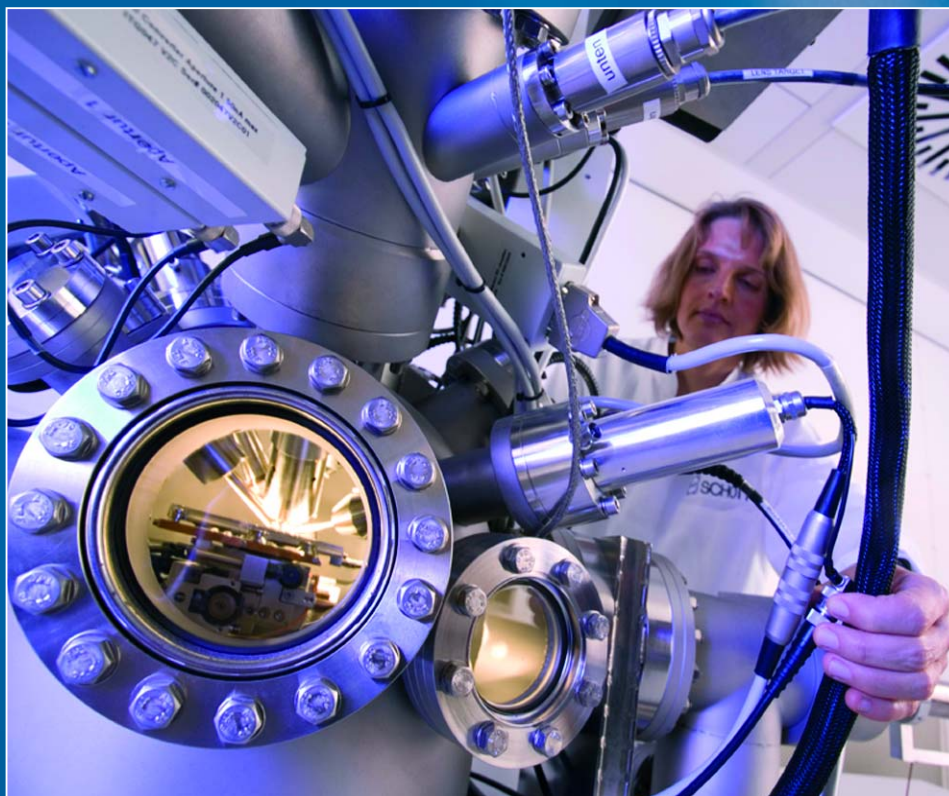


# R & D Services

Analysis Measurement Service



**SCHOTT**  
glass made of ideas

# Challenge in R & D Services

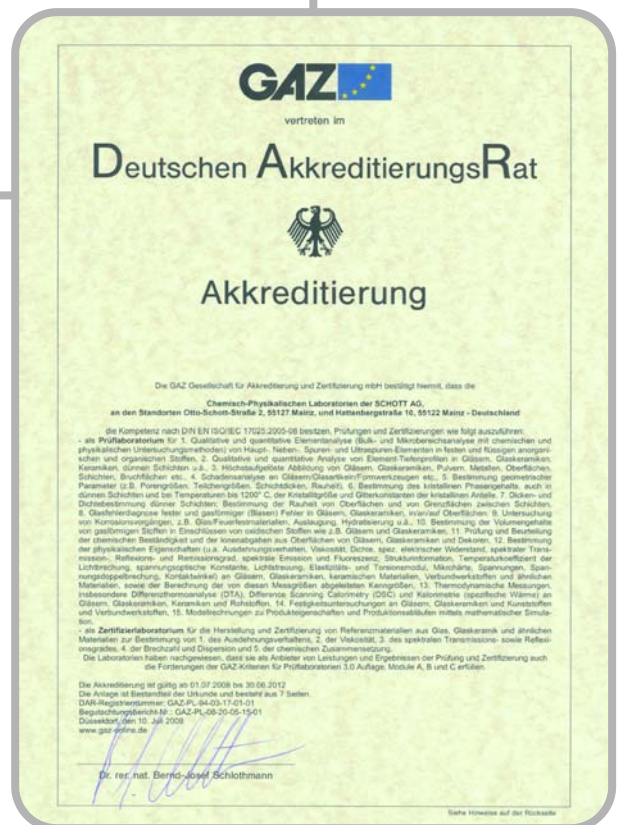
## Schott Research

Since Schott's founding, more than 120 years ago, research and development have been top priorities. Currently, some 200 employees work at "Otto-Schott-Forschungszentrum" (Otto Schott Research Center), Europe's most advanced research center for special glass. The research & development group is a service division for the Schott Group's 40 production facilities worldwide, and it concentrates its activities on application-oriented problems.



## R & D Services - Analysis Measurement Service (AMS)

You can benefit from the knowledge and experience of Schott's scientists, engineers and technicians. Your analysis and measurement jobs can be carried out by the leading manufacturer of special glass. We have the answer to your question: when analysis needs to be conducted, or glasses, glass ceramics, ceramics or thin layers need to be measured. We will gladly provide any advice you require. Our service laboratories, which are [DIN EN ISO/IEC 17025:2005-08](#) accredited, have the capability of finding precise and reliable solutions, even for your most challenging problems.



## Solutions by AMS

Our specialists provide complete support in approaching any and all of your questions regarding structures, defects, bubbles, chemical compositions, optical and mechanical properties of glasses, glass ceramics, ceramics and thin layers. Using highly sophisticated and precise analysis methods, our qualified research staff will help you to evaluate your problems. We are your partner in handling your questions and concerns scientifically.

Give us a call, or send us an e-mail.



## Main contact

Technology Services

Dr. Tobias Kälber

Phone ++49 (0) 6131/66-7271

Fax ++49 (0) 3641/66-2004

E-Mail [tobias.kaelber@schott.com](mailto:tobias.kaelber@schott.com)



# Surface Competence

The service package **Surface Competence** combines core competencies in surface analysis, scientific advisory service and surface conditioning into an efficient instrument. The strong interaction between scientific competencies and analytical methods allows a fast development of solutions tailored to customer needs. Besides pure analytical service and long-term development projects we also offer flexibly adjusted problem solving and consulting. Through **Surface Competence** it is possible to integrate the measurement methods and competencies of Technical Physics, Thermal Characterization, Chemical Characterization, Optical Methods, Technology and Process Development as needed into the process of problem solving.

## Surface analysis and microstructure analysis

State-of-the-art analytical equipment in the field of surface and microstructure analysis and sustained further development assure high quality. Additionally, the accreditation according to [DIN EN ISO/IEC 17025:2005-08](#), guarantees reliable and traceable results. Focal points are:

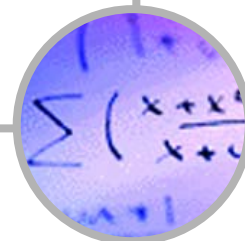
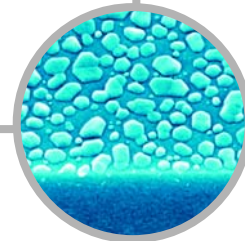
- Glass defect diagnostics
- Analysis of pharmaceutically relevant surfaces
- Characterization of thin layer systems
- Investigation of the microstructure and composition of glass and glass ceramics

## Interpretation of data and scientific expertise

Besides pure analysis the interpretation of the measurement data is the second important pillar of analytics. In order to gain maximal customer benefit a team of scientists, engineers, and technicians combines specific expertise in surface and solid state analysis with material and process know-how. This dovetailing allows efficient evaluation of data and the deduction of process-specific recommendations.

## Surface conditioning and cleaning

In the last couple of years demands on technical surfaces have risen strongly. Therefore, surface conditioning and cleaning increasingly are coming to the fore. The competencies in developing and evaluating surface conditioning processes together with surface analytics result in an efficient tool.



## Analytical methods

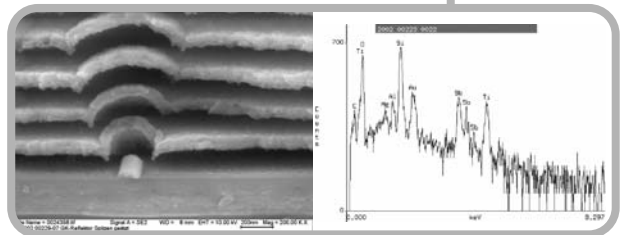
ToF-SIMS/SIMS Mass Spectrometry  
SEM/EDX Scanning Electron Microscopy  
TEM/EDX (in cooperation) Trans. Electron Microscopy  
LiMi Light Microscopy  
AFM Atomic Force Microscopy  
XRD, HT-XRD X-Ray Diffraction, also at temperatures up to 1200°C  
GIXR Grazing Incidence X-Ray Reflectivity for thin layers  
WLI White Light Interference Microscopy  
XPS (ESCA) in cooperation X-Ray Photoelectron Spectroscopy



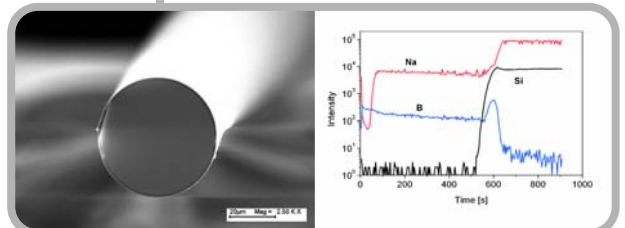
## Applications

Topography and roughness down to sub-nm range  
Composition of layer systems/surface-near regions  
Phase content and crystallite size  
Analysis of contaminations (organic/inorganic)  
Glass defect diagnostics  
Microscopical inspection/investigation

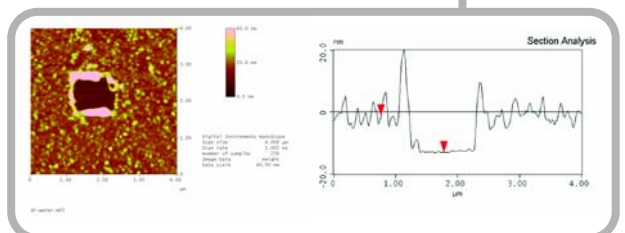
SEM/EDX analysis of a defective multi-layer system. The particle causing the defect was cross-sectioned for analysis, its size is approx. 100 nm.



ToF-SIMS depth profiling of a single fiber 50  $\mu\text{m}$  in diameter. The analyzed area is  $10 \times 10 \mu\text{m}^2$ .



In-situ (liquid cell) AFM analysis of an adsorbed antibody layer. The layer thickness was determined by partial removal of the layer and measurement of the step height (4 nm).



# Thermal Characterization

Our quality policy is to offer our customers in this field technical advice or consultation and customer-oriented services. Our three core competencies are thermal characterization, process analysis and process optimization up to the thermo-mechanical simulation. The strong interaction guarantees a classification of the analysis order to the specific area, the application of the optimum state-of-the-art analysis/characterization technology, and an implementation, respectively support, on location.

## Analytical tools for the determination of thermo-mechanical properties

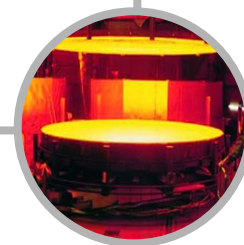
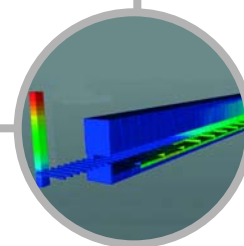
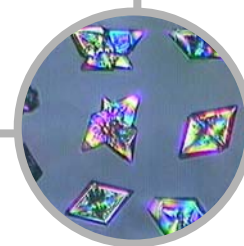
Our laboratory is a competent partner for nearly all thermal analysis issues. We deliver the thermo-mechanical properties of materials and if required their interpretation. With over twenty state-of-the-art measuring stations we are able to supply both, high-precision measurement results and valuable interpretations. Our quality management system, which is [DIN EN ISO/IEC 17025:2005-08](#) accredited, ensures highly precise analysis results.

## Thermo-mechanical simulation, modeling and process development

The basis of a selective and highly efficient modeling and process development is thermo-mechanical simulation. The capabilities for such simulations include, for example, the calculation of temperature distributions and mechanical stresses in materials, the calculation of radiation, or the simulation of reshaping and thermal processes, like ceramization processes of glass ceramics, with high accuracy.

## Process analysis and process optimization

Process analysis and process optimization are the connectors between our core competencies thermal analysis and thermo-mechanical simulation. The use of suitable characterization methods and their interpretation based on a process simulation by PC or using a pilot plant/laboratory station together with the scientific expertise of our personnel guarantee an optimization of production processes on location. Furthermore, the involvement and vital interaction within the other specific departments enables us to solve the process development projects of our customers with high quality and high efficiency.



## Analytical methods

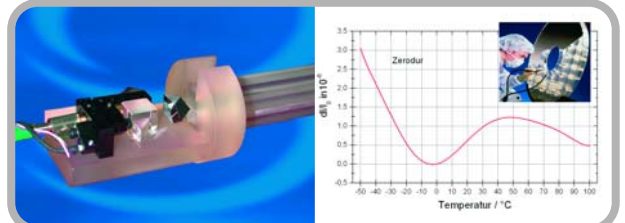
Thermal Expansion (CTE) from -180°C up to 1400°C  
 Viscosity from 300°C up to 1650°C  
 Electrical Volume Resistivity  $\tau_{k100}$   
 Density  
 Stress due to CTE-mismatch of glass-to-glass sealing  
 Simultaneous Thermal Analysis up to 1500°C  
 Differential Scanning Calorimetry, specific heat up to 1400°C  
 Fusibility of glass (detection of crystallization)  
 Thermal conductivity  
 Long-term thermal stability  
 Thermo-mechanical simulation, model and process development  
 Optimization of processes and specific product properties



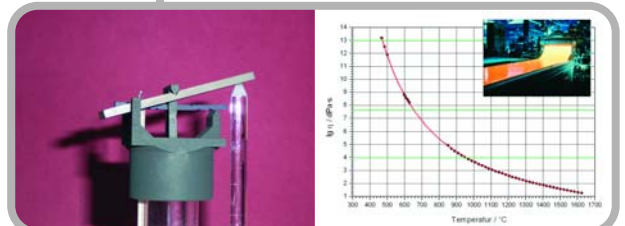
## Applications

Characterization of thermo-mechanical behaviour (expansion, viscosity, thermal analysis (DTA, DSC/TG))  
 Simulation and design/improvement of thermo-mechanical processes (e.g. heat transfer incl. radiation, reshaping, ceramization)  
 Sample preparation

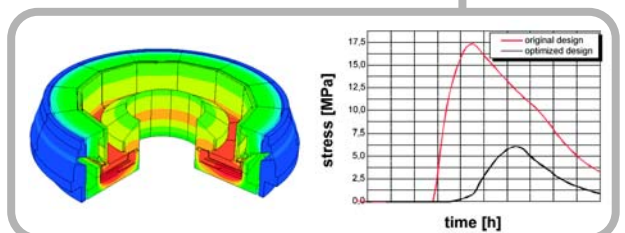
The coefficient of thermal expansion of a sample of ZERODUR®-mirror substrates for earthbound and orbital telescopes is determined by dilatometry using an interferometric measurement equipment.



The exact knowledge of the viscosity of a specific glass composition over the relevant temperature range is important for a robust molding process. For the determination of the lowest viscosity values a rotating viscosimeter is used with temperatures up to 1600 °C.



Result of a thermo-mechanical simulation of a temperature distribution in a specific furnace, which is used in production.  
 Based on these kind of simulation calculations, layout designs of the aggregates are possible. The result is an optimized design of the aggregate.



# Chemical Characterization

The [Chemical Characterization](#) group provides a wide array of inorganic material characterization techniques and methods. Our experience and special know-how lie in the fields of special glass, glass ceramic, microlithography and photovoltaic materials and the corresponding raw and process materials.

Our analytical capabilities and process know-how enable our experts to support and consult you in issues of process development, contamination analysis, failure analysis, chemical durability and degradation.

## Chemical analysis

Unusual analytical questions are our daily work. Based on more than 500 analytical methods and equipped with state-of-the-art analytical instruments we are used to find fast and efficient analytical solutions beyond routine analysis, ranging from ultratrace contamination analysis to high-precision main component determination.

Typical tasks are:

- High-precision determination of material compositions: *quality control and material or process development, IP issues*
- Screening composition analysis: *fast identification and trouble shooting*
- Trace and ultratrace analysis: *material qualification, failure analysis, RoHS certificates*

## Chemical properties

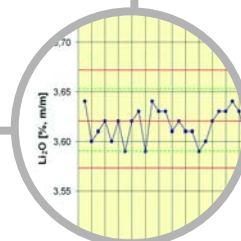
Focused on glass and glass ceramics, we provide numerous international standard methods, as well as special customized methods to characterize the chemical properties of the materials, for example the resistance to chemicals and extreme climates or their leaching behavior. A main focus is the examination of pharmaceutical packaging materials.

Beyond the analytical service we give scientific support in the field of wet chemical processes like etching, leaching or cleaning.

## Reliability through quality assurance

To reach the ambitious requirements of our customers, we emphasize a high quality level, which is regularly confirmed by accreditation audits according to [DIN EN ISO/IEC 17025:2005-08](#).

Matrix specific calibrations of the solid state analysis methods XRF and LA-ICP-MS guarantee accurate results. Our numerous glass-type-specific calibration programs were built up from more than 1000 reference samples.



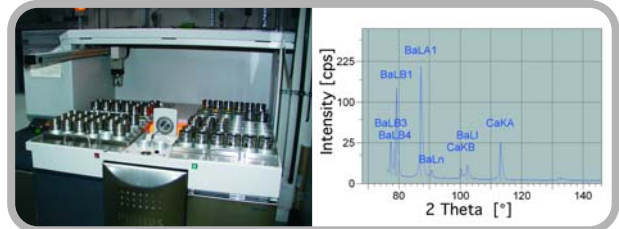
## Analytical methods

X-Ray Fluorescence Spectroscopy XRF  
 Mass Spectrometry ICP-MS and Laser Ablation ICP-MS  
 Atomic Absorption Spectrometry F-AAS, GF-AAS, HG-AAS  
 Atomic Emission Spectrometry ICP-OES, Spark-OES  
 Wet Chemistry Gravimetry, Titration, Photometry, Species analysis  
 Chemical durability tests  
 Hot gas extraction methods for C, O, S, N determination  
 Ion Chromatography  
 Various digestion techniques

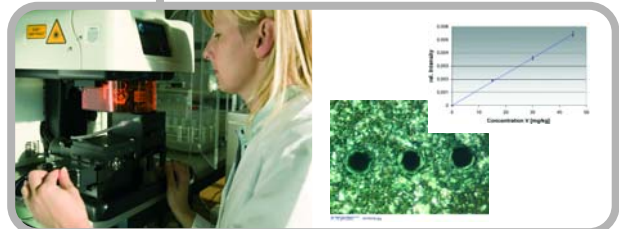
## Applications

Quantitative and qualitative composition analysis  
 Trace and ultratrace analysis, single/multi-element, screening  
 Chemical durability, corrosion, leaching behavior  
 Certification of glass or glass ceramic standards

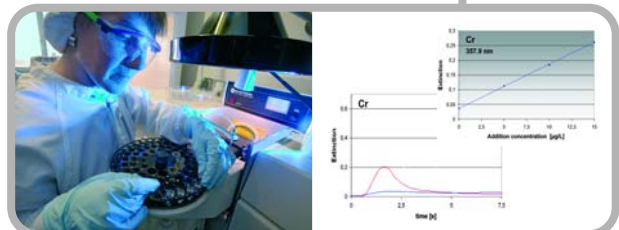
Determination of the composition of a special glass by X-Ray Fluorescence Spectrometry. High accuracy and precision are obtained by matrix-specific calibration.



Determination of trace elements in glass ceramic by Laser Ablation ICP Mass Spectrometry.



Ultratrace analysis of chromium in zirconium oxide with Graphite Furnace Atomic Absorption Spectrometry GF-AAS in clean room environment.



# Optics Competence

Many applications of optical materials require an accurate knowledge of their optical properties. Our tasks are optical characterizations of glass and glass ceramic materials, traceable back to international standards.

- We enable non-destructive optical characterization methods for fast and precise evaluation of application-related optical and mechanical properties.
- We have the capability for optical detection of impurities in glass and glass ceramic materials, even in the ultratrace range.
- We offer know-how and test performance for UV-irradiation stability, e.g. solarisation.
- Based on optical scattering methods we characterize the structure by using different scattering techniques.
- We develop optical metrology and construct respective test equipment for the operation under production conditions.

## Bulk diagnostics

High-quality results are assured by the use of state-of-the-art analytical equipment in the field of bulk and real structure analysis. The analytical methods are adapted to future demands by a sustained development together with our accreditation according to [DIN EN ISO/IEC 17025:2005-08](#). Focal points are:

- Scattering diagnostics (Rayleigh R90, Mie, Forward, TIS).
- Analysis of light conversion (fluorescence, phosphorescence, quantum yield).
- Characterization of fluorescence, transmission, remission, reflexion and refractive index/dispersion at room temperature and temperature dependent optical properties between 10 and 450 K.
- Investigation of vibrational microstructure and composition of glass and glass ceramics (Raman, FT-IR).

## Development of novel optical methods

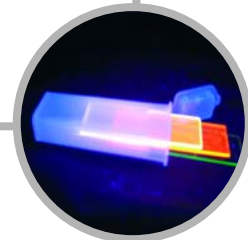
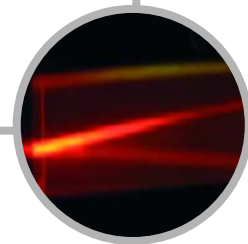
Novel methods are required for the characterization of innovative materials and composites. The design and development of precise and efficient optical metrology or other physical testing methods are based on the long experience of our scientists and engineers. Solutions are tailored to customer needs.

## Glass-based reference materials

In the last couple of years, demands on standard and reference materials have risen strongly. For prominent optical properties, e.g. fluorescence intensity, transmittance and reflectance, we offer glass-based reference materials.

Intense cooperation with federal metrology institutions, e.g. BAM and PTB, guarantee the reliability and accuracy of the desired reference materials and characterization procedures.

Certificates for transmittance, reflectance and fluorescence are available on request.



## Analytical methods

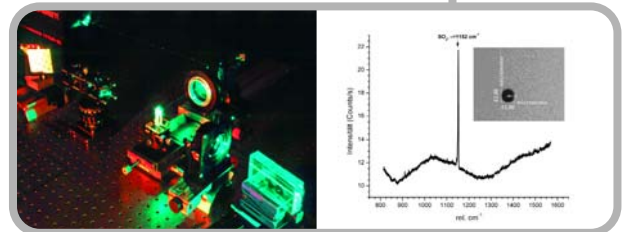
Transmission, reflexion, remission, absorption in UV-VIS-IR range  
 Thermal emission and temperature dependent transmission  
 Refractive index and dispersion UV-VIS-NIR  
 Stress-optical coefficient and stress-induced birefringence  
 Spectral and temporal resolved fluorescence, phosphorescence  
 Raman spectroscopy  
 Light Scattering UV-VIS-NIR (Total Integrated Scattering TIS, Rayleigh R90, Forward scattering)  
 Solarisation tests (DUV, UV, Solar)  
 also: E-modulus, Poisson ratio



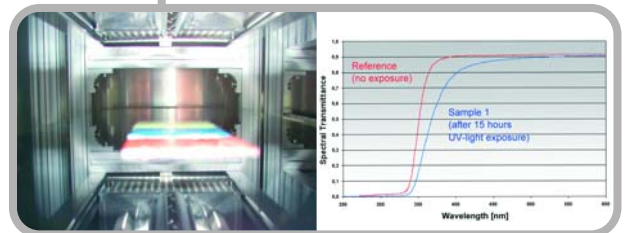
## Applications

Evaluation of scattering regime and size distribution using Rayleigh scattering between 400 and 800 nm, TIS and forward scattering between 200 and 2500 nm  
 Performance and interpretation of optical acceleration procedures for reliability and lifetime prediction  
 Development of optical metrology with highest precision  
 Development and manufacturing of tailored optical solutions  
 Delivery of certificates and reference materials for transmission, reflexion, fluorescence and refractive index  
 OH-content and hydrogen in glass and glass ceramics  
 Optical properties of glass and glass ceramics between room and melting temperature

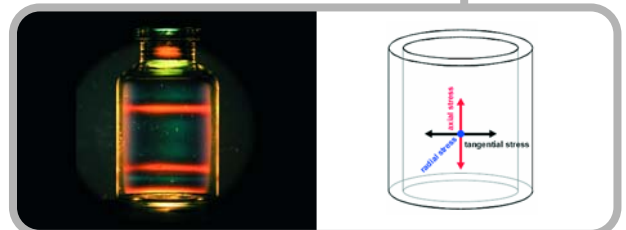
Raman analysis of gaseous, fluid and solid inclusions in glass. Inclusions and bubbles well below 50 microns can be identified and quantified. Moreover the structural properties of solids are characterized.



UV solarisation test equipment for staining test in solar and optical industry. The accessible power density exceeds more than an order of magnitude the solar power of the sun. Accelerated testing can be applied for several 100 cm<sup>2</sup> of sample surface.



Stress-optic diagnostics are used to determine residual and mechanical stress in glass and glass ceramic products in order to predict their reliability. Based on the polarisation dependent light distribution the integral tension profile is visualized. For special geometries, e.g. bottles used for pharmaceutical packaging, even rotational stress components are characterized.



# Technical Physics

The focus of [Technical Physics](#) is on the characterization of damage mechanisms in production as well as on reliability and lifetime predictions for products made of special materials and material combinations.

Therefore, it is necessary to combine different methods:

- Experimental measurement and testing
- Fractography
- Statistical analysis
- Mathematical simulation

This tool box is the basis for problem solving in production processes as well as for the development of new products.

## Damage judgement

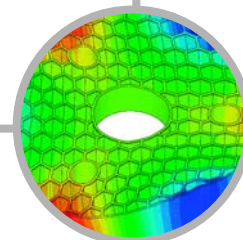
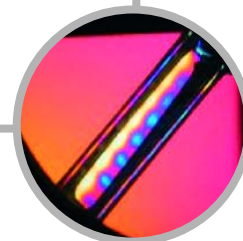
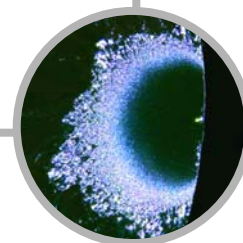
In case of problems in production or failure of products during use the failure cause has to be identified first. The failure mechanisms (thermo-mechanic fatigue or overload, corrosion, ...) have to be identified and the testing methods have to be adjusted.

## Experimental testing with statistical evaluation

The basis of quantitative results are measurements within the accreditation according to [DIN EN ISO/IEC 17025:2005-08](#). Coming from established measurement methods, an increasing number of methods are offered to determine reliability and lifetime data of material combinations.

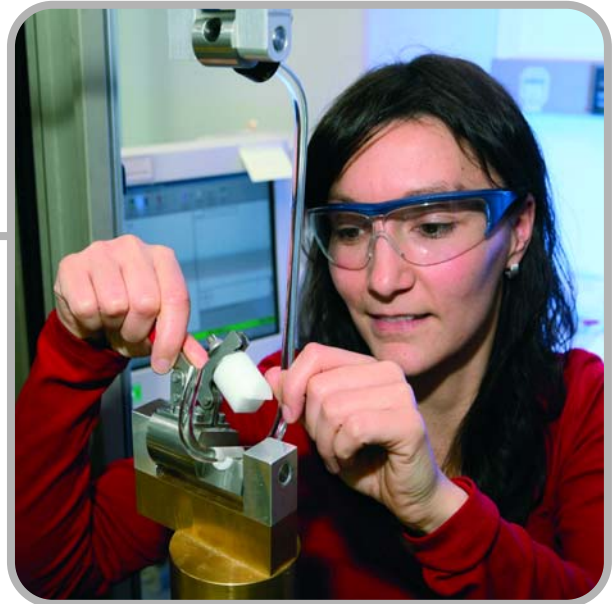
## Mathematical simulation

Process models based on scientific mechanisms are used to evaluate the damage growth during production and during use of products. Using FEA calculations and mathematical optimization algorithms, the development time can be reduced instead of working by "trial and error".



## Analytical methods

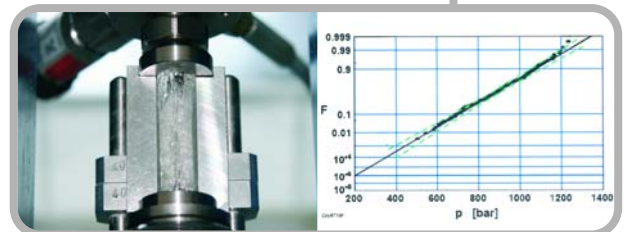
- Static strength, tension-compression (uniaxial), bending (2pt., 3pt., 4pt., ring-on-ring), bursting (hydrostatic)
- Dynamic strength, notch test, DCDC (crack growth), thermal shock, climate testing
- Fractography, crack origin, fracture mirror, stress-optical measurements
- Statistical analysis of strength data
- Indentation measurements (Knoop, Vickers, Martens), micro- and nano-hardness, fracture toughness, crack initiation load, elastic and plastic indentation
- Hydrogen absorption by getter materials
- FEA calculations



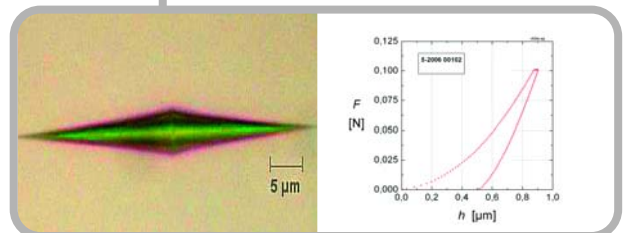
## Applications

- Prediction of product lifetime
- Identification of failure cause and failure probability
- Strength measurements
- Identification of lot variations by indentation measurements
- Process analysis and process improvement by FEA calculations
- Development and optimization of measurement equipment

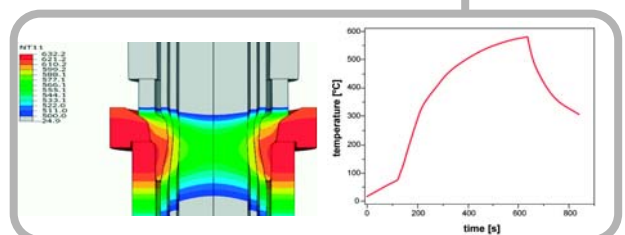
Bursting measurement of pharmaceutical products for the determination of failure probability.



Indentation methods for determination of hardness (Knoop, Vickers, Martens) and elasto-plastic properties (elastic modulus, plastic and elastic work) of glass, glass ceramics and ceramics.



Mathematical simulation of a hot-forming process for sealing glass fibers with metal rings.







**SCHOTT AG**

Research and Technology Development

Hattenbergstrasse 10

55122 Mainz

Germany

Phone: +49 (0)6131/66-7271

E-mail: [tobias.kaelber@schott.com](mailto:tobias.kaelber@schott.com)

[www.schott.com](http://www.schott.com)

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glass made of ideas