

肖特高精密光学玻璃助力精密光学元件和设备迭代和创新

SCHOTT High Precision Glass enables  
optical component and equipment innovation

EPIC TechWatch at CIOE, September 2023

# Agenda

01

About SCHOTT

02

ZERODUR®

03

Optical Glass



# Meet SCHOTT – Headquarters in Mainz, Germany



## Reliable partner for more than 130 years

- **1884:** founding of the company in Jena
- **1952:** rebuilding of the foundation company in Mainz



## Worldwide locations

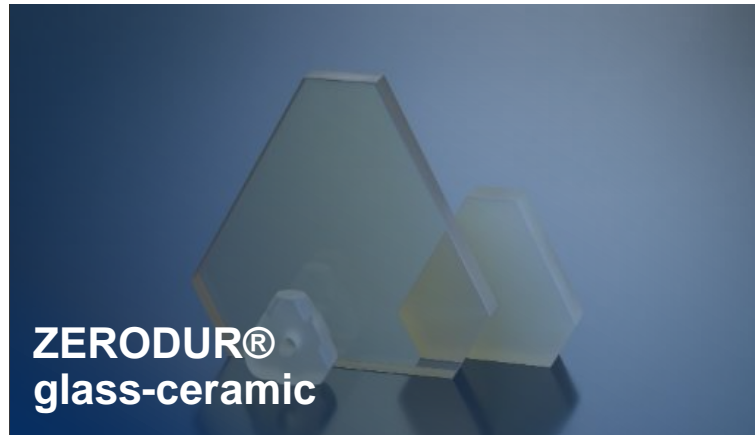
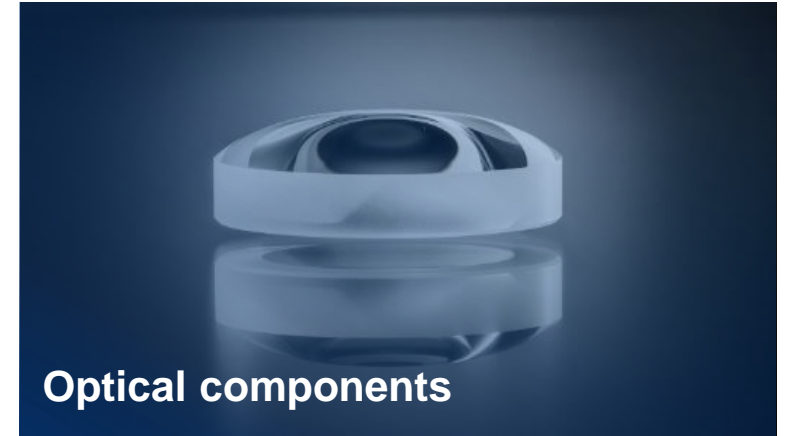
- 42 production sites
- 26 sales offices
- In 33 countries



## Our goal is sustainable growth

- EUR 2.8 billion global sales
- 17,200 employees
- 685 researchers
- 3.500 patents

# SCHOTT Advanced Optics







# 02

## ZERODUR® 零度®

Low-thermal-expansion material for lithography applications

用于光刻的低膨胀系数材料

SCHOTT Advanced Optics – your reliable partner

特先进光学事业部 – 您可靠的合作伙伴



# ZERODUR®: 55 years of highest precision in six different industries

## 零度®：在6个对精度要求最高的不同的领域有55年的历史



Link prüfen

[sites.schott.com/the-power-of-zerodur](https://www.schott.com/sites.schott.com/the-power-of-zerodur)

Astronomy天文



1968

Aviation航空



1978

IC Lithography IC光刻



1996

Projects

Industrialized

1972



Metrology计量

1984



Space太空

1998



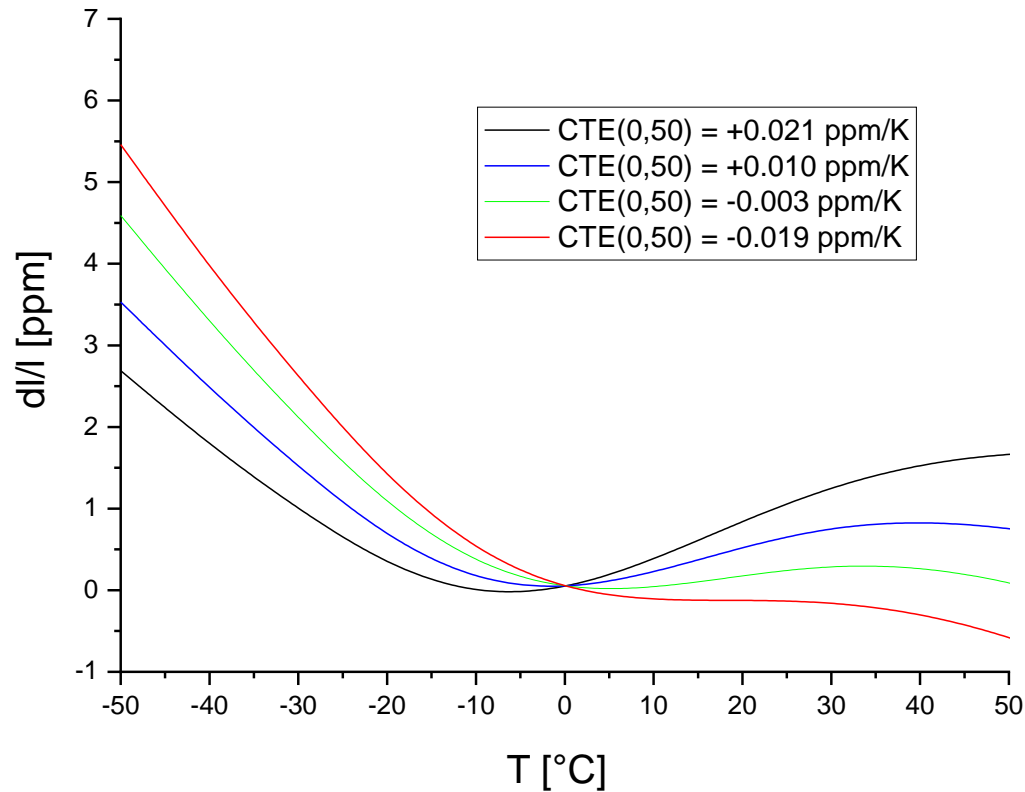
FPD Lithography FPD光刻



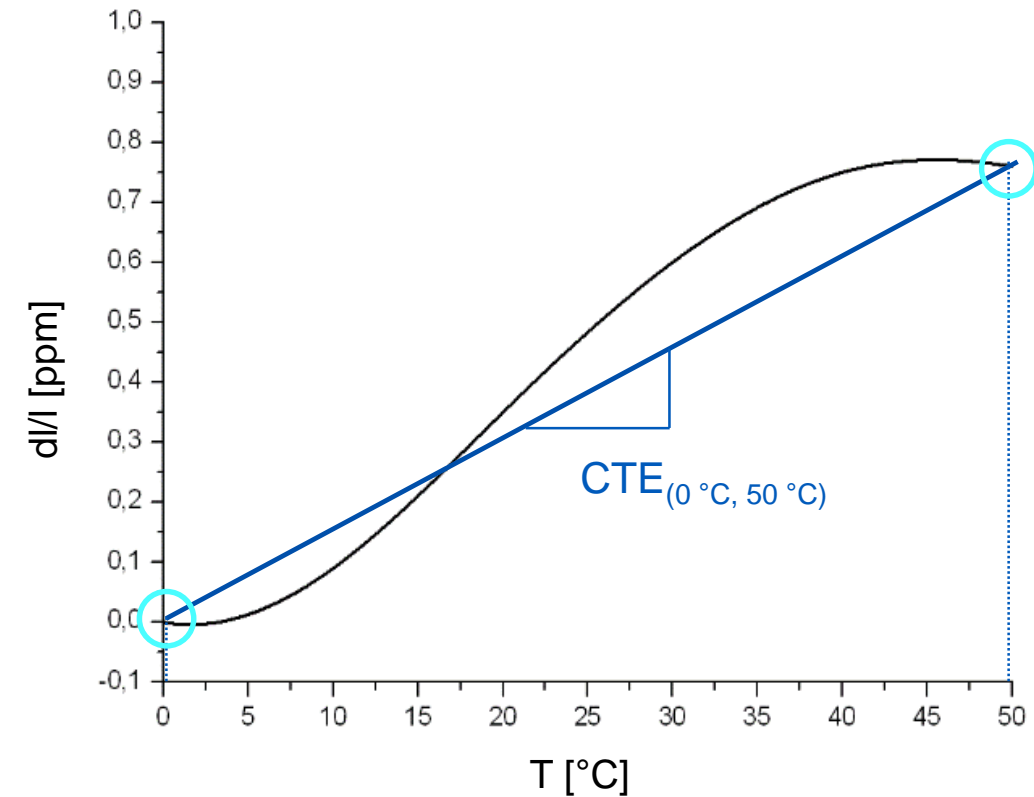
# ZERODUR® is known for its extremely low coefficient of thermal expansion (CTE) between 0 °C and 50 °C

## 零度® 因其具有极低的膨胀系数而闻名

Thermal expansion for various ZERODUR® samples  
不同零度®样品的热膨胀系数

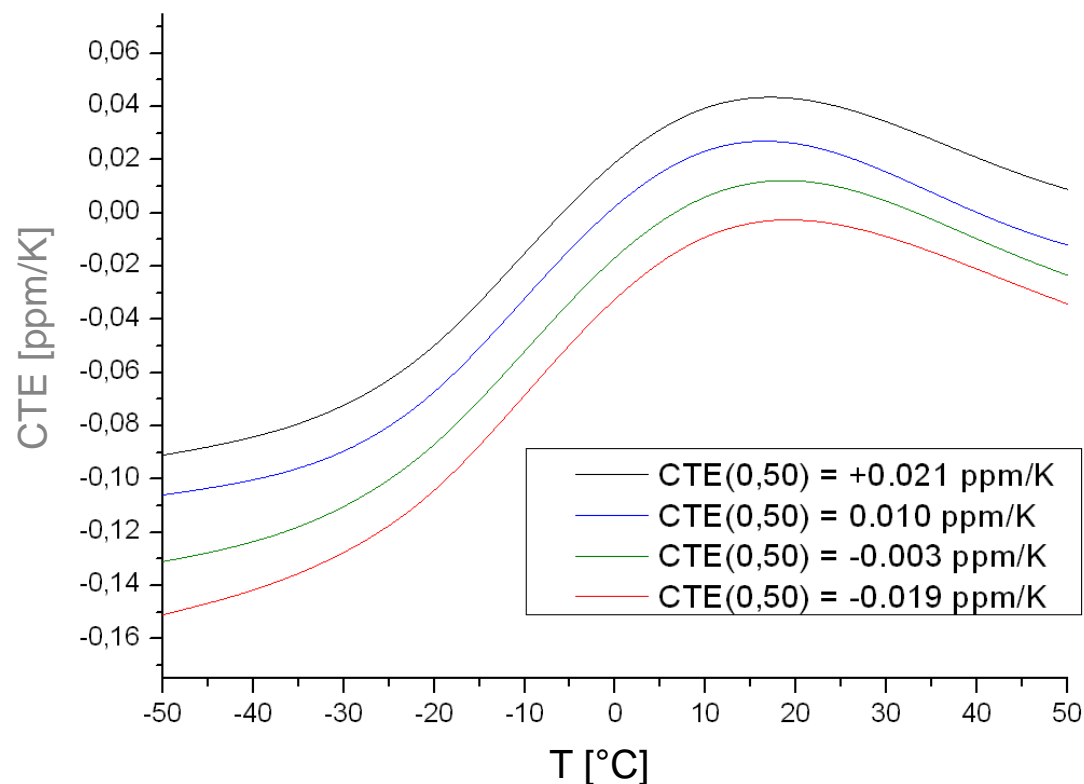


Coefficient of thermal expansion CTE  
热膨胀系数CTE

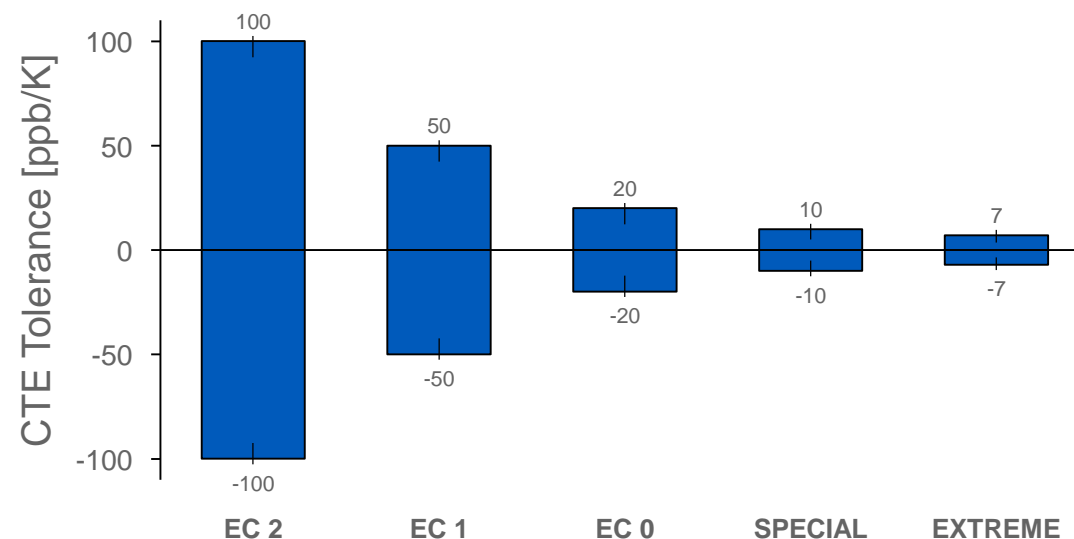


# Adjustment of ZERODUR® ceramization allows for different expansion classes to match different customer-application requirements 可根据不同客户的应用要求对零度®的膨胀系数等级进行调整

Coefficient of thermal expansion for various ZERODUR® samples  
不同零度®样品的热膨胀系数



ZERODUR® expansion classes  
零度®膨胀系数的不同等级

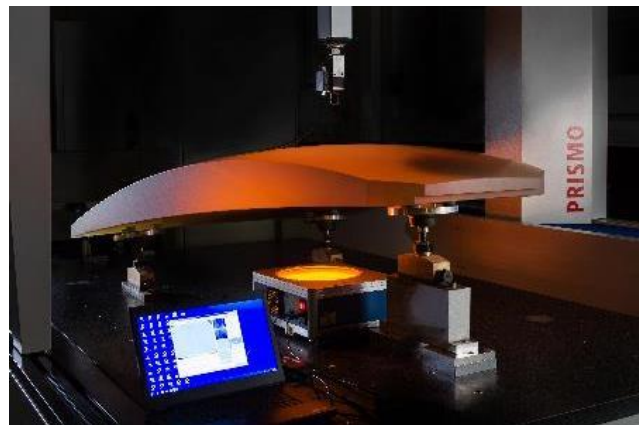
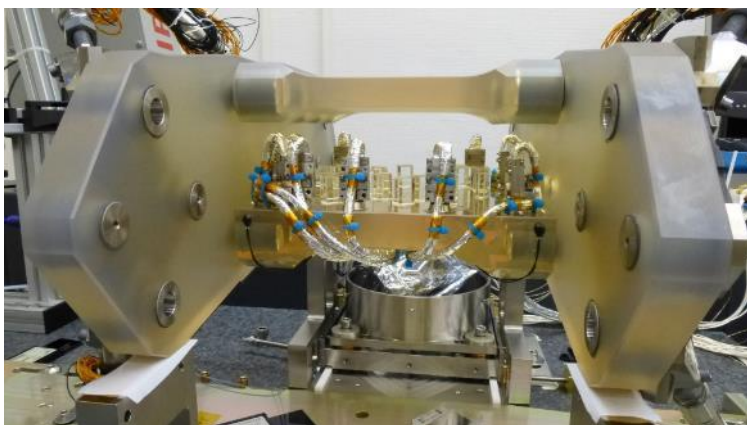
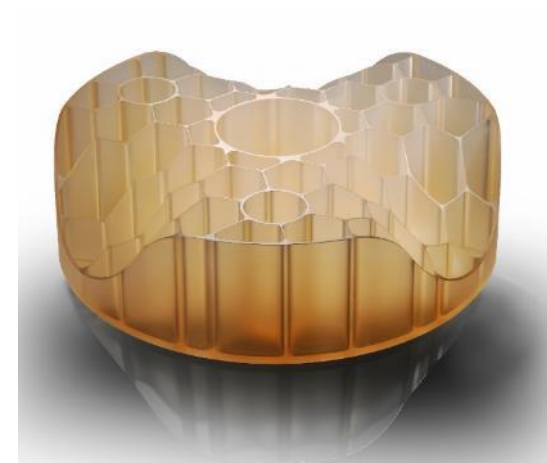
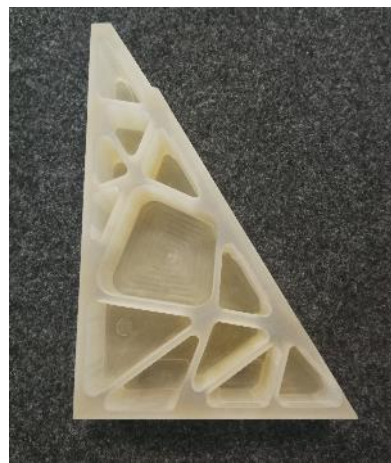


Expansion class **TAILORED**:  
Optimized for application T-profile  
定制化CTE



# ZERODUR® is machinable into various shapes and structures

## 零度®可以被加工成各种各样的形状和结构



- Dimensions尺寸: 10 mm – 4500 mm
- Mirror substrates 反射镜镜坯
- Stages and other structural parts  
工件台和结构件
- Optical benches 光学样板
- Laser cavities 激光腔体
- ...

# SCHOTT capabilities and know-how on ZERODUR® support our customers to enable their high-precision applications

肖特在零度®方面的能力和专业知识支持我们的客户实现其高精度应用。

Your strong & reliable partner – SCHOTT ZERODUR®

您坚实可靠的合作伙伴 – 肖特 零度®



## Application know-how

SCHOTT experts are working on production, processing, and optimization of ZERODUR® – all around the world.



## Material data

ZERODUR® is the best characterized low-thermal-expansion material on the market (e.g. bending strength / lifetime, CTE homogeneity, etc.)



## Publications

SCHOTT has published more than 90 technical papers on ZERODUR®.



## Material understanding

Ongoing research leads to best-in-class material-property understanding.



## Material availability

SCHOTT's capacities can serve any current and future market demands of ZERODUR®.



## Processing capability

A new manufacturing center allows for processing of ZERODUR® – even in complex shapes and tolerances.



## Measurement capability

Most precise coordinate-measurement machines enable reliable and reproducible processing.



## Support

With expertise and know-how we can support our customers using ZERODUR®.

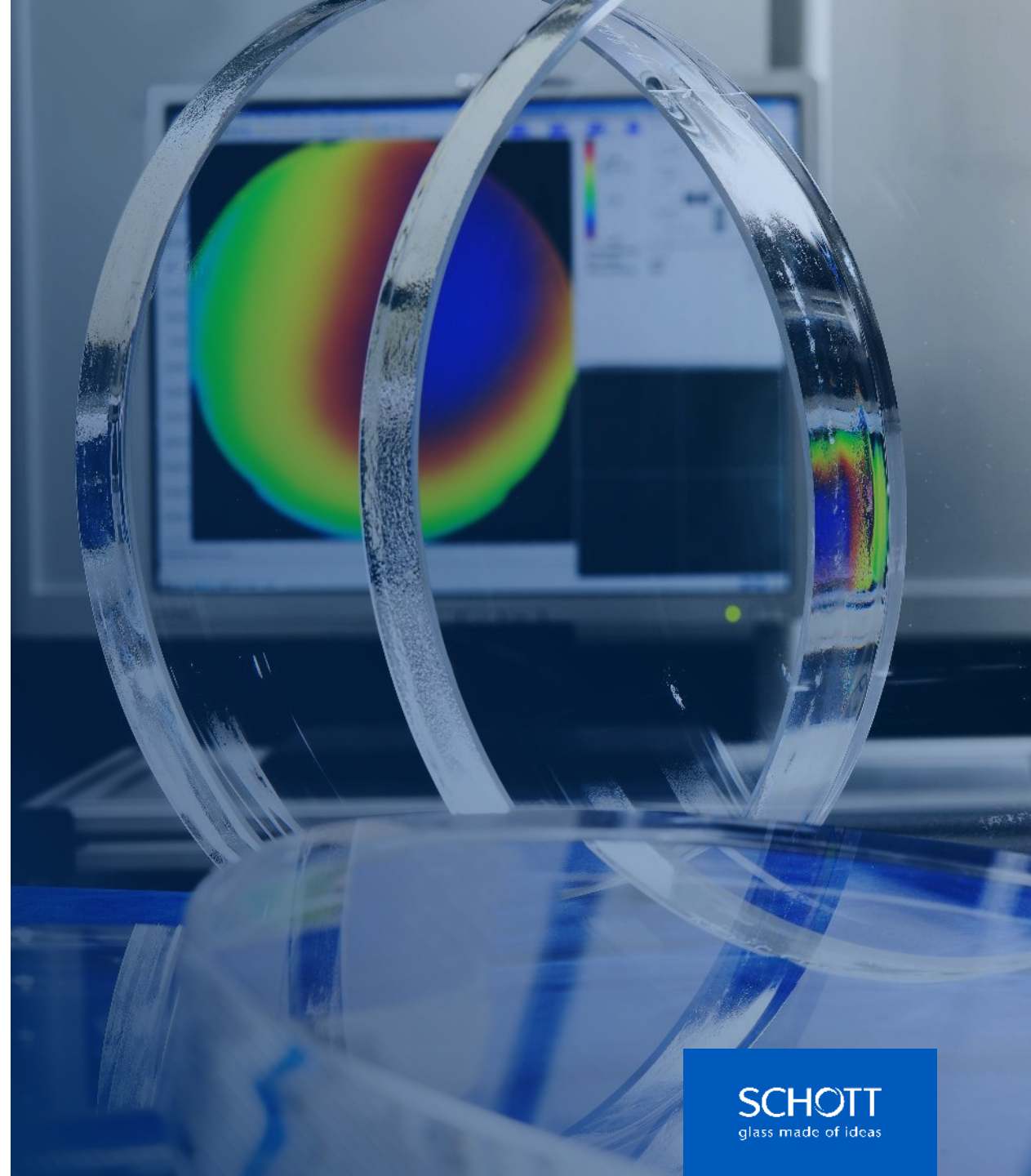
# 03

## SCHOTT Advanced Optics

i-Line glass

肖特 先进光学事业部

i 线玻璃 & 高均匀性光学玻璃





# Optical glass

130 years experience in producing optical glasses

## Portfolio

- More than 120 optical glasses
- 7 radiation resistant glasses
- Pressings up to 8 kg / 320 mm diameter
- Cut blanks up to 1000 mm diameter
- Various core rods
- High homogeneous glass with H5 and better
- Pressings with homogeneity grade H3 available
- High transmission HT and HTultra glasses
- Special glass developments (e.g. for superior athermal designs)

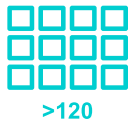


## Stable & reliable

- Inventor of industrial optical glass production with more than 130 years experience
- Stable processes: lowest batch-to batch variation as basis for stable processes over the entire product lifetime
- Durable: proven reliability of radiation resistant glass after decades in space

## One-stop-shop

- Only optical glass production in the western hemisphere, ensuring long term glass availability (positive list)
- Full range supplier of optical glasses from raw material up to finished components



### Wide portfolio

Full range supplier with more than 120 optical glasses



### Tightest tolerances

Only SCHOTT offers optical properties with step 0.5 in the market



### High homogeneity

Enabling higher resolution with a wide range of glasses



### Tailored solutions

Pressings with customized optical positions enable superior optical designs



### Best color correction

Combining KZFS with FK/PK glasses enables superb color imaging



### Online web shop

Enabling direct access to available formats and optical positions

# The extended SCHOTT i-line glass portfolio

## 肖特 i 线玻璃产品组合

SCHOTT portfolio				SCHOTT solarization values acc. to JOGIS	
Glass type	nd	vd	Int. transmission at 365nm and 10mm thickness	Rating*	achievable level
FK5HTi	1,48748	70,47	0,999	very good	<5
N-BK7HTi	1,51680	64,17	0,997	excellent	<2
N-SK5HTi	1,58913	61,27	0,992	very good	<5
LLF1HTi	1,54815	45,9	0,997	excellent	<2
LF5HTi	1,58144	40,89	0,996	excellent	<1,5
F2HTi	1,62004	36,37	0,985	excellent	<1,5

\*rating: 20 < solarisation <=10 is standard | 10 < solarisation <=5 is good | 5 < solarisation <=2 is very good | 2 < solarisation <=0 is excellent

# i-glass characteristics

## i 线玻璃特性



### Superior performance 性能优异

- High UV-transmittance at 365nm
- Highest homogeneity of refractive index e.g. 1E-6 (H5) absolute index variation on 200mm diameter
- Large formats up to 300mm in diameter
- Excellent internal quality
- Negligible stress birefringence due to well-defined annealing process
- Maximum index variation per delivery lot of  $\pm 30E-6$



### High reliability:

- Leading, partly proprietary metrology
- Assured and certified quality
- Long-term availability out of Germany



EXPERIENCE

### Long-term experience

- Experts in melting and annealing processes
- Local technical support out of Suzhou
- State of the art metrology to ensure superior data quality
- Customized glasses and features: Huge base of glasses available



# Strong growing demand expected for (multidirectional) homogeneous blanks

## Applications like

- Interferometric position measurement in lithography
- Targeting systems in defense applications
- Beam guiding elements in wave front sensitive metrology

**Require typically** small cubes with a low wave front distortion:

- Glass types: SCHOTT N-BK7®, N-F2, SF2, N-SF2, ...
- Dimensions  $< (100 \text{ mm})^3$
- Stress birefringence level of  $< 4 \text{ nm/cm}$
- Homogeneity PV-value  $< 1 \text{ ppm (H5)}$  in 2D

## SCHOTT Value Proposition:

- Stable supply of homogeneous parts over decades
- Reliable production via global footprint (Germany, US, Malaysia)
- Strong application support for customized specifications
- Outstanding homogeneity and stress levels
- Full optical glass portfolio with a large stock available

## Process description:

- Special raw glass selection
- Lower annealing rates to minimize stress level
- Improved measurement capability e.g. automated interferometric aperture testing
- More efficient in processing the raw glass
- Optimizing the raw glass format to improve glass waste ratio

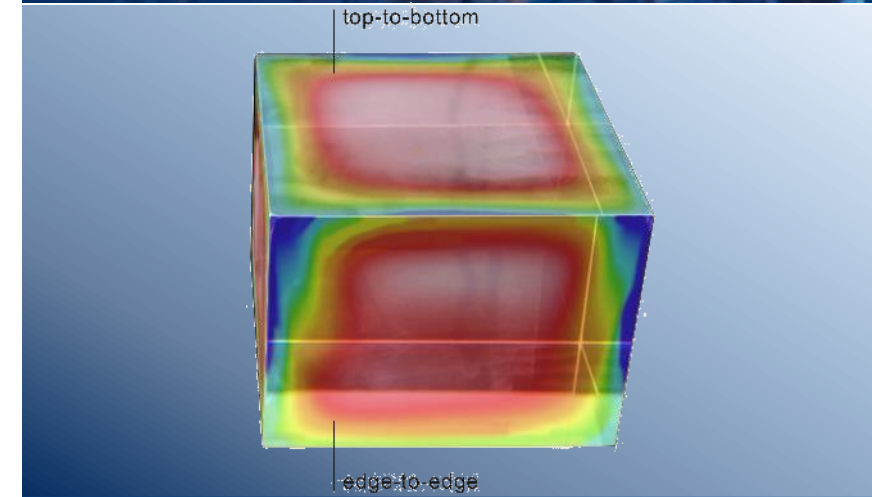
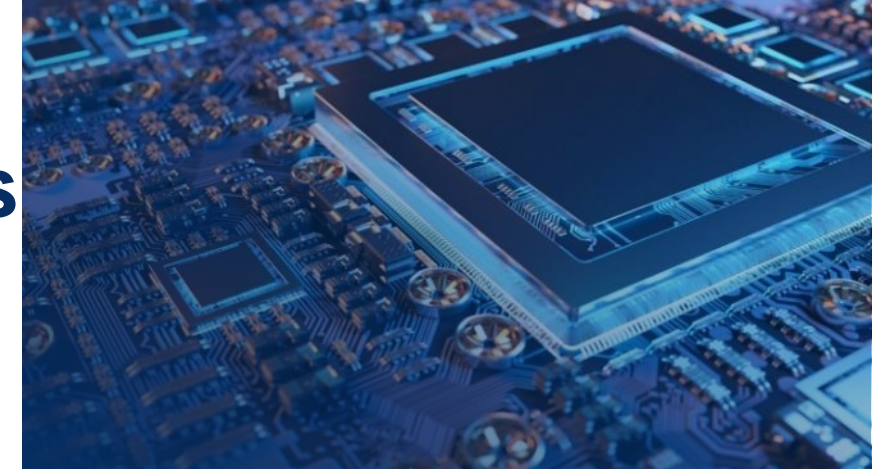
## References:

TIE-26 <https://www.schott.com/en-us/products/optical-glass-p1000267/downloads>

Rupp et al. EOSAM 2022, "Improved production of large and multidirectional homogeneous optical glass", 2022

15 © SCHOTT AG, SCHOTT@EPIC TechWatch CIOE, 07/09/2023

Confidential



**SCHOTT**  
glass made of ideas

# Requirements for large strips are challenging ...

Typical requirements of selected applications

## Applications like ...

- large interferometers in metrology,
- large laser fusion components in science and
- large atmospheric dispersion correctors in astro & space (telescopes)

## Large homogeneous SCHOTT N-BK7® blanks overview

- SCHOTT achieved to produce blanks in the **1-meter class up to a homogeneity grade of H4** (peak-to-valley refractive index variation below 2 ppm) with the measures taken:
  - proper selection of batch material,
  - one order of magnitude tighter control of the process parameters,
  - lower annealing rates and a special annealing setup.
- On stock:
  - **qualified rectangular blanks** in various formats up to 990 x 540 x 105 mm<sup>3</sup> with homogeneity up to grade H4.
  - **qualified round blanks** with geometries up to diameter 1150 mm and thickness 260 mm thickness with homogeneity up to grade H3.
- Next spot to produce customized large N-BK7 blanks is summer 2022, **please contact us with your individual specification.**

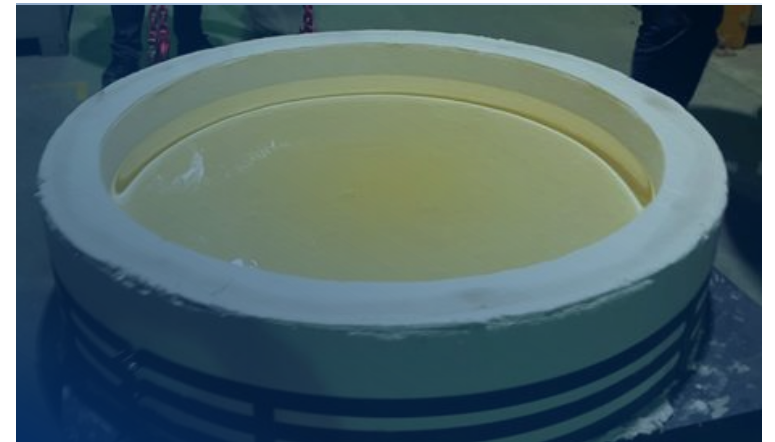
References:

TIE-41 <https://www.schott.com/en-us/products/optical-glass-p1000267/downloads>

Jedamzik et al. Proc. SPIE 10914, " Optical glass: Refractive index homogeneity from small to large parts: An overview", 2019

**16** © SCHOTT AG, SCHOTT@EPIC TechWatch CIOE, 07/09/2023

Confidential





**Thank you very much for your kind  
attention!**