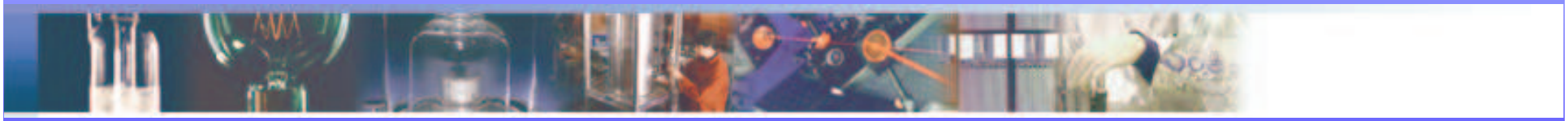
Entwicklung und Fertigung von hochgenauen Geräten und Ultra-Präzisionsteilen für die Grundlagenforschung im Weltraum

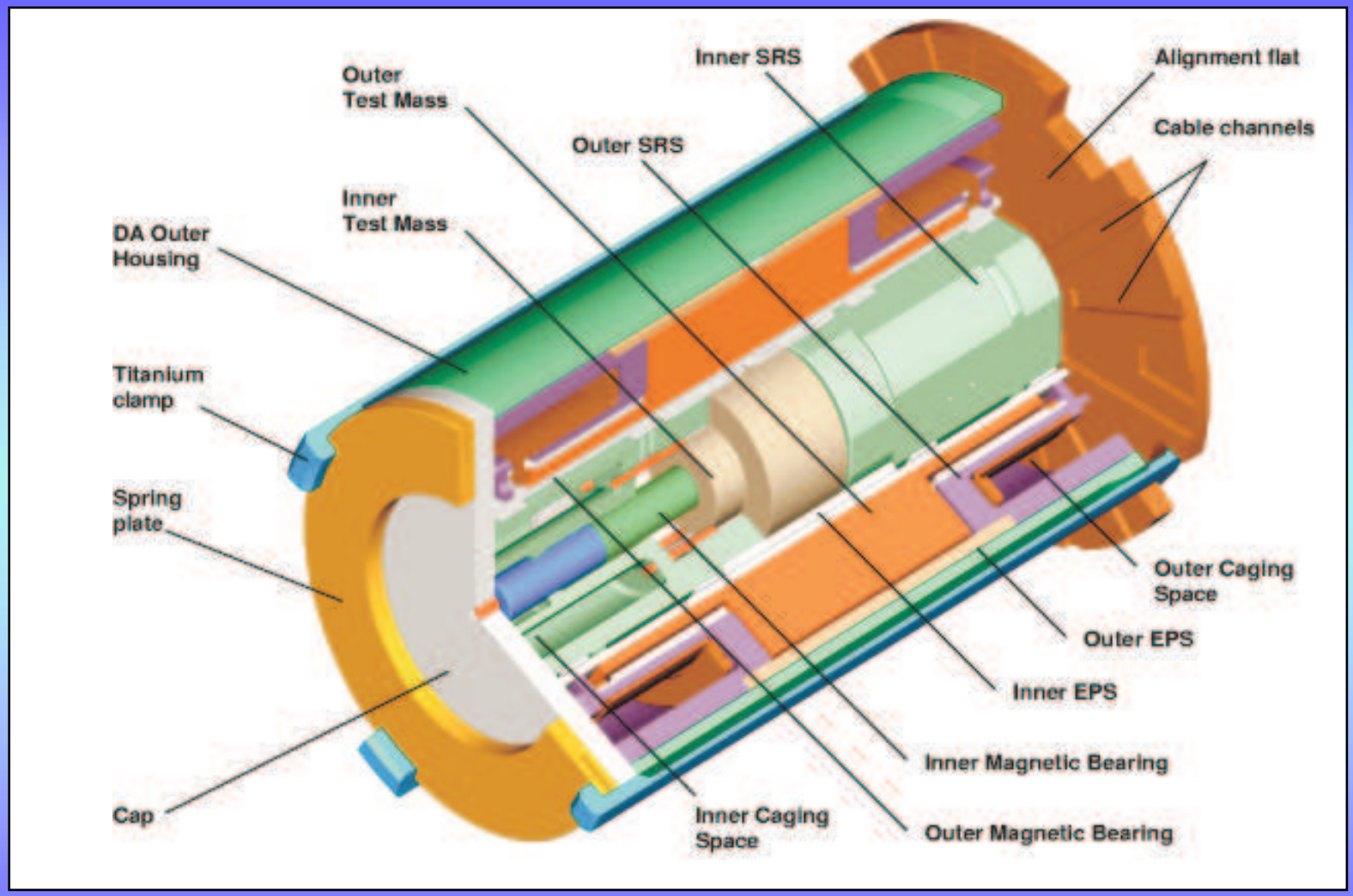
Hansjörg Dittus — Universität Bremen, ZARM, Bremen, Germany

Wolfgang Vodel — Friedrich-Schiller-Universität, Jena, Germany

Frank Löffler — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany



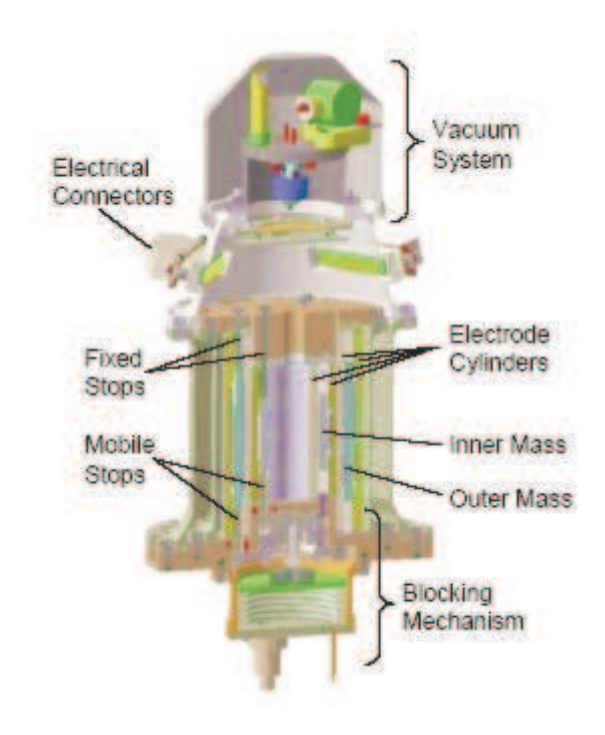
Differential Accelerometer for STEP

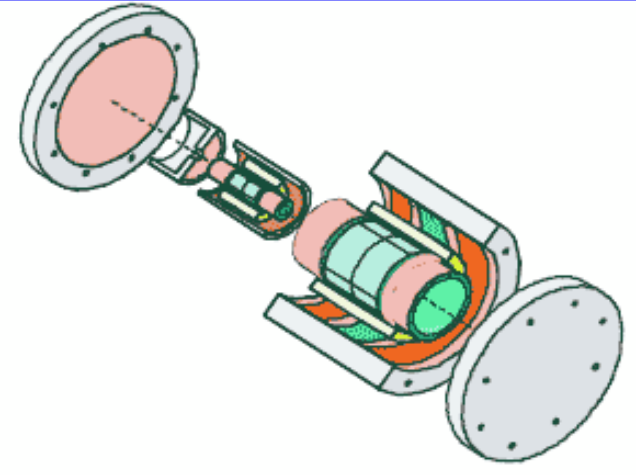


10^{-18}

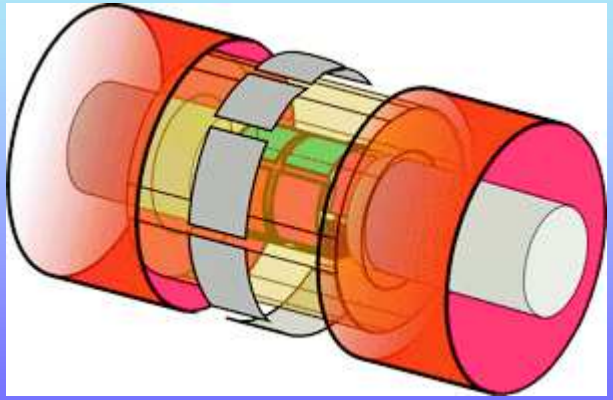
Francis Everitt and John Mester, Stanford University

MICROSCOPE



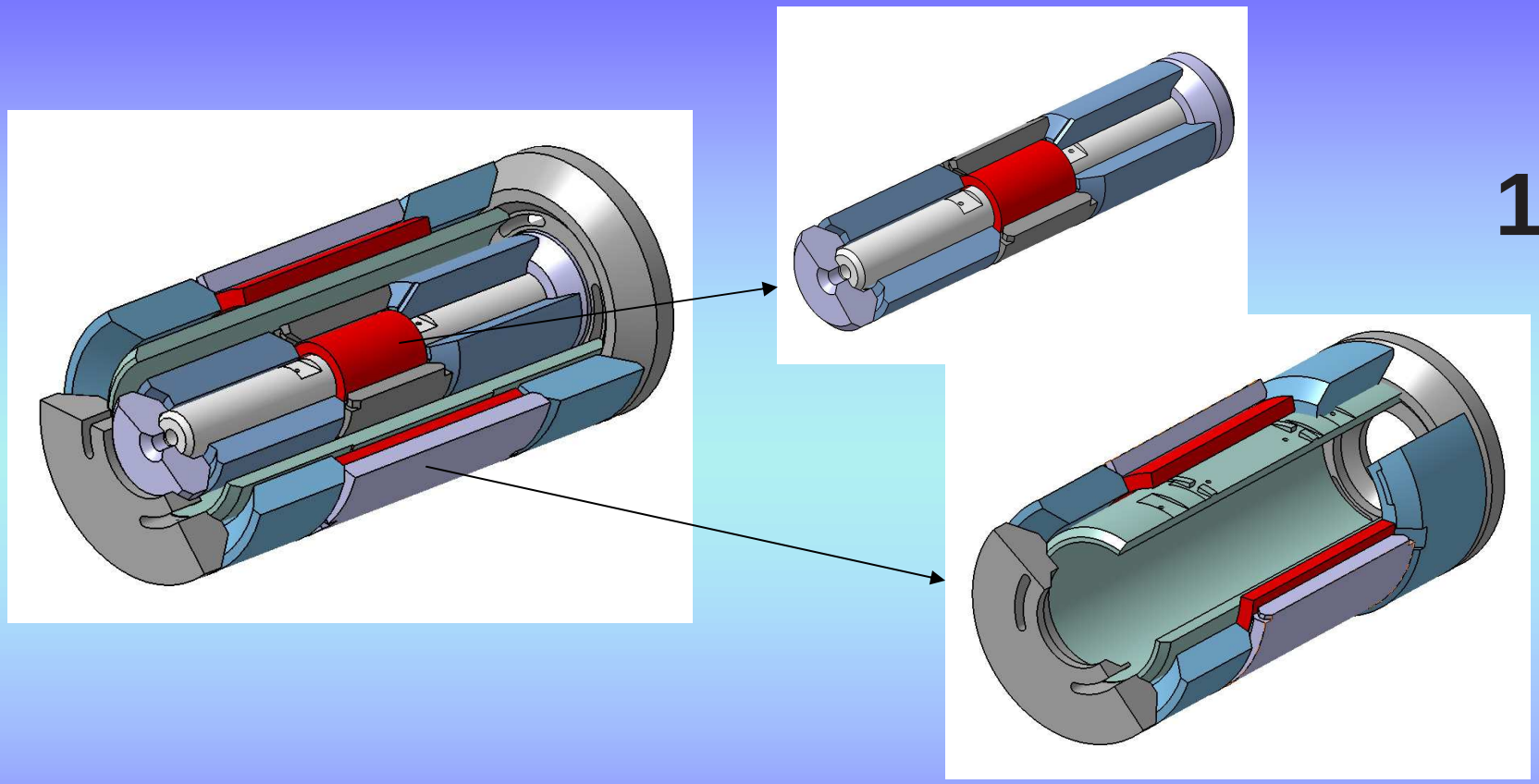


10 $^{-15}$



Manuel Rodrigues and Pierre Touboul, ONERA

Drop Tower Test

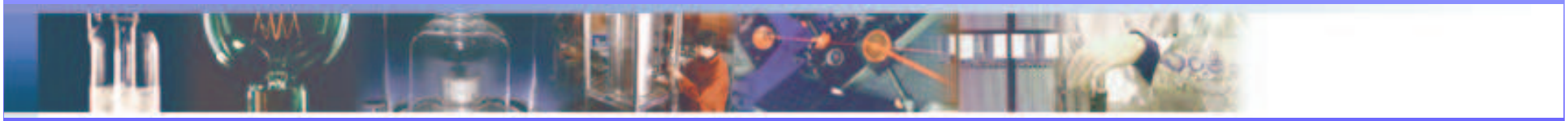


10^{-12}

Hansjörg Dittus et al., ZARM

Beispiele

- **Testmassen**
- **Dünnschichtstrukturen auf 3d-Oberflächen**



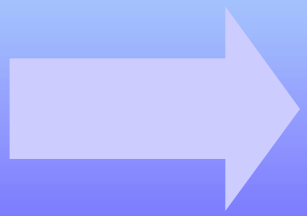
Fertigung der Testmassen

Anforderungen an die Testmassen

- **Material**
- **Geometrie**
- **Toleranzen**

Fertigung der Testmassen

- **Rohmaterial**
- **Fertigungstechnologie**
- **In-Situ-Messung**
- **Kalibrierung**



Testmasse

Mögliche Fehler im Ausgangsmaterial

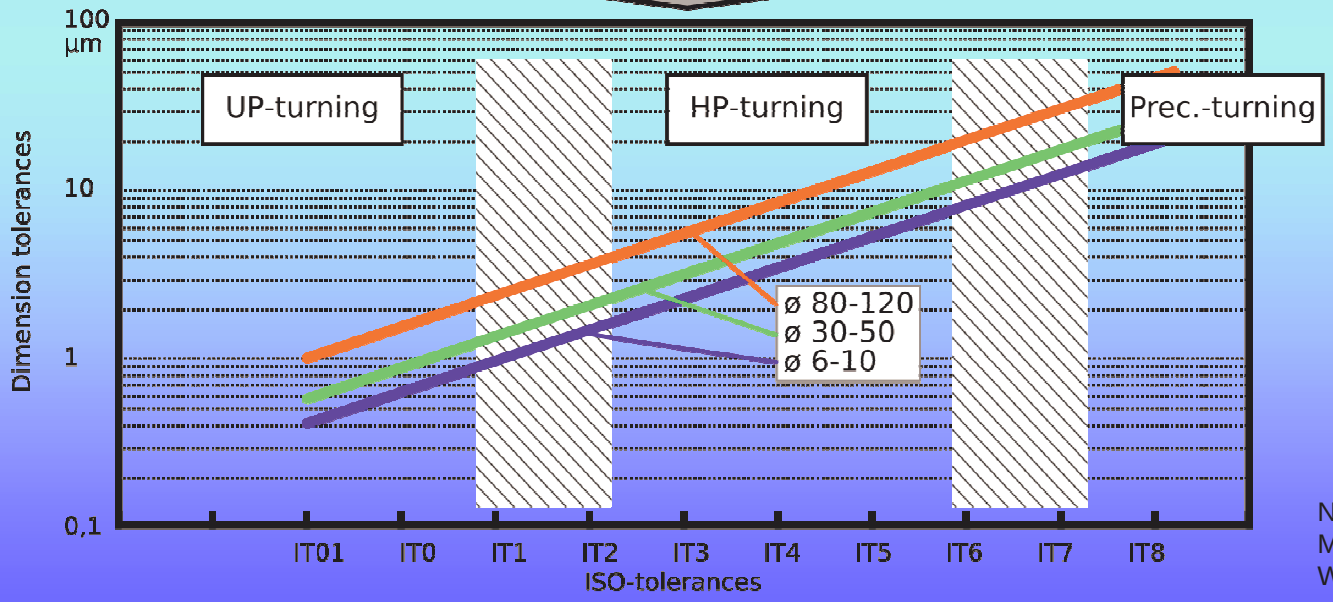
- Gitterfehlstelle
- Zwischengitteratom
- Mischkristallverfestigung
- Versetzung (z. B. als Folge einer Kaltverfestigung)
- Korngrenzen
- Ausscheidungen (z. B. auf Grund unterschiedlicher Löslichkeiten)
- Dispersionen
- Gießfehler (z. B. Lunker)

Einige Einflussfaktoren für die Fertigungsgenauigkeit

- Fertigungsprozess
  - → Prinzip
  - → Toleranzen
  - → Deformation (elastisch, plastisch ..)
    - → Spannung im Material und/oder an der Oberfläche
- Werkzeug
  - → Material
  - → Geometrie
  - → Verschleiß
- Klemmung
  - → Deformation während der Fertigung
- ...
- ...
- ...

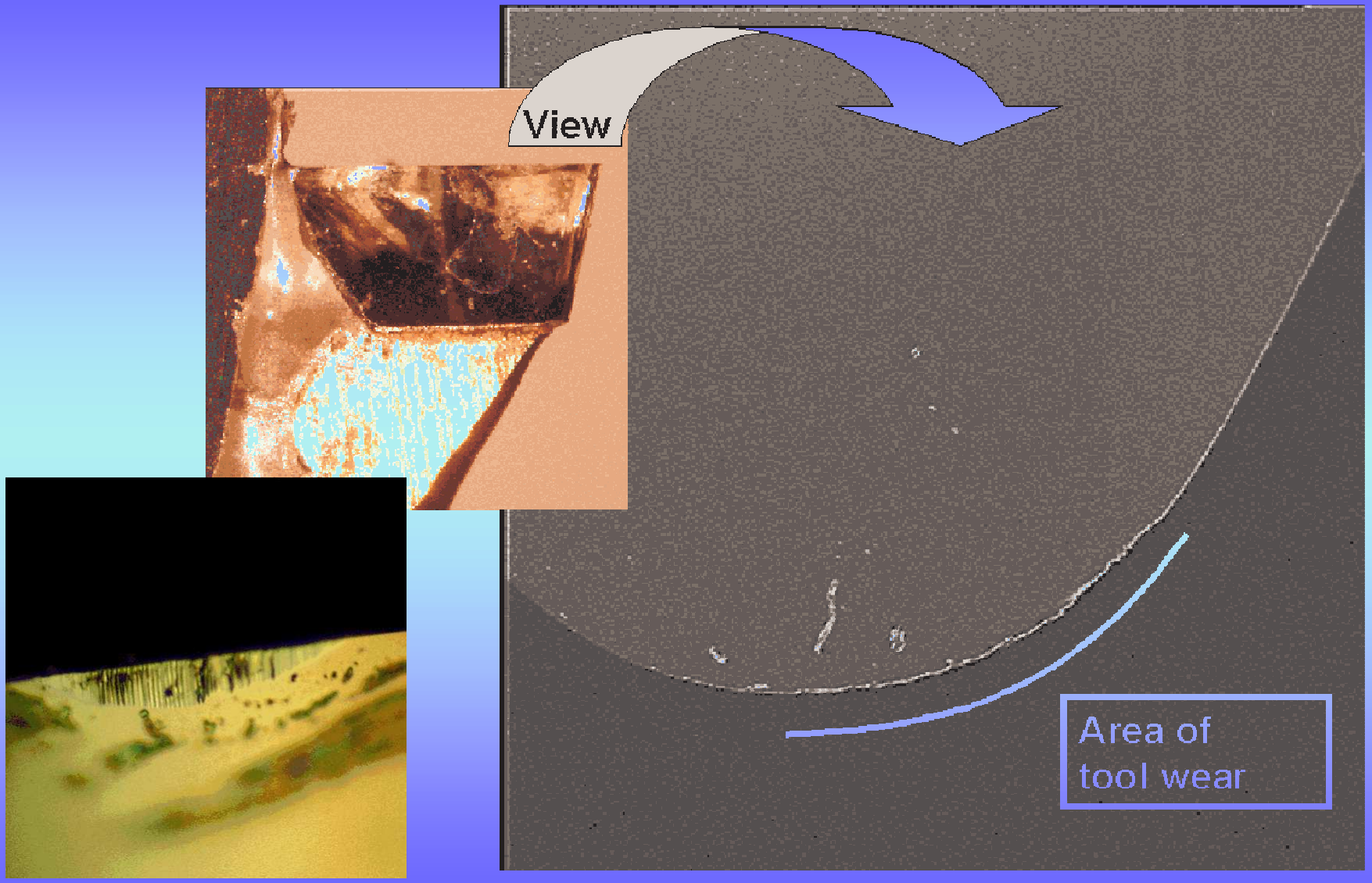
Production Tolerances

Ultra-precision turning		High-precision turning		Precision turning	
Materials:	Cu-alloys, Al-alloys, …	Materials:	NF-metals, steels, …	Materials:	NF-metals, steels, …
Tool materials:	Diamond	Tool materials:	CBN, CC, …	Tool materials:	CC, HSS, …
Feed:	few µm (typical)	Feed:	10 µm (typical)	Feed:	100 µm (typical)



Nach:
M. Weck, C. Brecher:
Werkzeugmaschinen

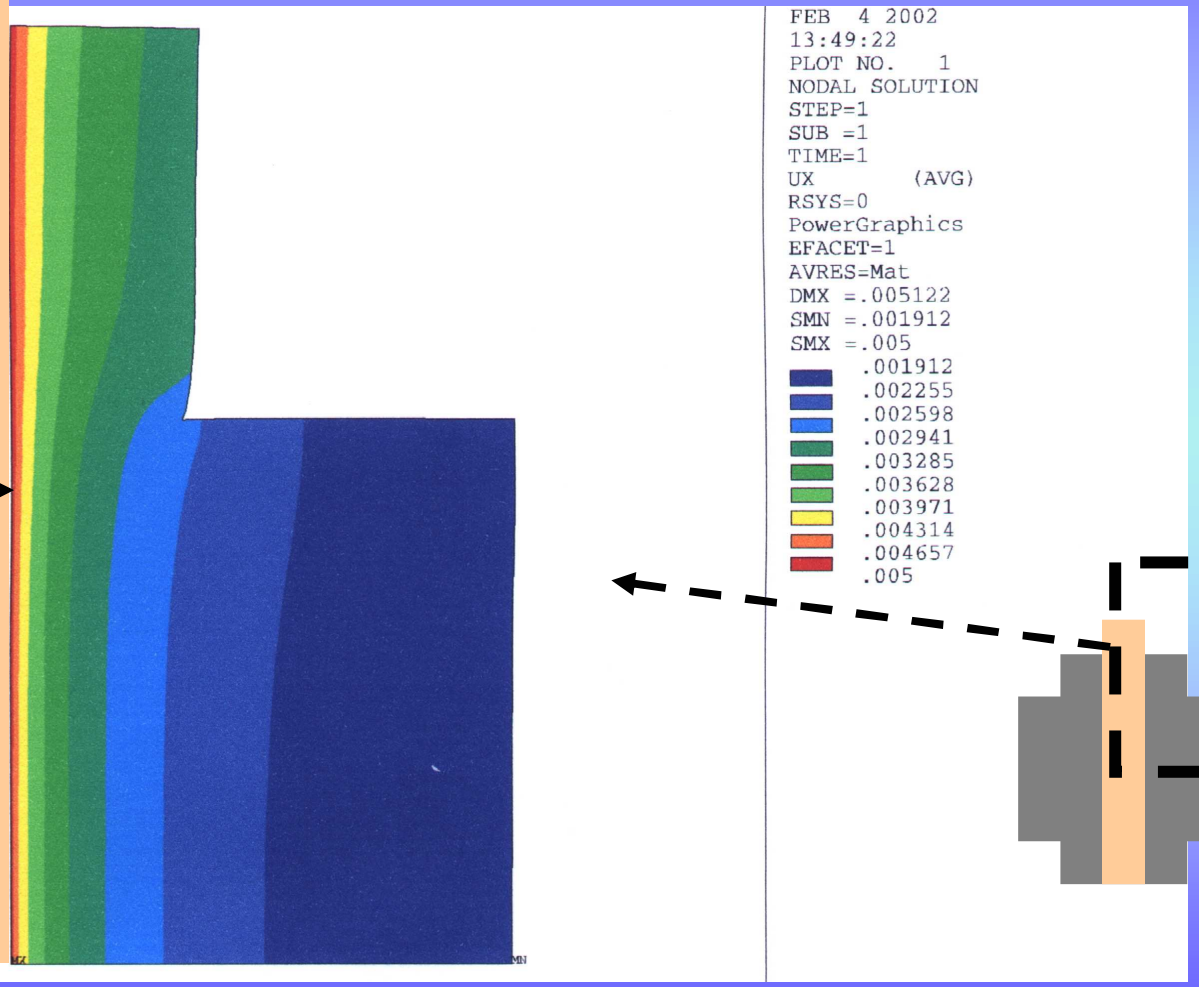
Wear of the diamond tool after turning a Pt/Ir inner test mass



Deformation of the Outer Contour During Clamping on the Zerodur Cylinder

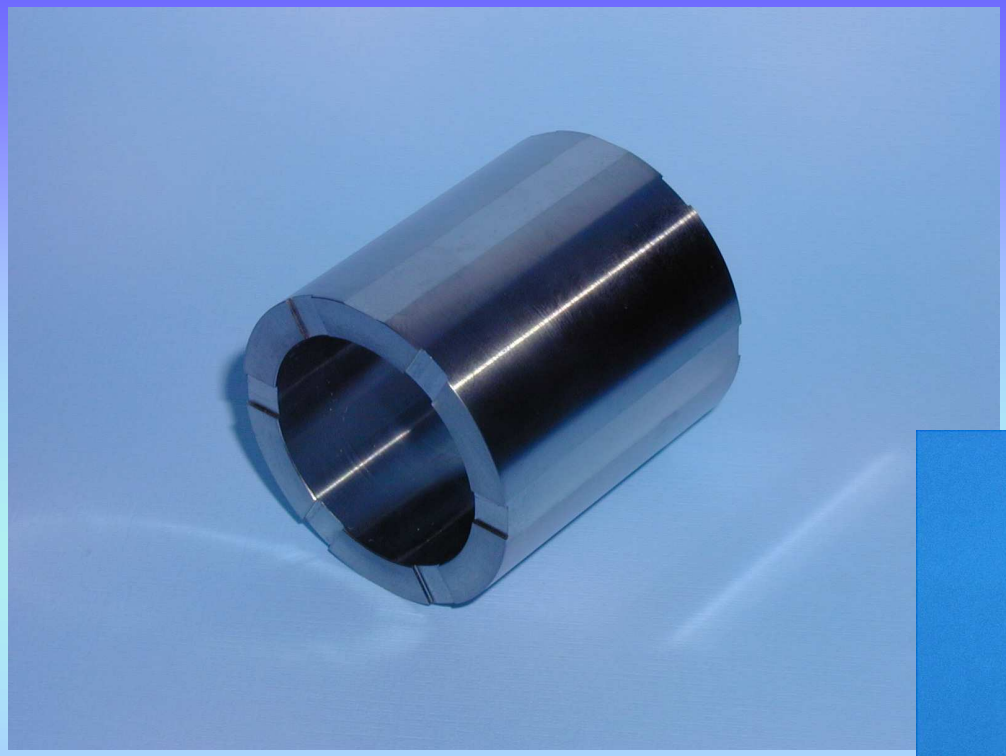
zerodur cylinder

5 µm deformation



In-Situ Measurement

MICROSCOPE and STEP Inner Test Masses



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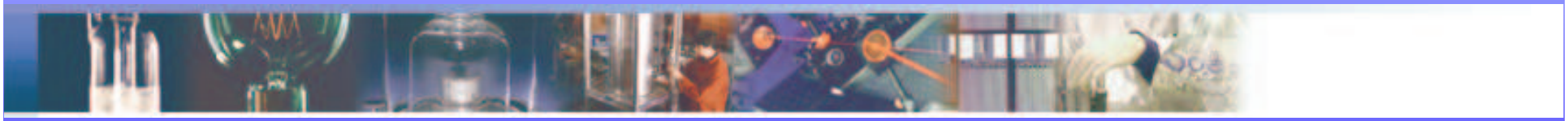


Inner Guide – Sputtering the Superconducting Layer

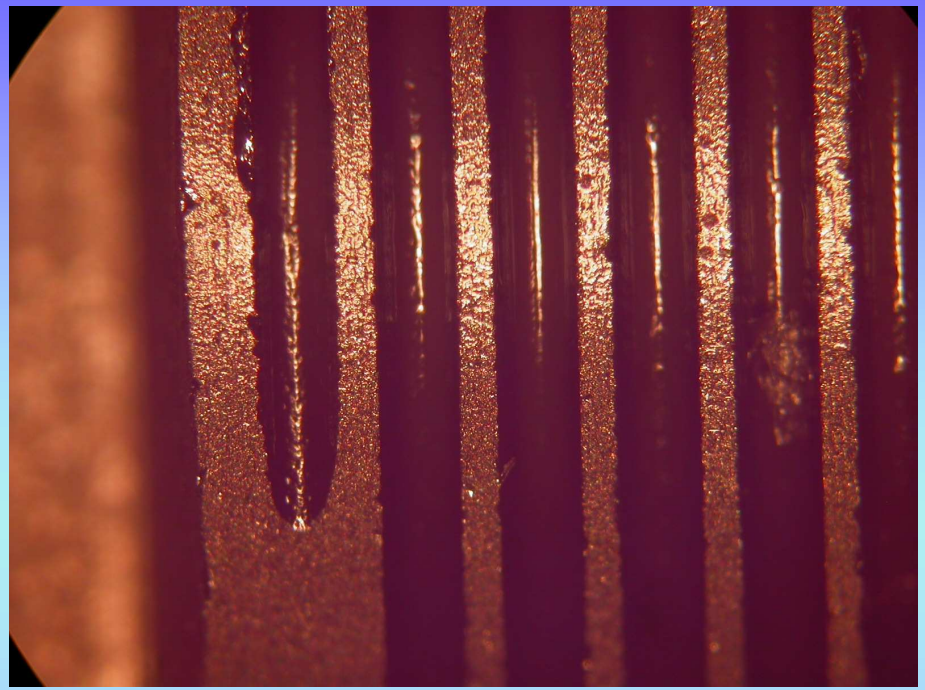
Nb outer coating

For means of adhesion improvement a thin Al layer is sputtered beforehand.

The inner guide is rotated several time during the sputter process to achieve a constant thickness.

Photography of two Nb coated inner guide tubes

Inner Guide – Fabricating the Coils

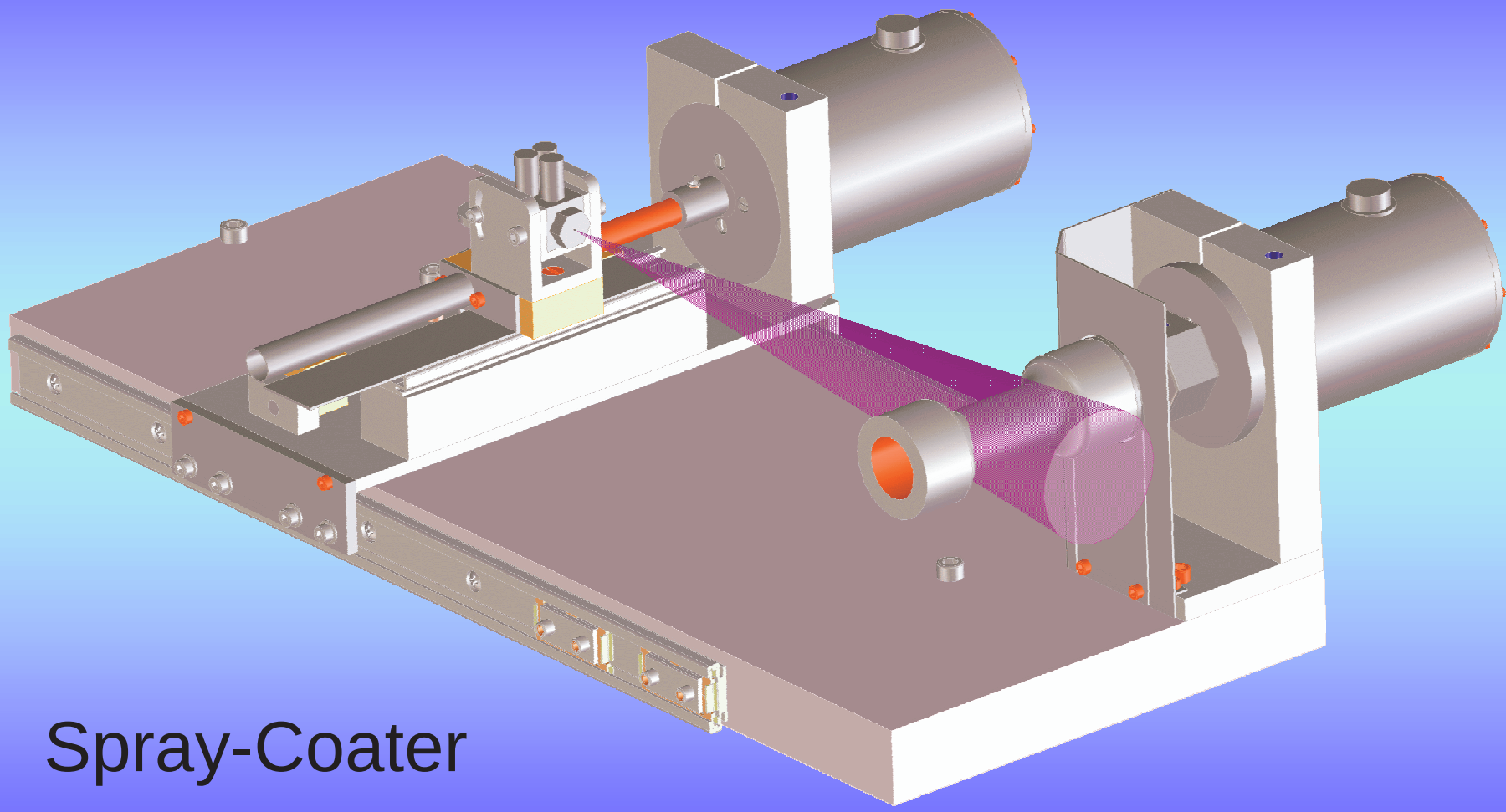


Superconducting Coils on inner guide tube

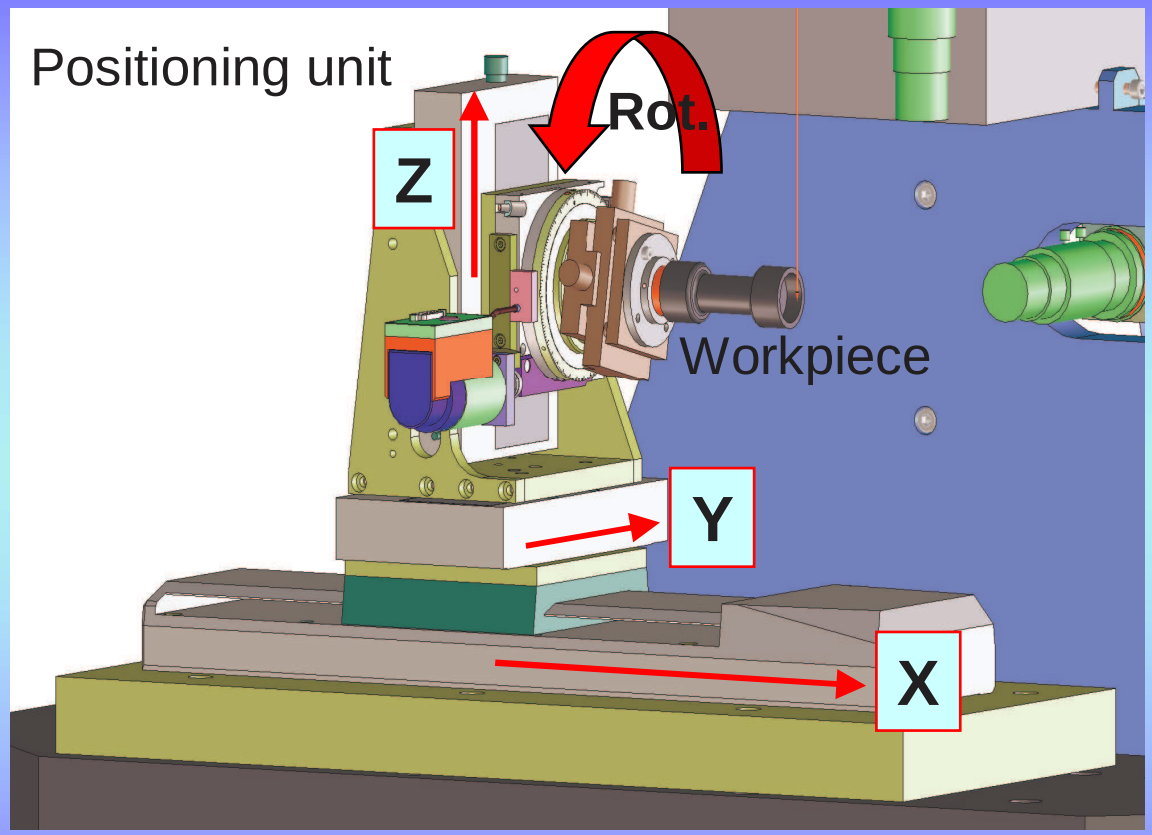
Coils manufactured by milling

Coils

Starting point of the milling process



Spray-Coater



Four axis robotics

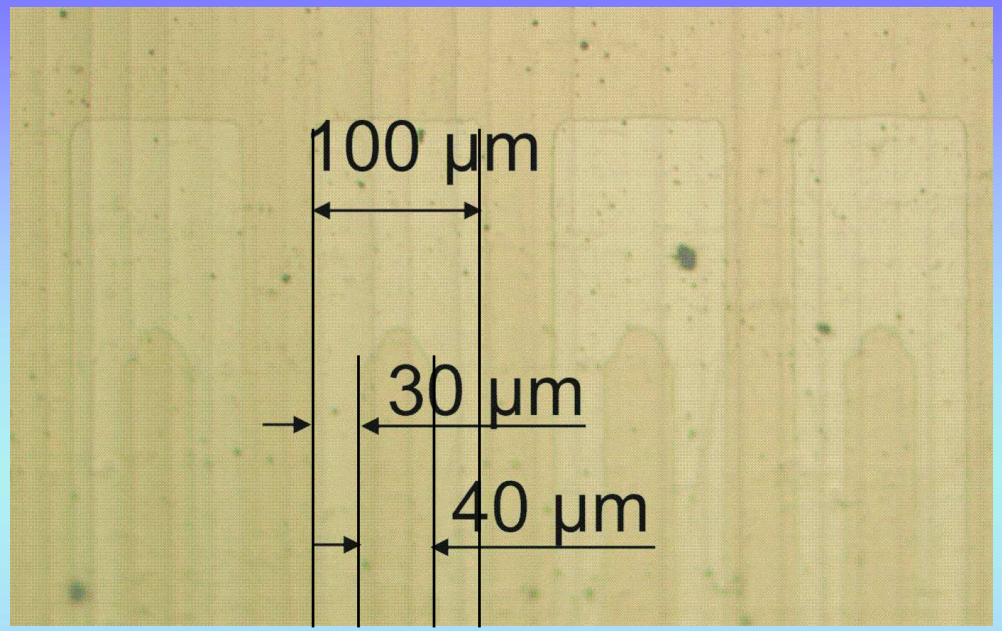
Resolution < 1 µm

Laser pulses
triggered by robotics

2 cameras

=> Multilayer
fabrication possible

RSGs on Tensile Testing Shaft



RSG structures on tensile testing shaft

Linewidth: designed value

Inner Coating of Zerodur sleeves


Zerodur sleeve

Au inner coating

For means of adhesion improvement a thin Al layer is sputtered beforehand.

Au is sputtered from an rod cathode.

The setup signifies a dedicated magnetron.

Lösung