Low Temperature
Ion Beam Sputter Coatings

Dr. Thomas Gischkat

Project Manager Optical Coatings @ RhySearch

Motivation

- Optical functionality require proper coating design and thin film properties, e.g. laser applications:
  - low optical losses (ppm)
  - high laser damage resistance

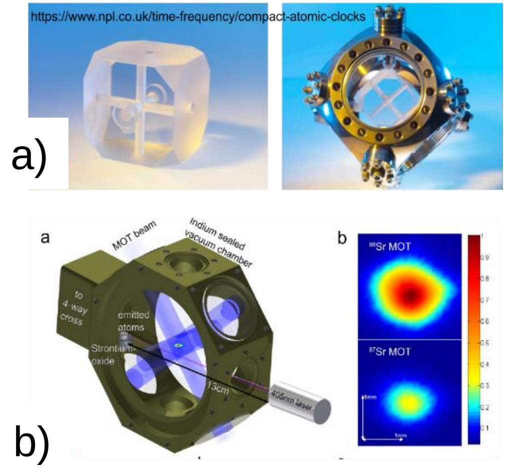

Fig.: Atomic clocks design.

a) O. Koc, W. He, D. Swierad, L. Smith, J. Hughes, K. Bong, and Y. Singh, *Laser controlled atom source for optical clocks*, Sci. Rep., 6 (2016) 37321.

b) [*https://www.npl.co.uk/time-frequency/compact-atomic-clocks*](https://www.npl.co.uk/time-frequency/compact-atomic-clocks)

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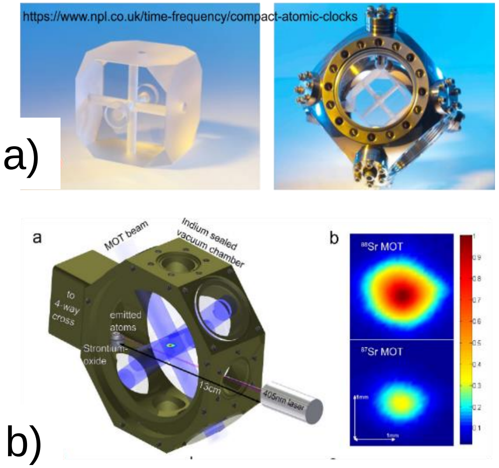
- Temperature sensitive substrates and processes, e.g. polymers or cemented components require:
  - ➢ Temp. ≪ 100°C

a)

b)



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  - Coating technology (energy)
  - Deposition parameters, e.g. temperature

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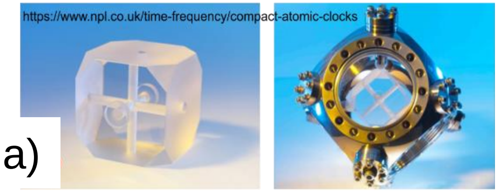

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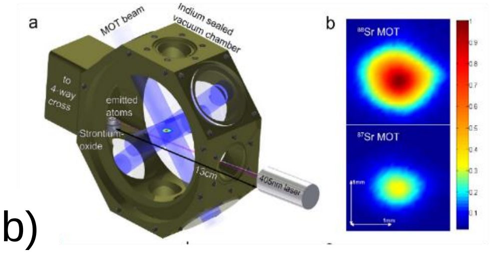

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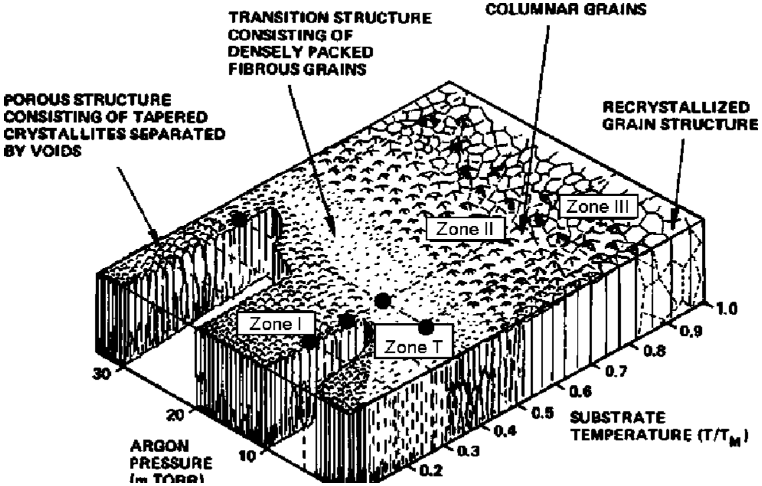

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- Thin film properties depending on:
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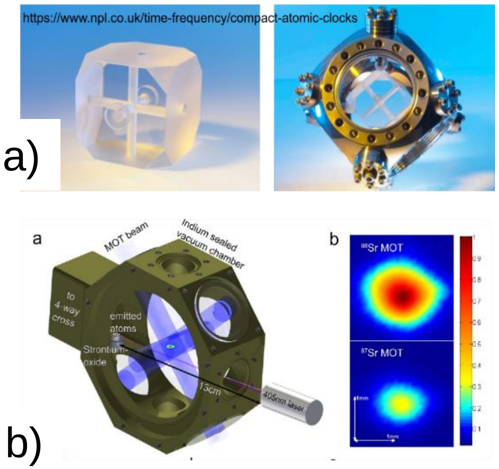
  - ➢ Deposition parameters, e.g. temperature
- Standard: $T_{coating} \geq 100°C$
- ➢ Active cooling required for deposition below $T_{coating} \ll 100°C$
- ➢ Investigations on thin film properties as a function of $T_{coating} \ll 100°C$



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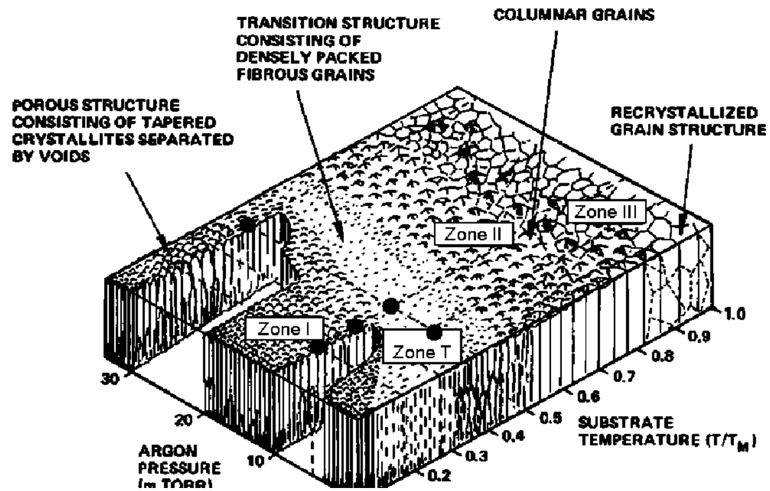

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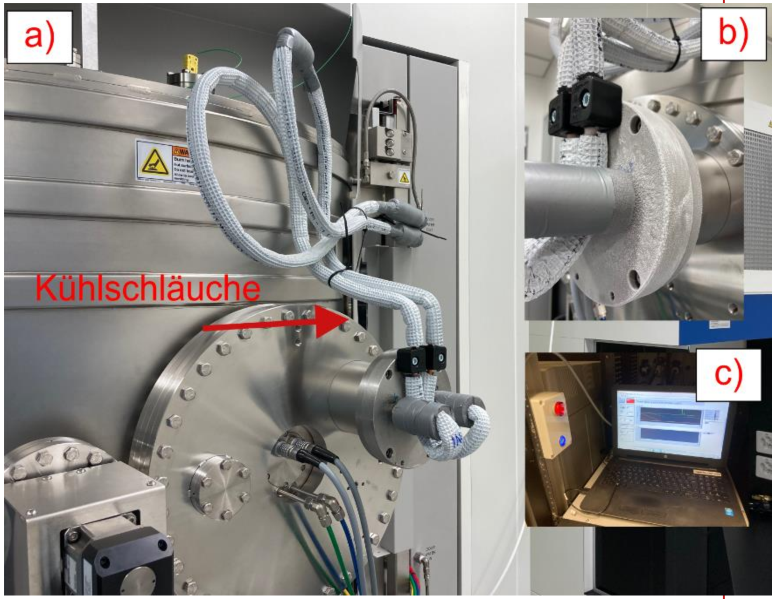
Experimental overview

Coating tool

- Veeco Spector 1.5 Dual Ion Beam Sputter Tool
- 12“ high-speed-fixture
- Cryo-pump system

Cooling System

- Cooling power max.: 350 W
- Cooling liquid: R513A (non-flamable)
- 2 inch customized holder (fix)
- Thermal contact: UHV grease



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RhySearch
Das Forschungs- und Innovationszentrum Rheintal

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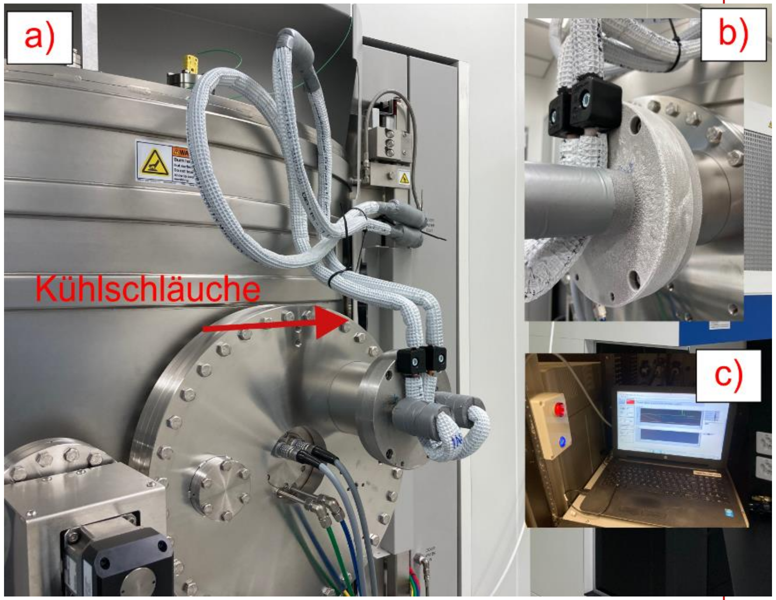


Coating

- Material: SiO_2, Ta_2O_5
- Coating Temp.: 0°C, 100°C
- Thermal Treatment: 24h@400°C
- Substrates: Ø25.4 x 2 mm^2 fused silica; 10 x 10 mm^2 Si

Thin film characterization:

- n, k: Spectrophotometry PerkinElmer Lambda 1050
- Laser damage resistance: 355 nm, 532 nm, 10 ns, 80 Hz
- Optical losses: cavity ring down (CRD) @638 nm, laser induced deflection (LID) @532 nm

Results: Active Cooling

- Temperature distribution:
  - $\pm$ 1 K on Ø2"

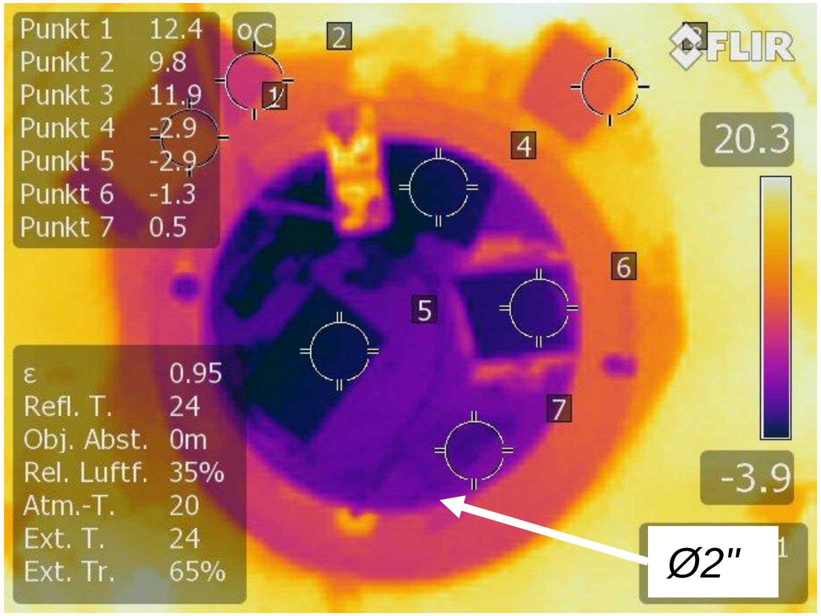
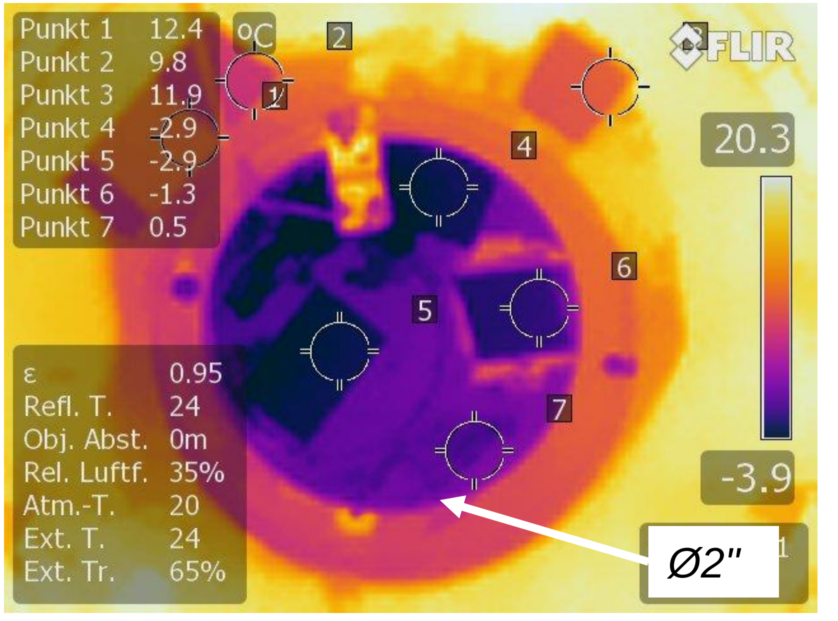


Fig.: Picture of the temperature distribution using a FLIR IR-camera.

Results: Active Cooling

- Temperature distribution:
  - $\pm$ 1 K on Ø2"
- Minimal achievable temperature on substrate:
  - w/o load: ≈ - 10°C
  - w load: ≈ 0°C
  - ➢ ΔT ≈ 10 K



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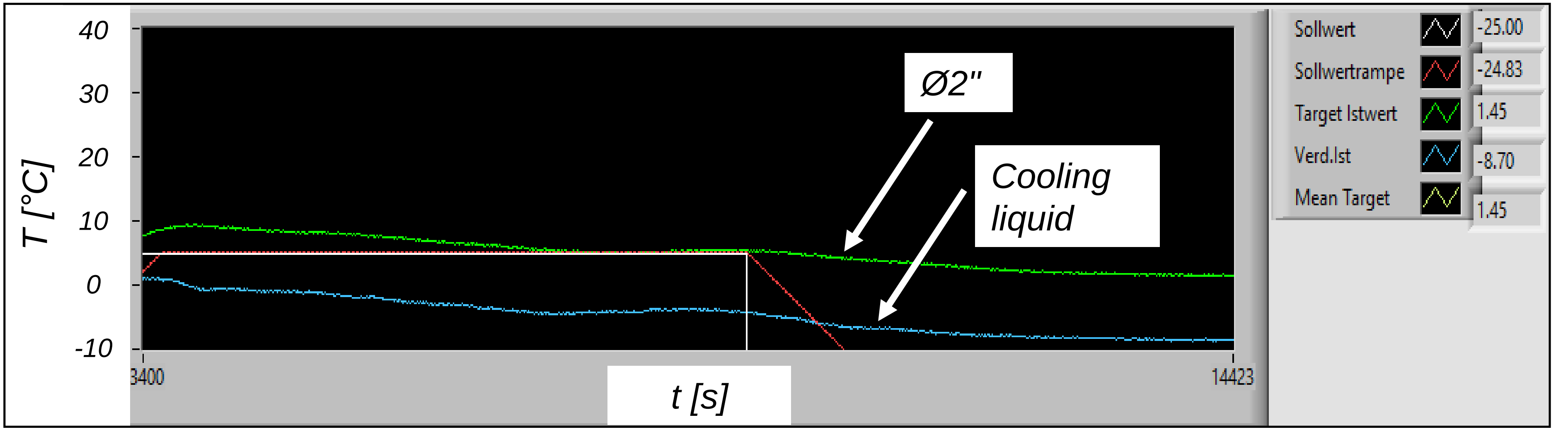

Fig.: Temperature on the substrate and the of the cooling liquid during sputter process.

Results: Low Temperature IBS Coatings

300 nm single layer, 24h@400°C

- Refractive index @ 500 nm:
  - SiO_2: ≈ 1.48
  - Ta_2O_5: ≈ 2.13

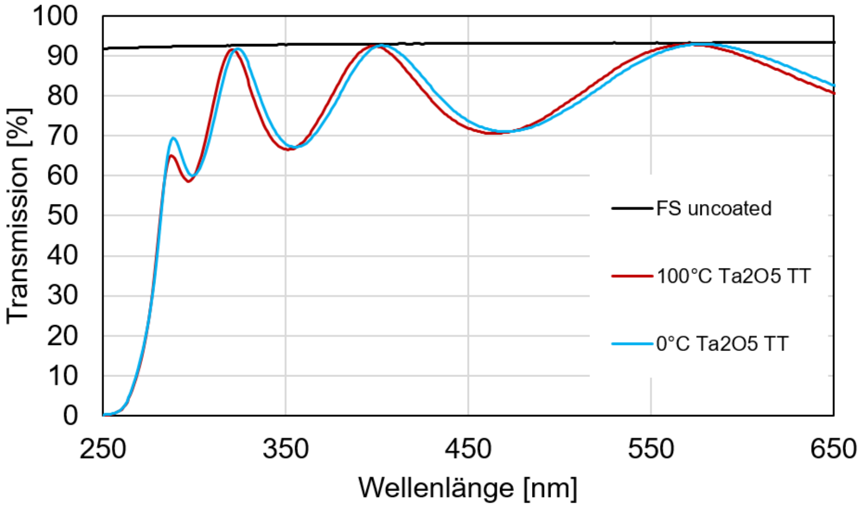

Fig.: Transmission spectra of 300 nm Ta_2O_5 coated at 0°C and 100°C.

Conclusion and Outlook

Active Cooling

- Controllable temperature down to 0°C
- Reproducible thermal conduct is an issue

Low Temperature Ion Beam Sputter Coatings

- No negative influence on film growth and structure
- “Positive“ trend for cold coatings
  - Lower losses
  - Higher LIDT

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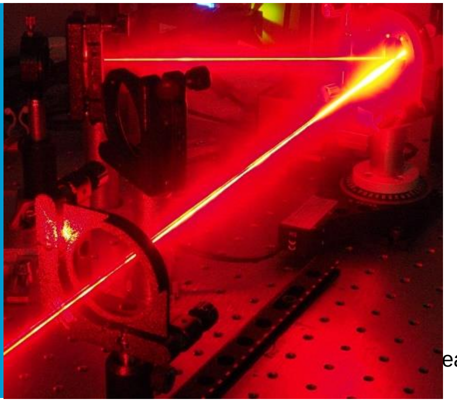

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- “Positive“ trend for cold coatings
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- **Open Questions:**
  - **Only a “optimization“ effect?**
  - **What happens to other materials?**
  - **What happens at lower temperatures?**

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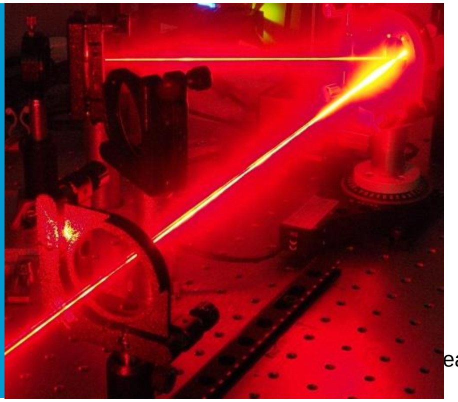

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