PEOPLE MATTER

research
development
consulting

LASER ZENTRUM HANNOVER e.V.

Property variations of Laser components under vacuum conditions

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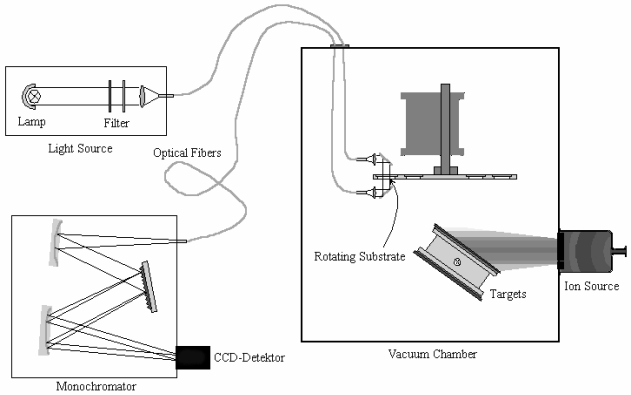
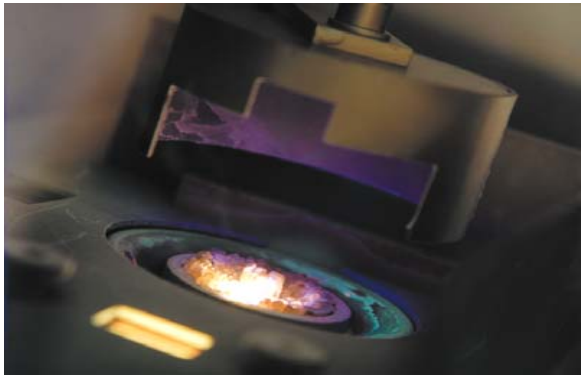


Coatings
Production of optical coatings following customer specifications

Characterization
Development of test procedures, service for analysis devices

Process development
Optimization of coating processes, online-process monitoring

Process Development



Thermal Processes

E-beam and boat evaporation
Consulting and Implementation for industrial production
Coatings for deep-UV and vacuum-UV applications

Ion Assisted Deposition (IAD)

Characterization and optimization of ion sources
Process monitoring and controlling
Rapid manufacturing, MIR-spectral range

Ion Beam Sputtering (IBS)

Low optical losses, dense layer system
High power edge filters, Rugate filters
Precision IBS coating technology

Coatings

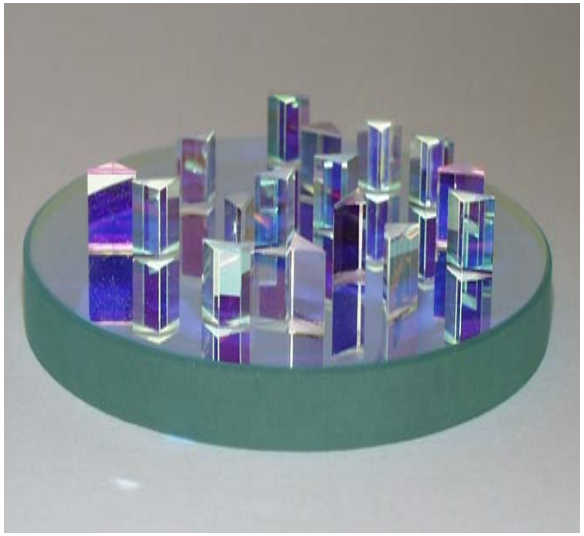
Production of custom-requested coatings

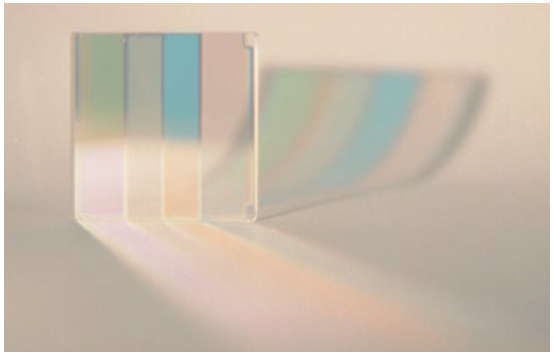
Spectral range 130nm to 5µm
Small batch sizes, special requirements

- optical performance, low losses
- damage threshold, stability
- complex spectral requirements

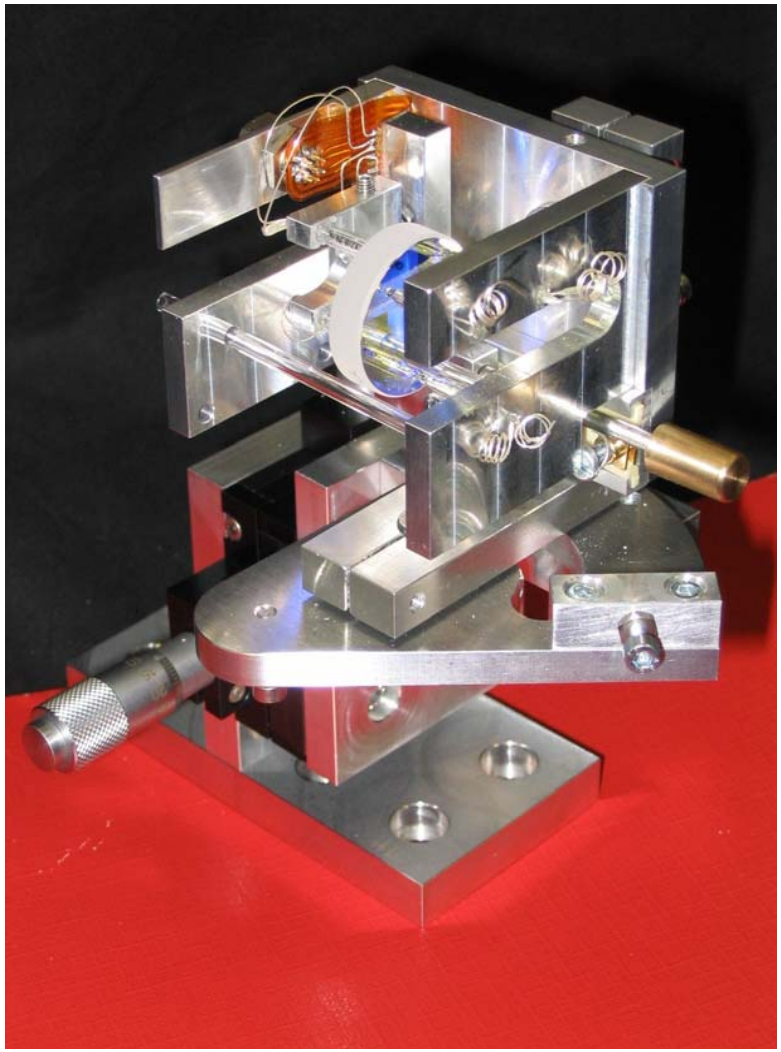
Special substrates and materials

- complex geometries
- laser and nonlinear crystals
- fiber and laser diode facets
- special coating materials





Optics Characterization



Damage threshold ISO 11254
157 nm, 193 nm
780 nm (ultra-short pulses), 1064 nm
single and multiple-pulse testing

Absorptance ISO 11551
355nm, 532 nm, 1064 nm, 10.6 µm

Total scattering ISO 13696
157 nm, 193 nm, 633 nm, 1064 nm

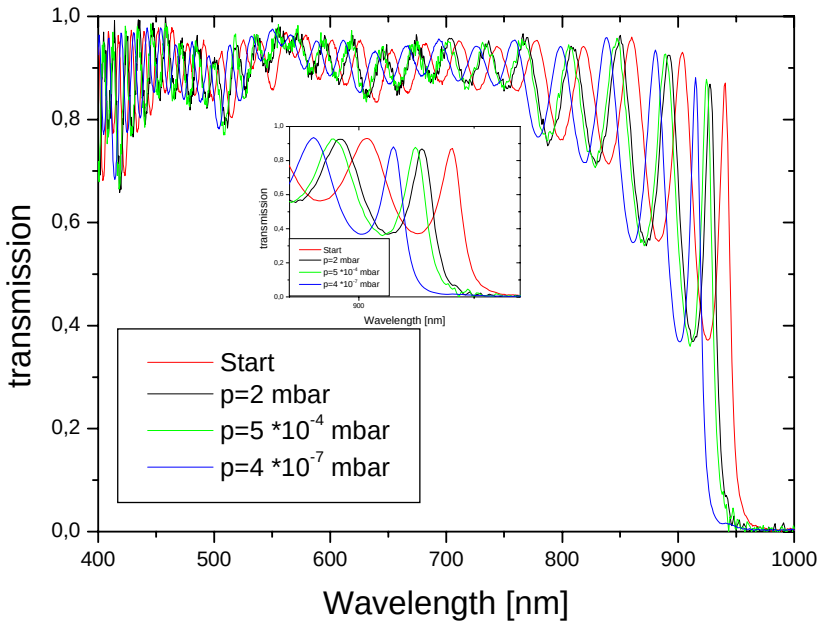
Spectrophotometry ISO 15368
120 – 240 nm, 190 – 3200 nm, 2.5 – 25 µm

Precise Reflectometry ISO 13697
532nm, 1064 nm, 10.6 µm

Development of standard characterization procedures (DIN, CEN und ISO)

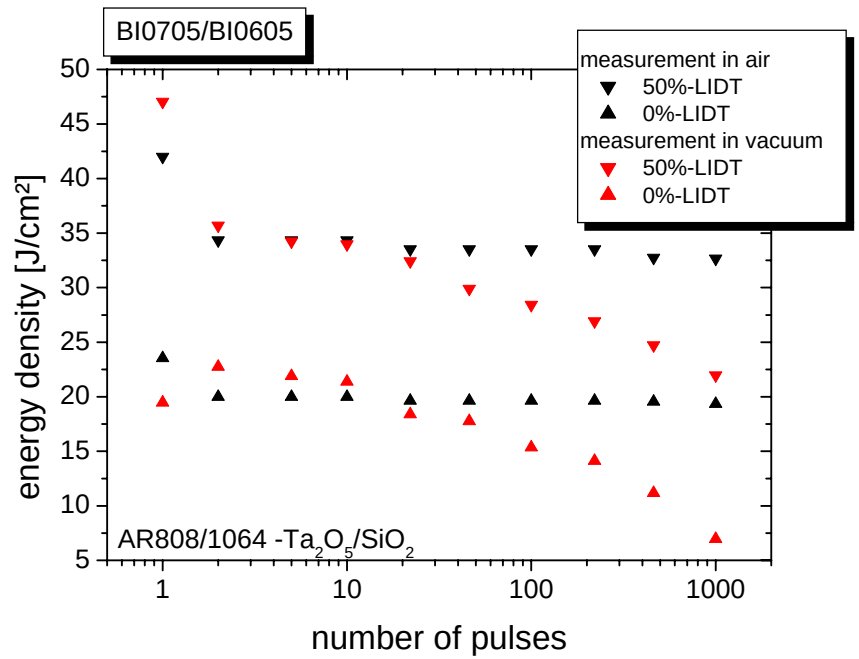
What changes?

Spectral behavior



Damage threshold

(measurement according ISO11254)

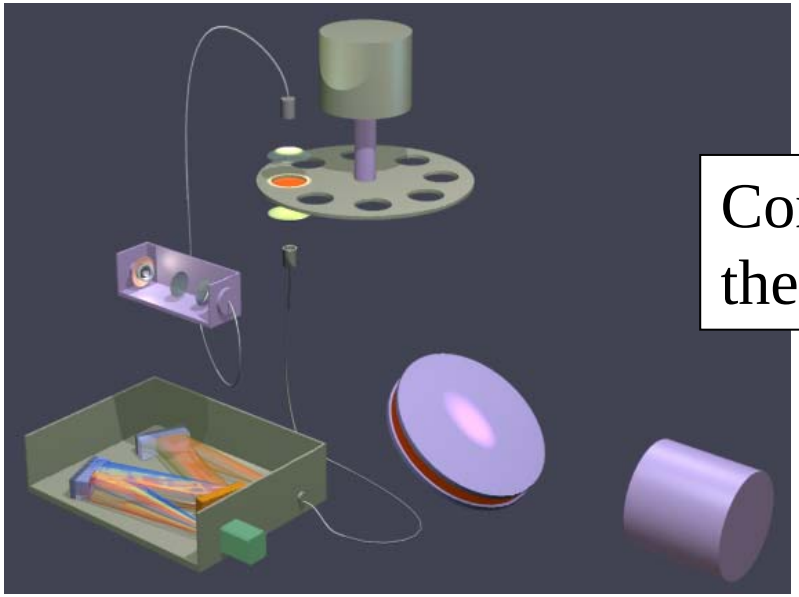


- Spectral curves of a HR1064 coated in a conventional electron beam process [$(HL)_{19}H$ -Ta_2O_5/SiO_2]. The spectrum significantly shifts to shorter wavelength under vacuum conditions.

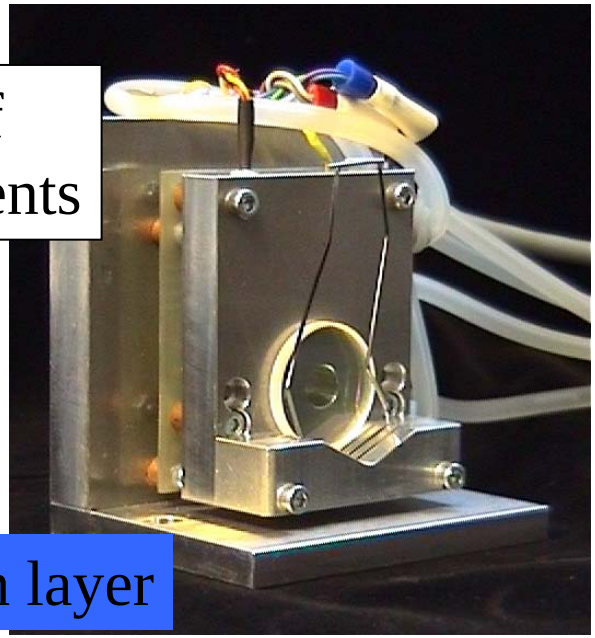
- Damage threshold decreases strongly in vacuum!!!

Changing of the spectral behavior

- Method: spectral photometrical measurement in the coating plant (BBM).



- Method: spectral photometrical measurement of thermal shift in with a special heating set-up.



Comparison of the measurements

Content of water in layer

Where is the water located in the layer?

- Focus on the physical absorption
  (The chemical bounding of hydroxide molecules on the silica is also possible.)

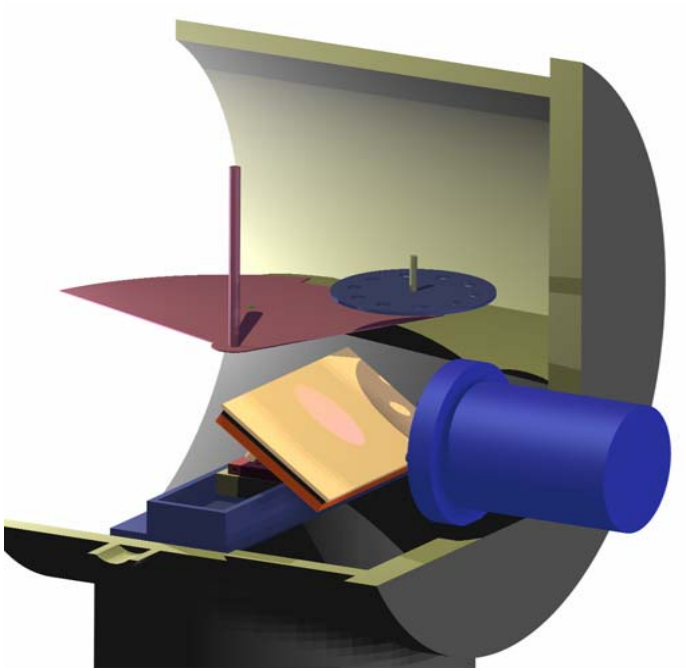
Porous microstructure

- Including of water in the structure
- Changing of the refractive index
- Absorption in the infrared
- Obviously, changes of the laser light resistance

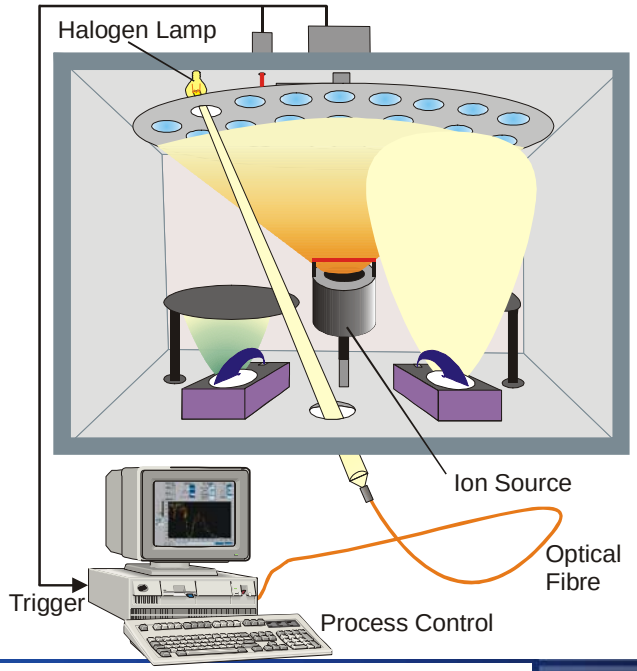
Demanded of layers with a higher density of the micro-structure

1. IBS
2. IAD

Coating processes



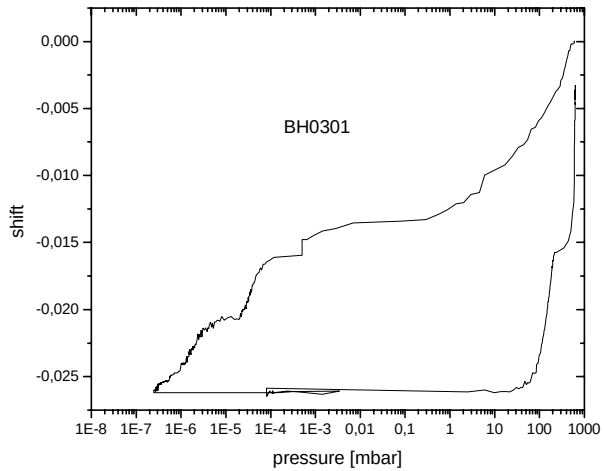
IBS- Coating plant
- Low loss optics (laser gyro mirror)
- Crystal coatings
- High power (Rugate)
- Shift free, water free
- But: High stress

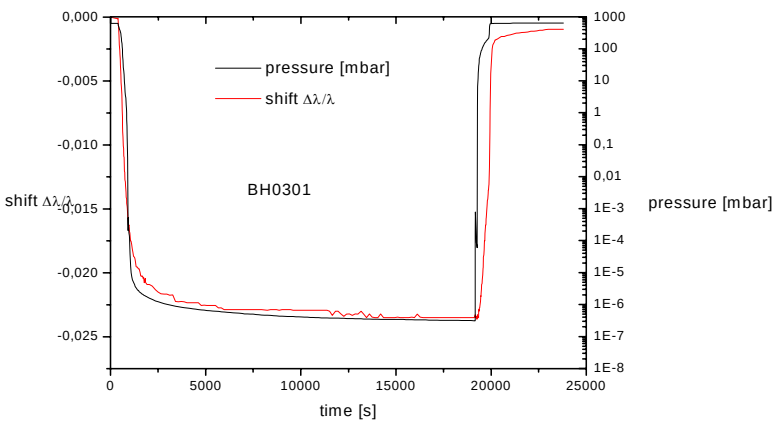


IAD- Coating plant
- Water free optics for the MIR-application
- Shift free
- Optionally stress free
- But: Contamination???→ Test of different Ion sources (APS, Lion, Denton CC105)

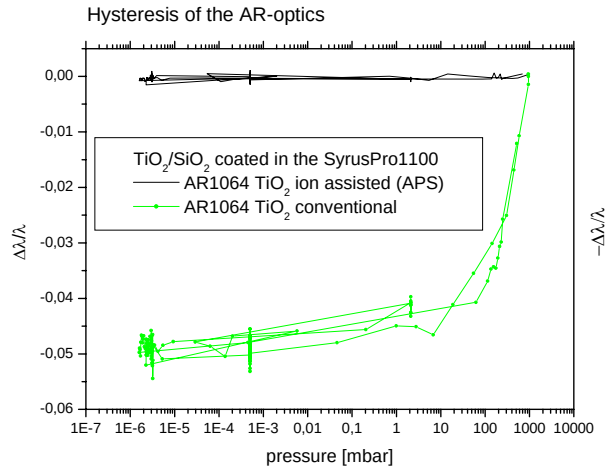
Results of shift measurements

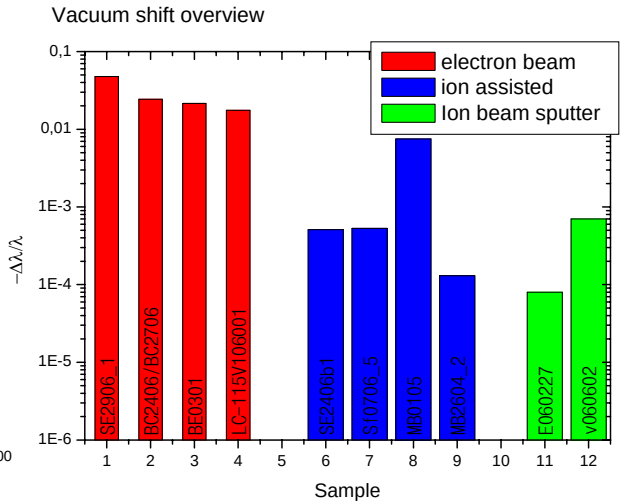
Vacuum shift of a HR1064 conventional





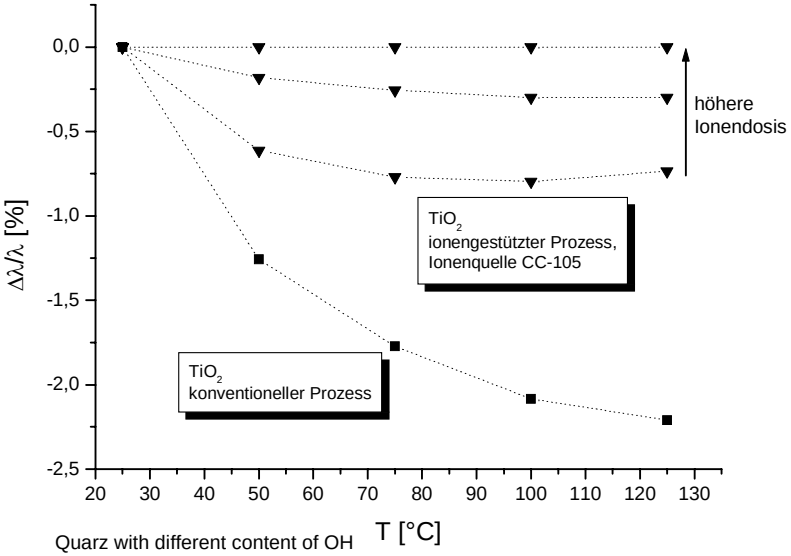
Vacuum shift of AR-coatings



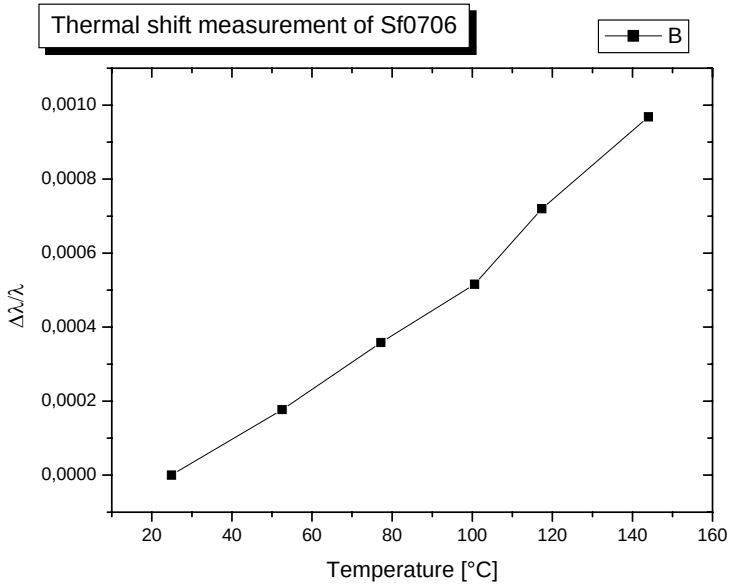


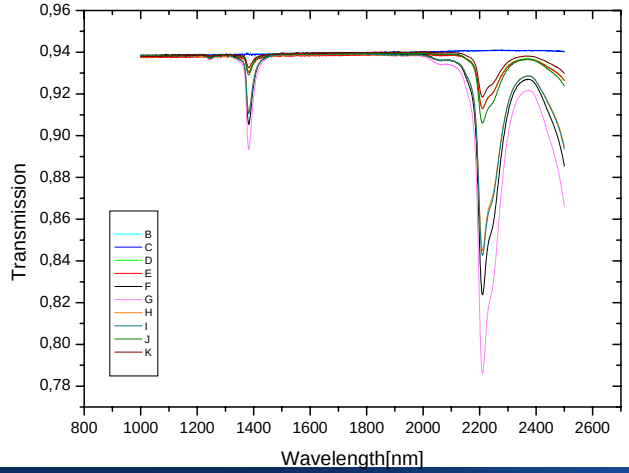
- The samples have shown different behaviors during evacuation and venting.
- The vacuum shift of IBS-samples is negligible. For IAD –samples the vacuum shift depends on the Ion dose.
- Time of relaxation is in the range of 1 to 5 hours.
- The relative accuracy of the measurement is 1E-3.

Thermal Shift Measurement



Quarz with different content of OH

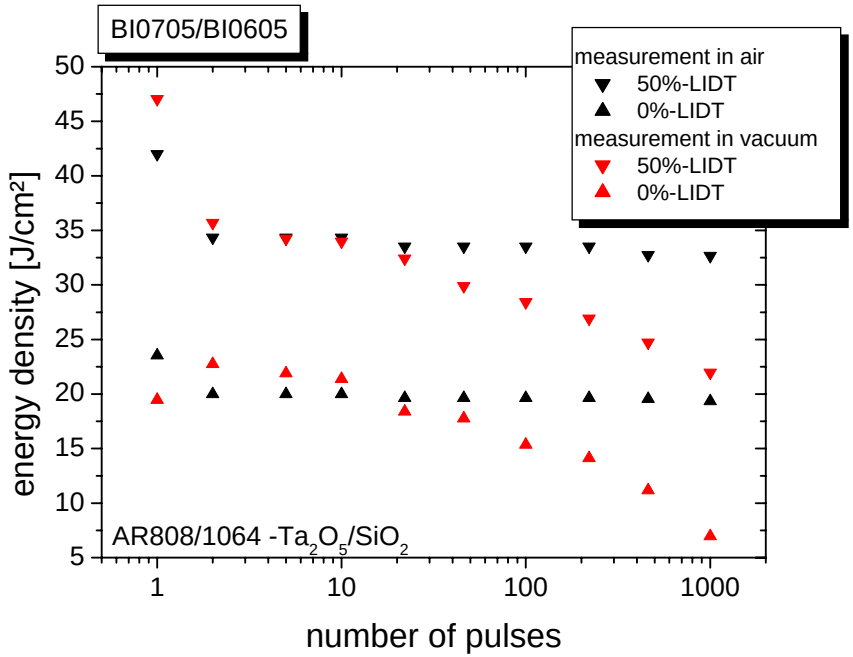




- Thermal shift reveals the content of water. The results correspond with the spectral measurements in the IR.
- Problem of thermal shift measurement is the annealing of the samples.

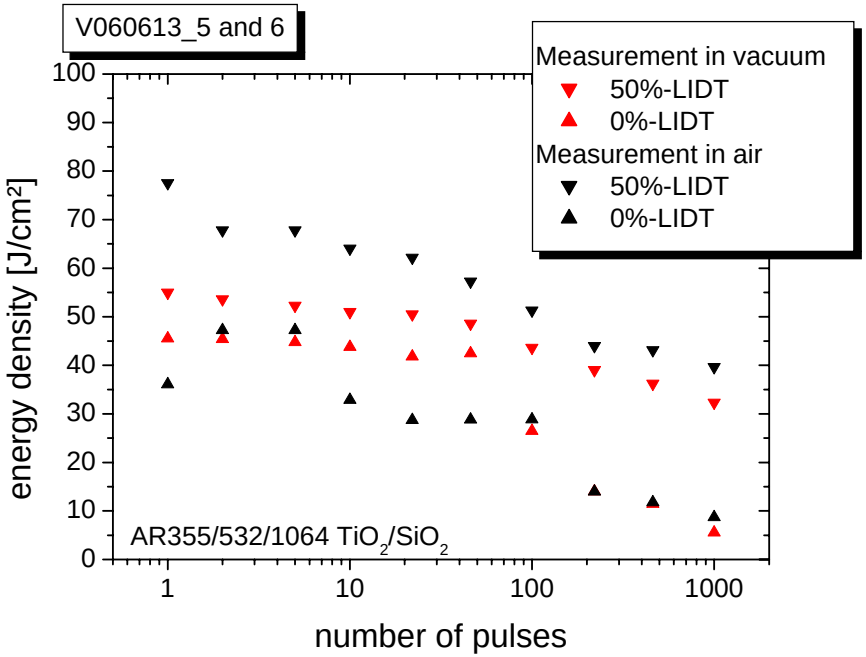
Damage of samples under vacuum conditions

AR- coating manufactured in an e^- -beam process



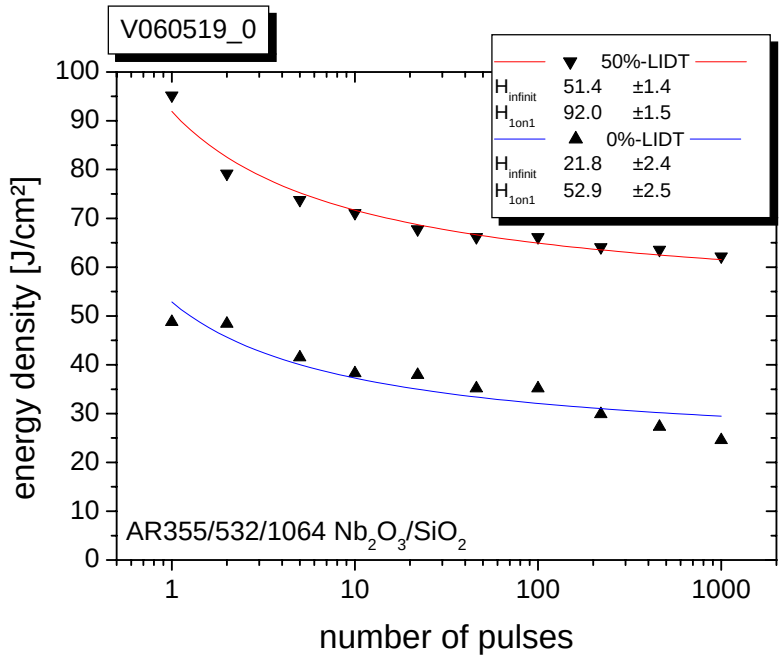
In air the LIDT is stable at 20 J/cm². In vacuum the LIDT decreases dramatically.

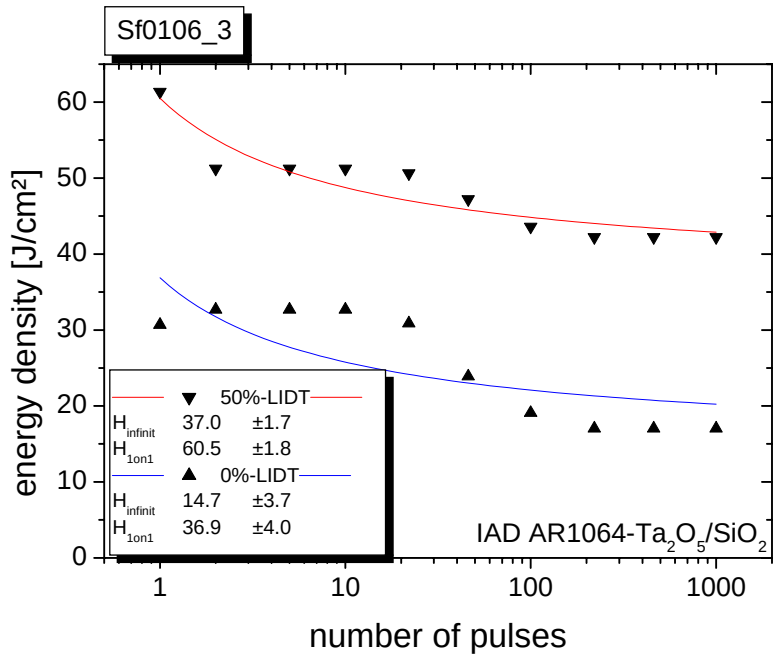
AR- coating manufactured in an IBS process



The damage threshold is relatively low, but environment conditions do not have an influence on the LIDT.

Damage Threshold in Air



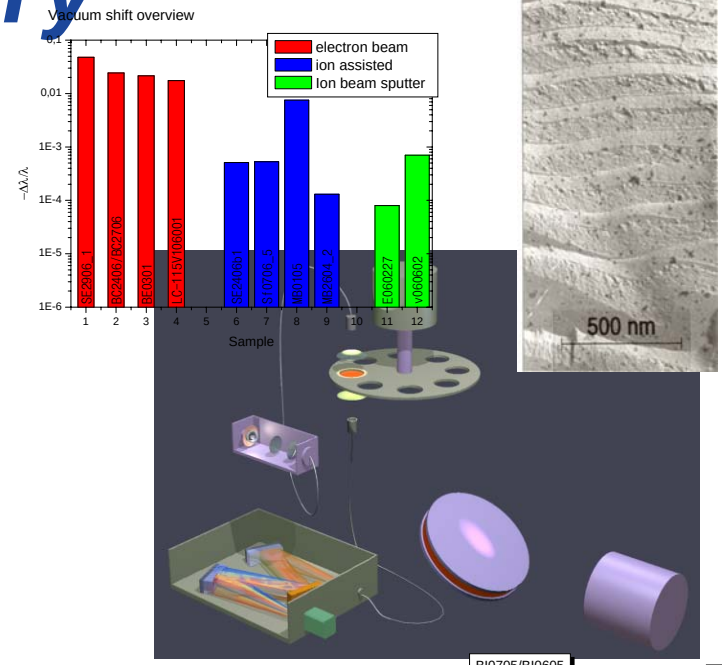


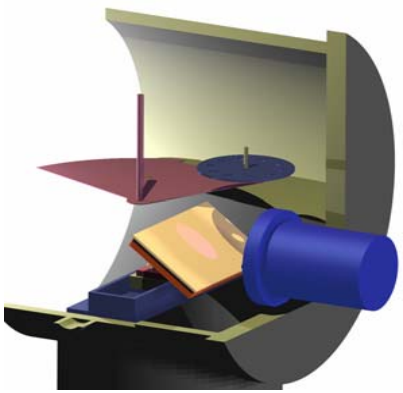
IBS-Coating
The increasing LIDT can be achieved using alternative coating materials. Vacuum test are planned.

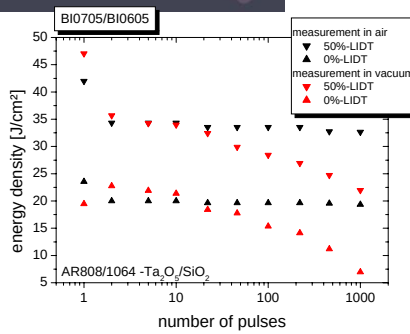
IAD:
The damage threshold is in the range of e^- - beam coatings. Vacuum test are planned.

Summary

- Vacuum and thermal shift measurement have shown spectral shifts.
- Coatings of different processes were tested
- Coating properties change under vacuum conditions







Acknowledgements

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