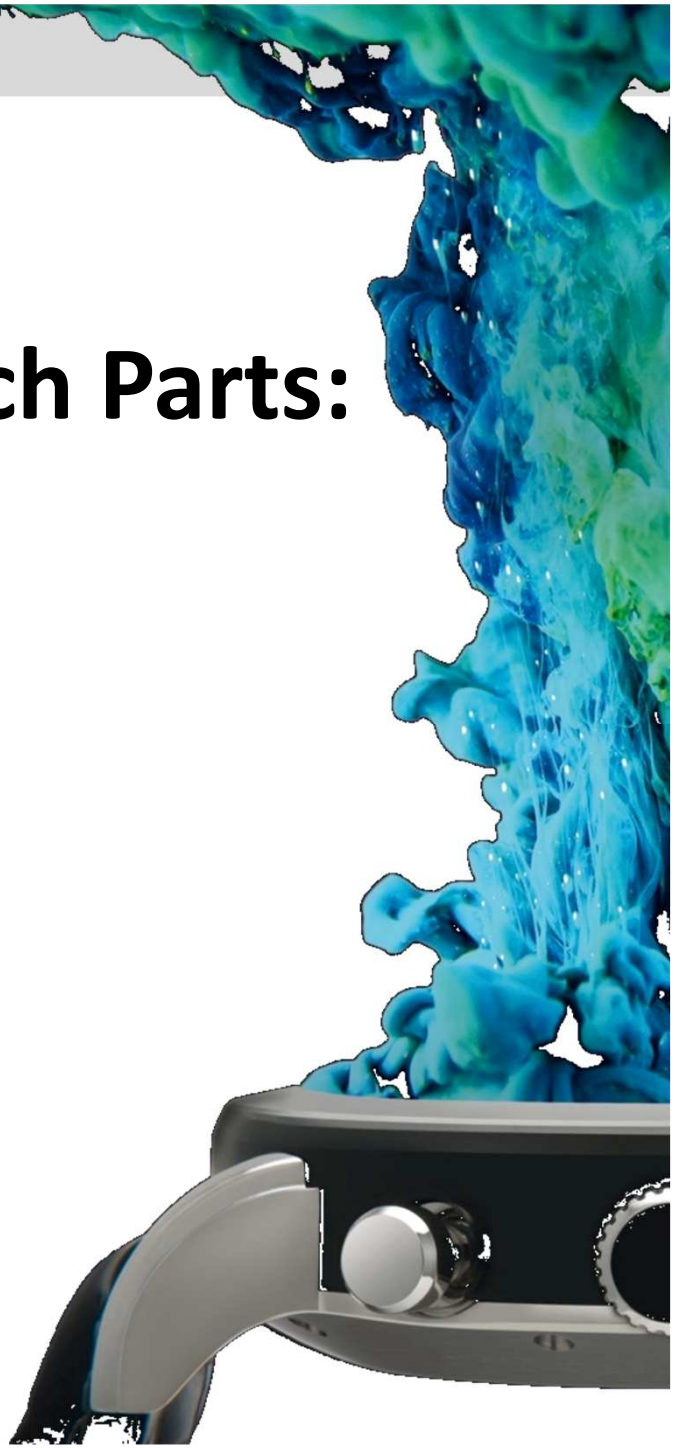
BLÖSCH

Optical Coatings for Watch Parts: Wear Resistance and Laser Damage Behaviour



Dr. Gabriel DUMITRU

Buchs SG, 11/06/2015

BCI

BLÖSCH

Contents

- W. Blösch AG
- AR coatings by …
- Tests and results
- Laser matting / engraving
- Decorative combinations
- Conclusions

BCI

W. Blösch AG

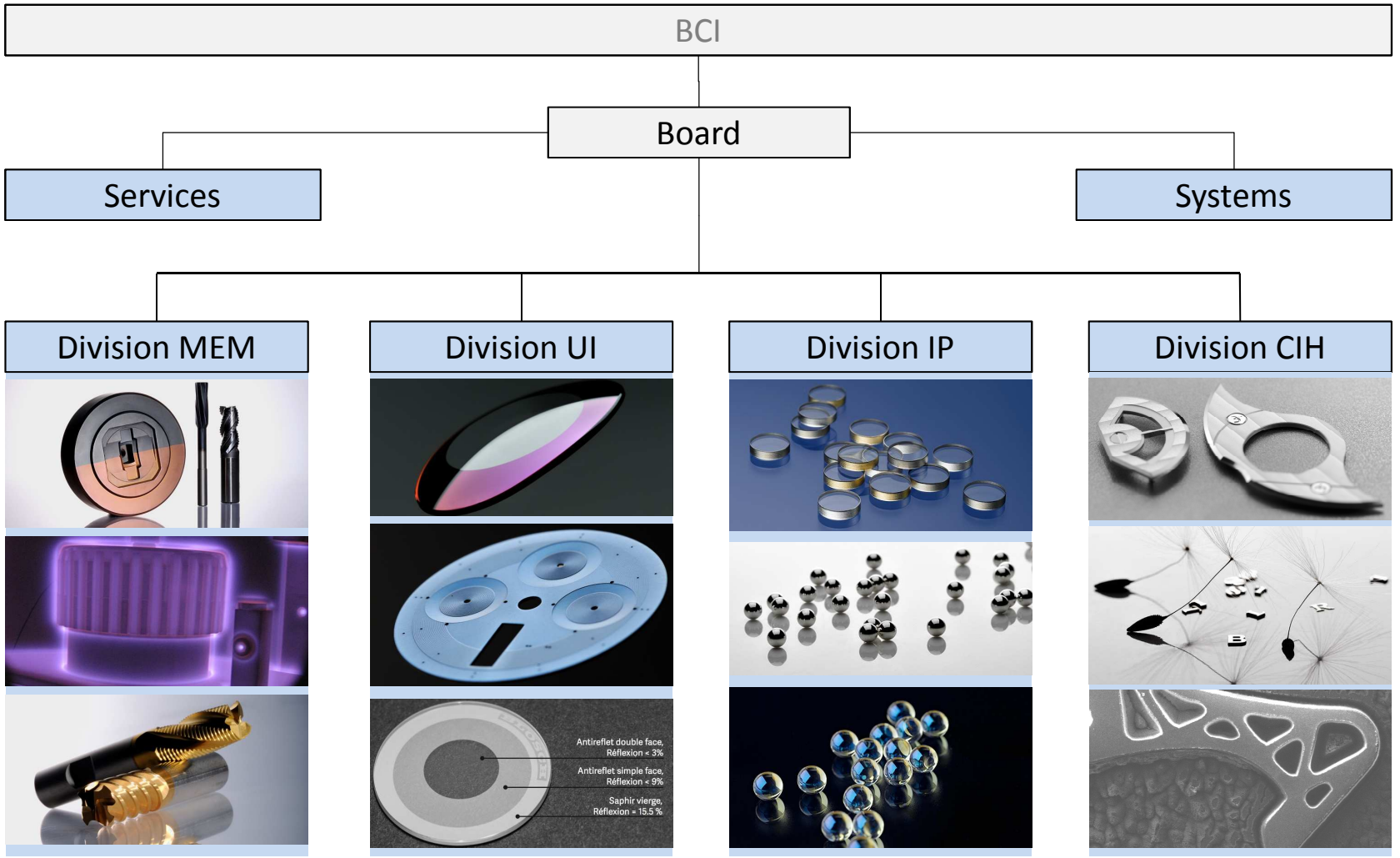
Independent, family own company

- founded in 1947 by Walter Blösch †
- led by Peter Blösch
- 3rd generation already active in the company

Company values

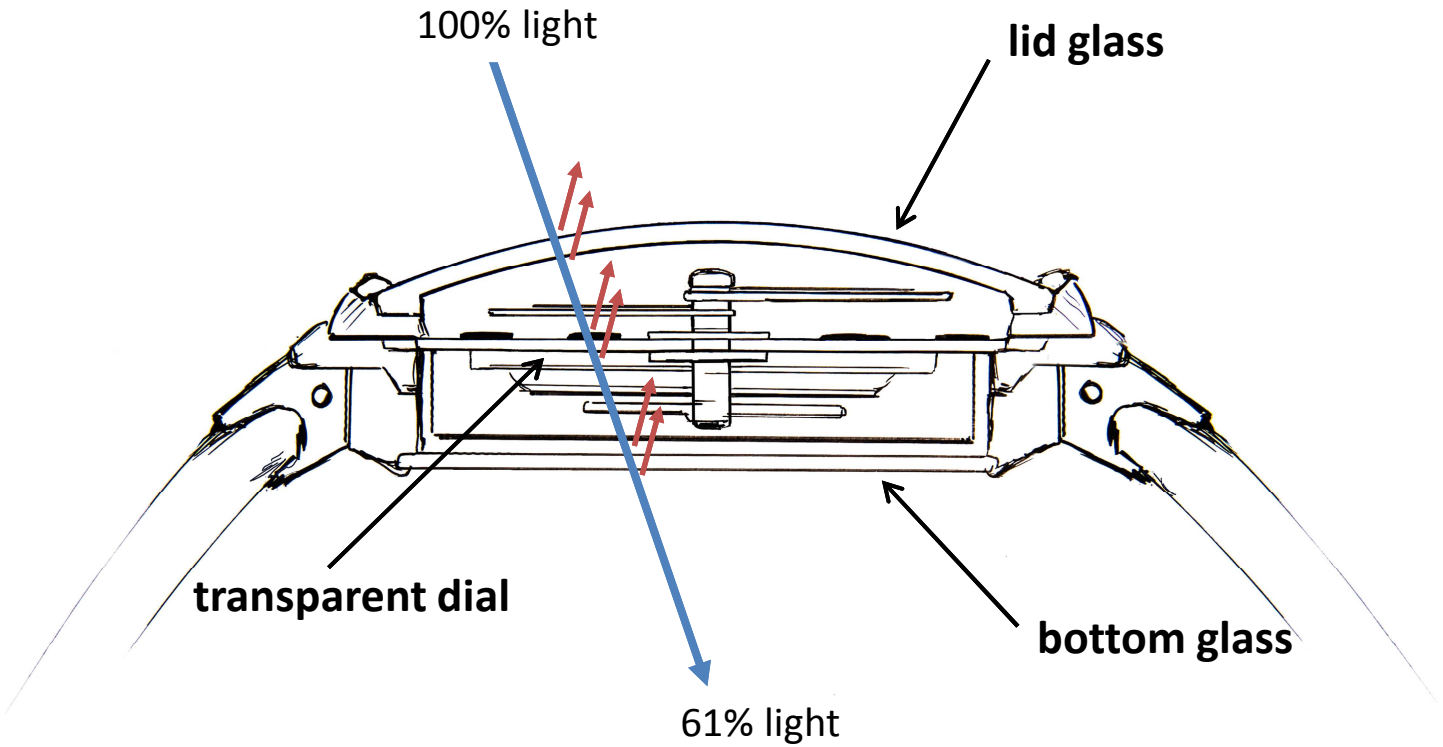
- authenticity
- high tech as tradition
- scientific approach
- limpid communication
- responsible production

W. Blösch AG

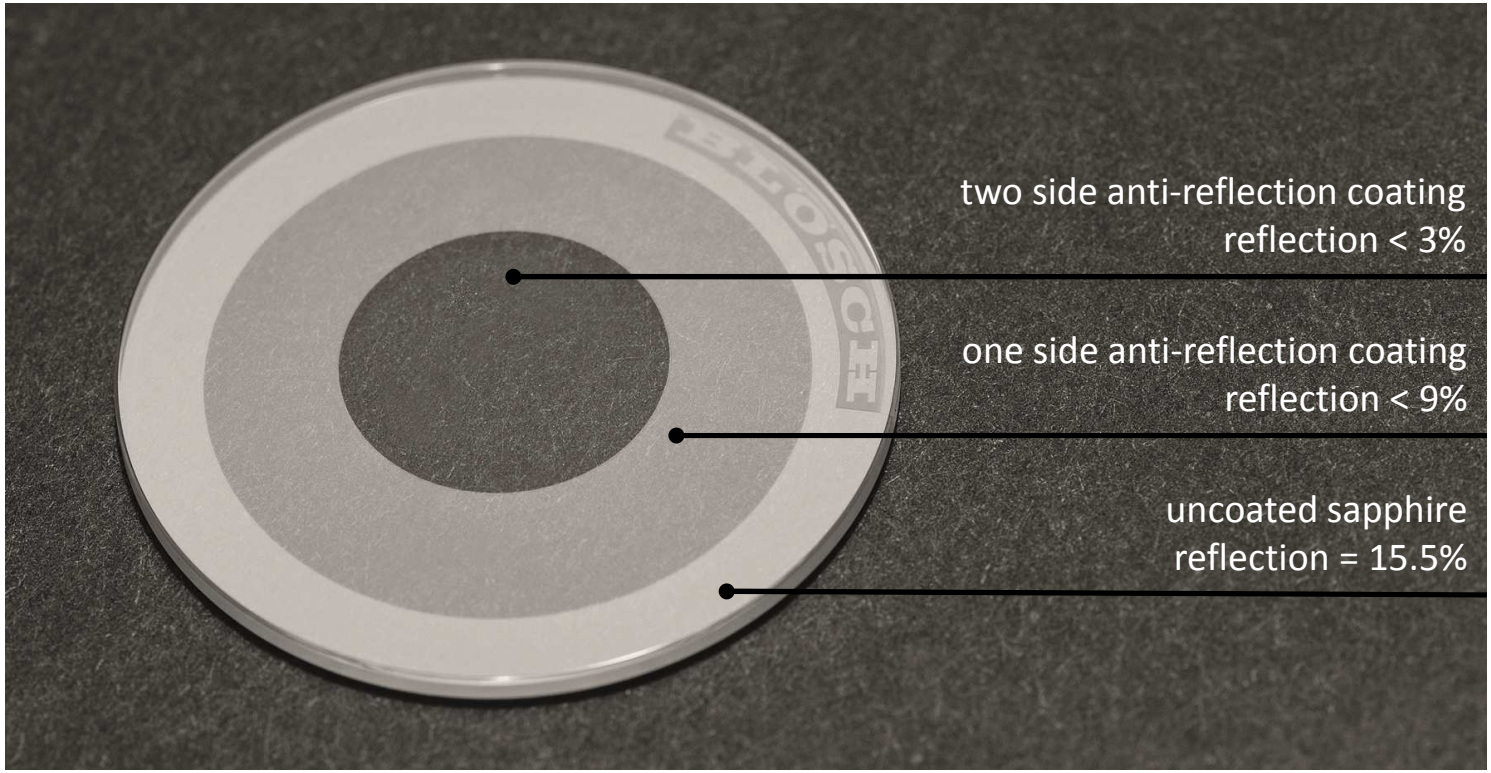

BCI
Board
Services
Systems
Division MEM
Division UI
Division IP
Division CIH
Antireflet double face, Réflexion < 3%
Antireflet simple face, Réflexion < 9%
Saphir vierge, Réflexion = 15.5 %

AR-Coatings: Example

- Luxury watches use sapphire
  - very hard (25GPa) and scratch resistant
  - but high reflection of ≈7.75% per interface



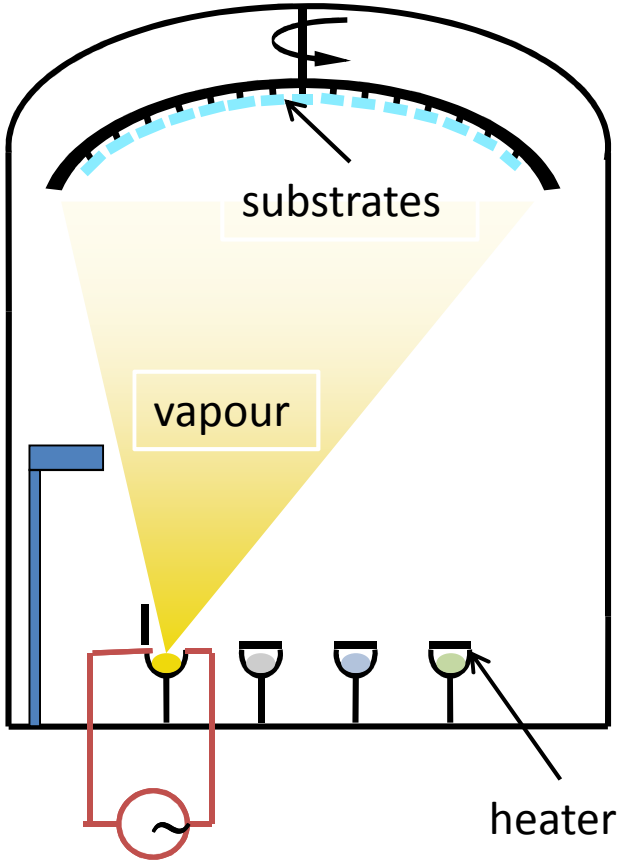
AR-Coatings: Function



AR-Coatings by Resistive Evaporation

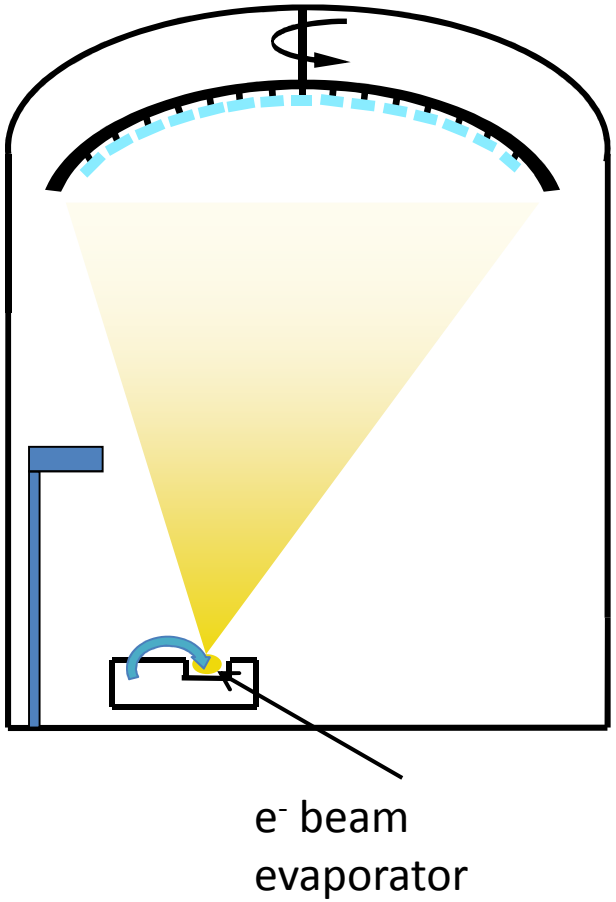
- Resistive evaporation (RE)
  - high current passing a resistance, heating the material
  - needed current for evaporation depends on density of the material

- Possible materials:
  - MgF_2
  - SiO, TiO
  - Metals (Cr, Pd, Al, Cu,…)



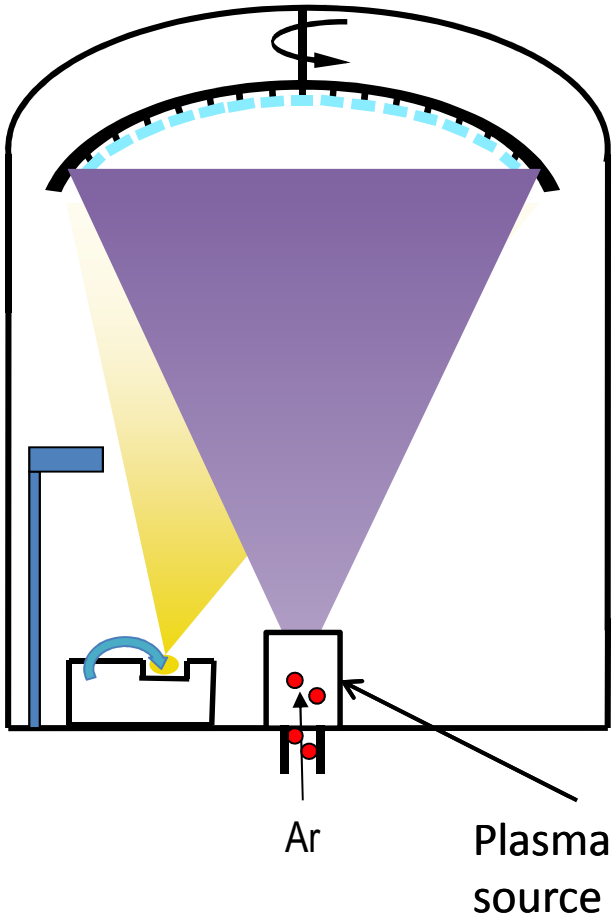
AR-Coatings by E-Beam Evaporation

- Electron beam evaporation (EBE)
  - electron beam is focused on material
  - kinetic energy of the electrons is transferred through to the material through inelastic collisions
  - this yields high temperature, so that materials can evaporate



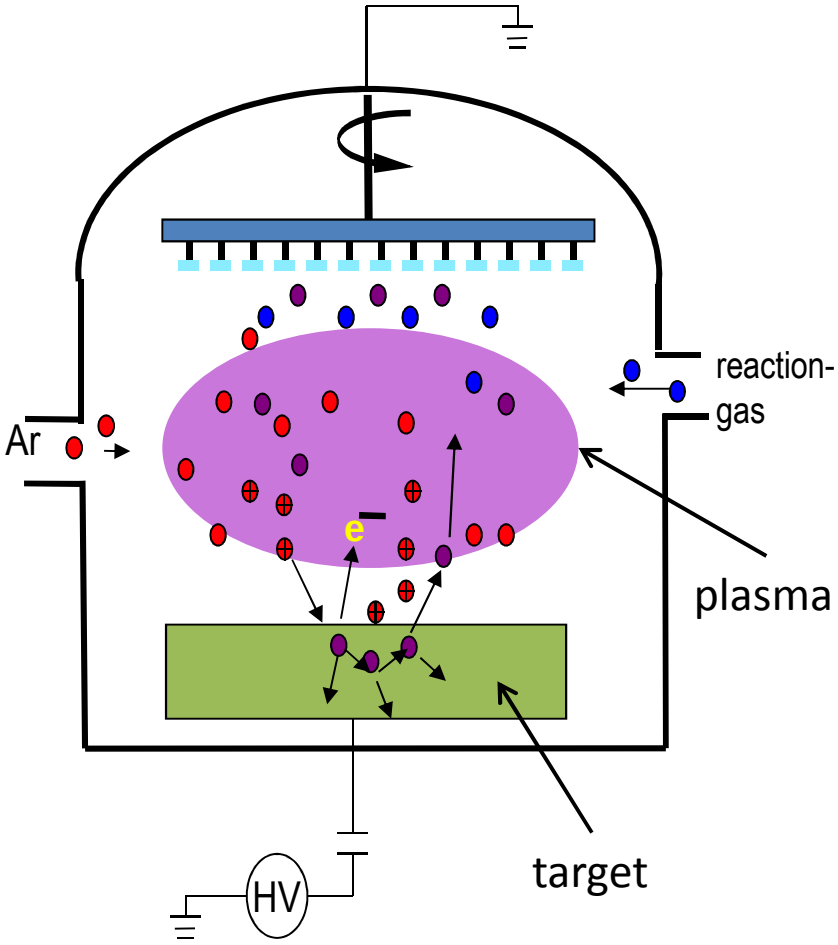
AR-Coatings by PIAD

- Plasma Ion Assisted Deposition (PIAD)
  - electron beam evaporation with plasma support
  - Ar-plasma
  - argon-ions densify the layers to improve their properties
  - plasma increases reproducibility



AR-Coatings by Sputtering

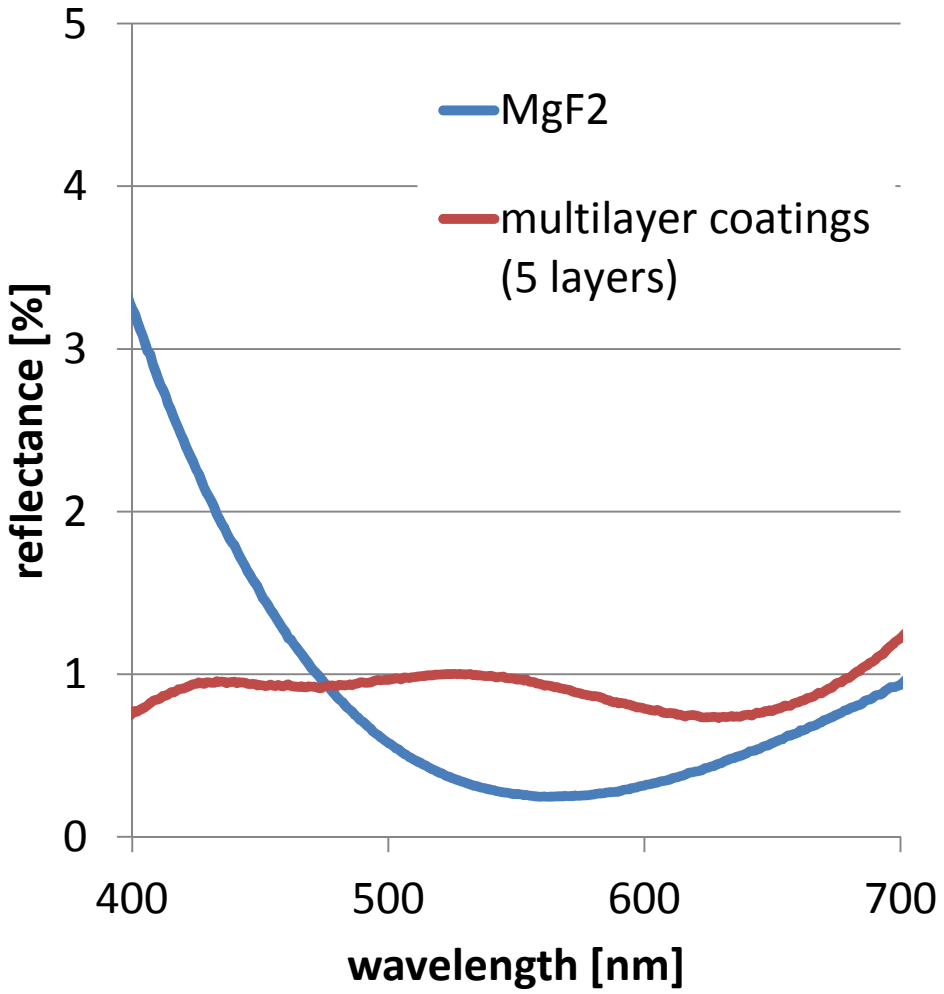
- Sputtering
  - electric field between substrates and target
  - Ar-ions are generated and accelerated to cathode
  - cathode = target material
  - sublimation process (solid->gaseous)
  - because of energy-transition particles move to substrates



AR-Coatings: Optical Properties

- MgF_2
  - single layer
  - high overall reflection
  - intensive violet rest reflection
  - resistance evaporation

- Multilayer coatings
  - overall reflection below 1%
  - color neutral rest reflection
  - since electron beam evaporation



AR-Coatings: Mechanical Properties

- Customers in watch industry wish “hard” coatings

- Facts
  - Does the customer really know what “hard” means?
  - Hardness is not the only important property.

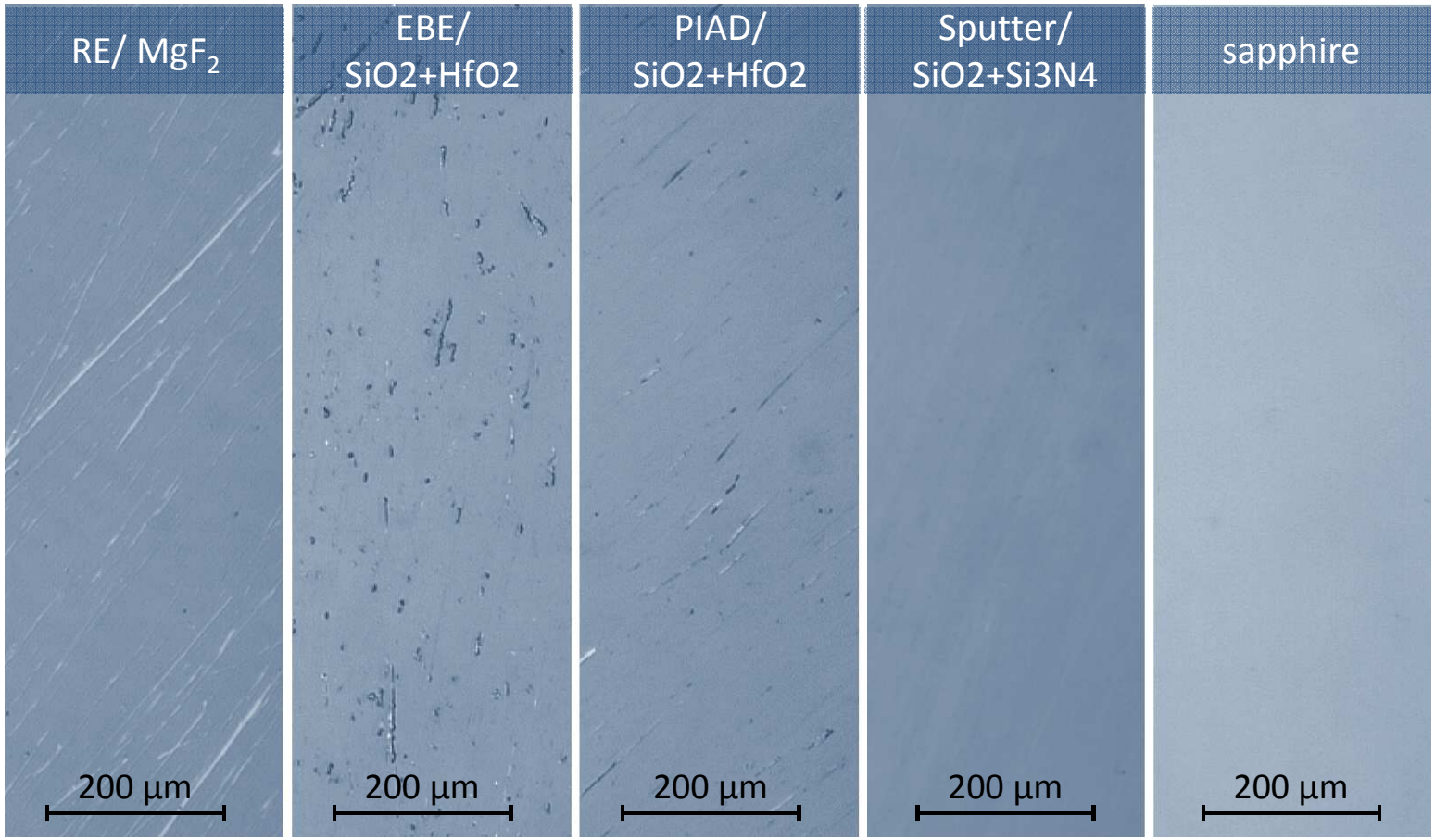
- Coatings for watch industry resistant against:
  - scratches, abrasive influences, local hits
  - wear

Analysis of AR-Coatings: Abrasion Resistance

- Bayer test
  - Based on norm ASTM F735-94
  - Test parameters
    - corundum sand with grain size of 300-400µm
    - sand filling height = 20mm
    - test duration=6750cycles, amplitude=60mm, frequency=7.5Hz
  - Test result is the thickness loss of coatings
    - calculated from reflection spectrum

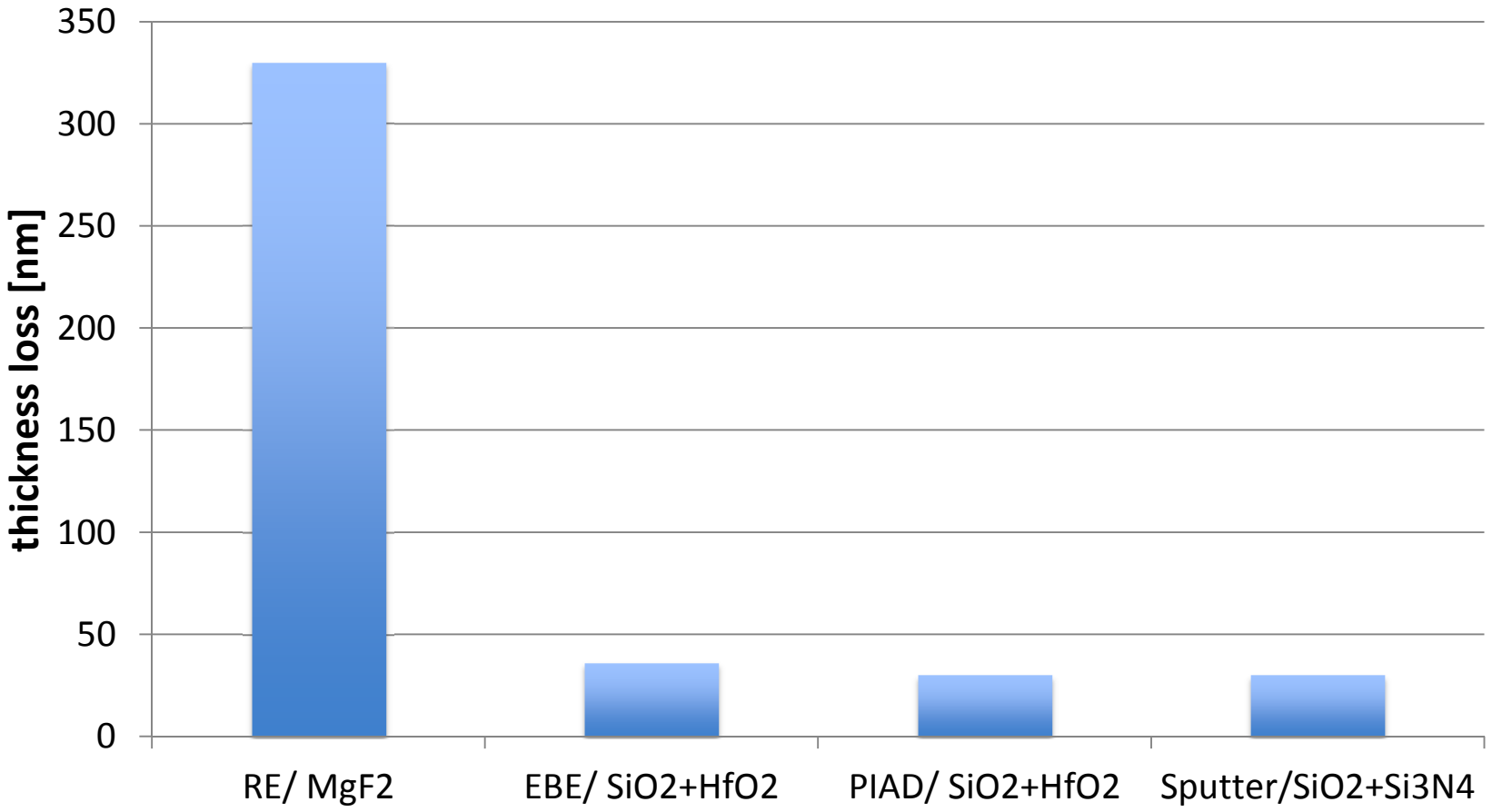
Abrasion Resistance

- Pictures of surface after Bayer test



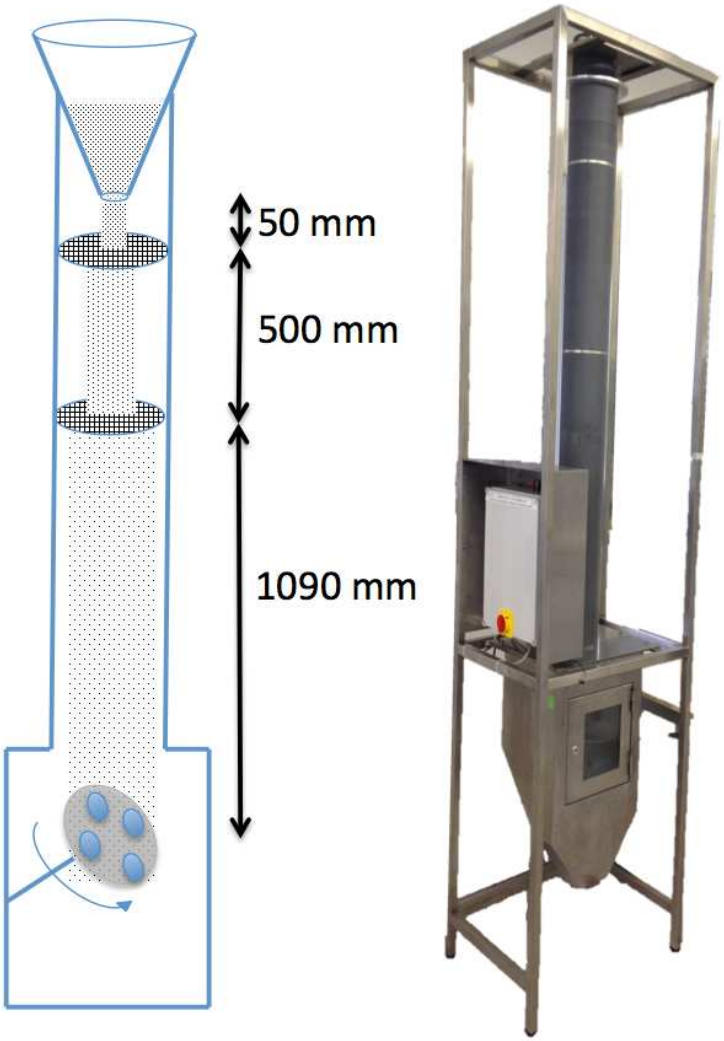
Abrasion Resistance

- Bayer test



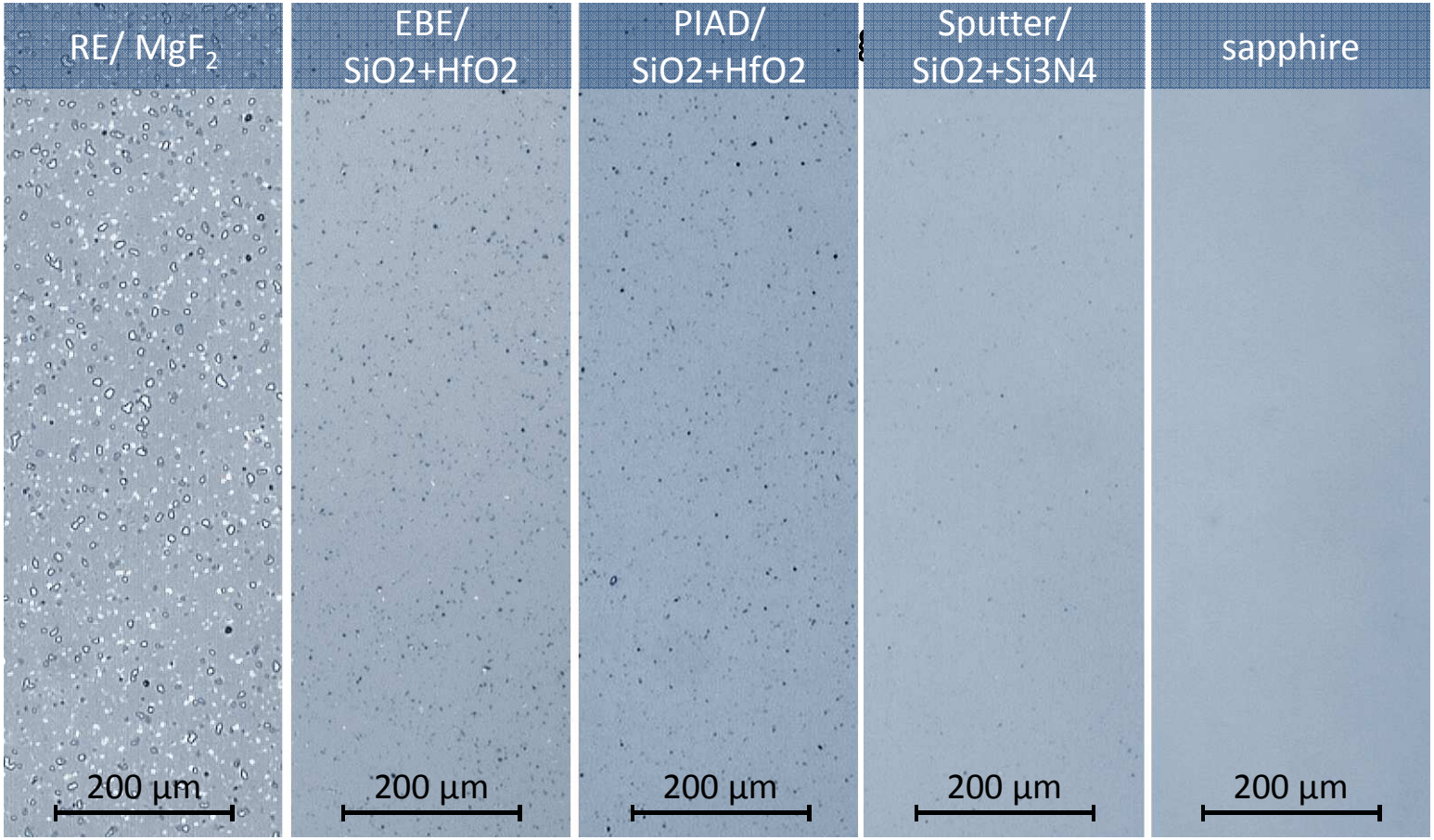
Analysis of AR-Coatings: Shock Resistance

- Sand trickling test
  - Based on norm DIN 52348
  - Test parameters
    - 3kg corundum sand with grain size 150-210µm
    - Fall height 1.65m
    - Rotation speed of samples 250RPM
  - Test results is increase of diffuse light (haze)
    - Range 400-720nm



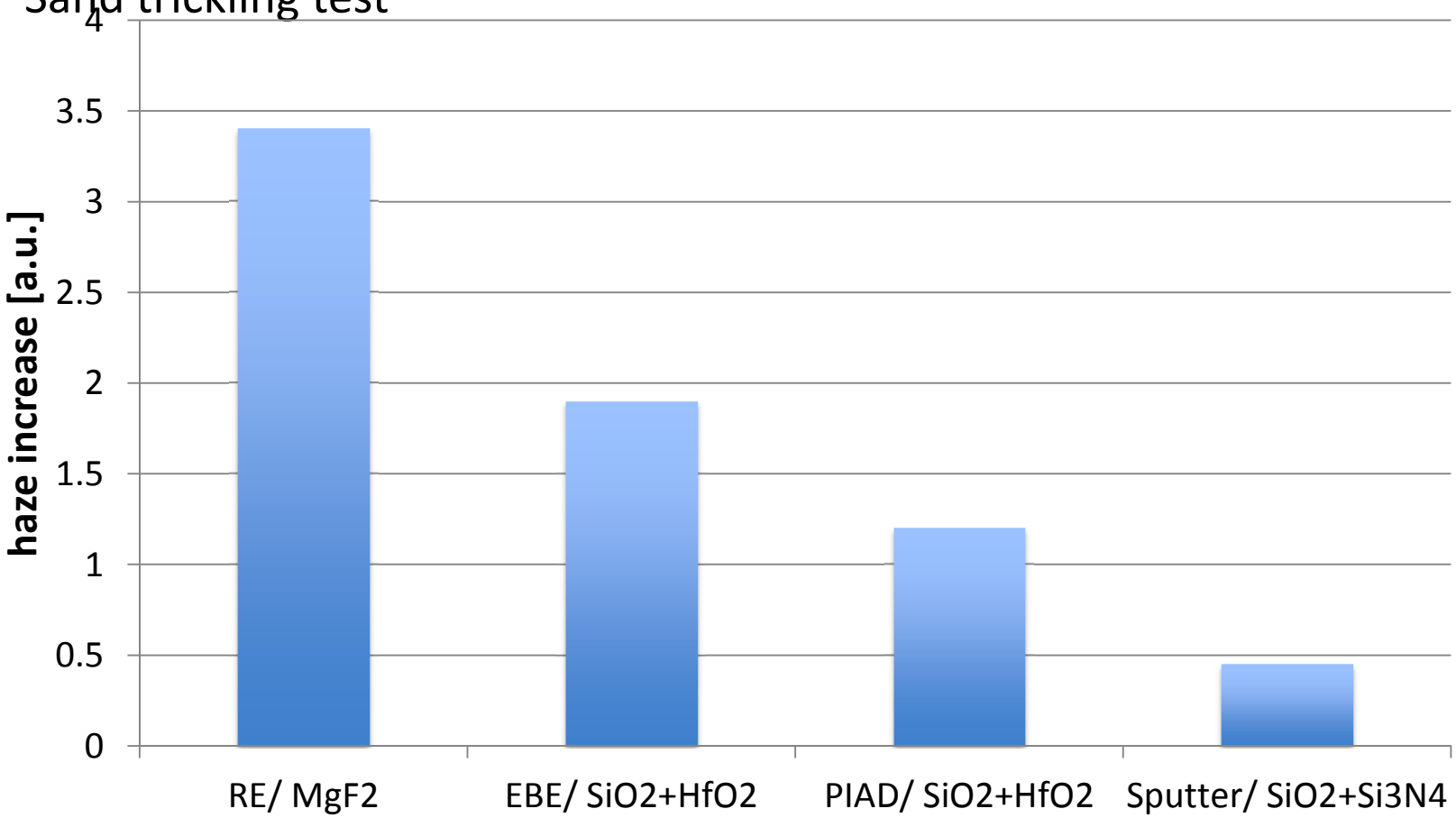
Shock Resistance

- Sand trickling test:



Shock Resistance

- Sand trickling test

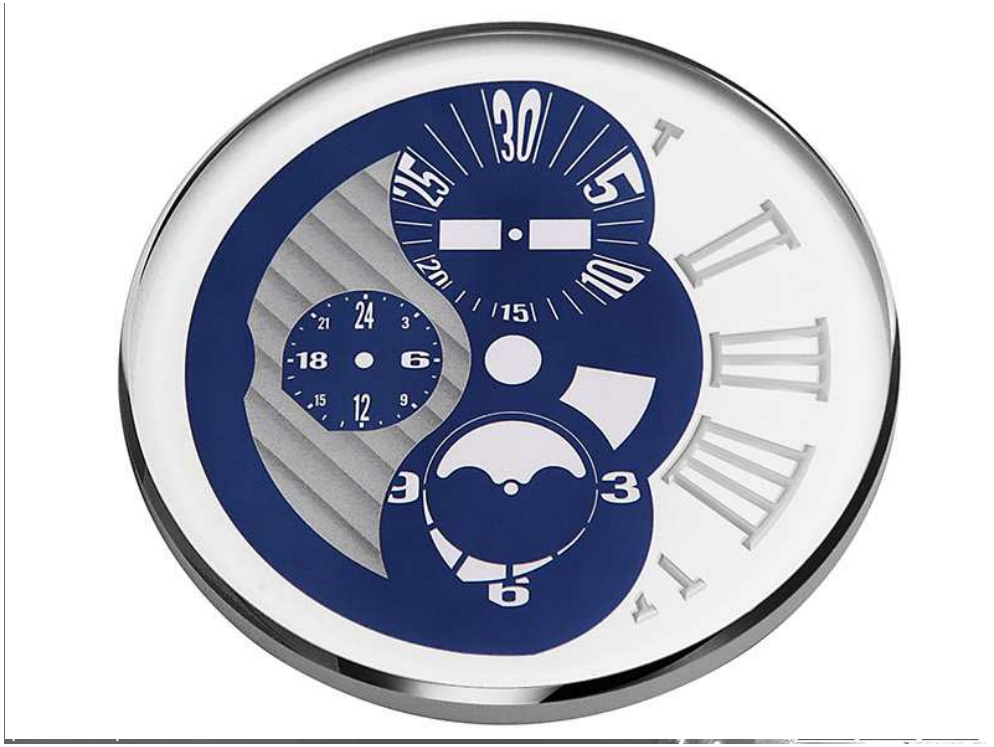


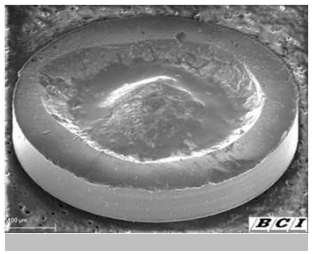
Analysis of AR-Coatings: Do-it-yourself

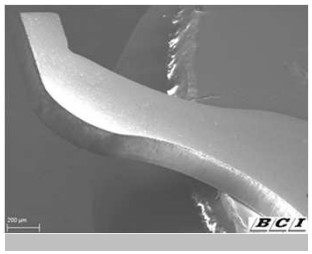
BLÖSCH

Laser @ Blösch

- welding
- toolmaking
- pad printing *clichés*
- fine cutting
- sapphire structuring







BCI

Material Challenges

Fabrication

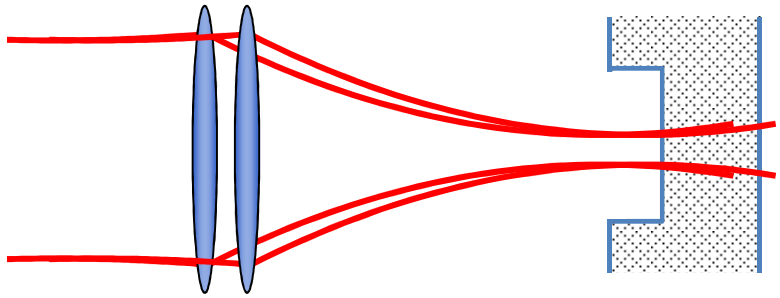
- crystal growing may yield:
  - point defects
  - dislocations
  - substructure grains

  (depending on growth type)
- grinding, lapping, polishing:
  - subsurface affected layer
  - mechanical stresses
  - microcracks
- thermal treatment:
  - should improve surface / volume properties
  - may reduce internal stresses

(Dobrovinskaya, Elena R. *Sapphire*. New York: Springer, 2009)

Transparency

- machining tool passes through



- nonlinear effects

	n_2 (10^{-15} cm^2/W)
sapphire	0.3
diamond	1.3
glass	0.3

  - surface / volume cracks
  - back side damages

(Boyd, Robert W. *Nonlinear Optics*. San Diego: Elsevier, 2003)

Matting & Greyscale

- surface layer texturing
- different shades
- sharp field edges

Practice:
ca. 8 J/cm^2

- precisely defined grey tone

BLÖSCH

Engraving

- depths up to 0.5 mm
- sharp edges
- fairly steep walls
- translucid bottoms

- cracks (thermal annealing)
- backside damages (thin pieces)

BCI

BLÖSCH

Texturing & PVD Coating

- surface layer texturing
- mat metallisation

- precisely defined colour tone

BCI

BLÖSCH

PVD Coating & Texturing

- sharp field edges
- colour gradient
- sapphire transparency

- sapphire surface damages

BCI

AR Coating & Texturing

- anti-counterfeiting
- sapphire transparency
- sapphire surface damages

BLÖSCH

Conclusions

- enormous design opportunities:
  mat metallisation, anti-counterfeiting
- plasma support (PIAD, Sputtering…),
  as key element for good coatings
- different analytical tests are necessary
  to evaluate a coating

- inconsistent test results
- laser induced
  volume / surface damages

BCI