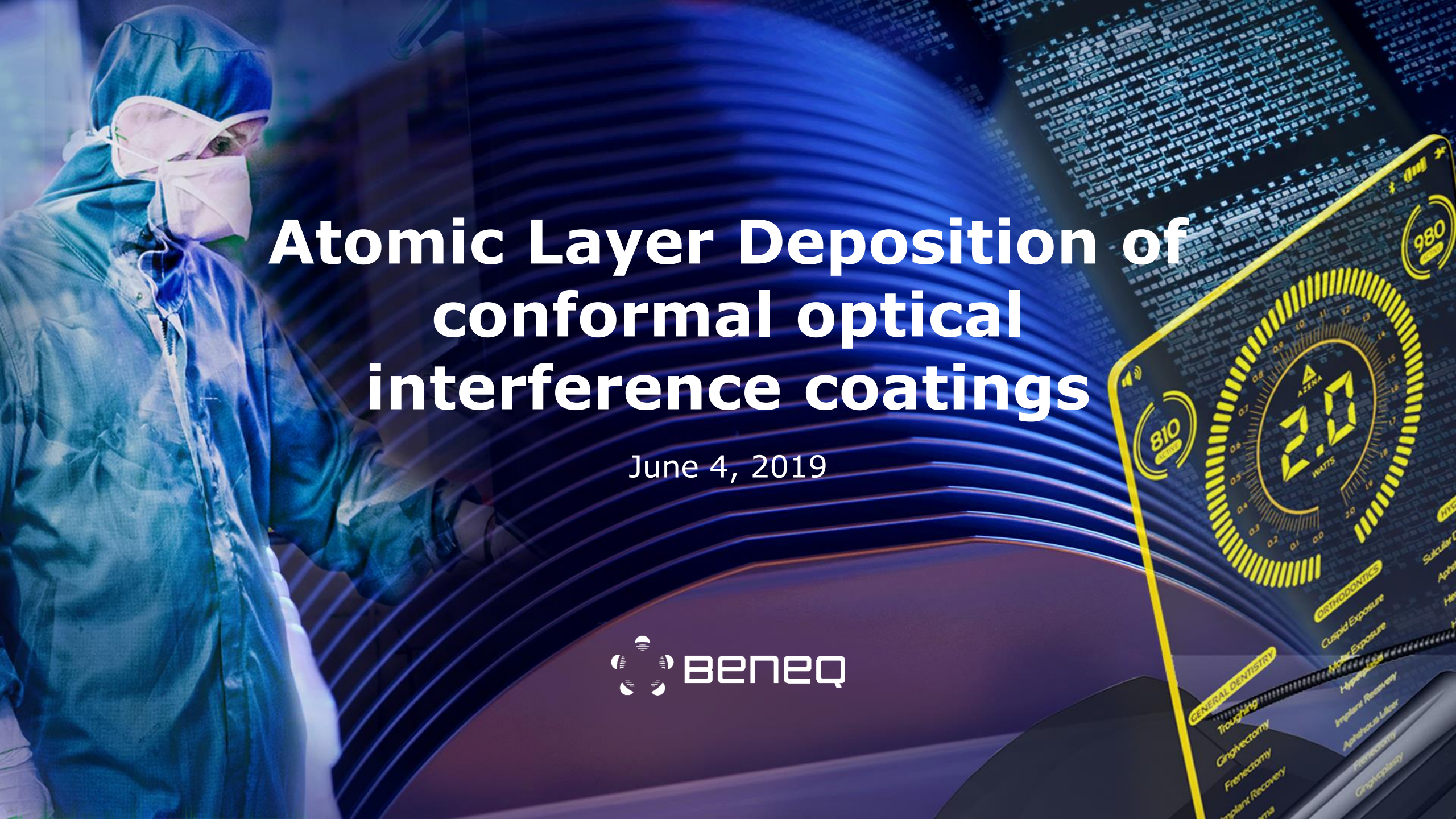


Atomic Layer Deposition of conformal optical interference coatings

June 4, 2019

BENEQ

Atomic Layer Deposition of conformal optical interference coatings industrially

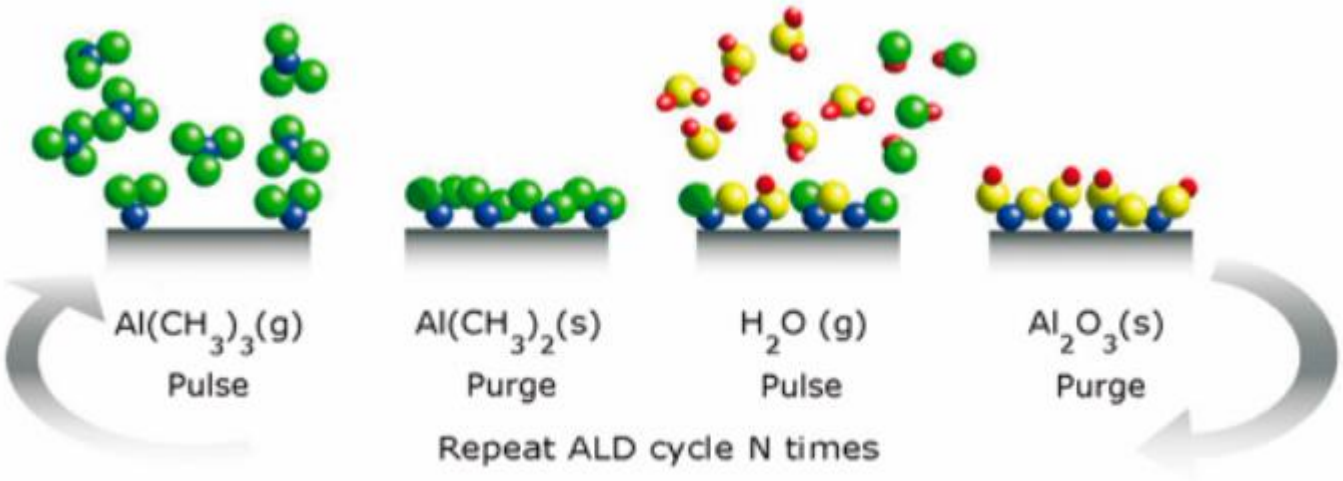
- For commercial production of
  - Multiple optics per coating run
  - Large optics
- Industrial tools (e.g. Beneq P400A, P800) are used for low cost per coated item

Beneq C2R Production/R&D –Spatial ALD reactor. Beneq Oy.

Beneq P800 Production/R&D –ALD reactor. Beneq Oy.

Atomic Layer Deposition of conformal optical interference coatings

- Vacuum coating (1 mbar) method
- One precursor (chemical) at a time on surface
- Self-saturating surface reactions
- Purging step between precursor exposures

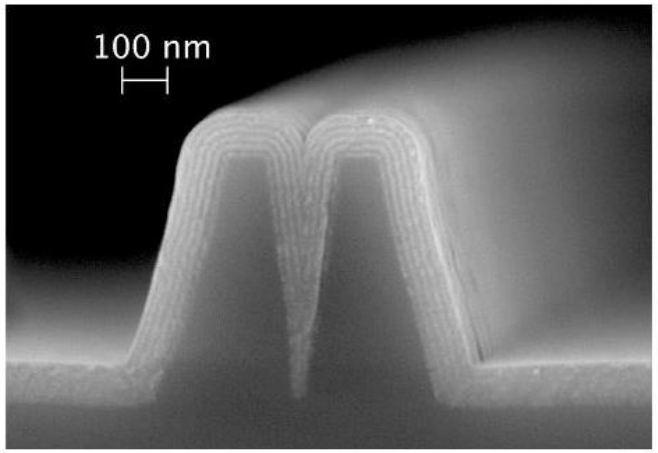


Schematic of an ALD cycle. Beneq Oy.

Atomic Layer Deposition of conformal optical interference coatings

- Conformality is enabled by surface-controlled growth
- From micro- to macro-conformal
- No rotation/movement of samples required
- Optimization for shapes – easy to construct test structures

Nanoscale

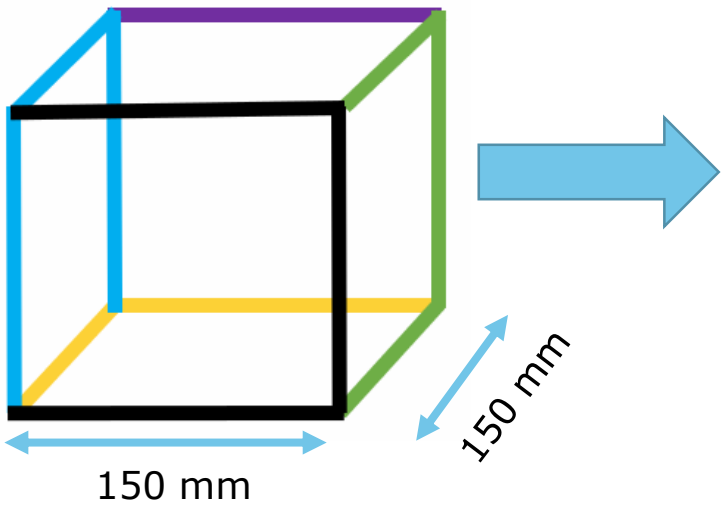


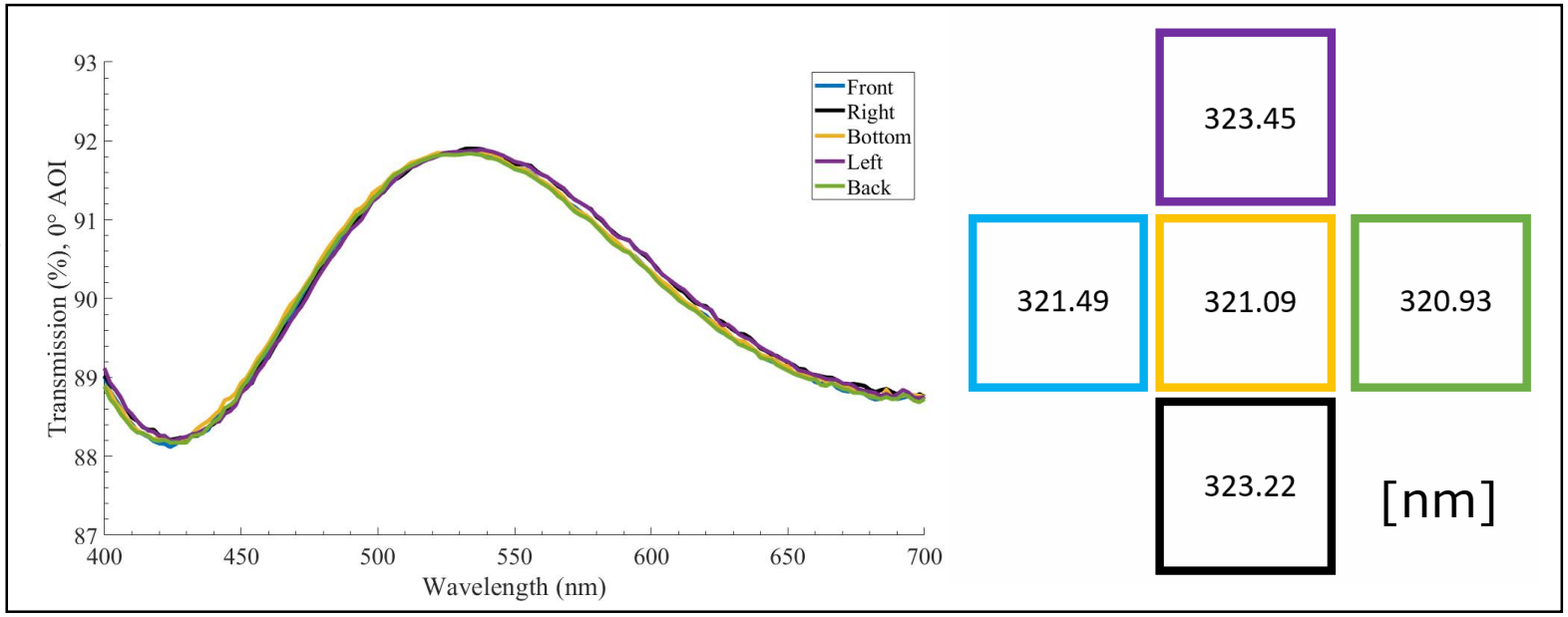
Macroscale

Alasaarela, T. Atomic layer deposited titanium dioxide in optical waveguiding applications. 2011. Academic Dissertation. Aalto University School of Electrical Engineering Department of Micro- and Nanosciences Photonics Group.

Atomic Layer Deposition of conformal optical interference coatings

- Macroconformality is simple to study and prove on custom shapes
- Process can be further optimized for a specific shape



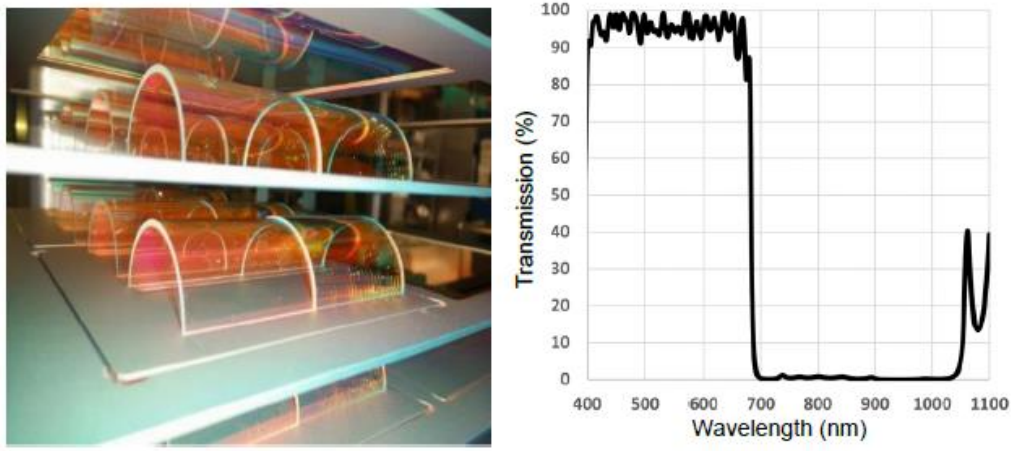


Above: Schematic of a 150 mm –sided top-open cube. Glass substrate attached to each side.

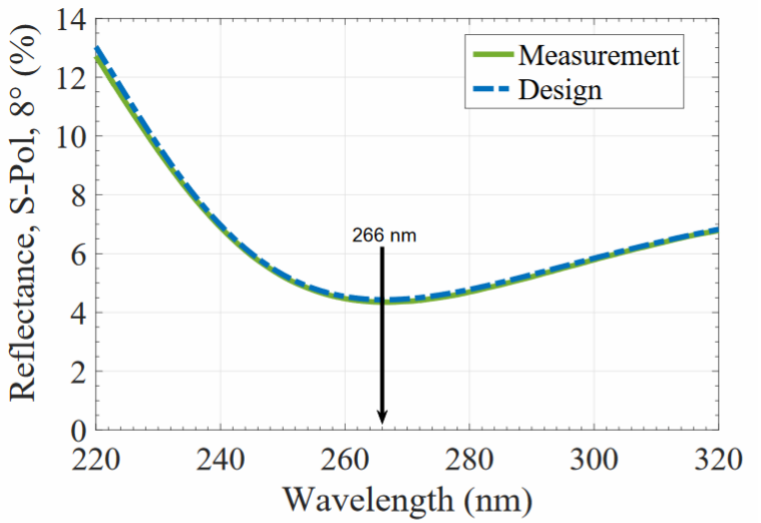
Left: Measured transmission of glasses after ALD-Al_2O_3 deposition
Right: Fitted thickness values (nm) for corresponding sides. Variation < 0.4 %

Atomic Layer Deposition of conformal optical interference coatings

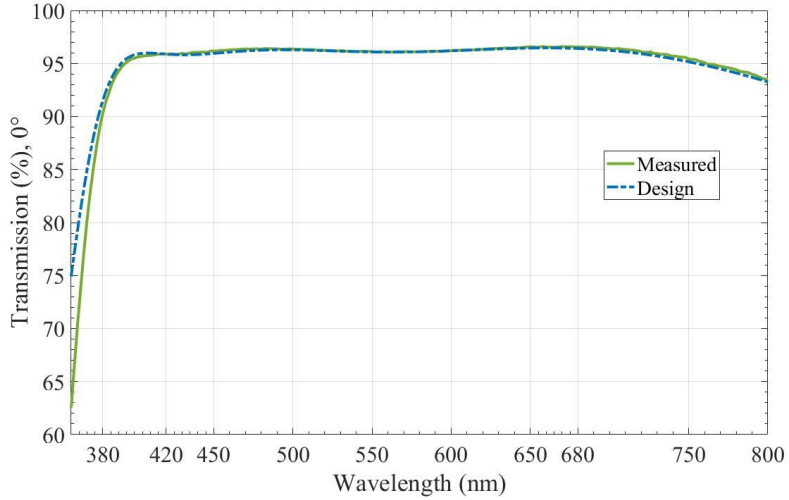
- All ”typical” coatings easily realizable from design
  - AR
  - HR
  - Bandpass/Bandstop
  - Beamsplitters
- Typically, no in-situ monitoring is required (repeatable layer-by-layer growth)



ALD-Al2O3/TiO2 short-wave edge pass filter (5.5 µm thick). Beneq Oy.



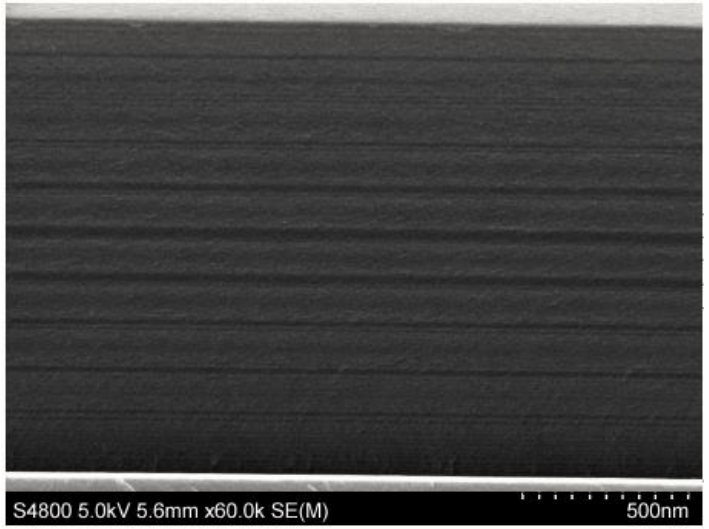
ALD-Al2O3-SiO2 AR for UV 266 nm laser (single-sided coating). Beneq Oy.

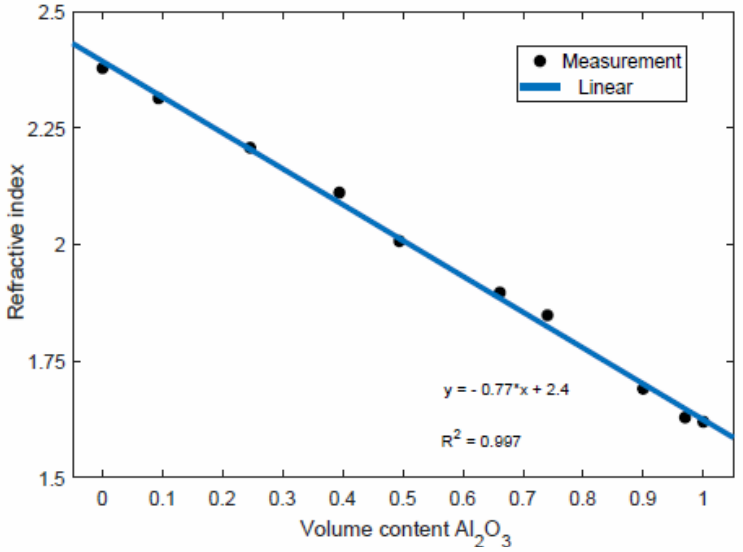


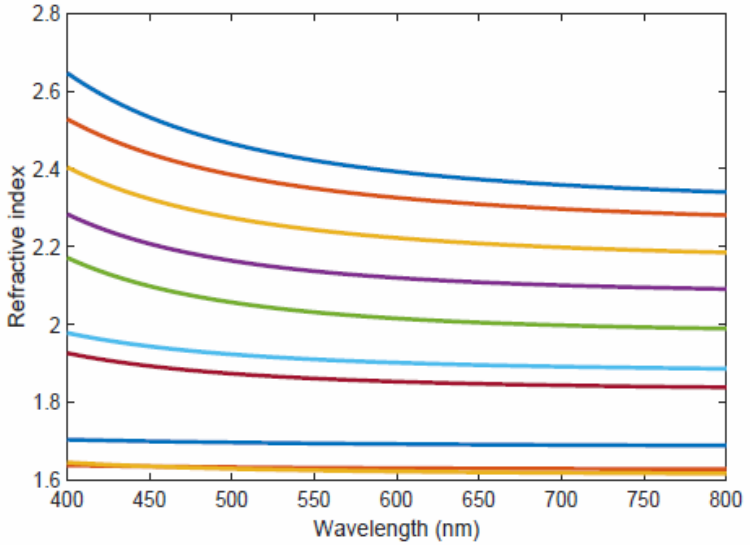
ALD-SiO2/TiO2 Visible-range AR (single-sided coating). Beneq Oy.

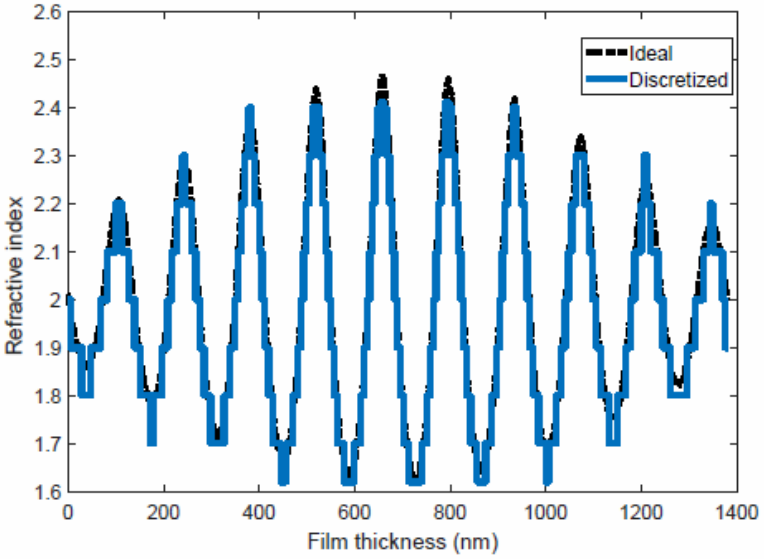
Atomic Layer Deposition of conformal optical interference coatings

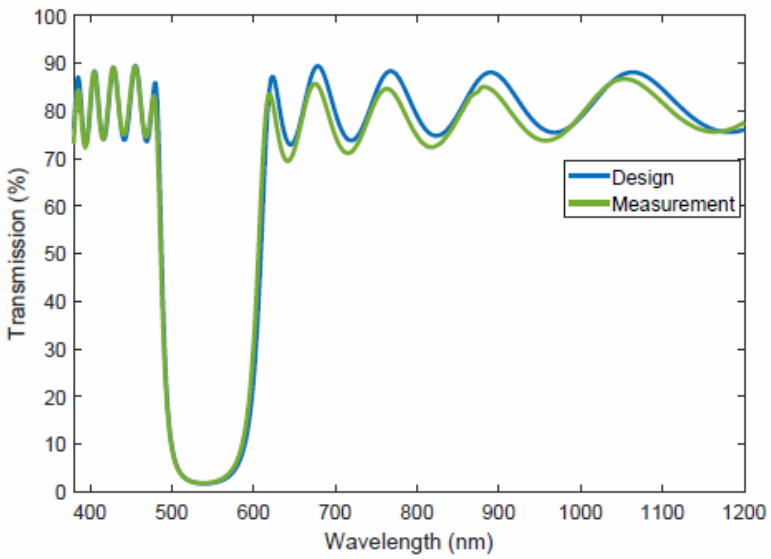
- Engineering of materials easy to perform
- Optical properties of laminated ALD-Al2O3-TiO2 films investigated (figures)
- Behaviour predictable and easy to model
- Example application: Apodized rugate bandstop filter











For more information and discussion, come meet us!

Poster TEP.5
Beneq Inc. Booth 1006

Beneq® is a leading supplier of production and research equipment for atomic layer deposition (ALD), a provider of thin film coating services, and the world's premier manufacturer of thin film electroluminescent (TFEL and TASEL) displays.

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