Fraunhofer FEP

Fraunhofer Institute for
Organic Electronics, Electron Beam
and Plasma Technology FEP

# Large area anti-reflective coatings


*Large area anti-reflective coating on glass substrate*


*Vertical in-line sputtering for coating of large area surfaces*

## Large area anti-reflective coatings

Various anti-reflective (AR) coating systems on glass or polymer surfaces are required in many fields of application. The aim is the adaptation between the different refractive indices of glass and ambient media (e. g. air). This can be easily be realized for one wavelength λ by the deposition of one low-index layer in the optical thickness of a quarter-wave of this special wavelength. In air, the optimal refractive index of such a layer results in $n_{layer}=\sqrt{(n_{glass})}$ .

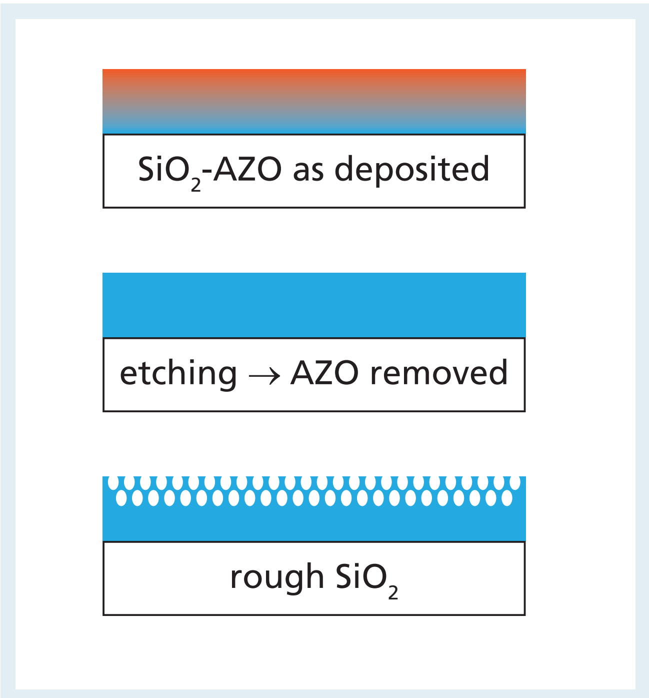
However, such a perfectly suitable AR material cannot be found for most of the potential glass materials. Therefore, it is necessary to replace it by multilayer systems with alternating low and high index layers of naturally occurring transparent metal oxides or e. g. nitrides, etc.

In practical applications, broader bandwidths of reduced reflectance are usually required, for example wavelength ranges of several hundreds of nanometers in the visible spectral range (VIS). consequently more sophisticated multilayer designs are needed for this purpose.

Anti-reflective surface functionality can be realized by different optical principles: Nanostructured surfaces, gradient coatings and interference multilayer coating systems.

**Structured surfaces** have a graded refractive index between glass (or polymer) substrate and air by an adjusted porosity of coating material or substrate surface. In this way, the approximation of the effective medium between coating or substrate material and air-filled cavities is valid.

## Nanostructured surfaces




*Nanostructures for anti-reflective surfaces*

Example I:

- Co-sputtering of a $SiO_2$:AZO-mixing layer of gradual concentration profile
- Wet-etching by hydrochloric acid (HCl) selectively removes the AZO fraction from the $SiO_2$:AZO-mixing layer
- Result is an $SiO_2$-coating of graded porosity → thus of graded refractive index

Example II:

- Plasma etching process PolAR® of Fraunhofer FEP directly at polymer surface (e. g. of flexible foil)
- Result is a significantly reduced reflectance of polymer surfaces by nanostructure

Advantages of nanostructured AR-coatings:

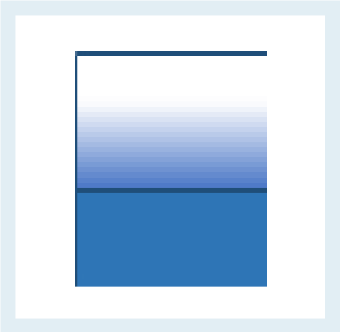
- Color-neutral
- Comparably wide-banded

Disadvantages of nanostructured AR-coatings:

- Mechanically sensitive surface → lowered mechanical durability in real applications (covered installation preferred)

*Anti-reflective coating on ultra-thin flexible glass*

## Gradient coatings

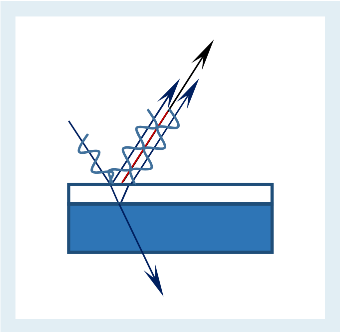


*Gradient coatings*

Anti-reflective **gradient coatings** need a decreasing refractive index of the gradient layer(s) from glass to ambient media (air). This can be realized by two principles:

- Mixture of 2 coating materials of different refractive index (Co-sputtering)
  → effective-medium-approximation of effective refractive index
  → materials concentration gradually changes in film-growth direction of the coating
- Mixture of one coating material and air-filled voids
  → leads to a structured surface

## Interference coatings



*Destructive interference at optical multilayer thin film stack*

**Interference multilayer coating systems** are based on quarter-wave optical thin film thicknesses or on effective refractive indices of sublayer-sequences.

- Quarter wave-principle or e. g. needle designs
- Experienced use of several thin film design software solutions at Fraunhofer FEP

These multilayer designs can be additionally optimized for example regarding:

- Color targets (chromaticity coordinates)
- Mechanical stress management
- Anti-dust properties
- Water and dirt repellency
- Anti-fingerprint properties

## Our offer

All these AR systems are offered by Fraunhofer FEP Dresden at an area of up to 0.6 × 1.2 m². The coating systems can be adapted to real application conditions:

- Temperature and environmental stability
- Corrosion resistance
- Mechanical durability
- Mechanical stress optimization

We are able to adjust various process parameters of the coating and/or etching processes:

- Sputtering of planar or rotatable targets
- Large variety of coating materials: Si, Ta, Nb, Ti, Zr, … and their oxides and nitrides; ITO, AZO, …
- Targets metallic or ceramic; reactively controlled sputter processes
- Pulse modi (DC, unipolar, bipolar)
- Plasma etching station

We look forward to developing your specific solution for a precisely custom-fit anti-reflective multilayer, gradient or structured design for your real application requirements.

# Contact

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