Fraunhofer FEP

Fraunhofer Institute for Electron Beam and Plasma Technology FEP

Crystalline titanium dioxide layers

A material for many applications

Titanium dioxide, a chemically stable and biologically inert material, is used in many different applications. In the field of medicine, titanium is the number one choice for implants and endoprostheses as well as high-end instruments. This is in large part due to the passivating oxide layer which forms on the surface under atmospheric conditions. This native oxide layer as such is bioinert, which means it is passive in contact with organic materials. Certain crystalline modifications are required if one wants to realize additional functional benefits with the material.

Crystalline titanium oxide layers can be activated by exposure to UV light or daylight. After activation, they exhibit superhydrophilic characteristics, which means perfect wettability with water. Hydrophilization is reached after only a short UV activation and lasts several hours. Therefore, activation promotes initial wetting and adhesion, for example for implants.

Crystalline titanium oxide layers also show photocatalytic properties. They can be used to decompose organic materials under photoactivation, for example to disintegrate biofilms in hygiene or environmental applications or in air and water purification.

Fraunhofer FEP applies titanium dioxide layers with the highest purity using vacuum coating processes such as pulsed magnetron sputtering or plasma-activated evaporation. These processes are used for the highly productive layer deposition on various substrates ranging from small to large – from flat substrates to 3D parts. The photoactivatable properties of these robust, mechanically stable titanium oxide layers can therefore be used in a wide variety of application.

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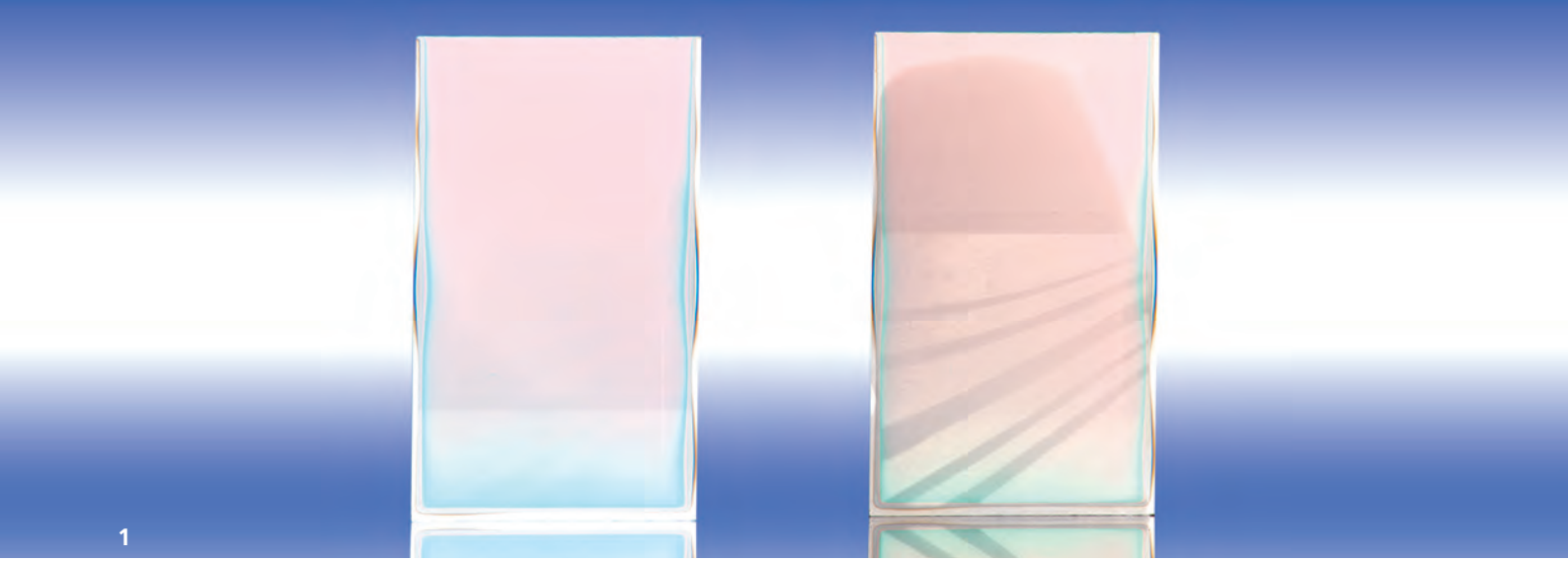

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Applications

Photocatalysis

- Self-cleaning and easy-to-clean surfaces
  Decomposition of organic contaminants adhering to surfaces through oxidation and reduction processes
- Antibacterial surfaces
  For example, for safety cabinets in laboratories by destroying adhering microorganisms through decomposition reactions
- Photocatalytic purification and reforming
  of gases or liquids through the decomposition of organic molecules

Photoinduced hydrophilicity

Reducing the contact angle to below 10° results in a closed water film on the surface.

- Anti-fog surfaces
  for mirrors, eyeglasses, glass panes, etc., by preventing the formation of droplets
- Influencing initial processes
  in the interaction between the surface and the physiological environment

Technology

At Fraunhofer FEP, we deposit titanium dioxide layers by reactive pulsed magnetron sputtering or plasma-activated evaporation. The process parameters can be varied to achieve the following application-specific coating characteristics:

- Hardness: 7 … 17 GPa
- Refractive index: n = 2.4 … 2.7 (@ 550 nm)
- Crystallinity: amorphous, anatase, rutile and mixed phases
- Good adhesion to a wide variety of materials
- Diffusion barrier against metal ions, oxygen and water vapor
- Electrical insulation capacity
- Water contact angle before layer activation

Advantages of the technology

- Stable vacuum coating processes with high uniformity and purity of the layers
- Large-area coating with high productivity enables cost-effective production
- Crystalline layers are already possible at substrate temperatures of 130 to 250°C (on average 200°C lower than with conventional processes), so they can also be deposited on temperature-sensitive substrates.
- Possibility of coating 3-dimensional objects
- Doping or combination with other materials during the sputtering process to achieve additional properties
- Improvement of photocatalytic activity by using visible light instead of UV radiation

Our offer

- Coating and material development for glass, metal, ceramic and plastic substrates
- Feasibility studies
- Process development, process and technology transfer to the customer

Layer benefits

- Permanent effect because layer materials are not consumed
- Environmentally friendly, because no chemicals (such as binder materials) are released by the layer
- No antibiotics are needed for anti- bacterial effects
- Effect can be controlled through light exposure

1 Condensation of a masked activated TiO_2 layer