

Product Information

Titanium Oxide(II) Patinal®

Titanium Oxide(III) Patinal®

Titanium Oxide(IV) Patinal®

GENERAL INFORMATION

A number of titanium (sub)oxides, e.g. TiO , Ti_2O_3 , TiO_2 , can be used as evaporation material for the deposition of titanium dioxide (TiO_2) layers. Each starting material shows a specific combination of advantages and disadvantages with respect to evaporation characteristics and achievable layer properties. Therefore, the intended use of the layer and the constraints in the specific deposition process determine which starting material represents the best compromise. The principle behavior of the titanium oxides during evaporation is similar.

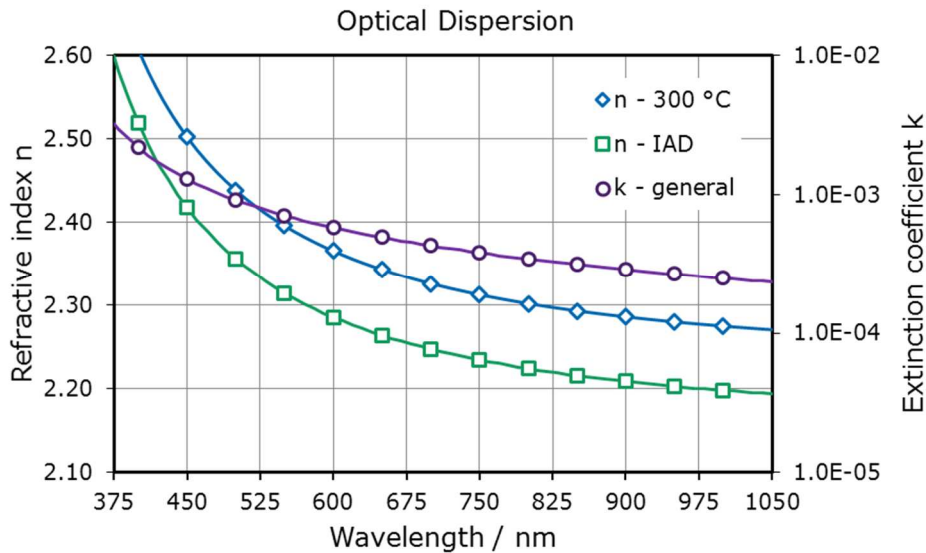
AREAS OF APPLICATION

- AR and multilayer coatings on glass and plastic substrates
- UV protection for plastic substrates

THIN FILM PROPERTIES

| | |
|----------------------------|---------------------------|
| Range of transparency | 400 nm – 12 μm |
| Refractive index at 500 nm | ~ 2.40 |
| Absorption edge | ~ 390 nm |
| Thin film stress | Tensile |





The resulting optical properties of the thin film are strongly dependent on the deposition rate, substrate temperature and oxygen partial pressure. Strict control of these parameters allows excellent reproducibility. At substrate temperatures below 200 °C amorphous films are obtained, and at temperatures above 300 °C films with a rutile structure.

| Wavl / nm | 400 | 500 | 600 | 750 | 900 | 1050 |
|-------------|---------|---------|---------|---------|---------|---------|
| n - IAD | 2.60 | 2.44 | 2.37 | 2.31 | 2.29 | 2.27 |
| n - 300 °C | 2.52 | 2.36 | 2.29 | 2.23 | 2.21 | 2.20 |
| k - general | 2.0E-04 | 9.0E-04 | 5.8E-04 | 3.8E-04 | 2.8E-04 | 2.4E-04 |

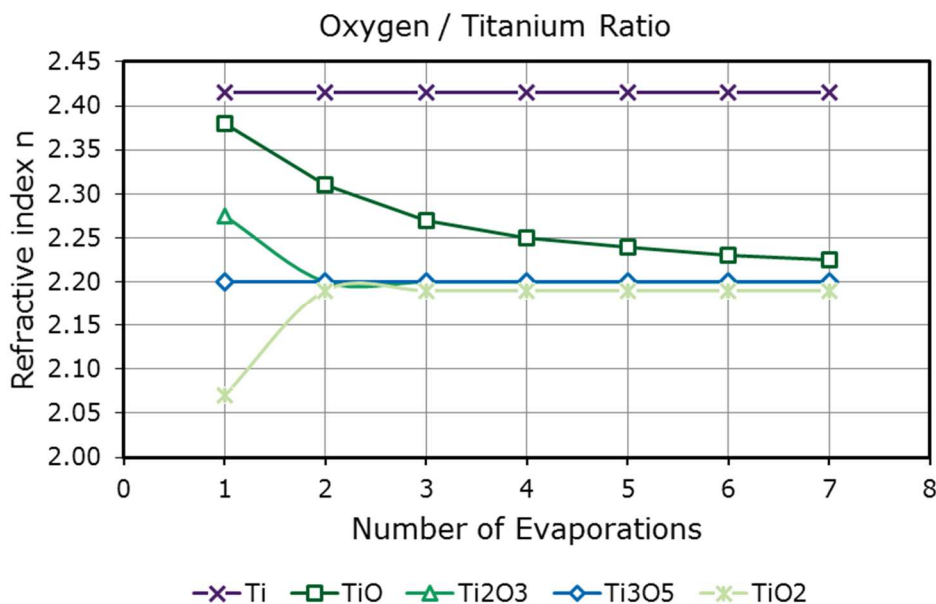


NOTES FOR EVAPORATION

| | |
|-------------------------|---|
| Evaporator source | Resistance heater thermal evaporator Electron beam evaporator |
| Boat / Liner | Ta or W boat Copper crucible or Mo liner |
| Melting temperature | 1750 °C (TiO), 2130 °C (Ti ₂ O ₃), 1855 °C (TiO ₂) |
| Deposition rate | ~0.2 – 0.4 nm/s |
| Oxygen partial pressure | 1-2·10 ⁻⁴ mbar |
| Substrate temperature | Conventional (without IAD): 250 to 350 °C |
| QCR-settings | Density 4.26 g/cm ³ , z-ratio 0.4 |

Upon heating to evaporation temperature, titanium(IV) oxide (TiO₂) releases oxygen. It is advisable to prepare a completely homogeneous melt from a larger amount of substance before evaporation.

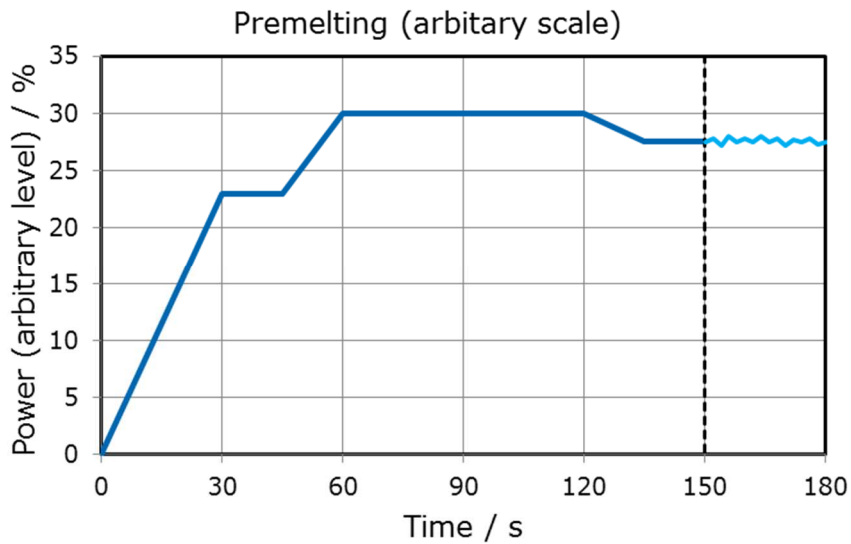
Titanium(III) oxide (Ti₂O₃) is a preferable starting material to make thin films of TiO₂. The material is evaporated reactively. The advantage of Ti₂O₃ over TiO₂ as evaporation material is based on the fact that no oxygen is released during the melting process, thereby reducing the risk of spattering.



Index of refraction of TiO_x films as a function of the number of evaporations for various titanium starting materials, (Appl Opt. 1976 Dec 1;15(12):2986-91, Pulker et al.).



The following figure shows the preconditioning process used:



PRODUCTS

Titanium(II) Oxide Patinal® is available as granules.

| Product Code | Description | Purity* | Dimensions |
|--------------|--------------------------------------|------------------|----------------------------|
| 1.08303 | Titanium(II) Oxide Granules Patinal® | ≥ 99.9 % (3N) | Granules, about 0.8 – 2 mm |

* The purity values are based on the specified trace metals.

Titanium(III) Oxide Patinal® is available as tablets.

| Product Code | Description | Purity* | Dimensions |
|--------------|--------------------------------------|--------------------|--|
| 1.10203 | Titanium(III) Oxide Tablets Patinal® | ≥ 99.95 % (3N5) | Tablets, about 1g, Ø 10.4 mm x h 5.1 mm |

* The purity values are based on the specified trace metals.

Titanium(IV) Oxide Patinal® is available as tablets.

| Product Code | Description | Purity* | Dimensions |
|--------------|---|--------------------|--|
| 1.11771 | Titanium(IV) Oxide Tablets Black Patinal® | ≥ 99.95 % (3N5) | Tablets, about 2g, Ø 12.5 mm x h 5.5 mm |

* The purity values are based on the specified trace metals.

Appearance

| | |
|---------|-------------------|
| 1.08303 | Golden yellow |
| 1.10203 | Dark-violet, dull |
| 1.11771 | Black |



SPECIFICATION

| | 1.08303 | 1.10203 | 1.11771 |
|---------------|-----------|------------|-----------|
| Cobalt (Co) | ≤ 0.001 % | ≤ 0.0005 % | ≤ 0.001 % |
| Copper (Cu) | ≤ 0.005 % | ≤ 0.001 % | ≤ 0.001 % |
| Chromium (Cr) | ≤ 0.005 % | ≤ 0.005 % | ≤ 0.002 % |
| Iron (Fe) | ≤ 0.05 % | ≤ 0.02 % | ≤ 0.01 % |
| Vanadium (V) | ≤ 0.01 % | ≤ 0.01 % | ≤ 0.005 % |

RoHS information

The RoHS compliance information is part of the Certificate of Analysis (CoA) for each batch of Patinal® material.

Application test

Each batch has to pass a specific application test assessing its evaporation behaviour.

Sizes

| | |
|---------|---|
| 1.08303 | Granules 0.8 - 2 mm ≥ 80 % |
| 1.10203 | Tablets h = 4.7 - 5.5 mm Ø = 10.0 - 10.8 mm |
| 1.11771 | Tablets h = 5.0 - 6.0 mm Ø = 12.0 - 13.0 mm |



Quality assurance

Research, production and sales of our Patinal® evaporation materials take place under a certified DIN EN ISO 9001 quality management system and DIN EN ISO 14001 environmental management system. The quality of the materials is assured by our manufacturing processes, in-process controls and quality tests. Each batch is released only after passing our chemical analysis and application tests designed to confirm the suitability of the material for the evaporation process.

Handling precautions

Product safety information required for safe use is not included in this document. Before handling, read product and safety sheets and container labels for safe use, physical and health hazard information. The material safety data sheet is available online at www.patinal.com, from your EMD representative or distributor, or by calling your global Merck KGaA, Darmstadt, Germany, contact.

Disclaimer

Products are warranted to meet the specifications set forth on their label/packaging and/or certificate of analysis at the time of shipment or for the expressly stated duration. EMD MAKES NO REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE REGARDING OUR PRODUCTS OR ANY INFORMATION PROVIDED IN CONNECTION THEREWITH. Customer is responsible for and must independently determine suitability of EMD's products for customer's products, intended use and processes, including the non-infringement of any third parties' intellectual property rights. EMD shall not in any event be liable for incidental, consequential, indirect, exemplary or special damages of any kind resulting from any use or failure of the products: All sales are subject to EMD's complete Terms and Conditions of Sale. Prices are subject to change without notice. EMD reserves the right to discontinue products without prior notice.

EMD, EMD Performance Materials, the vibrant M, Patinal are trademarks of Merck KGaA, Darmstadt, Germany.

