

### Titanium Oxide(II) Patinal®

### Titanium Oxide(III) Patinal®

### Titanium Oxide(IV) Patinal®

#### GENERAL INFORMATION

A number of titanium (sub)oxides, e.g.  $\text{TiO}$ ,  $\text{Ti}_2\text{O}_3$ ,  $\text{TiO}_2$ , can be used as evaporation material for the deposition of titanium dioxide ( $\text{TiO}_2$ ) 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.

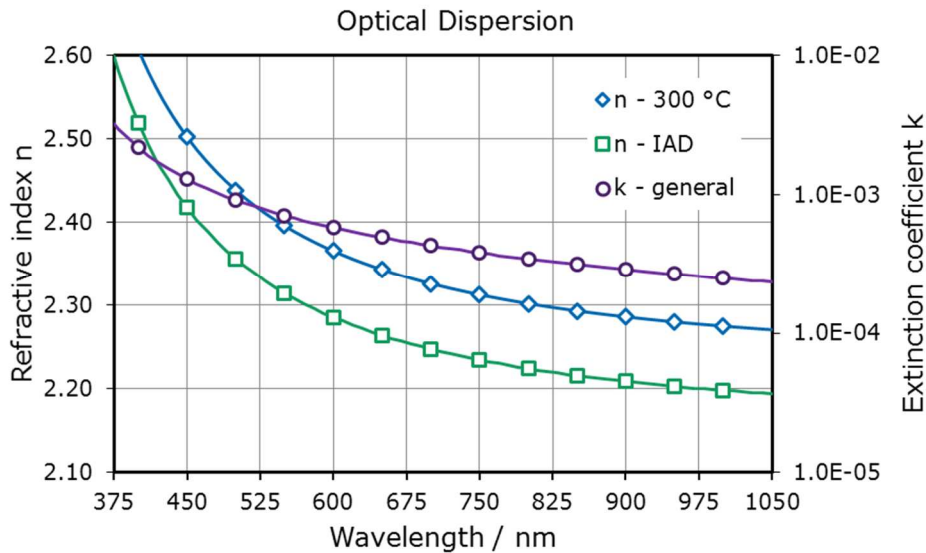
#### AREAS OF APPLICATION

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

#### THIN FILM PROPERTIES

Range of transparency	400 nm – 12 $\mu\text{m}$
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

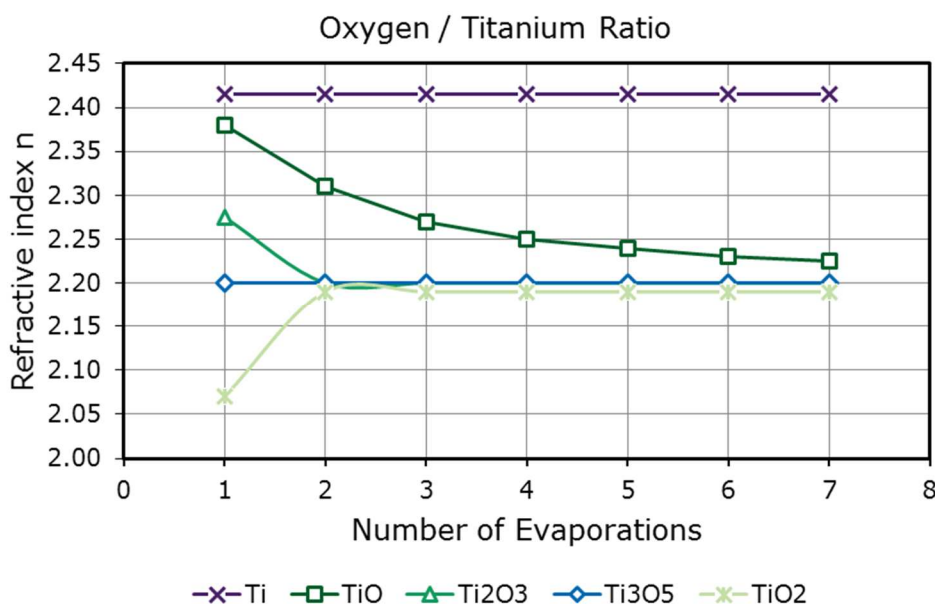


## NOTES FOR EVAPORATION

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 <sub>2</sub> O <sub>3</sub> ), 1855 °C (TiO <sub>2</sub> )
Deposition rate	~0.2 – 0.4 nm/s
Oxygen partial pressure	1-2·10 <sup>-4</sup> mbar
Substrate temperature	Conventional (without IAD): 250 to 350 °C
QCR-settings	Density 4.26 g/cm <sup>3</sup> , z-ratio 0.4

Upon heating to evaporation temperature, titanium(IV) oxide (TiO<sub>2</sub>) releases oxygen. It is advisable to prepare a completely homogeneous melt from a larger amount of substance before evaporation.

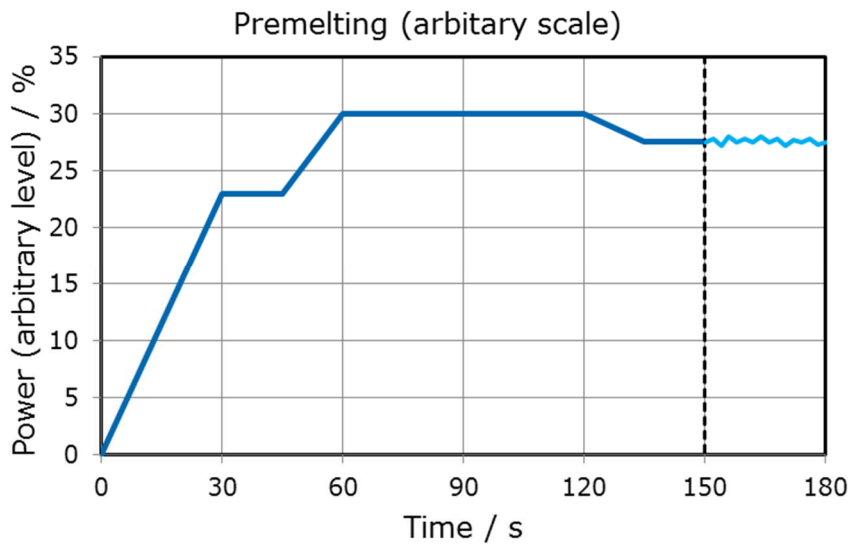
Titanium(III) oxide (Ti<sub>2</sub>O<sub>3</sub>) is a preferable starting material to make thin films of TiO<sub>2</sub>. The material is evaporated reactively. The advantage of Ti<sub>2</sub>O<sub>3</sub> over TiO<sub>2</sub> as evaporation material is based on the fact that no oxygen is released during the melting process, thereby reducing the risk of spattering.



*Index of refraction of TiOx 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:



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## 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](http://www.patinal.com), from your EMD representative or distributor, or by calling your global Merck KGaA, Darmstadt, Germany, contact.

## Disclaimer

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