



# Patinal<sup>®</sup>

## Evaporation Materials

PRODUCT INFORMATION

**Hafnium(IV) oxide Patinal<sup>®</sup>**

# Hafnium(IV) oxide Patinal®



## NOTES AND EXPLANATIONS

We advise our customers regarding technical applications to the best of our knowledge within the scope of the possibilities open to us, but without obligation. Current laws and regulations must be observed at all times. This also applies in respect of any protected rights of third parties. Our suggestions do not relieve our customers of the necessity to test our products, on their own responsibility, for suitability for the purpose envisaged. Quotations from our literature are only permitted with our written authority, and the source must be stated.

The products information sheet is based both on our own investigations and on literature data. The properties of the materials in thin coatings are affected by the choice of deposition conditions. For this reason, coating properties quoted are to be understood as being typical values and cannot be guaranteed. As far as possible, the conditions under which the coating properties were achieved are indicated.

## QUALITY CONTROL

The data given in the "specification" section are guaranteed values which are monitored by checking a representative sample from each production batch using the methods indicated.

The "tests" section describes all the analysis carried out on the product in question. It is our aim here to determine for the material the characteristic data which are of crucial importance for their use and for the quality of the end product.

## SAFETY NOTE

Working safety requires that products which are formed during evaporation be kept in the closed system. If fine dust develops during cleaning of evaporation equipment suitable respiratory protection must be provided (approved respirators).

# Hafnium(IV) oxide Patinal®



## GENERAL INFORMATION

Hafnium oxide is used for thin films with high refractive index in AR coatings, filters, mirrors, and beam splitters for the spectral region from 230 nm to about 7  $\mu\text{m}$ . It is especially suitable for films for 248 nm with low absorption.

Hafnium oxide can only be evaporated with electron beam evaporator. For deposition of homogeneous films with high density elevated substrate temperatures are necessary. Enhancement of density and refractive index can be achieved by using ion assisted deposition processes.

## PROPERTIES OF THE BULK SUBSTANCE

Chemical composition	HfO <sub>2</sub>
Appearance	1.11529: white discs 1.12450: dark grey tablets 1.11626: dark grey granules
Melting temperature	about 2812 °C
Evaporation temperature	about 2400 °C

## ITEMS

The evaporation substance Hafnium(IV)-oxide Patinal® is available in two variations: A light material sintered in air atmosphere, and a dark material sintered in vacuum. The vacuum-sintered material has a slight deficiency in oxygen content, a higher sintering density and a better electric conductivity, compared to the air-sintered material.

1.12450 Hafnium(IV)-oxide UV (grey) tablets about 2 g Patinal®

1.11626 Hafnium(IV)-oxide UV (grey) granules about 1-4 mm Patinal®

1.11529 Hafnium(IV)-oxide UV Discs about 6 g Patinal®

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## SPECIFICATION

Cobalt (Co)	≤ 0.0005	%
Copper (Cu)	≤ 0.0005	%
Chromium (Cr)	≤ 0.005	%
Iron (Fe)	≤ 0.005	%
Titanium (Ti)	≤ 0.005	%
Vanadium (V)	≤ 0.005	%
Zirconium (Zr)	≤ 1.0	%
Application test	conforms	

## RoHS information:

Cd (Cadmium)	≤ 0,01 %
Cr (Chromium)	≤ 0,1 %
Hg (Mercury)	≤ 0,1 %
Pb (Lead)	≤ 0,1 %
PBB (polybrominated biphenyls)	≤ 0,1 %
PBDE (polybrominated diphenyl ethers)	≤ 0,1 %

*The Chromium(VI) concentration (RoHS requirements: ≤ 0.1 %) is always smaller than or equal to the total chromium concentration.*

## Dimensions:

1.12450 Hafnium oxide UV (grey) tablets about 2 g Patinal®

<b>Thickness</b>	<b>about 4 mm</b>
Diameter	about 9 mm

1.11626 Hafnium oxide UV (grey) granules about 1-4 mm Patinal®

Particle size 1-4 mm	≥ 80	%
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1.11529 Hafnium oxide UV Discs Diameter 14 mm thickness 5 mm Patinal®

<b>Thickness</b>	<b>about 5 mm</b>
Diameter	about 14 mm

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## EVAPORATION PROCEDURE

Hafnium oxide requires e-beam heating. All conditions and results described below have been achieved in a turbo-molecular pumped Leybold A 700 Q box coater equipped with an e-beam source. Process control was performed with an Inficon IC 6000.

Prior to deposition of the coatings the material has to be premelted below a shutter (see Fig. 1). In special application, e.g. for production of multilayer coatings, it may be necessary to do premelting in several steps to have a sufficient amount of molten material in the crucible.

## RECOMMENDED COATING CONDITIONS

<b>Evaporation source</b>	<b>electron beam</b>
Crucible	Copper, watercooled
Oxygen partial pressure	$2 \cdot 10^{-4}$ mbar
Deposition rate	0.2 to 0.8 nm/sec
Substrate temperature	30 to 350 °C
Density setting	9.68 g/cm <sup>3</sup>

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Fig. 1 shows the preconditioning process used.

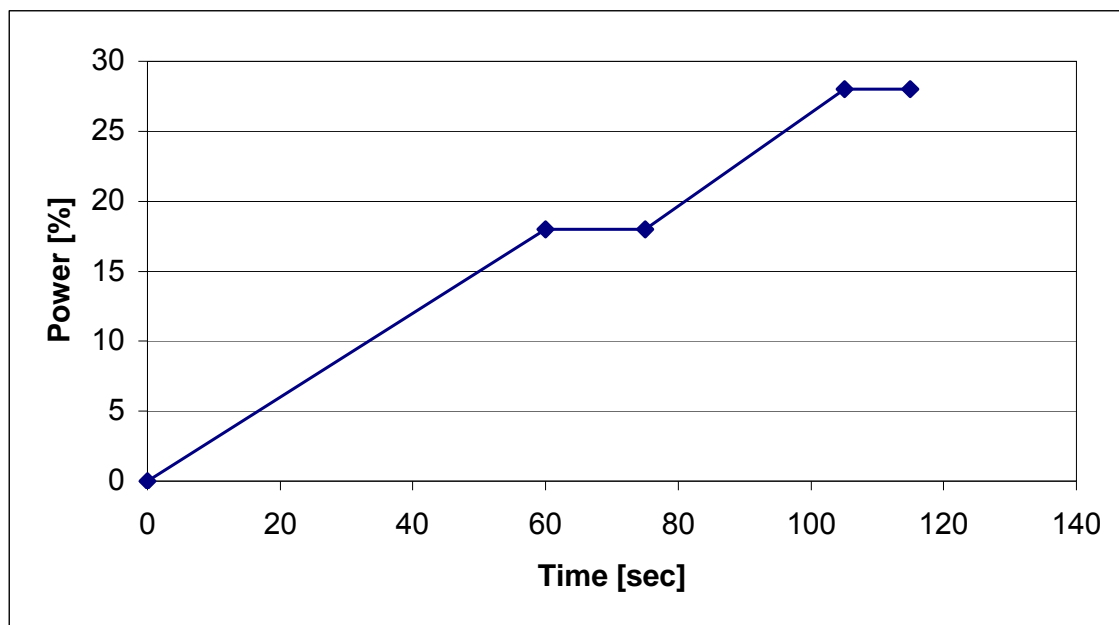


Fig. 1: preconditioning for Hafnium oxide



## PROPERTIES OF THIN FILMS

Fig 2. shows transmission, reflection, and absorption spectrum typical for coatings of Hafnium oxide. The physical thickness is about 220 nm. The coating was deposited onto fused silica at about 180 °C substrate temperature. Transmission and reflection was measured using a so called VW reflectance attachment. The short wavelength absorption edge is about 230 nm. In the IR, the transmission range extends to about 7 μm.

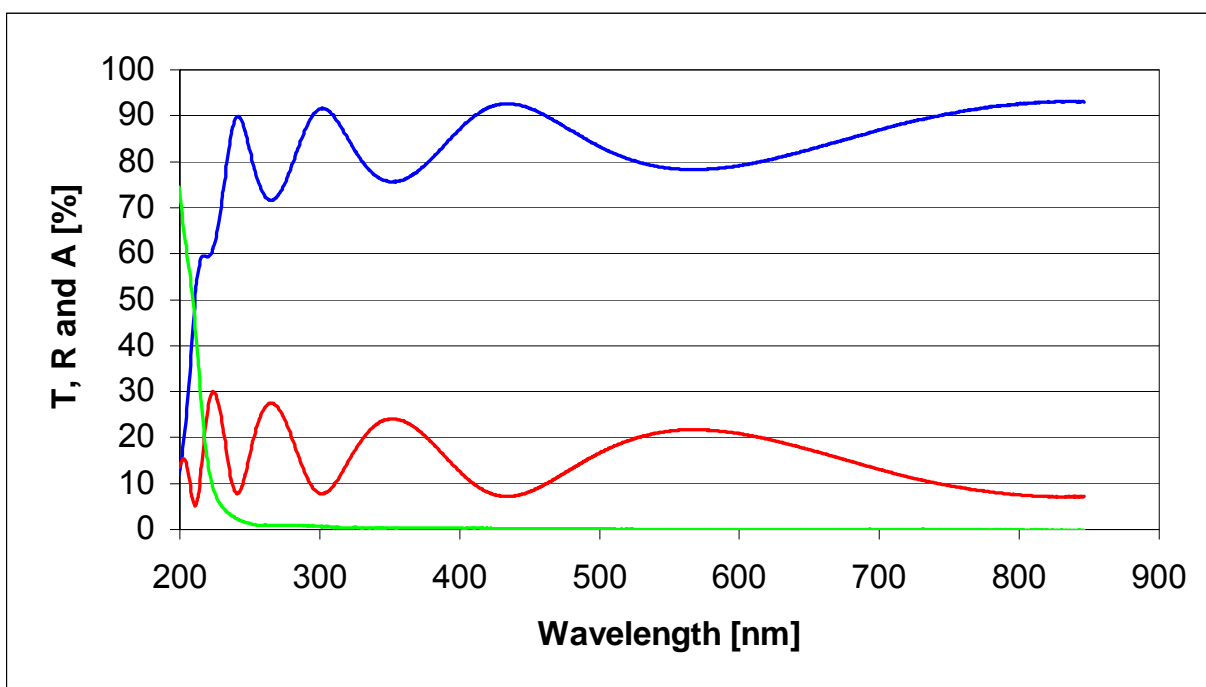


Fig 2: Transmission, reflection and absorption spectrum of Hafnium oxide film

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The following table shows dispersion data for refractive index and absorption index for the Hafnium oxide coating shown in Fig. 1. The data are calculated from the measured transmission and reflection data.

Wavelength [nm]	Refractive index	Absorption index
230	2.232	$6 \times 10^{-3}$
250	2.161	$1 \times 10^{-3}$
300	2.064	$2 \times 10^{-4}$
400	1.984	$< 1 \times 10^{-4}$
500	1.952	$< 1 \times 10^{-4}$
600	1.935	$< 1 \times 10^{-4}$
700	1.925	$< 1 \times 10^{-4}$
800	1.919	$< 1 \times 10^{-4}$

## AREAS OF APPLICATION

Coatings made of Hafnium oxide are suitable for following applications:

AR coatings for UV, VIS und NIR

multilayer coatings for filters, mirrors, beamsplitters etc.



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## REFERENCES

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