Patinal®

Evaporation Materials

PRODUCT INFORMATION

Aluminium oxide Patinal®

EMD Chemicals Inc. Phone 856-423-6300
Internet: www.emdchemicals.com Mail: optics@emdchemicals.com

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).

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GENERAL INFORMATION

Formula	Al_2O_3
Molecular weight	101.96 g/mol
Composition	Al 52.93 % O 47.07 %
Appearance	Colorless glass-like granules
Melting point	2043 °C

ITEMS AND PACKAGING SIZES

015345.0100	Aluminium oxide granules about 1-3 mm Patinal® 100 g pack
015345.1000	Aluminium oxide granules about 1-3 mm Patinal® 1 kg pack
001058.0100	Aluminium oxide granules about 1-5 mm Patinal® 100 g pack
001058.1000	Aluminium oxide granules about 1-5 mm Patinal® 1 kg pack
001062.0100	Aluminium oxide Tablets about 0,6 g Patinal® Diameter 10 mm, Thickness 4.5 mm 100 g pack
001062.1000	Aluminium oxide Tablets about 0.6 g Patinal® Diameter 10 mm, Thickness 4.5 mm 1 kg pack

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SPECIFICATION

Cobalt (Co)	≤ 0.0005 %
Chromium (Cr)	≤ 0.001 %
Copper (Cu)	≤ 0.0005 %
Iron (Fe)	≤ 0.005 %
Vanadium (V)	≤ 0.0005 %
Particle size	≥ 80 %
Application test	conforms

APPLICATION TEST

Equipment: Leybold L 560
Electron Beam Evaporator (EB) ESV 6 with water-cooled copper crucible

Three crucibles of a 5-crucible plate are filled as full as possible with granules and placed in the EB. The apparatus is evacuated to a pressure of less than $2 * 10^{-5}$ mbar and the regulator for the substrate heating is set to 250 °C. When the pressure has been reached - but at the earliest after 20 minutes - the substance is heated in the first crucible within 60 sec to evaporation temperature (corresponding to 14 % power). After further 20 sec, the power is increased to 18 % over the course of 20 sec. The aperture is opened 20 sec later and a λ/2 coating is deposited on a test glass (BK7, with a matt finish on the rear) at a rate of 1.0 nm/sec. The reflection (λ = 550 nm), the pressure and the rate are recorded during the deposition. The refractive index of the coating is calculated from the maximum reflection.

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The crucible loads 2 and 3 are treated in the same way.

The properties of the coating depend, i.a., on the focusing of the electron beam. In order to obtain good and reproducible results, the energy of the beam must be distributed as evenly as possible over the surface of the granules. In addition, the heating and waiting times indicated must be observed in all cases.

A batch is not released as evaporation substance if

1. the substance splashes during the experiment,

2. the refractive index of 1.63 - 1.68 is not achieved under the stated conditions,

3. the pressure increases to above $1 * 10^{-4}$ mbar during the experiment

4. the rate is not constant during the coating or differs greatly from the expected value at the pre-specified power or if a substantially different power is necessary for the pre-specified rate (considerable adjustment of the automatic system).

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NOTES FOR EVAPORATION

Evaporator	Electron beam evaporator with water-cooled copper crucible
Evaporation temperature	2000 - 2200 °C
Deposition rate	about 1 nm/sec
Density	3.97 g/cm^3
z-ratio	0.336

In order to avoid splashing during evaporation one must work with low energy density or with a greatly extended beam spot. The characteristics of vapor deposited films depend on the substrate temperature during evaporation. At temperatures around 300 °C especially compact, hard films with high refractive index are obtained.

Aluminium oxide can be evaporated reactively as well as non-reactively. For reactive evaporation typically an oxygen pressure of $1 * 10^{-4}$ mbar should be selected.

APPLICATION

Protective layers

Antireflection (AR) coatings, e.g. 3-layer AR-coating on glass

- Aluminium oxide λ/4)
- Substance H1 highly refractive λ/2)
- Magnesium fluoride λ/4)

High reflecting coatings, e.g. in combination with SiO_2 for laser mirrors in the UV

Dielectric layers for electronic applications, e.g thin film hybrid circuits

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PROPERTIES OF THE THIN FILM

Range of transparency	200 - 5000 nm
Refractive index	1.72 at 248 nm 1.58 at 500 nm and 120 °C substrate temperature 1.66 at500 nm and 250 °C substrate temperature
Absorption index	< 0.001 at 248 nm $2.3 * 10^{-5}$ at 515 nm $8.0 * 10^{-6}$ at 1060 nm
Dielectric constant	8.0
Dielectric loss tan δ	0.004
Electrical breakdown field	2.9 - 4.6 MV/cm
Tensile stress	$1.3 * 10^{6}$ N/m^2 (86 kp/inch^2)
Thermal conductivity	0.33 W/cm*K
Structure	amorphous
Etching of vapor deposited films	with Phosphoric acid at 90 °C with Hydrofluoric acid with a mixture of 2.4 % by vol. of Hydrofluoric acid and 1.6 % by vol. of Nitric acid in water

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PROPERTIES OF THE SOLID SUBSTANCE

Crystalline form	α Al_2O_3 (Corundum): rhombic γ Al_2O_3 cubic
Solubility	insoluble in water very slightly soluble in acids and alkalis
Density (α Al_2O_3)	3.97 g/cm^3
Melting point	2043 °C
Thermal conductivity	0.27 W/cm∗K
Thermal expansion coefficient at 50 °C for synthetic Corundum single crystals	
parallel to the c-axis	6.7 ∗ 10^{-6} K^{-1}
perpendicular to the c-axis	5 ∗ 10^{-6} K^{-1}
Specific heat at 26.85 °C	0.777 J/g K
Hardness (Mohs)	9
Young's modulus for synthetic Corundum	5.1 ∗ 10^{11} N/m^2
Specific resistance (at 25 °C)	~ 10^{16} □ cm
Dielectric constant for synthetic Corundum single crystal	
parallel to the c-axis	11.2
perpendicular to the c-axis	13.2
Range of transparency	200 - 5000 nm
Refractive index	1.765

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