MAGOXID-COAT®/ KEPLA-COAT®

functional finishing of light metals
through plasma-chemical coating

aalberts surface technologies

MAGOXID-COAT® / KEPLA-COAT®

with Aalberts surface technologies your components are in safe hands

Alberts surface technologies is the right market partner for you when it comes to surface finishing of light metals.

- MAGOXID-COAT® and KEPLA-COAT® combine technical know-how with outstanding process technology
- Experience from thousands of projects in all key industries
- Diversity of processes for individual component characteristics
- Highest precision – own electrolytes
- High light-absorption capacity of black layers
- Components up to 2 m in length can be coated
- Alberts surface technologies Berlin – the centre of excellence for plasma-chemical processes

Fully automatic large part unit for plasma-chemical coatings in the plant in Berlin.

All technical values published in this brochure are subject to the test conditions specified. We therefore emphasise that the applications and operating conditions, along with the end user's practical experience, will ultimately determine the level of performance achieved by the coating and/or coating system.

what is MAGOXID-COAT® and KEPLA-COAT®?

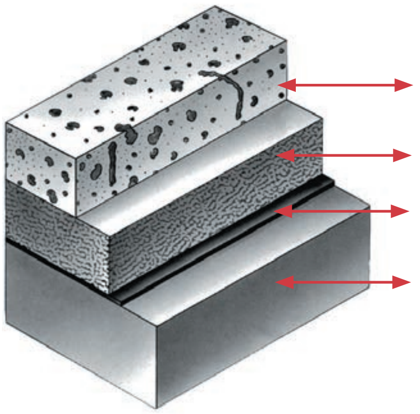
Both processes are anodic plasmachemical surface treatments with functional characteristics, which – added up – cannot be achieved with conventional electroplating. MAGOXID-COAT® can be used to apply finishes to magnesium alloys, while KEPLA-COAT® is designed for use on aluminum and titanium alloys.
The plasma-chemical process is used to produce oxide-ceramic layers which, in addition to providing a high level of protection against wear and corrosion, also fulfil requirements regarding hardness, uniform layer formation, fatigue strength, dimensional accuracy or temperature load capacity.

how are these layers built-up?

MAGOXID-COAT® and KEPLA-COAT® are electrolytic processes which make use of an external power source. The workpiece being processed takes on the function of the anode. The surface of the material is transformed into corresponding oxides. The electrolytes used are saline solutions. Anodising takes place as a plasma is discharged in the electrolyte on the surface of the workpiece being processed. The effect of the oxygen plasma produced in the electrolyte on the metal surface causes partial short-term surface melting and a bonded oxide ceramic-metal compound forms on the workpiece. Due to an increase in volume, 50% of the produced oxide layer grows outwards. Edges, cavities and relief designs are coated uniformly. In other words, there is none of the edge build-up that occurs in conventional electroplating processes.

the structure of the layers

On an initial thin layer, the barrier layer, which is in direct contact with the metal substrate, there is a low pore-count oxide ceramic layer. This layer carries a further oxide ceramic layer of equal thickness, which does have a high pore-count. The second layer may serve as adherent base for paint or impregnations such as, those with PTFE.



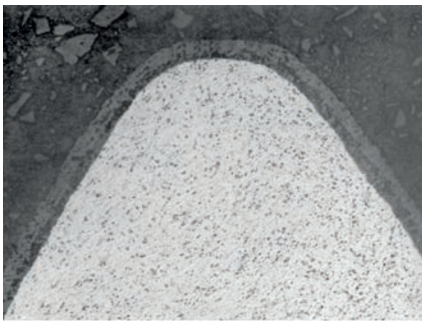
1 = High pore-count oxide ceramic layer

2 = Low pore-count oxide ceramic layer

3 = Barrier layer ~ 100 nm

4 = Aluminum-, titanium- or magnesium-substrate

The schematic diagram provides a graphic representation of the oxide ceramic /metal bonding created by the MAGOXID-COAT® or KEPLA-COAT® process



Metallographic microsection of a KEPLA-COAT® layer on a thread ridge.

MAGOXID-COAT® / KEPLA-COAT®

fields of use and applications

MAGOXID-COAT® finished materials.

With a density of just 1.74 g/cm³, magnesium is the lightest of the metals used for structural purposes. Magnesium alloys treated with MAGOXID-COAT® have proven themselves over many years.
MAGOXID-COAT® is suitable use with all common magnesium alloys, such as AZ31, AZ61, AZ81, AZ91, AM20, AM50 or AM60 – along with alloys containing noble earths and zirconium such as ZE41 and WE43.

chemical composition and structure

This conversion surface consists of a crystalline oxide ceramic layer, which contains a large proportion of highly resistant compounds such as spinels, e.g. $MgAl_2O_4$.

layer thicknesses and tolerances

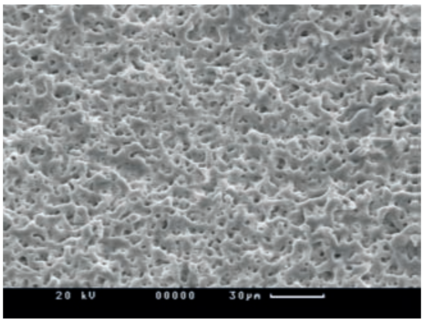
The maximum possible coating thickness depends on the alloy being treated. In the case of alloy AZ91, a layer of 10-20 µm is sufficient to fulfill functional requirements. With MAGOXID-COAT®, a tolerance of ±5 µm, with an average coating thickness of 20 µm is normal.

wear resistance

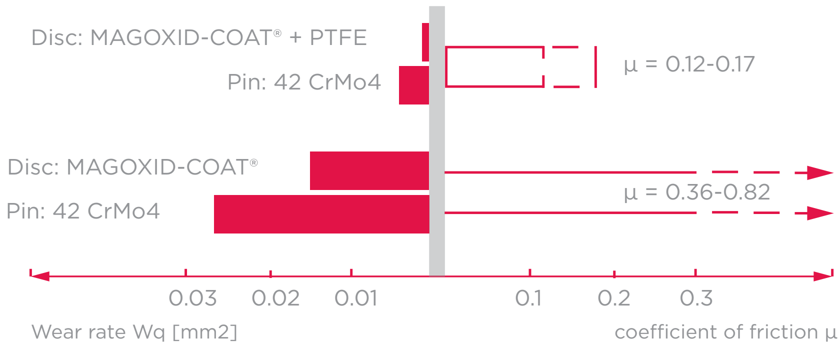
Its high density and composition makes the MAGOXID-COAT® layer highly resistant to wear.

anti-friction characteristics

The surface structure of the MAGOXID-COAT® layer permits the reception of PTFE or other lubricants. The oxide layer is a solidified melt with corresponding roughness profile (see SEM photograph left). It shows that there are no peaked roughnesses which may lead to layer break aways.



SEM image of a MAGOXID-COAT® layer.



Friction wear test with pin-disc-tribometer according to DIN 50 324 (Test conditions:
F_N = 10 N,
v = 0.1 m/s,
s = 1,000 m)

Over 25 years of practical experience with the plasma-chemical coating of light metals. Here a clarification of details in preparation for the next batch run in the Berlin plant takes place.

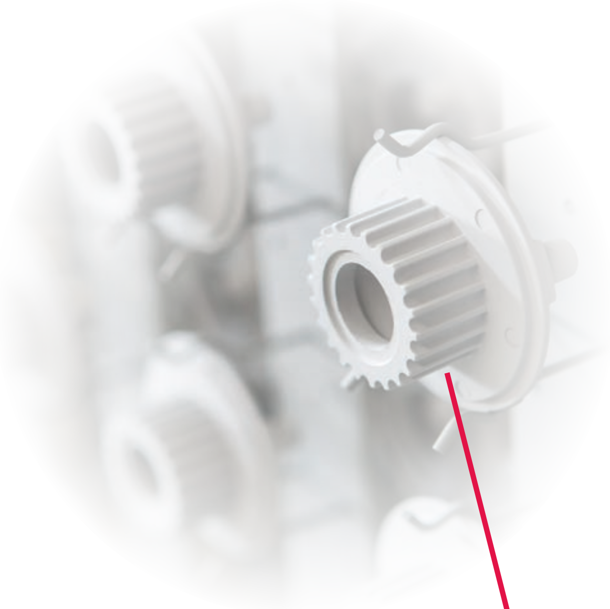
MAGOXID-COAT® / KEPLA-COAT®

fields of use and applications

1/ Magnesium component: before (left) and after (right) the plasma-chemical coating.

2/ MAGOXID-COAT® layer on magnesium toothed wheels: ideal for the lightweight construction of the Brose bottom bracket engine.

1/



2/

coating characteristics

corrosion resistance

Evaluation criterion for the corrosion resistance is the neutral salt spray test according to DIN EN ISO 9227. The tested base material was AZ91HP (plates from Norsk Hydro).

The MAGOXID-COAT® layers had a layer thickness of 25 µm. The results without and with Epoxide Powder Coating are shown in the table below.

Corrosion resistance of MAGOXID-COAT® layers according to DIN EN ISO 9227 and evaluation according to DIN EN ISO 10 289:

MAGOXID-COAT®	=	80 - 100 h
MAGOXID-COAT® + Epoxide Powder Coating	=	750 - 1,000 h

fatigue strength

Tests were carried out to determine the DIN 50 100-standard fatigue strength of the combination AZ91HP/MAGOXID-COAT® (20 µm). The resulting stress number curves show that the application of MAGOXID-COAT® treatment has only an insignificant negative effect on the fatigue strength of base material AZ91HP.

fatigue strength

(Point/Plate) 13 V/µm according to ISO 2376

appearance and color

White-grey (AZ91); tending to violet color tones (WE43, ZE41)

hardness

The hardness of MAGOXID-COAT® coatings is not clearly determinable due to the thin layer thickness and the soft base material.

roughness (according to DIN 4768)

E.g. AZ91: R_a = 1.6 µm with a layer thickness of 20 µm, initial roughness R_a = 0.5 µm

exhalation rate

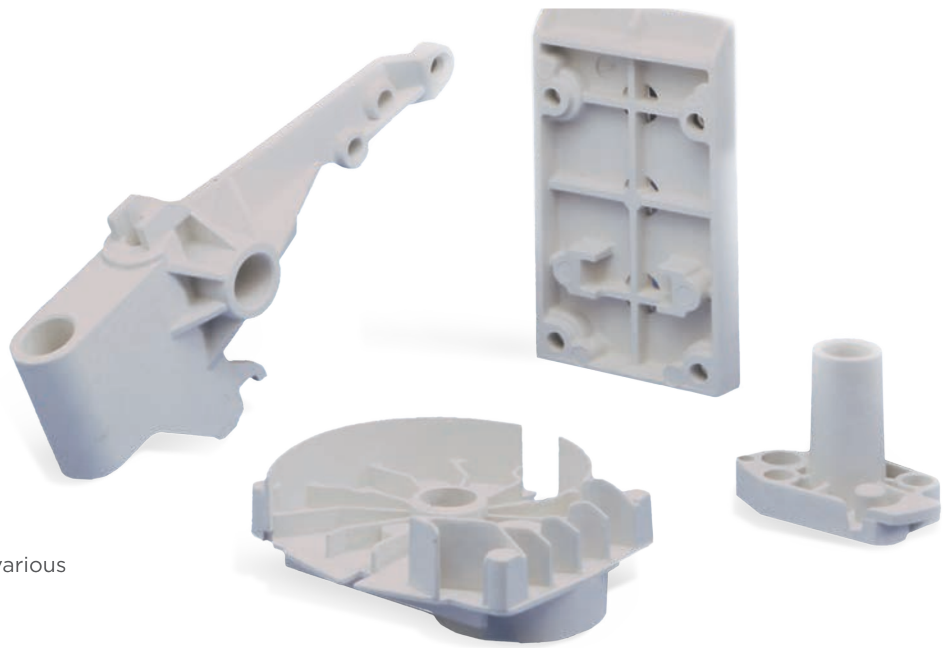
This was measured under specific vacuum conditions: 10^{-6} Pa · l · s^{-1} · cm^{-2}

Residual gas analysis revealed only slight traces of H_2O.

TML < 0.025 %

RML < 0.04 %

CVCM = 0 %



MAGOXID-COAT® treatment of various die-cast components.

MAGOXID-COAT® / KEPLA-COAT®

coating characteristics

KEPLA-COAT® finishes materials

KEPLA-COAT® is suitable for almost all wrought, cast and die-cast aluminum alloys. We gladly offer technical advice on the proper alloy selection.

chemical composition and structure

KEPLA-COAT® layers applied to aluminum alloys consist up to 60 % of α-Al_2O_3 (corundum), the rest consists predominantly of γ-Al_2O_3 and α-AlOOH (boehmite).

layer thicknesses and tolerances

Layer thicknesses depend on the alloy being treated and can be up to 150 µm. The common thickness for functional aluminum components is usually 40-60 µm.
The layer thickness tolerance for machined surfaces likewise depends on the alloy and is ±10 µm for a layer thickness of 50 µm. In special cases, tighter tolerances are possible.

dimensional accuracy

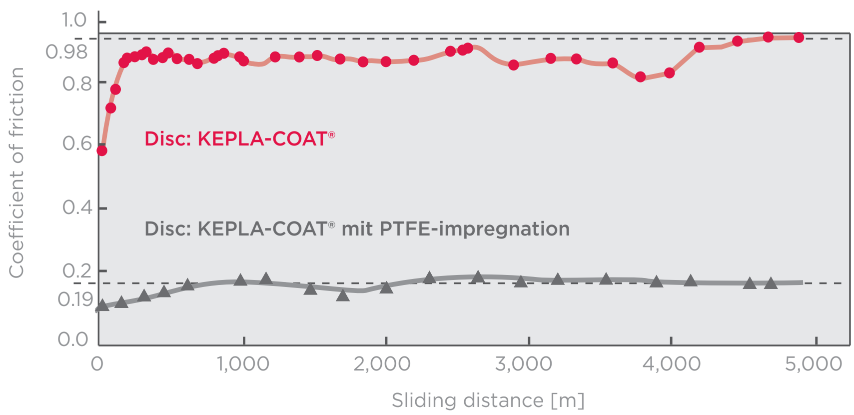
Layer build-up approx. 50 % into the material, 50 % grow outwards. There is no material deformation.

antifriction characteristics

The surface structure of the KEPLA-COAT® layer permits the application of PTFE or other lubricants. The oxide layer is a solidified melt with corresponding roughness profile. There are no peaked roughnesses which may lead to layer break-aways.

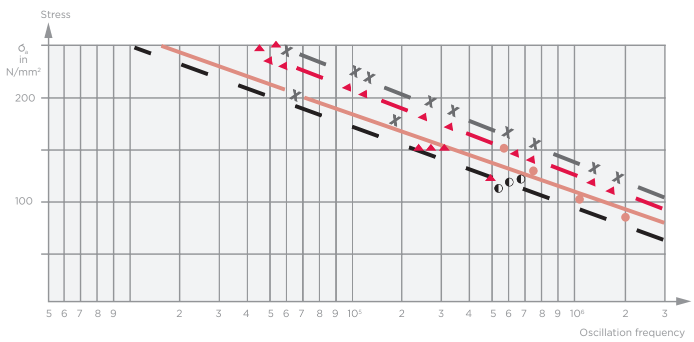
fatigue strength

KEPLA-COAT®-treated substrates show a considerably greater fatigue strength than substrates with comparable layers. It is 60-80 % of the initial strength of the base material.



Sliding wear test with pin-disc-tribometer according to DIN 50 324
F_N = 5N, v = 10 cm/s
Pin: 100Cr6,
Disc: AlMgSiPb (EN AW-5012)
Red curve:
Disc KEPLA-COAT®; 40 µm
Coefficient of friction:
Start: 0.61 – Finish: 0.98
Grey curve:
Disc KEPLA-COAT®; 40 µm
with PTFE impregnation
Coefficient of friction:
Start: 0.11; Finish: 0.19

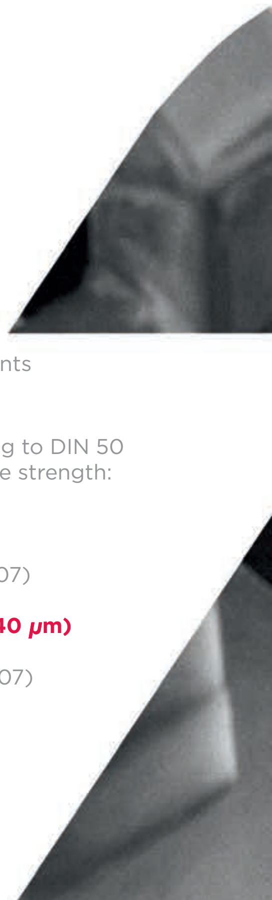
Average value of 3 measurements

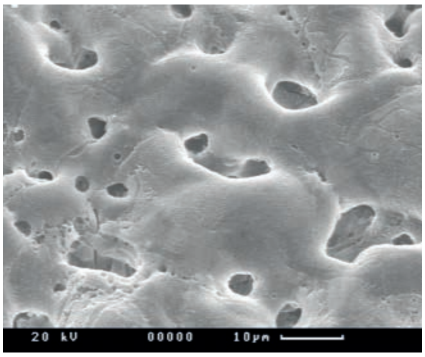


Stress-number curves according to DIN 50 100 for determination of fatigue strength:

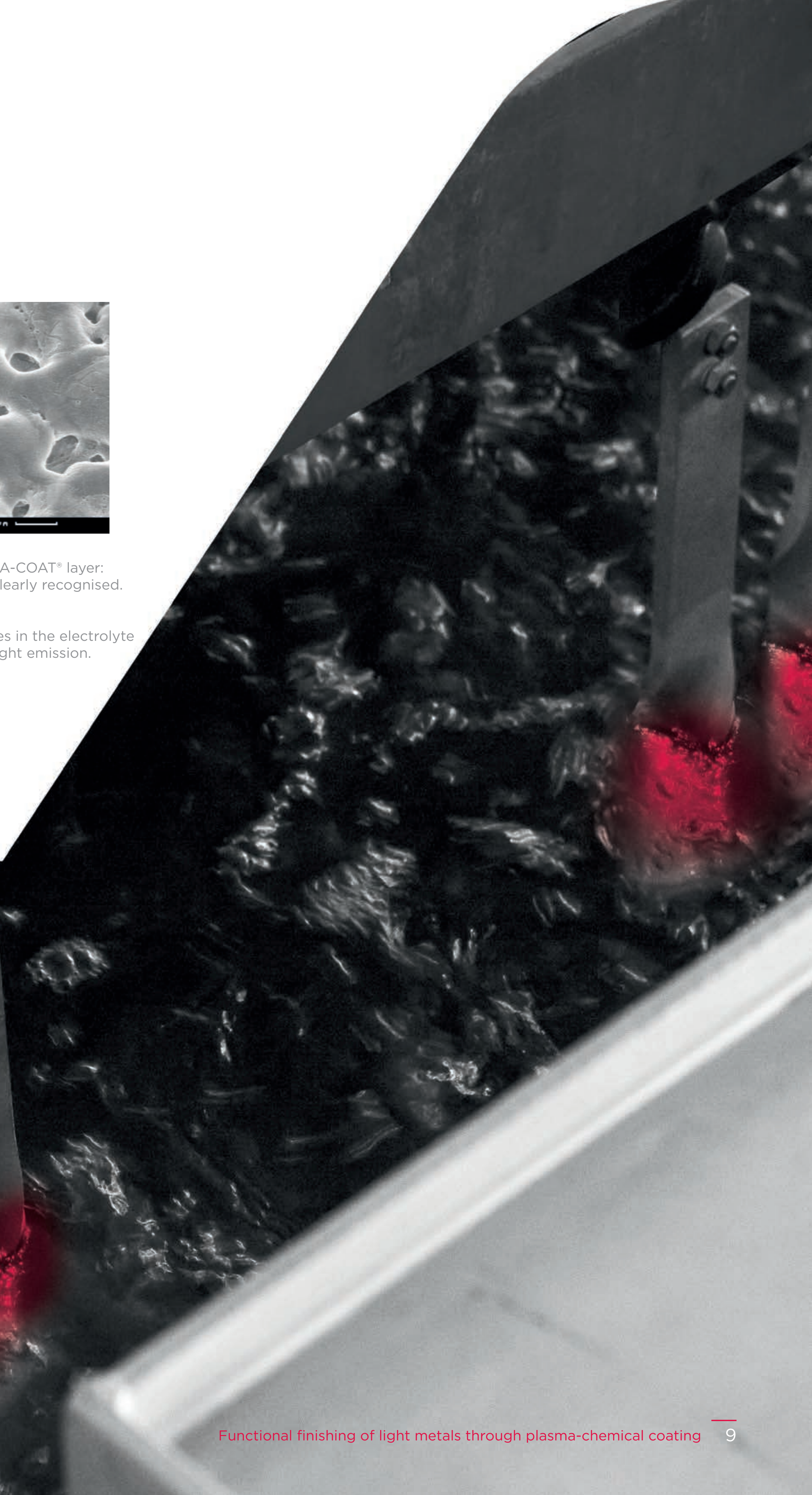
Original state of the alloys
● AlSi1MgMn (EN AW-6082)
X AlCu4PbMgMn (EN AW-2007)

Treated with KEPLA-COAT® (40 µm)
◐ AlSi1MgMn (EN AW-6082)
▲ AlCu4PbMgMn (EN AW-2007)





1/ SEM image of a KEPLA-COAT® layer:
The pores can be very clearly recognised.



2/ The plasma discharges in the electrolyte are shown by a strong light emission.

coating characteristics

corrosion resistance

White KEPLA-COAT® layers applied to aluminum alloys withstand corrosive gases such as chlorine and boron trichloride. A layer thickness of 30 µm on AlSi1MgMn (EN AW-6082) shows a corrosion resistance of more than 1,000 hours (rating Rp 10/9) in the salt fog test according to DIN EN ISO 9227 /DIN EN ISO 10 289.

wear resistance

Wear-resistance tests using the Taber wear-testing device revealed excellent wear resistance properties. The rate of wear is similar to that detected in hard anodic oxide coatings applied to aluminum.

dielectric strength

(Point/Plate) 10 V/µm according to ISO 2376

appearance and color

Generally grey-white

hardness

The hardness of the KEPLA-COAT® layer depends on the composition and structure of the base material. In the case of the alloy AlSi1MgMn (EN AW-6082), with a layer thickness of 30-50 µm, this value lies within a range of 500-1500 HV 0.025. Due to the specific formation of the oxide layer only the so-called "apparent hardness" is measured which largely depends on the volume of the pores. In cases of doubt, a sample job can be carried out for the purposes of determining the achievable levels of hardness and wear resistance.

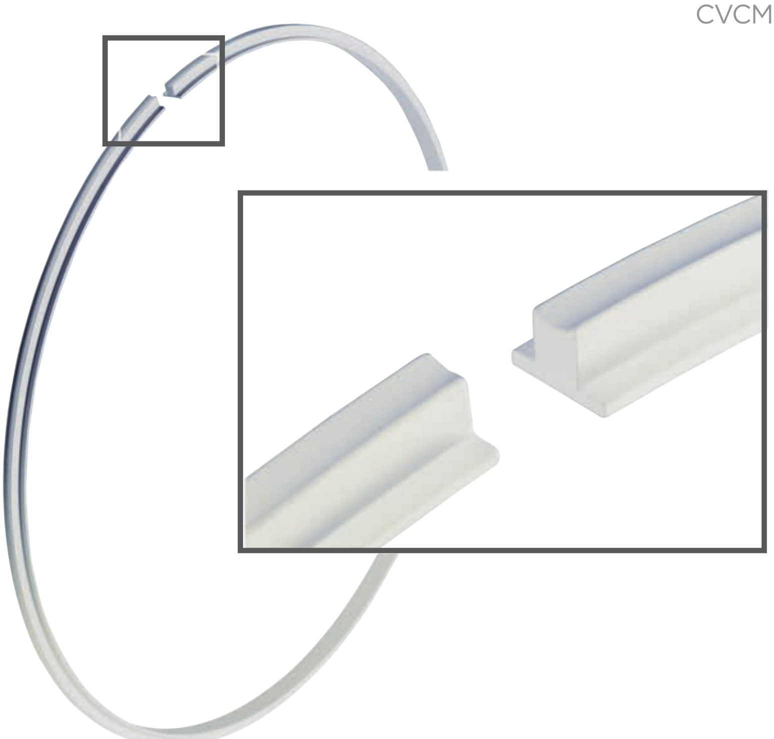
roughness (according to DIN 4768)

E.g. AlSi1MgMn (EN AW-6082): R_a = 1.2 µm with a layer thickness of 20 µm, initial roughness R_a = 0.14 µm

exhalation rate

This was measured under specific vacuum conditions: 10^{-6} Pa · l · s^{-1} · cm^{-2}. Residual gas analysis revealed only slight traces of H_2O.

TML < 0.025 %
RML < 0.04 %
CVCM = 0 %

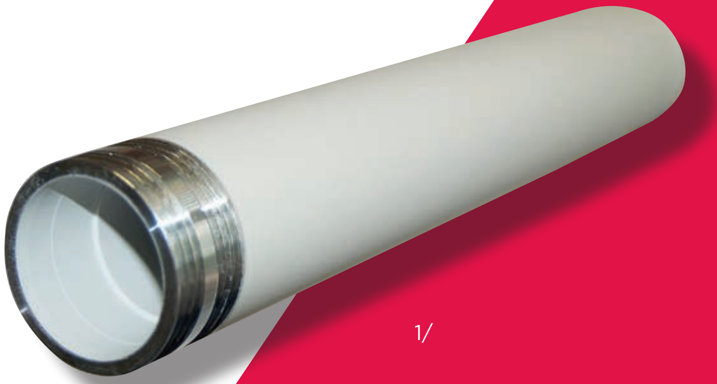


Centering rings made of AlSi1MgMn (EN AW-6082) are used as sealing elements for the connection of turbo molecular pumps with vacuum plants. In the event of a rotor-stator crash, the worst imaginable type of malfunction, the energy of rotation on the rotor is transmitted to the casing within milliseconds. In order that the centering rings can transmit via friction the developing high torques to the system, and to avoid a twisting of the pump in the flange, the surfaces must be extremely wear-resistant and must have a defined roughness.

For this purpose they are treated with the KEPLA-COAT® process. With this coating the coefficient of friction of the surface is increased, depending upon the friction counterpart, by a factor of 2 to 3. Furthermore, the 25 µm thick, very adhesive layer improves the corrosion resistance of the aluminum substrate.

1/ KEPLA-COAT® coated tube with uncoated thread.

2/ One example of the most demanding applications involving KEPLA-COAT®-treated components made of aluminum alloys: geometrically high-precision rotors made of AlSi1MgMn (EN AW-6082) that are fitted to the turbo molecular pumps used in plasma-etching processes.
A highly decisive factor in this area is the need for protective surfaces that are completely free of pores and cracks, and which are not affected by reaction gases.
The extremely high turning speed of the rotors means that they are also subject to correspondingly extreme mechanical stress. Conventional surface protection treatments – such as anodic oxidation, chromium or nickel plating – could not withstand these stresses.



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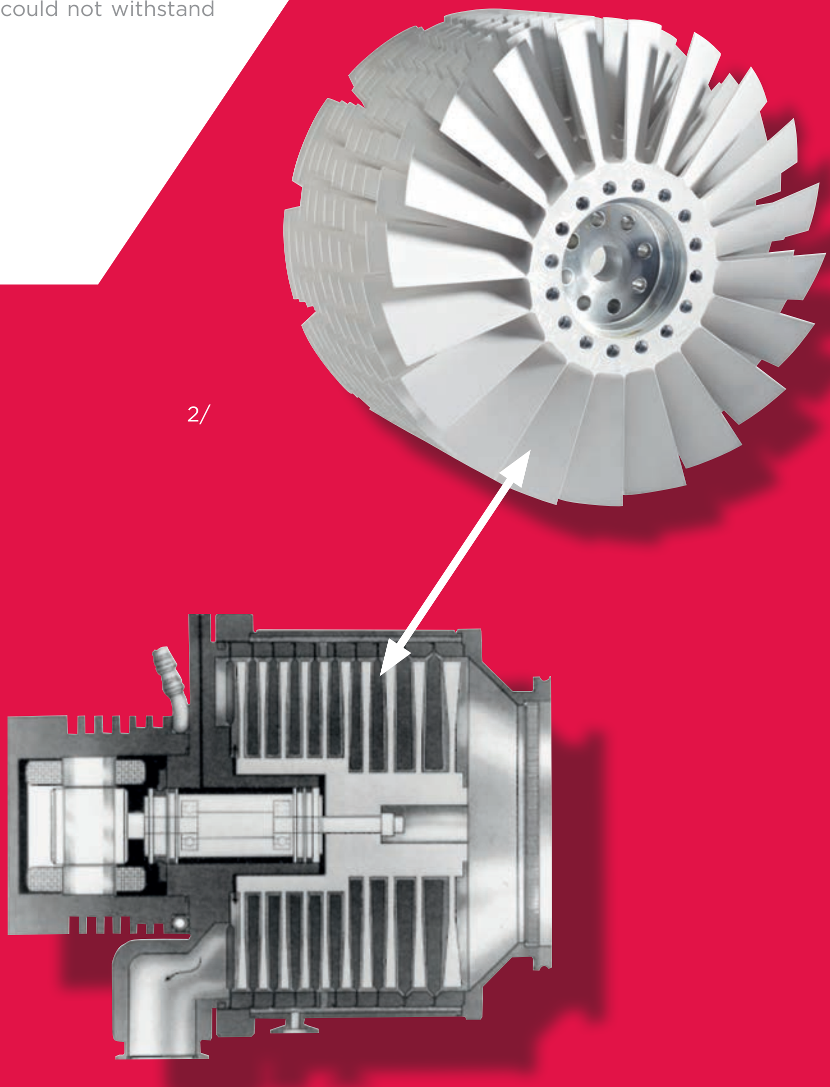

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MAGOXID-COAT® / KEPLA-COAT®

process variants MC black and KC black

the process

Black oxide ceramic layers can be applicated on magnesium alloys (MAGOXID-COAT® black) as well as on aluminum and titanium alloys (KEPLA-COAT® black). Both finishes contain fade-resistant and chemically inert spinels.

Fields of use and applications

MC black and KC black are suitable, for example, as internal coatings for optical components and also for fine precision screw threads. They are also ideal for application to heating radiators, for use in vacuum technology and in the aerospace sector.

typical thicknesses

8–15 µm (MAGOXID-COAT® black).
5–10 µm (KEPLA-COAT® black for aluminum-based material).
5–10 µm and 25–50 µm (KEPLA-COAT® black for titanium-based material).
Layer thickness tolerances depend on the alloy being treated.

coating characteristics

roughening (measurements according to DIN 4768)

After a 10 µm MAGOXID-COAT® black treatment, an initial value of R_a = 0.5 µm is increased to R_a = 1.1 µm. An initial roughness of R_a = 0.14 µm is transformed after a 10 µm KEPLA-COAT® black treatment to a roughness value of R_a = 0.5 µm.

temperature resistance

In the case of coatings applied to aluminum and magnesium alloys, temperature resistance is entirely dependent on the base material. KEPLA-COAT® black finishes applied to titanium alloys can withstand temperatures of up to 700 °C.

fatigue strength

The crystalline structure of these surface coatings means that there is only a marginal negative influence on fatigue strength.

exhalation rate

This was measured under specific vacuum conditions: 10^{-6} Pa · l · s^{-1} · cm^{-2}.
Residual gas analysis revealed only slight traces of H_2O.

TML	< 0.025 %
RML	< 0.04 %
CVCM	= 0 %

MAGOXID-COAT® black:

Optical and thermal characteristics

Layer thickness:	10 µm
Absorption coefficient:	> 95 %
Degree of reflection:	< 5 %
Color difference:	24 %
Brightness rating:	7 %
Emissivity:	81 %

KEPLA-COAT® black:

Optical and thermal characteristics

Layer thickness: 8 µm for Aluminum base material

Absorption coefficient:	> 95 %
Degree of reflection:	< 5 %
Color difference:	29 %
Brightness rating:	30 %
Emissivity:	65 %

Layer thickness: 8 µm for Titan base material

Absorption coefficient:	> 95 %
Degree of reflection:	< 5 %
Color difference:	25 %
Brightness rating:	15 %
Emissivity:	80 %

corrosion resistance

10 µm-thick black KEPLA-COAT® layers on AlSi1MgMn (EN AW-6082) withstand a test period of up to 500 hours (rating Rp 5) in the salt-spray chamber according to DIN EN ISO 9227/DIN EN ISO 10 289.

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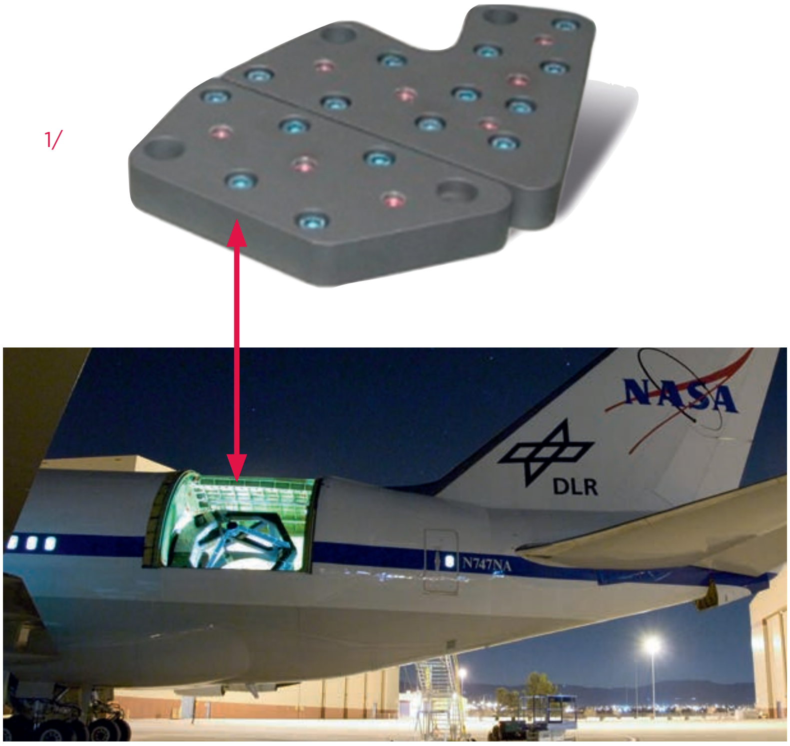

1/ KEPLA-COAT® coated titanium fittings for the mirror cells of the "SOFIA" IR telescope. Titanium fittings and titanium pins are located near the infrared beam path on the telescope structure.

To minimize light scatter, they are provided with a deep black, light-resistant, oxide ceramic coating (KEPLA-COAT® black).

2/ We gladly offer technical advice on the proper material and coating selection.

2/

MAGOXID-COAT® / KEPLA-COAT®

process variants
MC black and KC black

1/ Ring covers made of an aluminum alloy for stadium floodlights get a black KEPLA-COAT® layer, which is resistant to temperature and UV-radiation.

2/ A black MAGOXID-COAT® layer on housing and further components for an optical vehicle sensor reduces light reflections and cares for a good corrosion protection.

3/ Endoscopes for medical technology made of a titanium alloy. The black KEPLA-COAT® layer minimizes stray light and is optically perfect black.

4/ Surface milling machine head in magnesium design: Better tool handling through less weight and reduced machine load through lower inertia and smaller centrifugal forces.
A MAGOXID-COAT® layer protects against wear and corrosion.

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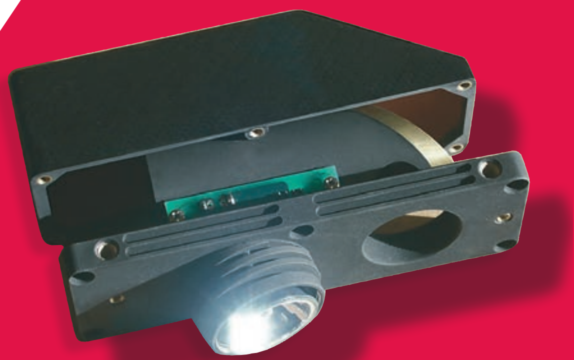
3/



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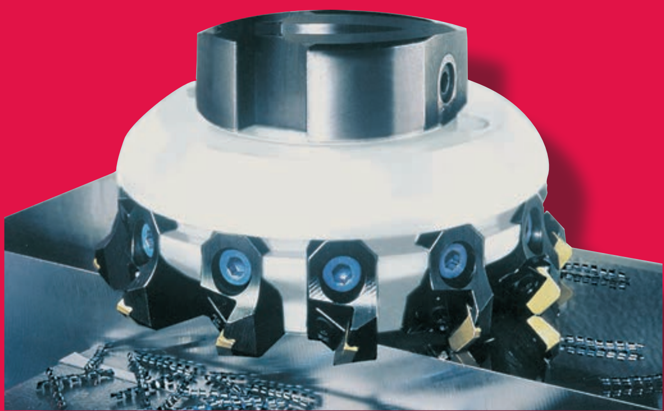


4/

oxide-ceramic layers for light metals

Motivation for the use of light metals is, of course, to save component weight. Magnesium alloys also offer advantages in the casting process. Finer structures can be created.

The plasma-chemical processes ensure wear- and corrosion-resistant surfaces (white variants) or UV-resistant and light-absorbing layers (black variants).

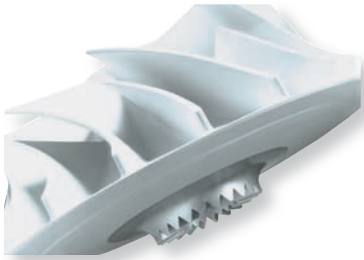
1/ A 40 µm thick KEPLA-COAT® layer provides the necessary corrosion and wear protection for a bore of a cylinder for two-stroke engine.

2/ 3D impeller for expansion turbines and turbo compressors. The 50 µm thick KEPLA-COAT® layer is resistant to vibration and withstands thermal shocks from +100 °C to -196 °C.

3/ Magnesium rims with white MAGOXID COAT® coating to increase corrosion and wear protection. The layer is also a kind of primer for subsequent surface treatments, which in this case consist of seven different coatings. The magnesium rims are used in high-performance sports cars.

1/

2/



3/

fields of use and applications

MAGOXID-COAT® white is used to coat magnesium components to protect them against wear and corrosion. MAGOXID-COAT® white can also be subsequently painted (including wheels for sports cars, bicycles and wheelchairs).

MAGOXID-COAT® black is used when magnesium components require very good light absorption and high UV resistance.

KEPLA-COAT® white is predominantly used for machine components, and is suitable for special applications where other layers fail due to lack of fatigue strength.

KEPLA-COAT® black is used where very good UV resistance and high light absorption are required. A "Berlin specialty" is the one-sided coating of 50 µm thin titanium foils with KEPLA-COAT® black, which are suitable e.g. for laminating of components.

Plant in Berlin with the production hall for coatings with MAGOXID-COAT® and KEPLA-COAT®.

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