### Application coatings

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Carbide</th>
<th>HSS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steel, Free-cutting steels, Mn-steels</strong></td>
<td>Endurum Raptor</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Steel, low-alloyed</strong></td>
<td>Endurum Raptor</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Steel, alloyed</strong></td>
<td>Endurum Raptor</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Steel, hardened, &lt;55 HRC</strong></td>
<td>Endurum Raptor</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Steel, hardened, 55–65 HRC</strong></td>
<td>Endurum Raptor</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Steel, stainless and acid-resistant</strong></td>
<td>nanoA</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Cast iron</strong></td>
<td>nanoA</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Nickel-based alloys</strong> (i.e. Inconel)**</td>
<td>nanoA</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Titanium/titanium-alloys</strong></td>
<td>nanoA</td>
<td>Fire</td>
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<tr>
<td><strong>Cobalt-chromium-alloys</strong></td>
<td>nanoA</td>
<td>Fire</td>
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<tr>
<td><strong>Precious metals</strong></td>
<td>nanoA</td>
<td>Fire</td>
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<tr>
<td><strong>Aluminium-wrought-alloys</strong></td>
<td>bright Carbo Cristall</td>
<td>Fire</td>
</tr>
<tr>
<td><strong>Aluminium-cast-alloys</strong> (&lt;12% Silizium)**</td>
<td>bright Carbo Cristall</td>
<td>Fire</td>
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<tr>
<td><strong>Aluminium-cast-alloys</strong> (&gt;12% Silizium)**</td>
<td>bright Carbo Cristall</td>
<td>Fire</td>
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<tr>
<td><strong>Copper/bronze/brass</strong></td>
<td>bright Carbo Cristall</td>
<td>Fire</td>
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<tr>
<td><strong>Ceramics</strong></td>
<td>bright Carbo Cristall</td>
<td>Fire</td>
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<tr>
<td><strong>Plastics, not reinforced</strong></td>
<td>bright Carbo Cristall</td>
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<tr>
<td><strong>Plastics, fibre-reinforced</strong></td>
<td>bright Carbo Cristall</td>
<td>Fire</td>
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<tr>
<td><strong>Graphite</strong></td>
<td>bright Carbo Cristall</td>
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</table>

**Note:** The overview shows the general application recommendations for Guhring coatings. Prioritisation is from top to bottom.
<table>
<thead>
<tr>
<th>TAPPING</th>
<th>THREAD MILLING</th>
<th>FLUTELESS TAPPING</th>
<th>REAMING</th>
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<tr>
<td>CARBIDE</td>
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1 with through hole, 2 with blind hole

Detailed information on the individual coatings can be found from page 16.
Contents

Milestones of our know-how
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Special solutions and after-sales
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The performance of modern cutting tools

is essentially determined by the tool material, the tool geometry, the cutting parameters and the coating. An overwhelming number of cutting tools applied are coated. As a manufacturer of precision tools Guhring already recognised the potential early on.

Since the introduction of the world’s first TiN-coating on HSS drills in 1980, Guhring can look back on decades of experience in the field of coating. From the start the refinement was carried out in-house.

In-house mechanical and process plant engineering results in further pooling of coating experiences in the company.

The adaptation of tool material, geometry and coating to the respective task can be entirely mapped at Guhring in-house. Specifically, it means in-house manufacture of carbide blanks that are then given a geometry optimised for the application task on Guhring grinding machines. The package is completed by adapted hard material coatings, refined on Guhring systems with in-house developed coatings.
From hype to status quo:

Development of hard material coatings in the metalworking industry

With the presentation of the world-wide first TiN-coating on HSS drills in 1980, Guhring set the milestone in the machining world. What was initially smiled at as a marketing tool – golden tools in metal cutting – became the status quo of an entire industry.

A suitable coating can significantly improve the performance of cutting tools. Increases by factor 2 to 3 are not impossible.

The range of different hard material coatings has been heavily extended in recent decades. Due to their high hardness, good friction characteristics as well as thermo-chemical resistance they offer considerable advantages in comparison to un-coated tools:

- **higher cutting parameters**
  - reduction in manufacturing costs per item

- **increased tool life and volume**
  - tool saving potential
  - reduction in auxiliary machine process time

- **possible conversion to MQL / dry machining**
  - reduced cleaning expense
  - reduced disposal expense
2017

- In excess of 50 coating centres world-wide
  by GUHRING

from 2000

- Development of diamond coatings and highly specialised coatings
  by GUHRING

1994

- Opening of first service centre for re-grinding and re-coating
  by GUHRING

1991

- Development of coating technologies
  by GUHRING

1980

- World-wide first TiN-coating on HSS drills
  by GUHRING
Fracture patterns are visualised via scanning electron microscopy (SEM) in order to make differences visible in the phase structure, morphology and structure dependent on process design and deposition conditions.

Fracture pattern, multi-layer coating, 25,000 x magnification

Fracture pattern, Arc-coating, 10,000 x magnification
Coating development

In the scope of an application related coating development, coating characteristics can be influenced by different parameters and boundary conditions.

- **Elementary composition of coatings**
  i.e. titanium, aluminium, chromium, silicon, nitrogen, carbon, oxygen

- **Coating architecture**
  i.e. single-layer, multi-layer, nano-composite, nano-layer, grading

- **Process parameters during coating**
  i.e. discharge current, substrate voltage, pressure, temperature

- **Coating thickness**
  typically between 1 and 10 μm

- **Cutting edge preparation prior to coating**
  micro-geometry

- **Post-treatment following coating**
  polishing

The possibilities are more or less unlimited.
The results range from all-rounder to differentiated specialist.

In this context we rely on the state-of-the-art laboratories of our in-house research and development.
As well as systems for depositing the coating there are also analytical processes available to determine the coating properties such as chemical composition, crystal structure, morphology, coating thickness, micro-hardness, friction value and adhesion.
The coating technology Guhring predominantly relies on the so-called arc evaporation from the group of PVD processes (physical vapour deposition). Here the metallic target (i.e. titanium or titanium-aluminium) is vaporised by an arc, subsequently reacts with the admitted reactive gas (i.e. nitrogen) and consequently deposits on the tool as a coating (i.e. titanium (Ti) + nitrogen (N) → titanium nitride (TiN)). This process has largely developed into the global standard for hard material coating of cutting tools due to the high deposit rate, the very good coating adhesion and the high density of the coatings.

Alongside other PVD processes as for example thermal vapourisation and sputtering are applied at Guhring. Thermal vapourisation with which the initial TiN-coatings were deposited can still be found in the threading tool area. As well as for TiN it is also applied for depositing TiCN (titanium carbon nitride). The so-called sputtering (atomising) is suitable for nearly every target material. It is used for example in order to vapourise poor electrically conductive materials. An essential feature and advantage of both vapourisation types is the low coating surface roughness, making polishing following coating not absolutely necessary.

Guhring also uses the CVD process (chemical vapour deposition) according to the hot-filament principle for the deposition of diamond coatings in-house!
A spherical calotte is ground into the surface to be inspected using a steel ball as well as an abrasive fluid. The ground form is sectioned through the coating up to the substrate lying underneath. The procedure serves to determine the wear resistance, the coating thickness as well as to evaluate the coating structure and is therefore an important element of a quality inspection.
No matter how fine: Coatings can be adapted.
Features such as composition, micro-structure or hardness have a direct influence on wear resistance, cutting forces, surface quality or cooling lubricant consumption. Decisive is always that the coating is adapted to the specific application task. No matter which parameters are focused on dependent on the application an unbelievably thin coating always guarantees a significant effect.
Thin coating, enormous effect

1 hair | 20 coatings

Fracture pattern
Arc-PVD coating on carbide substrate

3000 x magnification, approximately 0.003 mm

Human hair
3000 x magnification, approximately 0.06 mm
In-house plant engineering

The efficiency of our coatings is not accidental but has to be developed by specific research for each application task. This is only achieved by close co-operation between the actual coating development and process engineering.

Guhring has established an in-house coating division that develops and manufactures new coatings as well as the necessary coating technology. Thanks to in-house process plant engineering Guhring ensures the necessary precision, speed and flexibility to optimally adjust micro-geometry and coating to one another.
and our R&D

As well as coating systems, Guhring’s in-house mechanical engineering also develops technologies for cleaning and de-coating systems for the pre-treatment and post-treatment of tools. The aim of the pre-treatment process is to better adapt the tool’s micro-geometry to the respective application task and to improve the coating adhesion. Post-treatment is aimed at polishing the coated tool surface which further improves the application behaviour.
1st generation

world-wide first TiN-coating on drills

2nd generation

TiN-/TiAIN multi-layers

TiN
p.32

TiCN
p.32

Fire
p.33

TiAIN
p.34
Coating evolution

3rd generation
high Al-content, nano-layers, AlCrN-coatings, diamond-coatings

4th generation
nano-layers, nano-composite, chip-adapted chemistry, DLC

Cristall
p.28

Carbo
p.30

Signum
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Endurum
p.26

nanoFire
p.33

Raptor
p.22

Zenit
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SuperA
p.34

nanoA
p.35

Sirius
p.20

Ice
p.35

2000 2010
With a hardness of 5500 HV Guhring’s in-house developed Signum-coating is one of the hardest nitride coatings on the market. Guhring was able to achieve this extraordinary coating hardness thanks to the special nano composite structure with a TiAlN and TiAlSiN layer structure. In these nano composite structures extremely fine TiAlN-crystals [<10 nm] are embedded in a glass-type silicon nitride matrix. This results in an extremely high hardness, that is retained even at high temperatures. As there are no continuous grain boundary networks in this structure, the diffusion of chip material is heavily impeded by the coating. Therefore, the Signum-coating provides an especially high wear-resistance and at the same time a high diffusion resistance.
Main application
Tapping in VA (through holes)
Drilling/milling in VA

Stainless

- **structure**
  multi-layer, nano-structure

- **colour**
  pale gold

- **hardness**
  3400 HV 0.05

- **application temperature**
  < 900 °C

- **coating material**
  TiAlSiN-based with ZrN cover coating

---

When drilling in VA the cutting edges of cutting tools are subjected to extreme stresses. A mechanically especially wear resistant coating with a low friction value prevents damage to the cutting edges. Pre-requisite is a very low chemical interaction with stainless steels. The tough-hard TiAlN function coating guarantees a very high wear resistance. Zircon nitride in the cover coating significantly improves chip evacuation as the chemical reaction between coating and workpiece is reduced. Therefore, SIRIUS offers the best pre-requisites for the machining of VA materials.
Main application
Drilling/milling of carbon, free-cutting as well as low-alloyed steels

- **structure**
  multi-layer, graded

- **colour**
  pale gold

- **hardness**
  3900 HV 0.05

- **application temperature**
  < 600 °C

- **coating material**
  TiN/TiAIN based with ZrN cover coating

Gühring’s Raptor-coating relies on a proven TiN and TiAIN multi-layer structure combined with a ZrN based cover coating. The multi-layer structure guarantees good values of hardness and toughness making it possible to limit the mechanical wear. The cover coating minimises the chemical reaction between the coating and the material to be machined thereby reducing the development of edge build-up and the adhesion of the material to the cutting edge as much as possible.
Raptor
Titanium specialist
Zenit

Main application
Drilling/milling of titanium-alloys

- **structure**: multi-layer, nano-structure
- **colour**: pale gold
- **hardness**: 2500 HV 0.05
- **application temperature**: < 700 °C
- **coating material**: TiAlN-ZrN based

With the pale gold Zenit multi-layer system the aluminium content of established coatings was specifically reduced and partly replaced with Zircon. This causes a minimised chemical reaction when coming into contact with titanium alloys.

Thanks to the special structure of the coating system the reaction tendency between material and coating should be significantly reduced. Furthermore, this coating also brings significant benefits for the machining of cast aluminium (<10% Si) and wrought aluminium alloys. The focus here is primarily the prevention of built-up edges between coating and material.
Main application
Drilling carbon, free-cutting and manganese steel at low and medium cutting speeds

- **structure**
  multi-layer with nano-layers, nano composite
- **colour**
  copper
- **hardness**
  4000 HV 0.05
- **application temperature**
  < 800 °C
- **coating material**
  TiAlSiN based

Thanks to a nano-layer structure as well as reduced aluminium content Endurum was specifically adapted for the drilling of low-alloyed steels such as carbon, free-cutting and manganese-alloyed steels. By adding silicon it forms a nano composite structure causing a high hardness. In addition, thanks to the composition the reaction tendency is decisively reduced. Especially with low and medium cutting speeds it is the first choice for drilling operations.
Like its naturally occurring relative, this diamond-coating possesses an outstanding hardness in excess of 8000 HV. Thanks to the so-called sp³-structure in which the carbon atoms with both materials are spatially arranged, Cristall is qualified for highly abrasive applications such as for example the machining of GFRP and CFRP, aluminium-alloys, ceramics and graphite. Thanks to different coating thicknesses it is adapted to the specific application task. Due to the high coating temperature it is only possible to deposit it on carbide. Thanks to Guhring's in-house carbide production this is not a problem. Process related re-grinding and re-coating is not possible.
Non-ferrous metal specialist

Carbo

Main application
Drilling/milling/reaming/threading in aluminium and aluminium-alloys (up to max. 10% Si) non-ferrous metals (copper, brass, bronze) GFRP / CFRP, wood

- structure
  single-layer
- colour
  grey black
- hardness
  5000 HV 0.05
- application temperature
  < 500 °C
- coating material
  carbon (ta-C)

Thanks to its composition of 100% carbon and its high spatial bond content (sp²-content >60%) Carbo displays a high hardness and application temperature. Therefore, this also as ta-C (tetrahedral carbon) described coating type is suitable for a wide field of applications. Carbo closes the gap to Crystall, where un-coated tools or conventional carbide grades fail. For example, it concerns the machining of aluminium and aluminium-alloys (up to max. 10% silicon), non-ferrous metals, GFRP / CFRP or wood. Up to a certain abrasive stress the considerably more expensive diamond-coating can be substituted by Carbo. In addition, the coating of HSS and carbide as well as re-grinding and re-coating is possible.
Guhring already in the early 80’s introduced TiN-coating which can be applied for drilling and milling on HSS as well as on carbide as a cost-efficient broadband coating. It is still particularly widely spread in threading applications.

Due to the additional embedding of carbon, TiCN distinguishes itself with a higher toughness, hardness and a reduced friction coefficient compared to TiN. With its high wear resistance it is very well suited for more abrasive threading applications.
The Fire-coating was introduced at the end of the 90's. Its further development nanoFire came on the market in 2008. As well as titanium and nitrogen the coating also includes aluminium and distinguishes itself with a higher hardness as well as an improved thermo-chemical resistance. It is suitable for coating HSS as well as carbide. To today it is a very good choice for drilling and milling steel.
The TiAIN-coating with its titanium-aluminium structure displays similar characteristics to Fire and nanoFire. Thanks to its single-layer structure it is especially suitable for the coating of micro-precision tools.

The single-layer and aluminium rich SuperA is for example applied for milling hardened steel or titanium-alloys due to its high hardness and oxidation resistance.
The TiAlN based nanoA has proven itself especially in the machining of stainless steels, but is sometimes also applied for drilling and milling of cast iron, titanium, nickel based and cobalt-chrome alloys. Its nano-layered structure delays the fracture growth.

The titanium, aluminium and chrome based Ice specialises in the machining of non-ferrous metals, e.g. copper-alloys as well as bronze and brass.
Adapting your tools to your requirements

GUHRING
Special solutions

The application conditions during the cutting process as well as the demands on the cutting tools themselves are becoming ever more complex and individual.

Boundary conditions for tool adaptation:

- Cutting parameters
- Material
- Workpiece
- Demanded workpiece dimensions and surface finish quality
- Tool life
- Cycle times
- Machine Influence
- Cooling

To be able to map this complexity, more and more customer specific special solutions are applied in tooling as well as in coating. The demand for special tools is constantly increasing. In this context not only macro- and micro-geometry is adapted to the specific machining task but also the coating is selected accordingly.
Service centres

Our support from the service centre

Speed requires short routes, therefore, we have developed in excess of 50 service centres for you world-wide – and are constantly increasing this service. All service centres are equipped with high-performance production machines and Guhring developed coating systems. Every service centre has its own collection and delivery service. This way we can process your orders saving time and money. We provide this high-tech upgrade with Guhring coatings also for non-Guhring products.

- Resource conservation
- Reducing tooling costs
- Re-grinding to original geometry
- Re-grinding and re-coating non-Guhring tools
- Collection and delivery service
- Available world-wide
Tool refurbishing

Re-grinding and re-coating
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