

GUHRING®



GOLD STANDARD EXHIBIT 2035
US ENDODONTICS v. GOLD STANDARD
CASE IPR2015-00632

COATING SERVICES

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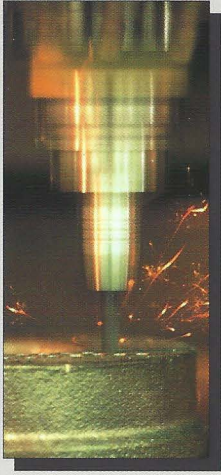


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HIGH PERFORMANCE THIN-FILM COATINGS FOR CUTTING TOOLS & WEAR PARTS



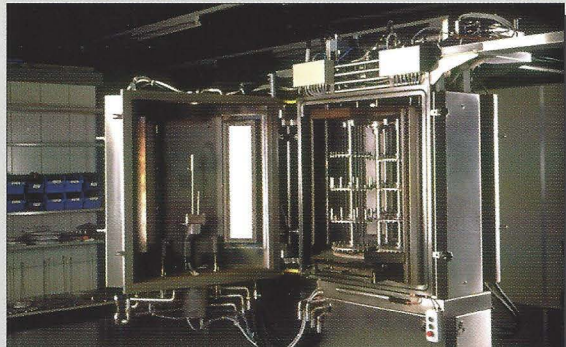
The importance of advanced coatings in achieving dramatic gains in cutting tool and wear part performance cannot be overstated. Properly applied, coatings improve many tool and part characteristics. They increase surface hardness, lower the friction coefficient and thermal conductivity, and provide a chemically inert surface. Performance benefits include: significantly increased tool and part life, reduced friction and heat buildup, and high resistance to edge buildup, galling and fissure

propagation. Applying the right coating can increase tool and part productivity from 100% to over 1000%!

TECHNOLOGICAL LEADER. As a cutting tool manufacturer, GUHRING offers a level of technical expertise without equal in the industry. GUHRING was the first to introduce TiN coating (Titanium Nitride) to cutting tools in 1980 and has remained a global leader in developing and applying new coating technology to improve both cutting tool and wear part performance. Today, GUHRING offers a full range of high performance thin-film coatings to meet customers' diverse needs, including:

- **TiN** (Titanium Nitride),
- **TiAlN** (Titanium Aluminum Nitride),
- **TiCN** (Titanium Carbonitride),
- **FIREX**[®] (special TiN-TiAlN multilayer hard coating),
- **AlTiN** (Aluminum Titanium Nitride),
- **MolyGlide**[®] (Molybdenum Disulfide-based soft coating), and other advanced hard, soft and combined coatings.

Each application presents different performance challenges, and GUHRING's advanced coating selection provides application-specific solutions, delivering higher hardness, increased heat and shock resistance, and greater lubricity as required. By effectively matching the right high performance coating to each application, GUHRING Coating Services maximizes tool and wear part productivity *and*



- ✓ **LONGER TOOL & WEAR PART LIFE**
- ✓ **FASTER OPERATING SPEEDS & FEEDS**
- ✓ **SIGNIFICANTLY INCREASED PRODUCTIVITY**

STATE-OF-THE-ART EQUIPMENT. Coatings are only as good as the process used to apply them. Advanced equipment, special training and experience are vital. GUHRING utilizes both state-of-the-art cathodic arc and reactive ion coating systems to deliver superior coating adhesion, uniform thickness and structure, and batch-to-batch reproducibility.

Advanced climate control systems maintain optimum facility air temperature, humidity and pressure, while removing dust and other airborne impurities. A custom-designed, fully automated ultrasonic



cleaning system maximizes tool and part pre-coating cleanliness, while precision stereo dynascopes enhance both pre- and post-coating visual inspection. Coating adhesion and thickness are closely monitored utilizing calotest and other advanced measuring equipment.

UNIQUE APPROACH. What takes place in the coating chamber is widely considered the most critical step in the coating process. However, if tools and parts are not properly prepared, coating quality can be severely compromised. At GUHRING, we take the time to prepare each job properly. First, we clean each tool and part thoroughly in our special five-stage ultrasonic cleaning system. Second, we sort each job by tool and part size, geometry, and material type to promote optimum coating uniformity and thickness. Properly cleaned and sorted, the tools and parts are then placed in the coating chamber. We monitor the coating process closely to ensure that neither the structural integrity nor geometry of the tools and parts is altered.

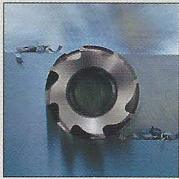
In sum, GUHRING's approach to coating combines high technology with personal attention to detail, resulting in a level of coating quality and service few can match.



TiN • S-coat

The gold S-coat is an excellent, all-around, cost-effective high performance coating which increases tool and part surface hardness to over 80 Rc, greater than tungsten carbide. As such, S-coated tools and parts last up to five times longer than uncoated tools and parts, and can be run at more aggressive speeds and feeds. Among TiN coating providers, no competitor has been able to match the performance profile of Guhring's S-coat.

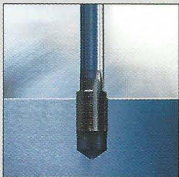
Titanium Nitride



TiCN • C-coat

The gray-violet C-coat achieves superior results when machining hard materials such as tool steels and steels over 40 Rc. Its multilayer structure provides an effective barrier to fissure propagation caused by dynamic stress, inhibiting surface fractures from propagating to the tool or wear part substrate. C-coat is recommended for high-shock applications such as tapping, interrupted cuts in drilling and milling, and heavy-duty forming operations such as punching and stamping.

Titanium Carbonitride



TiAlN • A-coat

The black-violet A-coat is recommended when extra hardness and heat resistance are required, as when machining abrasive materials such as cast iron and high silicon-content aluminum alloys. During cutting, an oxide (Al₂O₃) layer forms over the A-coat, providing extremely high heat resistance. A-coat also performs equally well in high thermal stress conditions, such as high speed turning, near-dry and dry machining, and deep and small diameter holemaking where cutting fluids have difficulty penetrating.

Titanium Aluminum Nitride



FIREX® • F-coat

Developed by Guhring in cooperation with Platit of Switzerland, the red-violet F-coat comprises distinct, alternating ultra-thin TiN and TiAlN coating layers and combines the performance benefits of popular single-layer coatings – the universal applicability of TiN, hardness and heat resistance of TiAlN, and shock resistance of TiCN. With hardness exceeding 90 Rc, F-coat sets a new standard in cutting tool and wear part performance enhancement. F-coat also displays excellent coating interface characteristics.

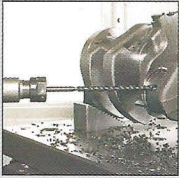
Special TiN-TiAlN Multilayer



AlTiN

Now, for application in materials 40 Rc and higher, there's a new Guhring coating – AlTiN! This dark gray coating is unique in its ability to provide the high heat resistance, high hardness and high friction coefficient needed to dramatically improve cutting tool performance in hardened materials. AlTiN is ideal for high speed, high velocity drilling, milling and turning of hard and/or abrasive materials, plus dry machining applications.

Aluminum Titanium Nitride



MolyGlide® • M-coat

The silver-colored M-coat is a unique MoS₂-based dry-film integrated lubricant, which acts as a gliding agent greatly reducing surface-to-surface friction. Perfect for machining gummy materials (Al, Al alloys, alloyed steels, Ni alloys, Ti alloys and copper) and difficult-to-lubricate applications (tapping and deep/small-diameter drilling or reaming), M-coat provides constant lubrication exactly where it is needed. M-coat can be applied over most hard coatings and even over steam-oxidized surfaces, and can be used in tandem with conventional coolants/lubricants or oils.

Molybdenum Disulfide-Based

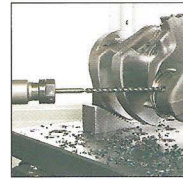
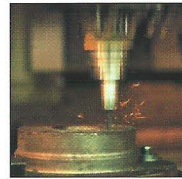
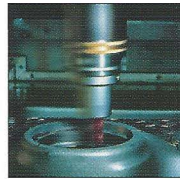
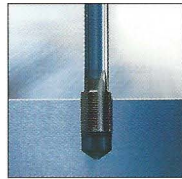
KEY CHARACTERISTICS OF GUHRING HIGH PERFORMANCE COATINGS

	TiN Titanium Nitride	TiCN Titanium Carbonitride	TiAlN Titanium Aluminum Nitride	FIREX® Special TiN-TiAlN Multilayer	AlTiN Aluminum Titanium Nitride	MolyGlide® MoS ₂ -Based
Type	Hard • Wear-resistant	Hard • Wear-resistant	Hard • Wear-resistant	Hard • Wear-resistant	Hard • Wear-resistant	Soft • Lubricating
Identifying Color	Gold	Gray Violet	Black Violet	Red Violet	Dark Gray	Silver
Coating Process	PVD Physical Vapor Deposition	PVD Physical Vapor Deposition	PVD Physical Vapor Deposition	PVD Physical Vapor Deposition	PVD Physical Vapor Deposition	PVD Physical Vapor Deposition
Coating Temperature	930 °F 500 °C	930 °F 500 °C	930 °F 500 °C	930 °F 500 °C	930 °F 500 °C	305 °F 150 °C
Layer Structure	Monolayer	Gradient	Monolayer	Multilayer	Monolayer	Monolayer
Thickness (µm)	1.5-5.0	1.5-5.0	1.5-5.0	1.5-5.0	1.5-5.0	1.0
Nanohardness (Gpa)	24	30	33	30-33	38	n.a.
Friction Coefficient (Fetting)	0.50	0.25	0.50	0.50	0.60	0.10
Thermal Stability	1100 °F 595 °C	840 °F 450 °C	1470 °F 800 °C	1470 °F 800 °C	1650 °F 900 °C	1470 °F 800 °C
Application Data	Broad application Cutting, forming & injection molding	High toughness & shock resistance for punching, stamping milling, hobbing & turning	High hardness & heat resistance for drilling, turning & dry high speed machining	Broad application High toughness, hardness & heat resistance	Increased Al-content delivers very high heat resistance for hard machining (>40 HRC), high speed machining, & dry high speed machining	Significantly increases tool/wear part lubricity, withstands high temperatures, & can be applied over hard coatings

GUHRING HIGH PERFORMANCE COATINGS SELECTION GUIDE

The table below provides general recommendations for optimum tool and part performance with GUHRING high performance TiN, TiCN, TiAlN, FIREX®, AlTiN and MolyGlide® coatings. GUHRING COATING SERVICES coats many types of tools and wear parts, including drills, reamers, taps, countersinks, turning inserts, end mills, milling cutters, hobs, milling inserts, punches, dies, forming tools, gears, pistons, die casting molds and components, and plastic injection molds and components. Coatings can be applied to high speed steel, stainless steel, tool steel, carbide and many other materials.

	TiN Titanium Nitride	TiCN Titanium Carbonitride	TiAlN Titanium Aluminum Nitride	FIREX® Alternating ultra-thin TiN-TiAlN layers	<small>New!</small> AlTiN Aluminum Titanium Nitride	<small>Integrated lubricant soft coating</small> MolyGlide® Molybdenum Disulfide-based
CUTTING TOOLS – Continuous Chip Drills • Reamers • Taps • Countersinks • Turning Inserts	✓	✓	✓	✓	✓	✓
CUTTING TOOLS – Interrupted Cut End Mills • Milling Cutters • Hobs • Milling Inserts	✓	✓		✓	✓	✓
PUNCHES, DIES & FORMING TOOLS	✓	✓		✓		✓
WEAR PARTS	✓	✓		✓		✓
DIE CASTING MOLDS & COMPONENTS PLASTIC INJECTION MOLDS & COMPONENTS	✓		✓	✓		✓



GUHRING®
No one offers more

For technical assistance and pricing information, contact:

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