STATON

Coating and Production of Tools

Company Milestones

1887 foundation of company ‘Schulz & Pollak’
1914 company damaged by fire
1919 restoration and enlargement of company, focus on production of tools and machines for wood processing, renamed to ‘United wood-working stock company’
1949 company merged into a large state-owned factory ‘Drevina’
1989 the turmoil of the ‘Velvet Revolution’
1994 transformation of company, separation of machinery branch of ‘Drevina’
1996 first engagement in PVD coatings and arc coating machines
1997 first PVD hard coatings – TiN and TiCN
1998 company renamed to ‘Staton, s.r.o.’
1999 production of soldered hard metal cutting tools initiated
2000 cooperation with Comenius University in Bratislava initiated
- PVD hard coatings TiAlN and AlTiN

2001 production of cutting tools with inserts initiated
2002 office of Comenius University in facilities of Staton, s.r.o., realized
- technology of decoating implemented

2004 nanostructured multilayer PVD hard coatings AlTiN
2005 design and construction of proprietary PVD coating system based on arc technology
- first CNC grinding machine purchased

2007 development of high-performance coating AlTiCrN (KTRN)
- certification by ISO 9001:2000 quality management system

2008 design and construction of novel proprietary arc source with reduced droplet production
2009 design and construction of proprietary coating system based on magnetron technology
2010 development of thermally resistant PVD coating AlTiCrSiN (CRONAL)
- certification by ISO 9001:2008 quality management system

2011 development of upgraded PVD coatings TiN, TiCN, TiCrN
- design and construction of proprietary PVD coating system based on HiPIMS technology

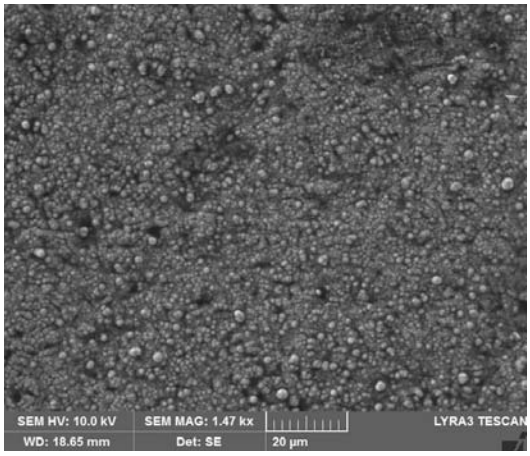
2012 development of DLC coatings deposited at low temperatures
2013 design and construction of proprietary coating system based on filtered arc technology
- acquisition of ecological ultrasonic cleaning vacuum system for degreasing

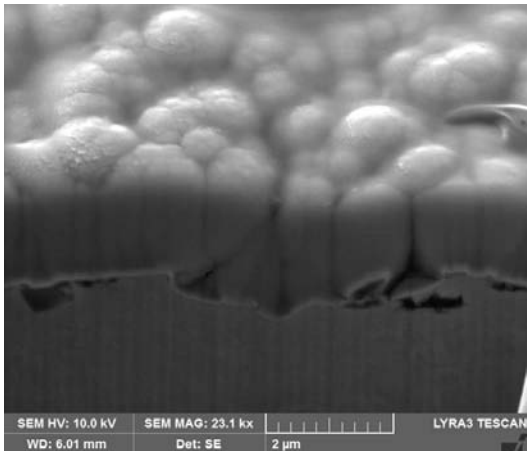
2014 research and development coating center established in cooperation with Comenius University
- certification by EN ISO 3834-2:2005 quality management system

2015 design and construction of proprietary PVD coating system based on a combination of filtered cathodic arc, DC magnetron sputtering and HiPIMS technologies
- development of PVD tribological coatings W–DLC
- development of nanolayered PVD coatings TiN/CrN ordered in a superlattice structure
- certification by STN EN 15085-2:2008 quality management system
- certification by ISO 9001:2008 quality management system

Staton, s.r.o., is a machinery company located in the northern Slovakia. We concentrate both in general and precision machining, development and construction of vacuum coaters and components, production and reconditioning of tools and improvement of quality of tools by deposition of superior PVD (Physical Vapor Deposition) and PECVD (Plasma Enhanced Chemical Vapor Deposition) coatings. Since its establishment in 1998, Staton, s.r.o., was driven by the vision to build up an internationally renowned company focused on the production of coating machines and development of novel coatings. Great emphasis is put on application of the newest scientific knowledge in the fields of nanotechnology and plasma technology worldwide. The aim is to offer complex services and coating solutions that increase the quality and performance of various types of tools and parts.

We have strong knowledge and practical experience with various advanced deposition techniques of PVD and PECVD. Our own research and development in our coating center goes hand in hand with cooperation with foremost universities and research institutes both in Slovakia and abroad which keeps us always one step ahead of competition. The closest cooperation has been achieved with Comenius University in Bratislava which started more than 15 years ago. As the last joint success, a detached laboratory of the university was established in the premises of Staton, s.r.o. The laboratory focuses in the research and development of novel plasma technologies and is well equipped with the state-of-the-art deposition and analytic devices.





Cooperation

Comenius University, Faculty of Mathematics, Physics and Informatics, Department of Experimental Physics
Bratislava, Slovak Republic

Slovak Academy of Sciences, Institute of Materials Research
Košice, Slovak Republic

Technical University of Košice, Faculty of Aeronautics, Department of Aviation Technical Studies
Košice, Slovak Republic

Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava
Trnava, Slovak Republic

University of Žilina, Faculty of Mechanical Engineering, Department of Design and Mechanical Elements
Žilina, Slovak Republic

Charles University, Faculty of Mathematics and Physics, Department of Macromolecular Physics
Prague, Czech Republic

Masaryk University, Faculty of Science, Department of Physical Electronics
Brno, Czech Republic

References

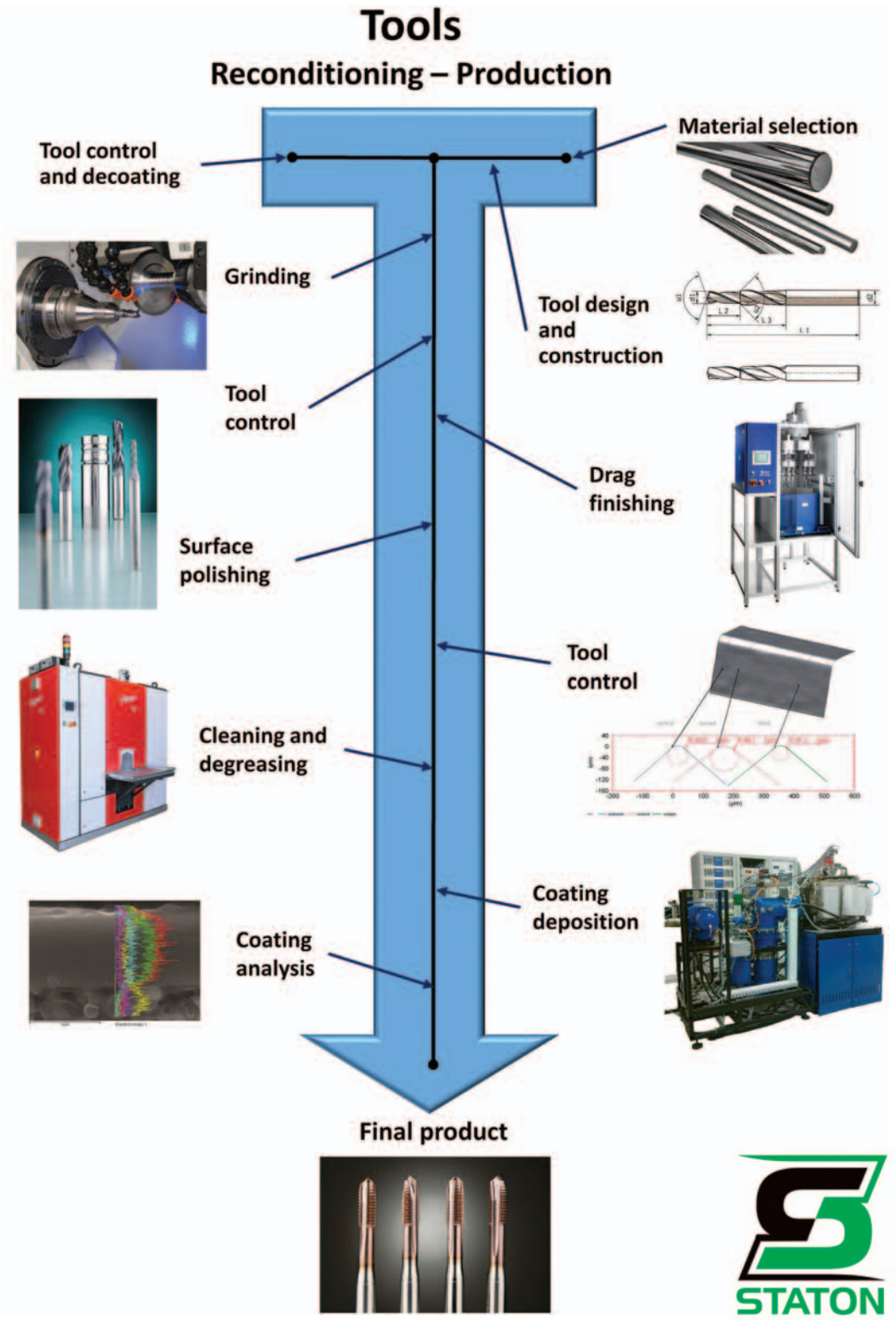
Certification

Our company has many years' experience with industrial production and solving of complex European projects. We know that quality is always at the top of the list of requirements. We take great care about quality of our products, services and other outputs. This approach has resulted in acknowledgement of Staton, s.r.o., by several quality management system certificates:

- ISO 9001:2008 – scope numbers:
  - 17 – Production, grinding and coating of the cutting tools
  - 34 – Welded constructions
  - 35 – Research and development in the fields of natural sciences and engineering
- EN ISO 3834-2:2005 – Welding systems
- STN EN 15085-2:2008 – certification level CL 2 – Welding of railway vehicles and components

Nevertheless, our industrial progress is not at all costs. We care about the natural environment and our technological processes follow the path of a sustainable future. Coating of surfaces by PVD techniques is superior to conventional methods, such as electroplating, in quality, ecology and safety. Electroplating is a wet, environmentally-unfriendly process and a source of hexavalent $Cr6^{+}$, which is considered carcinogenic and therefore becomes prohibited in increasing number of countries.

If you are interested in our products, cooperation or want to learn more about Staton, s.r.o., and plasma coating technology, do not hesitate to contact us at +421 43 429 23 62 or staton@staton.sk.

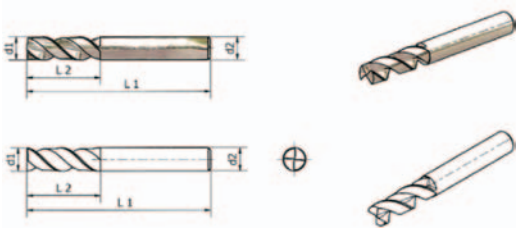


Complex services at Staton, s.r.o. – coating and production of tools

- Reconditioning of cutting tools using CNC grinders to like-new condition.
- Design and production of standard and specialized cutting tools.
- Coating of tools by high-performance coatings resulting in higher production and tool lifetime.
- Our creative technicians are happy to consult any of your specific requirements to find the optimal solution for you.

Production and reconditioning of cutting tools

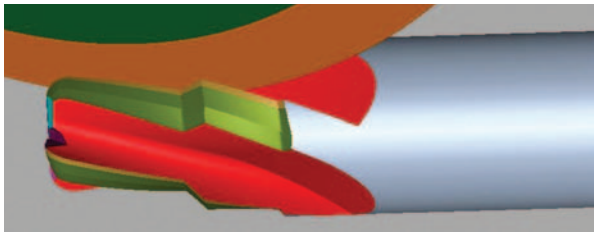
Staton, s.r.o., offers production of standard milling cutters and cutting tools. We produce specialized cemented carbide milling cutters according to the particular requirements of our customers:

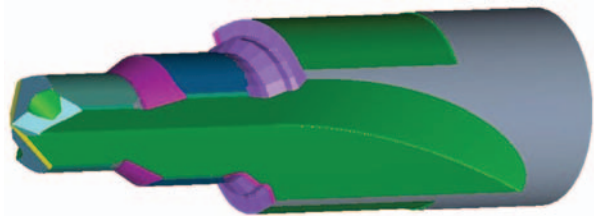


- Short and long of lengths L1 a L2 and diameters d1 and d2
- With various helix angles
- With Weldon style end
- With relieves
- With 2, 3, 4 and more teeth

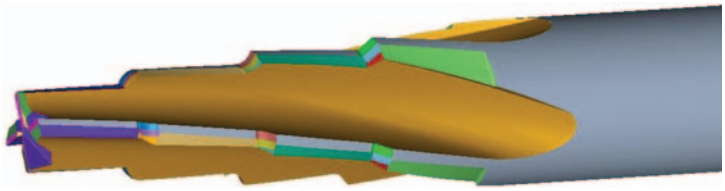
Further, we produce monolithic cemented carbide drill bits with 2 and 3 cutting edges. The geometries of the drill bits (all the dimensions and angles) can be modified according to the requirements of our customers.

- Step drill bits for cutting under the screw threads and special step drill bits
- With internal cooling





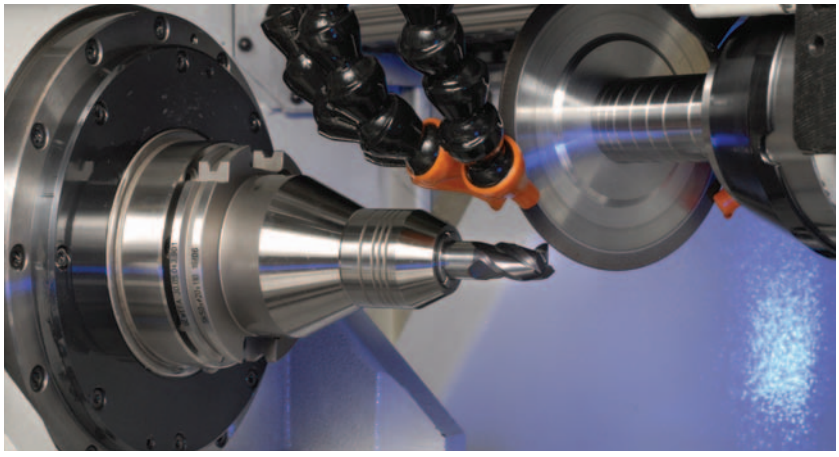
Apart of standard tools, Staton, s.r.o. Offers production of specialized milling cutter and drill bit tools with a profile geometry according to the shape of the particular machined parts. The design of new tools is prepared in 3D simulation programs Cyber Grinding and Tool Studio.



Reconditioning of cutting tools

Reconditioning of worn cutting tools involves control of quality of tools and removal of old coatings (decoating or stripping) from tools. Reconditioning of a tool restores its geometry, performance and reliability to like-new condition and quality. It results in improvement of cutting properties, coating adhesion and also in a better tool appearance. Repeated reconditioning thus reduces tooling costs and minimizes material waste.

Grinding of cutting and special tools

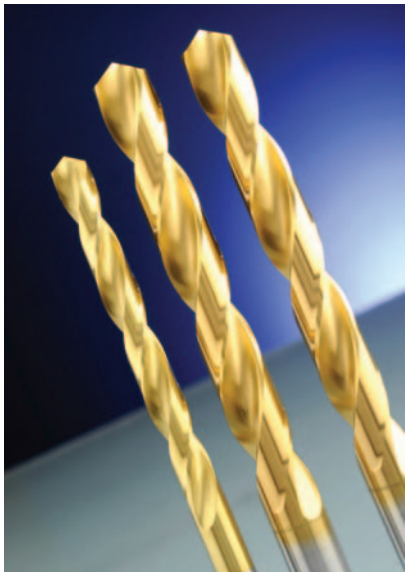


Staton, s.r.o., produces and sharpens cutting tools from cemented carbide and high speed steel (HSS). Tools are sharpened using 5-axis CNC grinders Helitronick Power and Helitronick Power Production produced by German company Walter.

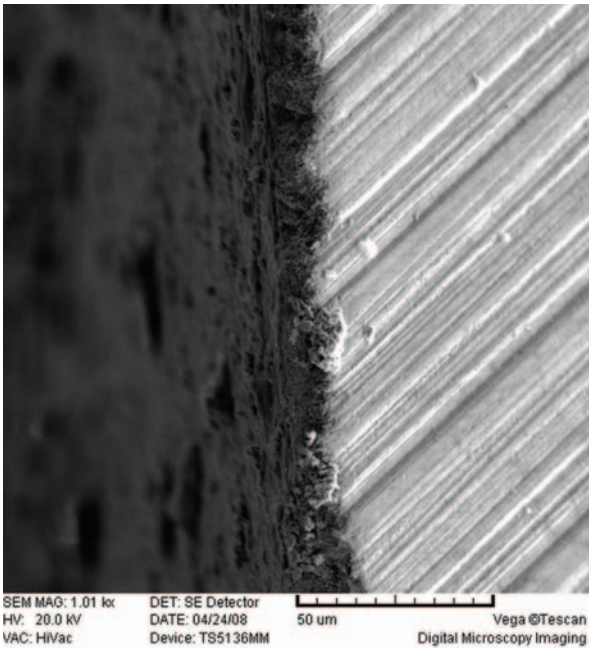
We sharpen the following tool types:

- Drill bits with 2 and 3 cutting edges of all geometries
- Gun drill bits
- Center drill bits
- Milling cutters
  - o Roughing or finishing
  - o Tapered
  - o Spherical and toroidal
  - o coping and engraving
  - o socket and disc
  - o gear and hob
- Drift and drill reamers
- Straight and spiral taps
- Shaper cutters

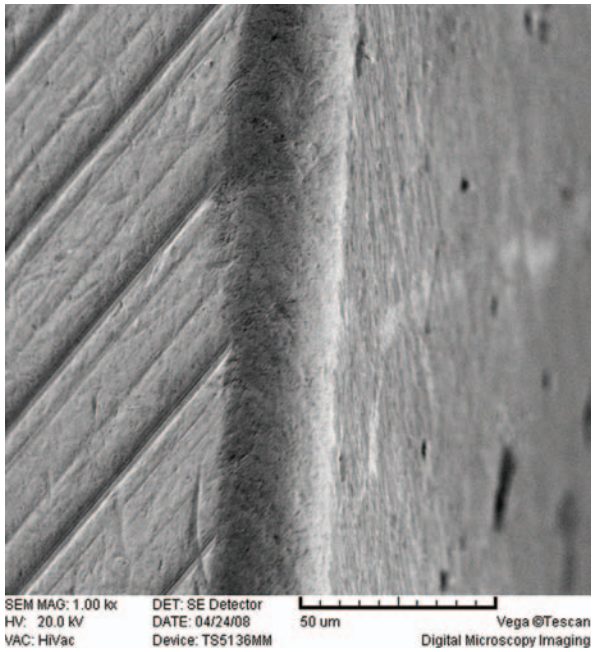
Increase of tool lifetime by drag finishing



Drag finishing is a specialized treatment of the cutting edge and the surface of a tool in special polishing media (abrasives). Drag finishing is applied after sharpening of the tool and before the coating process. Structures like burrs, microplanes crumbled away from the tool surface and tracks created by grinding diamond can be often found on the cutting edges after their sharpening. The controlled deburring and polishing during drag finishing process leads to elimination of roughness and to rounding of cutting edges. In result, the treatment substantially improves the quality of the tool surface prior to the coating process, enhances the coating adhesion and increases tool performance. The surface of the sharpened tool can be polished to a mirror shine.



Cutting edge after sharpening.



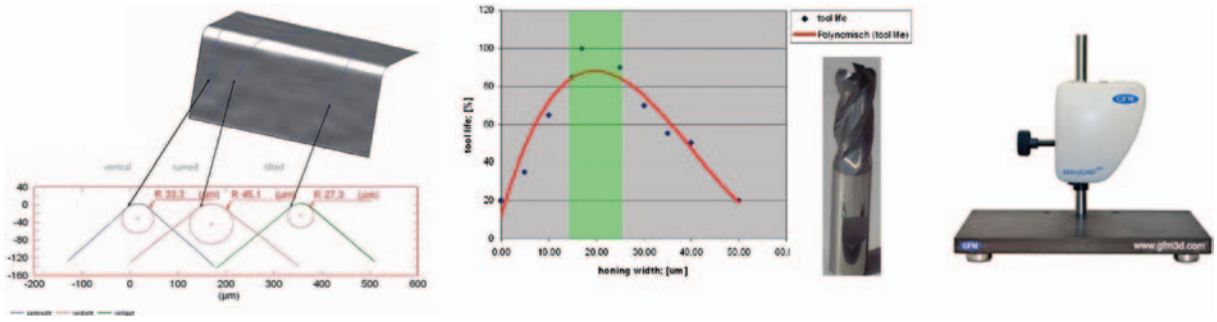
Cutting edge after drag finishing.

Measurement and control of cutting tools

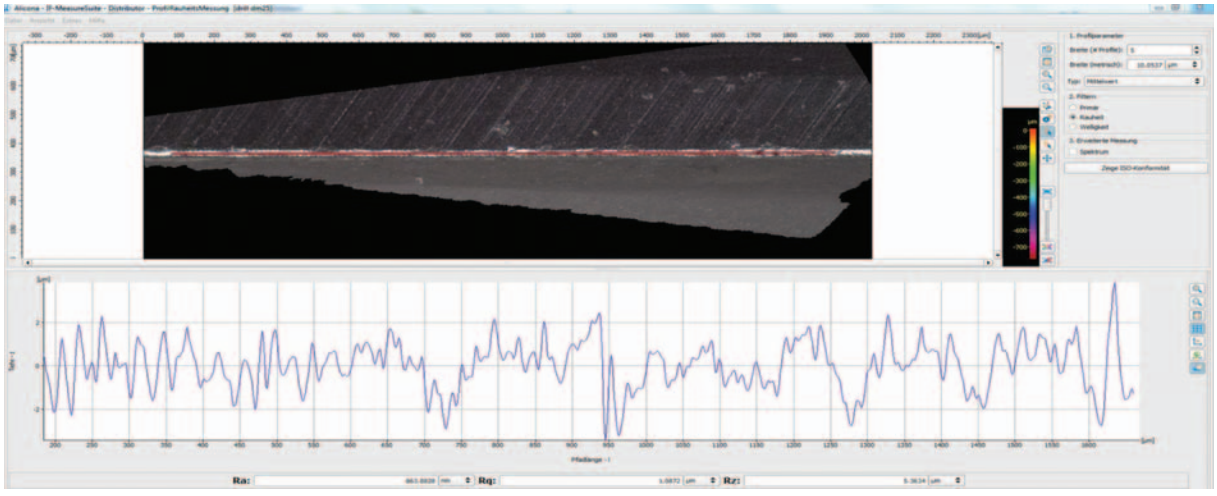
The process of sharpening by CNC grinders is controlled through FANUC system with a high dynamics and accuracy. Automatic measurement of the tool is accomplished by a tool probe RENISHAW which measures all the important parameters of the tool.

The resulting quality is controlled by 3D CNC optical device Walter Helicheck. Each sharpened tool receives a measurement report which is available for our customers upon request.

Measurement of radius of the cutting edge

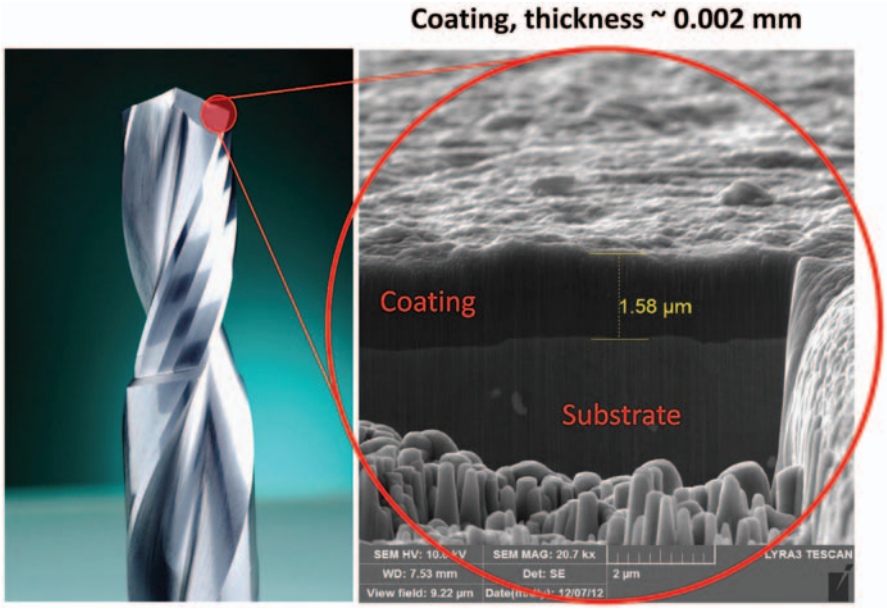


Measurement of the surface roughness

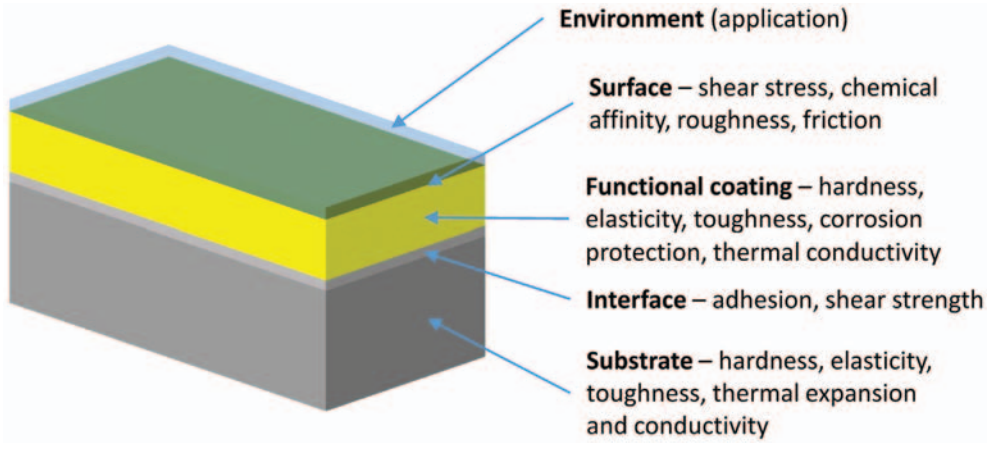


Coatings

A coating is a covering layer of a particular material that is applied to the surface of an object (the substrate). The purpose of applying the coating may be functional, decorative, or both. The functional coatings are typically deposited for protection of the substrate material (hard coatings) or to improve its mechanical, tribological or other physical or chemical properties. Thickness of a coating is an important parameter which affects properties of the coating to a great extent. The thickness of the hard protective and tribological coatings produced at Staton, s.r.o., is about 1 to 5 micrometers which is about 1% of the thickness of a human hair.



The coatings are deposited by plasma techniques in vacuum chambers which guarantee clean processes without presence of any impurities from ambient atmosphere which can harm the quality of the coating. And what more, vacuum techniques are environmentally friendly since no toxic waste is produced. The properties of a coating are further dependent on the structure and the composition of the coating. These can be tailored according to the requirements of any particular application.



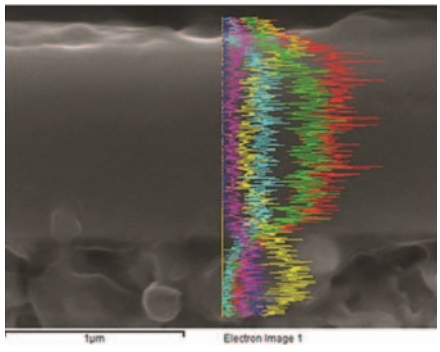
Coating center – development and analysis of coatings

The coating center of Staton, s.r.o., represents tradition of 20 years in deposition of wear and abrasion resistant hard coatings on tools and tribological protective coatings on bearings using advanced PVD (arc evaporation and magnetron sputtering) and PECVD (Plasma Enhanced Chemical Vapor Deposition) deposition techniques. Our valued employees have many years' experience in the fields of mechanical engineering, electro engineering, material science, thin films and physics of plasma. The design and construction of proprietary deposition machines together with research and development of novel types of nanostructured and nanocomposite coatings with superior quality is especially important for us and represents the core of our service for customers. And we are always keen to learn new promising approaches and improve the quality our products. Recently, we have implemented the novel techniques of HiPIMS (High Power Impulse Magnetron Sputtering) and HITUS (High Target Utilization Sputtering) for deposition of coatings of new generation.

The coating center serves at the same time as a detached laboratory of Comenius University in Bratislava. The laboratory focuses in the research and development of novel plasma technologies and characterization and analysis of the deposited coating. Properties (e.g. hardness, coefficient of friction, adhesion, stability, etc.) and performance of coatings strongly depend on the structure, composition and the coating method used. These can be precisely measured in our coating center which is very well equipped with the state-of-the-art analytic devices. The quality of the coatings delivered to our customers can thus be assured.

Analysis and measurement of coatings:

- structure and composition
- thickness
- adhesion
- hardness and modulus
- coefficient of friction and wear
- surface roughness
- thermal stability



Types of coatings produced at Staton, s.r.o.

Staton, s.r.o., produces various types of advanced coatings which differ according to the nature of their application. We offer coatings with various properties than can be further modified to suit particular requirements of our customers.

Coating application

- tools – wear and abrasion resistant hard coatings (e.g. nitrides, carbides, borides)
- bearings – tribological protective coatings (e.g. W–DLC, MoS_2)
- coin dies

Materials for deposition of coatings

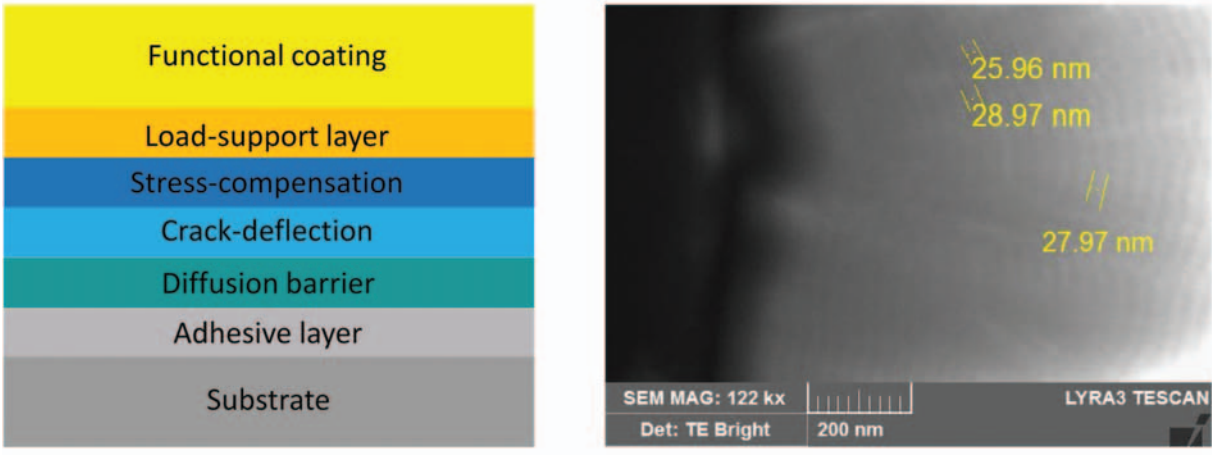
- arc evaporation targets: Ti, Al, Cr
- sputtering targets: Ti, Al, Cr, Mo, Nb, V, W, Si, TiAl, TiB_2
- gases: Ar, N_2, O_2, C_2H_2

Coating structure

- single elemental content
- composite
    - o multicomponent monolayer (mixture of elements in a single deposition step)
    - o multilayer (consecutive deposition of monolayers of different components)
    - o gradient (continuous change in deposition parameters)

Deposition technique

- vacuum cathodic arc evaporation
- magnetron sputtering
- combination of evaporation and sputtering



Nanostructured multilayer coatings: a schematic diagram of a multilayer coating with layers deposited for different purposes (left) and a view of a multilayer coating with repeating bilayer structure from an electron microscope.

Basic types of coatings offered

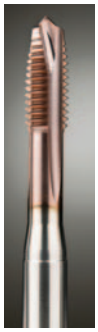
Staton, s.r.o., offers several different PVD coatings specially developed for various applications. Hard PVD coatings reduce wear and friction and thus enhance productivity, tool lifetime and quality of machining. Some of the offered wear and resistant hard PVD coatings are listed in the table below together with the description of the coatings most preferred by our customers. The full list of offered PVD coatings can be found on a separate sheet or on our website.

Coating type	Hardness [GPa]	Hardness [$HV_{0.05}$]	Thickness [µm]	Coefficient of friction	Thermal stability [°C]
TiN	23	2350	1 – 4	0.4	500
TiCN	27	2750	1 – 4	0.2	450
CrN	21	2100	1 – 4	0.6	700
TiAlN	32	3300	1 – 4	0.5	600
TiAlCN	29	3000	1 – 4	0.4	500
KTRN	34	3450	1 – 4	0.4	900
CRONAL	30	3050	1 – 4	0.5	1000
TiN/CrN SL	35	3600	1 – 2	0.4	600
W–DLC	18	1850	1 – 2	0.1	600

TiN – Titanium Nitride – basic general-purpose wear resistant coating

TiN is the most common wear and abrasion resistant hard coating. It decreases the friction, increases chemical and temperature stability and decreases sticking of material often occurring during machining of soft steels. TiN is suitable for coating of tools made of cemented carbides– drill bits, milling cutters, cutting tool inserts, taps, reamers, punch knives, cutting tools, shear and flexion tools, matrices, forms, etc. Since it is biocompatible, it can be used on medical instruments (surgical and dental) and implantable devices. Due to its golden color tone, TiN has found wide use also as a decorative coating. The used TiN coating is easily stripped from tool steels. The reconditioning of tools can considerably decrease costs especially when using expensive tooling.

TiCN – Titanium Carbo-Nitride – wear resistant coating against adhesive corrosion



TiCN is an excellent all-purpose coating. TiCN is harder and more impact resistant than TiN. It can be used to coat cutting tools, punching and forming tools, injection mold components and other wear components. Since it is biocompatible, it can be used on medical instruments and implantable devices. The machining speed can be increased and tool lifetime can be enhanced by as much as 8x in the dependence on the application, coolant and other machining conditions. The TiCN coating is recommended to be used for sufficiently cooled cutting due to its relative lower thermal stability. The used TiCN coating is easily stripped and the tool recoated. The reconditioning of expensive tools can thus considerably decrease costs.

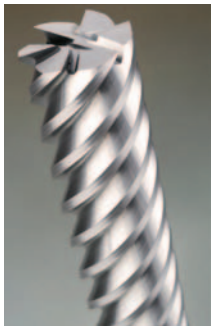
TiAlN – Titanium Aluminum Nitride – wear resistant coating for high speed cutting

TiAlN is a coating with excellent hardness and high thermal and oxidation resistance. Incorporation of aluminum resulted in an increase of the thermal resistance of this composite PVD coating with respect to the standard TiN coating by 100°C. TiAlN is typically coated on high speed cutting tools used on CNC machines for machining of materials of higher toughness and at severe cutting conditions. TiAlN is suitable especially for monolithic hard metal milling cutters, drill bits, cutting tool inserts and shaping knives. It can be used in dry or near-dry machining applications.

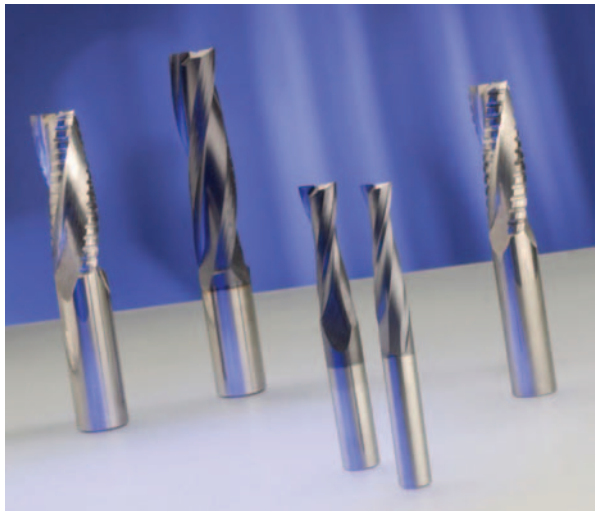
KTRN – Composite Temperature Resistant Nitride – high-performance wear resistant coating for machining of hard materials with interrupted cut

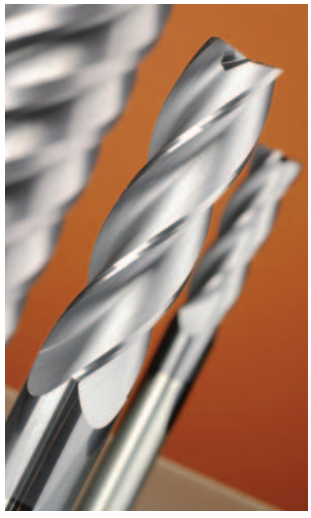
KTRN is suitable for applications where high chemical and thermal stability is required, e.g. CNC machines with the possibility of non-cooling machining. KTRN is an all-purpose coating suitable for machining of both easily and hardly workable materials, non-ferrous materials, alloy steel, stainless steels, cast iron, and is successfully used at extreme cutting conditions with continuous or interrupted cut (milling, turning). It is typically coated on monolithic cemented carbide milling cutters, drill bits and cutting tool inserts for CNC machining centers. KTRN coating is suitable also for tools made of high speed steels, e.g. milling cutters, drill bits, center drills. The high thermal resistance of the KTRN coating (up to 900°C) inhibits overheating of the cutting edge.

CRONAL – Chromium Aluminum Nitride – high-temperature wear resistant coating



CRONAL coating contains high amount of Cr and is specially designed for extreme cutting conditions at machining of tough materials and tempered steels with strength up to 1200 HV and for hardened steels with hardness up to 55 HRC. On the other hand, CRONAL coatings are not suitable for machining of cast iron. Machining at high cutting speeds and feeding rates and high working temperatures is possible. It is typically coated on monolithic cemented carbide milling cutters, drill bits and cutting tool inserts for CNC machining centers. It is very well suited for stamps and dies and in applications where high corrosion resistance is required.





Coating of tools

The coating division of Staton, s.r.o., has tradition of almost 20 years in deposition of wear and abrasion resistant hard coatings on cutting tools (e.g. drill bits, milling cutters, cutting tool inserts, taps, reamers, etc.) and forming tools (e.g. forms, matrices, shear and bending tools, etc.). The coating is performed using advanced technologies and procedures of arc evaporation and magnetron sputtering. Thin films, such as TiN, TiCN, TiAlN, CrAlSiN, TiBN, nanocomposites and multilayer coatings, substantially influence the properties and performance of a tool.

The dimensions of the coated tools are limited in size: length (diameter) = 600 mm, weight = 50 kg.

Influence of coatings on the properties of a tool

- prolonged toll lifetime
- reduce down-time
- reduce tooling costs per piece
- decrease the coefficient of friction
- increase the surface hardness
- increase the temperature stability of the tool tip
- increase the oxidation and chemical resistance
- allow machining of hardly workable materials
- allow increased feed and speed rates
- decrease cutting forces
- decrease roughness of the machined surfaces
- decrease material sticking
- minimalize the amount of cooling liquid used and allow even dry machining

➢ **substantial cost reduction**

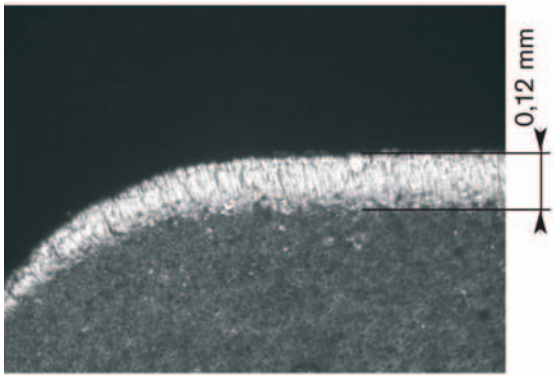
Coating of cutting tools – Composite Temperature Resistant Nitride coatings – KTRN

Staton, s.r.o., developed a novel type of hard abrasion resistant composite coatings deposited using a novel arc technology. The thermal and oxidation resistance of the KTRN coatings is maintained up to 1000°C, while their hardness reaches 3500 HV and adhesion exceeds 100 N. The KTRN coatings are designed especially for use on cutting tools (e.g. drill bits, milling cutters, cutting tool inserts, etc.) made of cemented carbides employed under high cutting speed conditions. The lifetime of the tools modified with KTRN coatings were assessed using CNC machining center Cincinati Milancron. The tested tool ware represented by cutting tool inserts supplied by Sandvik Coromant. The wear measure of the cutting edge was expressed in the dependence on the cutting length.

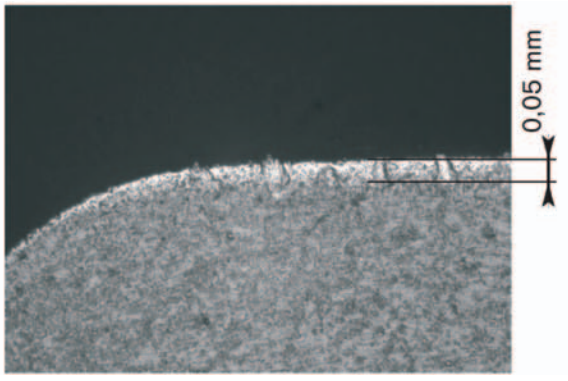
Test of performance and lifetime of cutting tools coated with KTRN coating

Cutting conditions:

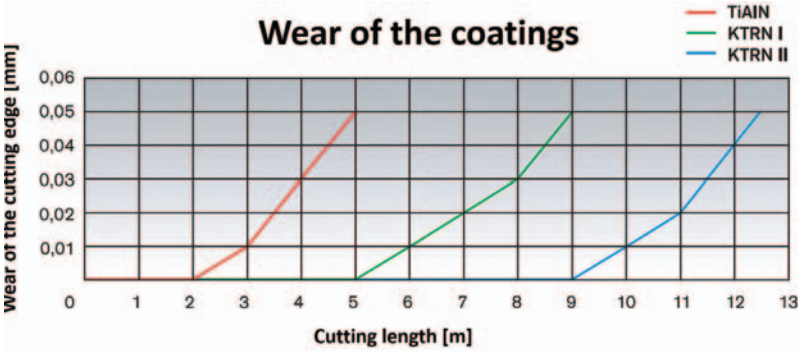
- machined material – cold-work tool steel X210Cr12, hardness 30 HRC
- cutting speed – 100 m/min
- depth – 2 mm
- travel – 0.2 mm/rev



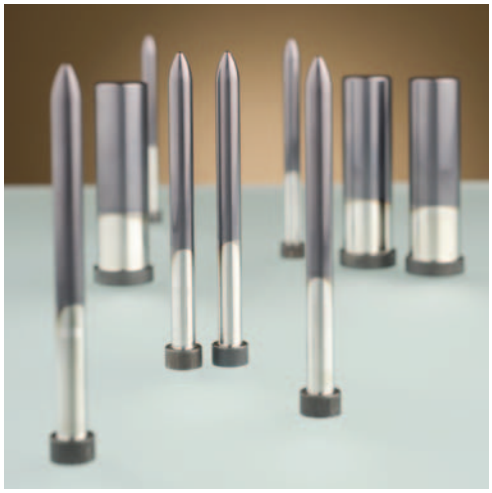
Front edge of the insert – reference TiAlN coating after 3 m long cutting, chip width 0.12 mm (magnification of 100x)



Front edge of the insert – KTRN coating after 8 m long cutting, chip width 0.05 mm (magnification of 100x)



Coating of forming tools

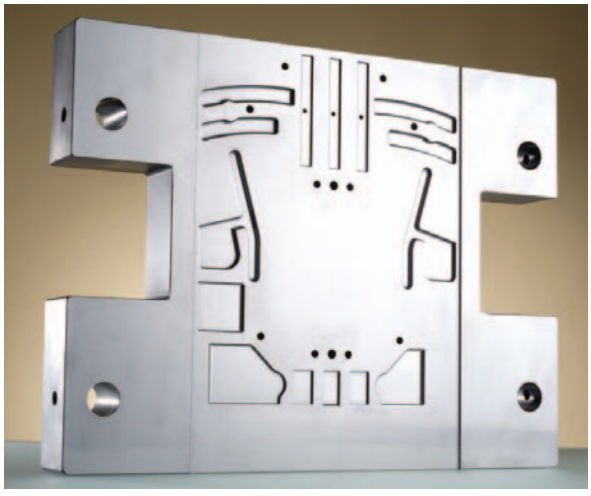


Modification of surfaces of forming tools, such as forms, matrices, nibblers, punches and bending tools, by PVD coatings with low coefficient of friction and high hardness improves their performance and productivity and extends their lifetime. The coating protects the tool from sticking of the cut material to nibbler, facilitates the removal of cut material during releasing of nibbler and prevents the tool from jamming. The PVD technology can be used for coating of various tooling types used for forming metal, plastic and composite materials.

The main advantages of coating of forming tools include:

- increased hardness and toughness and thus increased wear resistance
- decreased coefficient of friction and thus reduced lubricant usage
- increased corrosion resistance and thus prolonged tool lifetime
- improved tool quality and thus reduced downtime and tool maintenance
- wide range of applications possible

What more, the PVD deposition procedure takes place at temperatures of about 200 – 300°C and thus allows coating of forming tools and injection mold components made of tool steels which are typically tempered at 200 – 300°C without losing their intrinsic hardness (58 – 62 HRC).



Tribological coatings W–DLC

Coating properties:

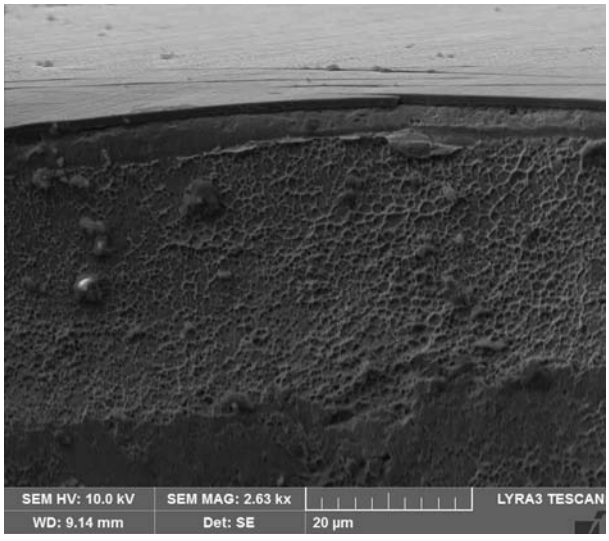
- High wear resistance
- Low coefficient of friction (COF ~ 0.1)
- Low roughness (R_a ~ 10 nm)
- High hardness (H ~ 18 GPa) even at high temperatures up to 600°C
- Resistance against corrosion
- Low intrinsic stress level – very good adhesion (L_c ~ 120 N)

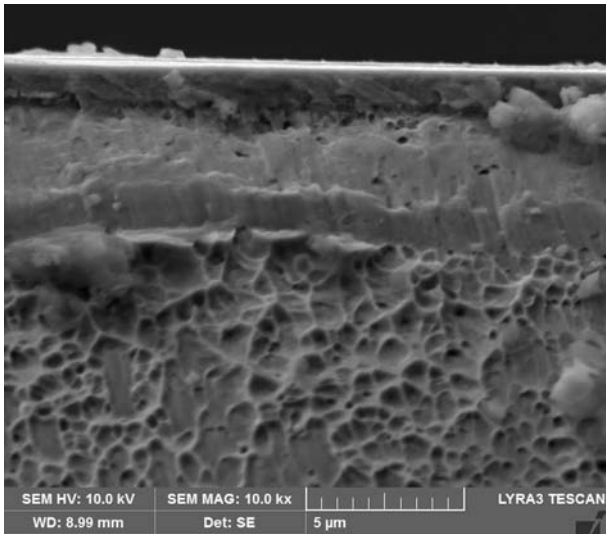
Mechanical parts from steels with low tempering temperature (below 200°C)

- bearing and cementation steels
- decrease in friction and thermal load
- reduces galling between sliding components
- decrease in noise
- decrease in energy consumption
- increase in lifetime

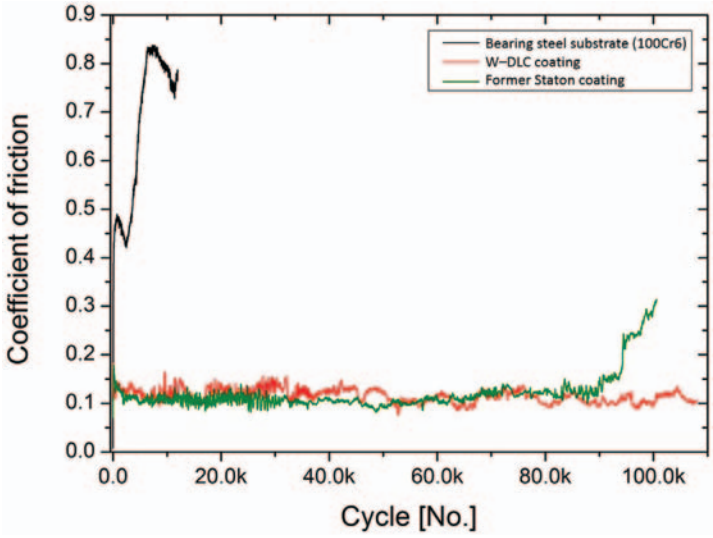
Machining of Al, Al alloys and other non-ferrous metals

- specially polished surfaces of tools (roughness R_a = 10 – 20 nm)
- decrease in roughness of machined surface
- helps to retain sharp edges on instruments
- elimination of sticking of Al to the cutting edge
- increase in tool lifetime

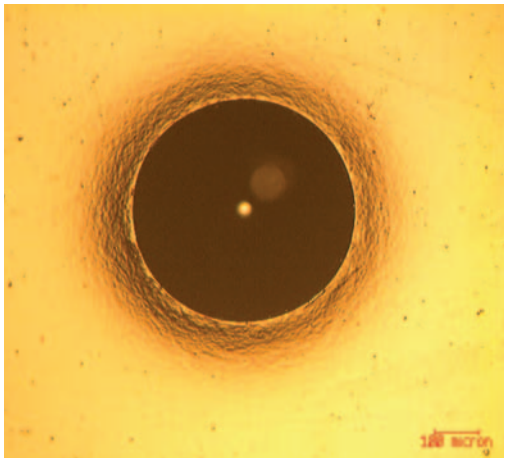




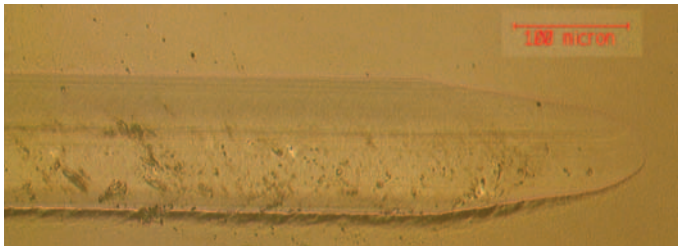
Long-term evaluation of coefficient of friction – more than 100,000 cycles on 100Cr6 substrates



Coating adhesion tests

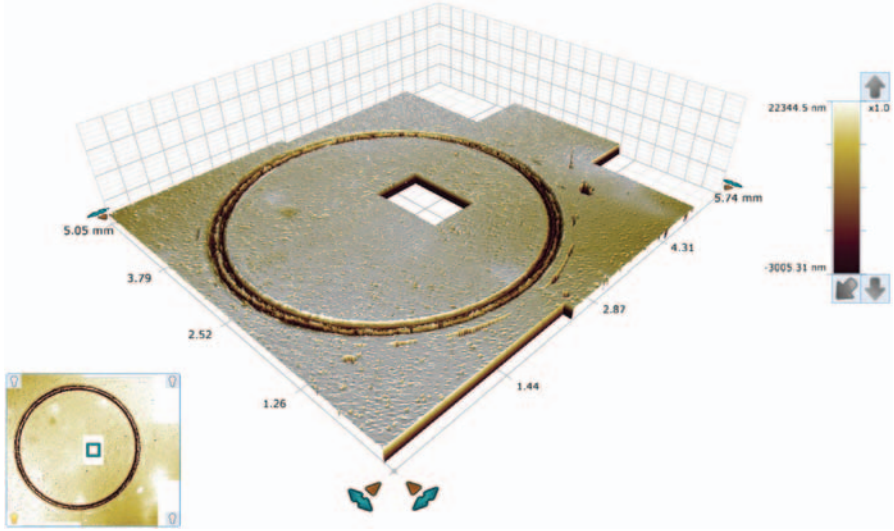


Indentation adhesion test: class **HF 1**



Scratch test critical load: higher than **120 N**

Coating wear tests

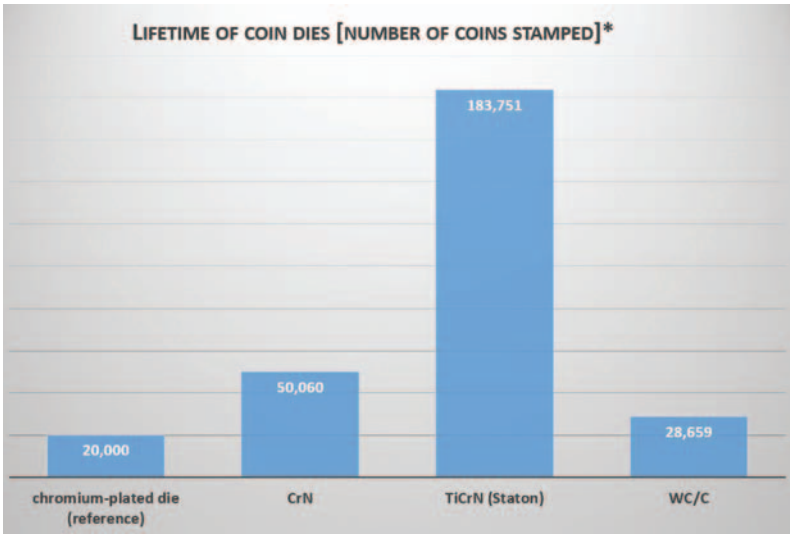


Coating of coin dies

The quality and reliability of the coin dies on the chosen material, thermal treatment during the production of the die and finalization and treatment of the functional surfaces. The utilization of the dies influences its intrinsic material properties and later a degradation occurs. Coating of the die functional surfaces using a suitable hard PVD coating can substantially increase the quality and lifetime of such die and is almost a must in the case of stamping coins with a PROOF quality. Staton, s.r.o., has developed specialized coatings for application on coin dies that largely improve the quality and reliability of the coin dies

Influence of surface modification by a coating on the lifetime of coin dies

The lifetime of coin dies for stamping of common coins in circulation can be improved more than twice when using hard chromium nitride PVD coating of the die when compared to a conventional chromium-plated die. Staton has developed a highly specialized TiCrN PVD coating for surface modification of dies used for stamping of circulation coins. The die coated with Staton TiCrN coating was proven in an independent test to be more than 9 times more effective than the conventional die.



*Independent test of Institute of Materials Research of the Slovak Academy of Sciences; published in 'MM Industrial Spectrum' journal, 2014/11.

PROOF quality coins

Apart of circulation coins, Staton focuses also on development of specialized PVD coatings for modification of surfaces of dies intended for PROOF coinage of silver and gold coins and medals.

Decorative coatings

Also products from conventional steels, alloys and even plastics can have a bright golden look. Decorative coatings can be successfully deposited on products and parts to highly improve their appearance and thus increase the aesthetical value. More important, the hard PVD coatings are scratch and wear resistant and thus ensure a perfect look even after long and intense use. The quality of the coating is represented also by the uniformity of the film.

Decorative coatings with various metallic colors can be used in many application, like automotive, architecture, household and luxury goods (jewelry, watches, glasses, etc.).

Other specialized applications of functional coatings developed by STATON

There are many other demanding applications for functional PVD coatings with superior quality. Corrosion and oxidation resistance in harsh environments is the great advantage of our specially designed CRONAL coating. For example, it has been successfully used to coat parts of hand guns. Independent tests showed that the CRONAL coating performed better as a common galvanic Ni coating.

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