Vacuum and Coating Systems
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

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.
Types of vacuum and deposition systems produced by Staton, s.r.o.

Staton, s.r.o., has more than ten years of experience with design and construction of proprietary vacuum and deposition systems. We offer construction of vacuum parts and components, deposition sources and/or complete deposition systems on demand according to particular requirements and specifications of our customers. Both PVD (Physical Vapor Deposition) and PECVD (Plasma Enhanced Chemical Vapor Deposition) systems are available. Here are some examples of the selectable items:

- Vacuum cathodic arc evaporation with and without filtration
- Magnetron sputtering with up to 10 sputtering sources
- Combination of arc evaporation and magnetron sputtering
- Deposition control and monitoring units
- DC power sources
- Rotatable and heatable substrate holders at high voltage
- Process automation

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.

Coating Center – development and analysis

The Coating Center of Staton, s.r.o., represents tradition of 20 years in deposition of functional coatings. 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.
Principles of operation of the PVD deposition techniques

Physical vapor deposition (PVD) represents a variety of vacuum deposition methods used to prepare coatings by condensation of a vaporized source film material onto various work piece surfaces (e.g., drill bits). The coating techniques involve purely physical processes, such as evaporation or plasma sputter bombardment with subsequent condensation at the surfaces to be coated. PVD is popular technique due to many advantages:

- enhancement of durability of products – hardness, wear and corrosion resistance
- utilization of virtually any type of inorganic and organic coating materials on an equally diverse group of substrates and surfaces
- environmentally friendly process

As such, PVD processes and coatings are used to enhance a number of products, including automotive parts like wheels and pistons, medical and surgical tools, cutting tools, dies and molds for all manner of material processing, optics, watches, food packaging and firearms.

The two most common variants of PVD are the arc evaporation and magnetron sputtering:

- **Arc evaporation** – a high-power electric arc discharged at the target (source) surface evaporates highly ionized material which condensates onto the substrate (work piece). Arc evaporation is relatively simple and therefore the most widely used PVD coating technique.
- **Magnetron sputtering** – glow plasma discharge concentrated around the target by magnetic field bombards the target material and sputters source material away as vapor which condensates onto the substrate. Sputtering is versatile and widely applicable technique.
Physical principles of cathodic arc evaporation and magnetron sputtering techniques

**Cathodic arc evaporation**

Electric arc (high current, low voltage) is used to vaporize material from a small area (a few micrometers wide) on the surface of a cathode target called cathode spot. The localized temperature at the cathode spot is extremely high (around 15,000°C). Vaporized material then condenses on a substrate surface and a thin film forms in result. The vapor flux contains considerable portion of ions and can contain also macroparticles (droplets). The cathodic arc evaporation technique can be used to deposit metallic, ceramic and composite films.

**Magnetron sputtering**

Sputtering is driven by momentum exchange between ions from plasma and atoms in the target material due to collisions. Atoms are ejected from a solid target material due to bombardment of the target by energetic incident (primary) particles which set off collision cascades in the target. When such cascades recoil and reach the target surface, atoms can be ejected. The sputtered particles then condense on the substrate and contribute to film growth. The magnetron sputtering technique can be used to deposit almost any material.
### Side-by-side comparison of cathodic arc evaporation and magnetron sputtering techniques

<table>
<thead>
<tr>
<th>Feature</th>
<th>Arc Evaporation</th>
<th>Magnetron Sputtering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism</td>
<td>Thermal energy</td>
<td>Momentum transfer</td>
</tr>
<tr>
<td>Type of plasma</td>
<td>Metal plasma (mainly), cathode erosion species</td>
<td>Glow discharge induced in low pressure background working gas</td>
</tr>
<tr>
<td>Function of plasma</td>
<td>Production of charged particle jet to be deposited on substrate</td>
<td>Bombardment of target by plasma ions to eject particles (atoms/molecules) of material to be deposited</td>
</tr>
</tbody>
</table>
| Electrical discharge characteristics | High current (30 – 500 A)  
Low voltage (10 – 50 V) | Low current (10² – 1 A)  
High voltage (100 – 1000 V) |
| Plasma density [m⁻³]           | 10¹⁶ – 10²⁰               | 10¹⁸ – 10¹⁸                                 |
| Ionization [%]                 | 50 – 100                 | 1 – 10                                     |
| Ion velocity [m/s]             | (1 – 2)·10⁴              | (3 – 6)·10³ (Ar⁺ ions)                     |
| Ion energy [eV]                | 50 – 150                 | 10 – 40                                    |
| Inert gas necessary            | No                       | Yes                                        |
| Reactive deposition            | Yes                      | Yes                                        |
| Materials deposition           | Conductive materials only | Almost any material possible                |
| Geometry of target             | Flexible                 | Flexible                                   |
| Deposition rate                | up to 100 nm/s           | Metals: up to 10 nm/s  
Dielectrics: up to 1 nm/s |
| Macroparticles                 | Yes                      | No                                         |
Vacuum cathodic arc evaporation is nowadays widely used to deposit hard PVD coatings for protection of surfaces of various cutting tools and thus extend their lifetime significantly. A wide variety of hard and superhard coatings and nanocomposite coatings can be prepared by this technology including TiN, TiAlN, CrN, TiAlCrN and TiAlSiN. Another important class of coatings are the diamond-like carbons (DLC). The DLC film from filtered-arc contains extremely high percentage of sp³ diamond which is known as tetrahedral amorphous carbon, or ta-C.

Apart of their relative simplicity, another great advantage of cathodic arc processes is their high degree of ionization of evaporated metal species (up to 100%), which results in exceptional coating adhesion and dense coatings. Also, the deposition rate can be very high. On the other hand, the important downside of the arc evaporation process is the formation of droplets, so called macro-particles, which are often incorporated into the growing film. The macroparticles thus affect the uniformity and coherence of the film and in some cases can even affect the performance of the coating. Nevertheless, STATON coating systems have implemented solutions to minimize the incorporation of the macroparticles into the film which leads to deposition of coatings with high quality. One of the po-
ssibilities is the use of magnetic field to control the motion of the arc on the cathode surface and thus minimize the production of the macroparticles. Another possibility is to use specially designed, so called filtered, arcs that utilize magnetic field to separate the formed droplets from the particle stream which is to be deposited on the substrate. Of course, both methods can be combined to increase the quality of the coating. At the same time, the cathode sources can be placed in any position in the system (horizontal or vertical), which makes the system design flexible.

<table>
<thead>
<tr>
<th>Basic parameters and characteristics</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum chamber dimensions</td>
<td>600 x 600 x 400 [mm]</td>
</tr>
<tr>
<td>Quantity of PVD sources</td>
<td></td>
</tr>
<tr>
<td>Cathodic arc</td>
<td>3 – 7 pcs.</td>
</tr>
<tr>
<td>Filtered cathodic arc</td>
<td>1 – 2 pcs.</td>
</tr>
<tr>
<td>DC magnetron</td>
<td>2 pcs.</td>
</tr>
<tr>
<td>Cathodic arc current</td>
<td>40 – 120 A</td>
</tr>
<tr>
<td>DC magnetron power</td>
<td>5 – 10 kW</td>
</tr>
<tr>
<td>Substrate bias power</td>
<td>18 kW</td>
</tr>
<tr>
<td>Quantity of coated substrates (cutters), I x Ø 100 x 10 mm</td>
<td>300 pcs.</td>
</tr>
<tr>
<td>Ultimate pressure</td>
<td>$10^{-6}$ mbar</td>
</tr>
<tr>
<td>Gas types</td>
<td>Ar, N₂, C₂H₂ or other</td>
</tr>
<tr>
<td>Inner heater power</td>
<td>12 kW</td>
</tr>
<tr>
<td>Main power</td>
<td>80 kW / 400 V / 50 Hz</td>
</tr>
<tr>
<td>Rotatable substrate holder (satellite)</td>
<td>automatic or manual</td>
</tr>
</tbody>
</table>
Magnetron sputtering technique utilizes magnetic fields and plasma discharge in a noble gas, most often argon, to release material species from a target surface at a relatively high rate. The magnetron sputtering source and the target material is cooled with water and kept at a low temperature which allows even sputtering of plastics using radio frequency (RF) power source. The formed coatings are very smooth without droplets and reveal excellent thickness and spatial uniformity. All this makes magnetron sputtering one of the most widely applicable deposition techniques. The technique is widely used to produce optical coatings, in automotive industry, to manufacture CDs and DVDs or to coat hard drives. The method allows use of reactive gases such as nitrogen and oxygen gases, so called reactive sputtering. Our systems allow also incorporation of the advanced HiPIMS technology which utilizes pulses of high peak power. The HiPIMS improves adhesion of coatings and allows deposition of unique coatings with extremely high hardness and density. The sputtering sources can be of various sizes and shapes (rectangular of circular) and can be placed in any position in the system (horizontal or vertical), which makes the system design flexible.
M6 – PVD deposition system with 6 outer magnetrons with possible implementation of HiPIMS power source.

M10 – PVD deposition system with 6 outer and 4 inner magnetrons with possible implementation of HiPIMS power source.

<table>
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<th>Basic parameters and characteristics</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Vacuum chamber dimensions</td>
<td>M6 500 x 500 x 500 [mm]</td>
</tr>
<tr>
<td></td>
<td>M10 650 x 650 x 500 [mm]</td>
</tr>
<tr>
<td>Quantity of magnetron cathodes</td>
<td>M6 6 pcs. (outer)</td>
</tr>
<tr>
<td></td>
<td>M10 10 pcs. (6 outer, 4 inner)</td>
</tr>
<tr>
<td>DC magnetron power</td>
<td>5 kW</td>
</tr>
<tr>
<td>HiPIMS magnetron power</td>
<td>1 – 2 kW</td>
</tr>
<tr>
<td>Substrate bias</td>
<td>1200 V / 15 A</td>
</tr>
<tr>
<td></td>
<td>1500 V / 12 A</td>
</tr>
<tr>
<td>Ultimate pressure</td>
<td>$10^{-6}$ mbar</td>
</tr>
<tr>
<td>Gas types</td>
<td>Ar, N$_2$, C$_2$H$_2$ or other</td>
</tr>
<tr>
<td>Inner heater power</td>
<td>12 kW</td>
</tr>
<tr>
<td>Mains voltage</td>
<td>3x 400 V ± 10%</td>
</tr>
<tr>
<td>Max mains input current</td>
<td>3x 32 A</td>
</tr>
<tr>
<td>Mains frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Rotatable substrate holder (satellite)</td>
<td>automatic or manual</td>
</tr>
</tbody>
</table>
Combination of arc evaporation and magnetron sputtering

Both PVD deposition techniques, vacuum cathodic arc evaporation and magnetron sputtering, can be conveniently combined in a single vacuum deposition system. Advantages of both methods can thus be utilized. Of course, also the combined system can be equipped with HiPIMS power source for deposition of advanced coating with unique properties.

Other products and solutions offered by Staton

- Deposition control and monitoring units
- DC power sources
- Rotatable and heatable substrate holders at high voltage
- Process automation