Rotating PVD Cathodes with Lifetime Guarantee
or
Current New Developments in the \( \pi \)-Technology

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\( \pi \)111, \( \pi \)211, \( \pi \)311 & \( \pi \)411 – the magical „11“ is the distinguishing mark of the \( \pi \)-system series from PLATIT with rotating cathode technology (Figure 1 [1]). The „11“ connects PLATIT not just with its native city of Solothurn [2]. PVD systems with rotating cathodes have been on the market for 11 years. In the meantime, there are 196 \( \pi \) systems in 38 countries (status as of the beginning of June 2014). Thanks to the large number of systems used in a wide variety of industries, a broad base of experience has been accumulated.

The technology established itself in the high-tech area, which of course was only possible due to constant enhancement. This article summarizes the goals of the new developments that will be presented at the AMB 2014 in Stuttgart.
1. New coatings thanks to flexibility (ALL4®, CROMVi3®, TiB2)

What does flexibility mean? Flexibility is the versatility and the possibility of being able to make a choice and change quickly between the many options.

The π systems cover the entire spectrum of current PVD coatings [1]:
- Conventional mono and gradient coatings,
- Multi and nanolayers,
- Nanocomposites and oxide coatings,
- DLC films as well as,
- Triple and quad coatings are possible.

The absolutely unique flexibility characteristic of the technology is the programmable stoichiometry of the coatings. The largely non-alloyed cylindrical tube targets are arranged very close to one another. At the same time, the targets are very close to the parts to be coated. This has the advantage that not just the vacuum chamber, but especially the whole system can be constructed very compactly. The height of the target is always longer than the height of the coatable area in the chamber. The composition of the coating can be generated with user programming along the entire coating construction. As an example, the new quad coating ALL4® (AlCrTiN4®) (Figure 2).
- begins with a CrTiN adhesion layer,
- creates the transition with good cohesion between adhesion and core layer with a AlCrTiN gradient,
- builds up in the middle an elastic core as multilayer with Al/CrN,
- continues the hard coating part with a AlCrTiN top coating and
- can complete the composition with the top coating CrCN as lubrication.

And all of this without expensive alloyed targets with 3 non-alloyed...
2. Productive decoating

The decoating of cutting tools for re-grinding is an important precondition for their recoating with high quality.

"Productive decoating" sounds paradoxical. Decoating does not produce any new product but removes an old, used coating so that the new coating can bond well on the reground tool and achieve high performance. Productive decoating means first and foremost speed. It may not "hold up" the production of the new coating.

The current decoating processes are slow. They require several hours or even days. To accelerate the process, it is possible to use an AlCr cathode in the center as a booster.

ALL® is an all-rounder, a universal coating, is used for milling, hobbing (Figure 3 [4]), fine punching, and also for forming.

Depending on the required coatings and the requirements posed of them, deposition can be realized with
- ARC- (LARC®: Lateral Rotating Cathodes and CERC®: Central Rotating Cathode),
- PECVD- (Plasma Enhanced Chemical Vapor Deposition) and
- Magnetron Sputtering (SCIL®: Sputtered Coating induced by LGD®) technologies.

The new TiB₂-coating is deposited with the latter technology from a specially-segmented central SCIL cathode (Figure 4). This coating is used first and foremost for aluminum cutting. For soft aluminum cutting, the edge build-up is critical. The pictures of the SEM and EDX analysis show that the new TiB₂-coating demonstrates very good behavior both with respect to
- abrasive wear resistance (tungsten from carbide is hardly visible through the coating).
- The CROMVic®- (DLC: ta:C) -coating was deposited with the new coating system π 211 whose development is not yet complete. It achieves the smallest built up edge. But the EDX "sees" too much tungsten, which also indicates insufficient abrasion resistance, e.g. due to too-low coating thickness (~0.5 μm). The basis of the new system is a new, patented "straight-on" ARC filter [5], with the help of which the droplets can be reduced significantly [1].

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The new PLATIT-CT decoating system (Figure 5[6]) reduces the time to less than one hour. It will be presented in a publication that will appear at the same time as this article[7].

3. LGD® – new etching procedure for optimal coating adhesion

Without having to install additional equipment (anodes, cathodes, filaments, ion sources, etc.), thanks to a new patented process, the rotating cathodes ensure optimal coating adhesion. The new LGD® process (Lateral Rotating Cathode Glow Discharge) generates a highly-efficient argon etching[8]. During LGD etching, a cathode is ignited in the direction of the chamber door while a second, adjacent cathode is switched as anode, see Figure 6. The electron flow between cathodes 1 and 2 generates a plasma with high ion density. Conditioned by the arrangement in the vacuum chamber, the plasma is fed through the carousel with the substrates. The plasma stream is not just efficient, but also very stable, which prevents the formation of additional hollow plasmas.

Figure 6 shows an extreme but clear example. The slightly corroded gripper was placed in a tool sleeve and etched with LGD. On the free area, the rust could be removed, the surface became shiny. Of course the areas covered by the sleeve remained rusty.

Figure 7: Optimized (extremely short) process flow with rotating cathodes of the x411 system for depositing of a complex QuadCoating®.
Thanks to the easy parameterization of the flexible LGD etching, this process can be used efficiently and to great advantage both for a wide variety of shaft tools as well as for substrates with complex surfaces such as forming tools. Indispensable is the technology for coating hobbing [4]

4. Low target costs due to \( \pi \)-cathodes

If simple monolayer coatings are deposited, then all cathode spaces can be occupied with the same targets. For the depositing, all cathodes are always run at full power and they achieve the highest productivity. Of course today, monolayer coatings have been replaced by much more complicated coating structures. This is precisely where the PLATIT systems, with their wide variety of cathodes, can exploit their full potential. In comparison to this, a system with common spot cathodes would have to have at least 3 different rows of cathodes to deposit the quad coating described above, which cuts productivity by two-thirds. With the rotating cathodes of the \( \pi \)411 system, door-to-door cycle times of less than 4 hours can be realized (Figure 7). And this for complex coatings. Are these complex coatings even feasible with conventional cathodes?

The target costs account for an important share of the variable costs. The \( \pi \)-cathodes provide a much larger target area than the conventional flat cathodes:
- \( \pi \)-times larger than a planar target with the same width and length,
- 17 times greater than a spot target with the same diameter.

Unfortunately, a comparison of the target costs per batch or per tool between rotating and common cathodes is not possible, since the system manufacturers do not disclose the life span of the spot cathodes. PLATIT conducted a long series of experiments on the rotating cathodes and collected data from customers around the world. Figure 8 shows an example from this data collection. In order to be more cost-effective, a conventional spot cathode set would have to be able to deposit at least fifty nACo\(^{60}\)-like coating batches without changing. (Of course under the same conditions, like thickness, loading, rotation etc.)

5. Cathode change centers allow lifetime guarantee

In the recent years, PLATIT has established cathode exchange centers (CEC= Cathode Exchange Centers [1], [9]) around the world (Figure 9). Thanks to the cathode exchange centers, the user must bear no storage costs for cathodes and targets.

With the help of the centers, the user always receives a completely-prepared cathode within a short time. That is:
- with only first-class, tested target materials,
- whereby all wear parts are replaced,
- the cathode is fully set and "burned in",
- the cathode is tested and certified in a 24-hour check under vacuum.

Each cathode is delivered with a new guarantee. That is, the user has a lifetime guarantee for the cathodes.
Summary
The technology of the rotating PVD cathodes has established itself in the cutting industry over the course of the last 11 years. The advantages are impressive when it comes to the quantity and quality:
- Very great flexibility
  - Wide variety of coatings,
  - Quick and easy rearranging to production of different coatings,
  - Own coating development possibilities,
- Homogeneous coating thickness distribution,
- Extremely good coating adhesion thanks to the new LGD process,
- High productivity thanks to extremely short process times, especially for complex high-performance coatings, and
- Low variable costs (such as target costs) and
- The unparalleled lifetime guarantee for cathodes.

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