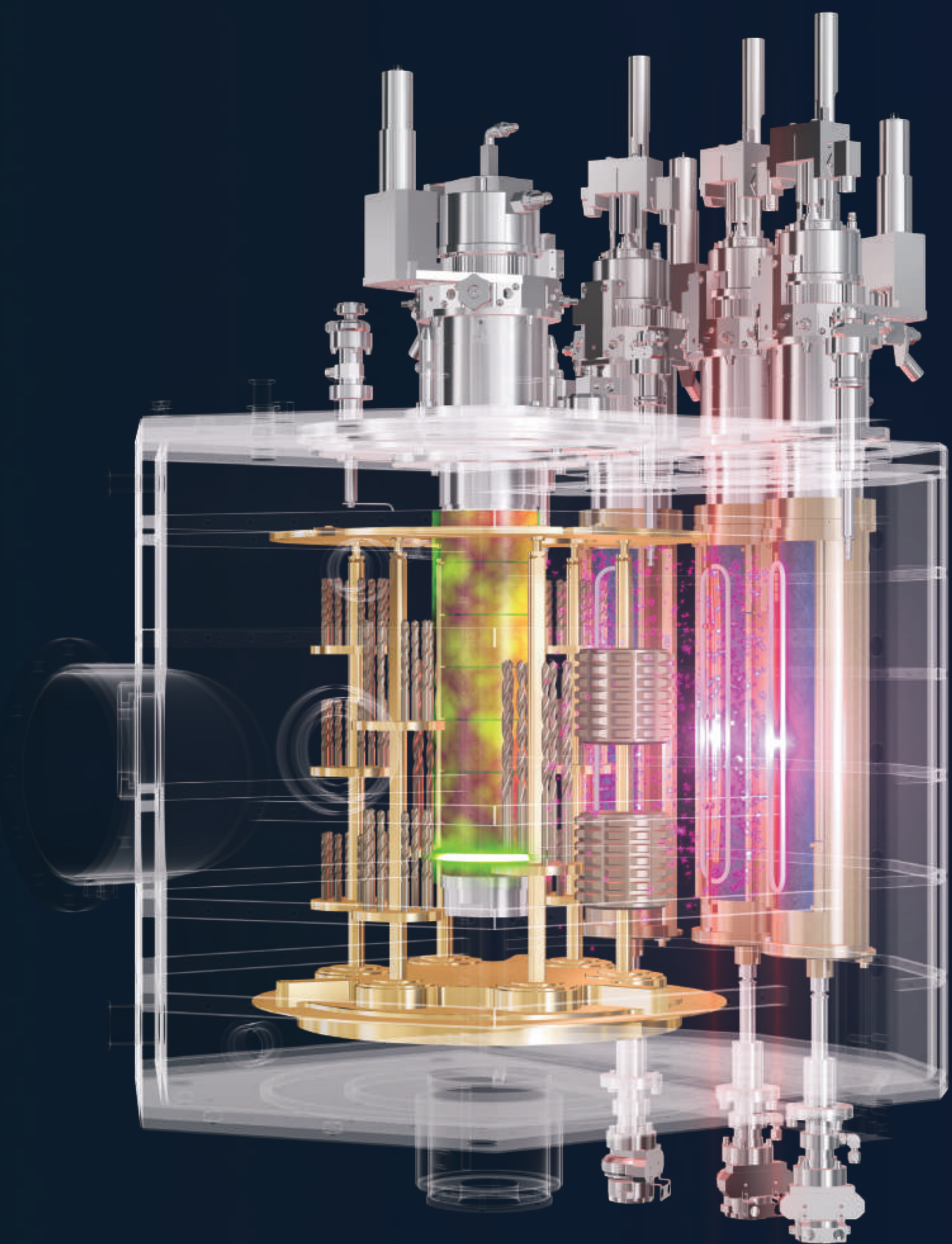
journal of
hp tooling
Dr. Harnisch Publications
ISSN 2628-5444
high precision tooling
Machine Tools, PCD, PVD, CVD, CBN, Hard Metal
reprint from
2019 – 2

Hybrid Coating for Tooling



Hybrid coating for tooling

authors: ● **Tibor Cselle - Andreas Lümkemann,** PLATIT AG, Selzach Switzerland
● **Mojmir Jilek,** PLATIT a.s., Sumperk, Czech Republic

Abstract: *Today, the ARC and sputtering processes dominate the PVD coating market. By combining multiple processes during a deposition process, a hybrid layer is created to combine the benefits of the different methods.*

The feasibility of different procedures is primarily important for SMEs, (small and medium-sized enterprises) because they can offer their greatest advantage, flexibility, also in coating processes. The true use of hybrid technology only applies when the processes can run simultaneously, not just in succession. The article presents various industrial practice results for the use of hybrid layers for cutting.

Hybrid coating for tooling

No question, the PVD coatings of cutting tools are dominated by the two main methods: ARCing and Sputtering. The question is, what the ratio of these methods is in the industry? The proportion of ARCing is estimated to be about 80-85 %, that of sputtering 10-15 %. The remainder can be assigned to the PECVD procedure.

What are the main advantages and disadvantages of these two most important methods? Compared to sputtering, the ARC technology generates a high degree of ionization with high coating density. It reaches excellent adhesion with high coating hardness and high productivity. The sputtering technology generates far fewer droplets and therefore, smooth coating surfaces.

Figure 1 compares the typical layer surface roughnesses for the following processes:

- ARCing with lateral and central cathodes (LARC®: (Lateral ARC Rotating Cathodes) and CERC®: (Central Rotating Cathode),
- sputtering (SCIL®: Sputtering Coating Induced by LGD®: Lateral Glow Discharge), and
- hybrid coating (LACS®: Lateral Arcing and Central Sputtering)

For most larger tools (larger than ∅ 2 mm), the droplets can be removed through polishing. There are several methods available for this[1], such as: brushing, micro blasting (dry and wet), drag finishing and stream grinding.

The polishing of micro tools is not possible or very expensive. Preferably the magnetic finishing can be recommended for these very tools.

In which cases are we talking about hybrid coating?

The use of multiple methods during a deposition process (in a batch) creates a hybrid layer. Why? To exploit and combine the advantages of different methods.

The realizability of different methods with an installation is primarily important for SMEs, because they can only exploit their greatest advantage, flexibility, if they can change the layers quickly in day-to-day operations and if they can react in the case of a cyclical change of businesses. The ability of hybrid plants to realize successive or simultaneous processes is of fundamental importance. That's why we made a distinction between

- sequential and
- simultaneous hybrid systems.

The true technological revolution is the ability to run the processes simultaneously. The ARC cathodes generate a highly ionized plasma, which enormously amplifies the ion density of the sputtered particles. For this solution you don't need the expensive HIPIMS electronics (High Performance Impulse Magnetron Sputtering).

Most clearly, one can see the advantages of hybrid layers in the doping of ARC layers with sputtered boron [3], [4], [5]. (Boron is just one example, the hybrid layers are by no means limited to the use of boron, which has falsely spread.)

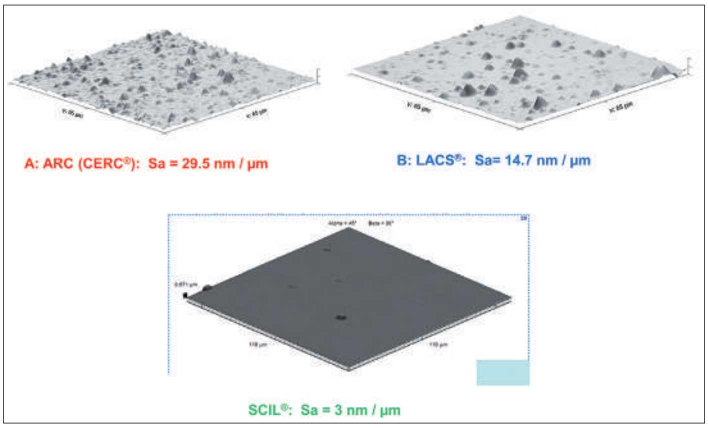


figure 1: Coating surface roughness comparison of ARC-, sputter- und hybrid-technologies

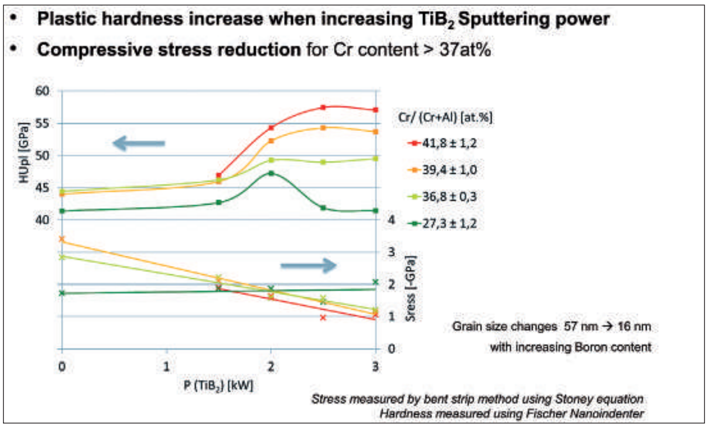


figure 2: Hardness & compressive stress at a hybrid coating with boron

The hybrid layer BorAC® (AlCrTiN/BN) was simultaneously deposited from three ARC cathodes and one sputtering cathode, increasing the sputtering power in steps *(figure 2)*. By reducing the grain size from 57 nm to 16 nm, the hardness increases with decreasing residual stress of the layer. It is not self-evident, on the contrary, it is surprising and amazing.

First practical results with hybrid layers produced by LACS® technology

Do these hybrid coatings also improve tool life for cutting tools? Compared to conventional standard coatings, the results are at least equivalent or better *(figure 3)*. Whereby a state-of-the-art, complex ARC layer (quadlayer ALL4®) can still beat the first versions of the hybrid layer BorAC®.

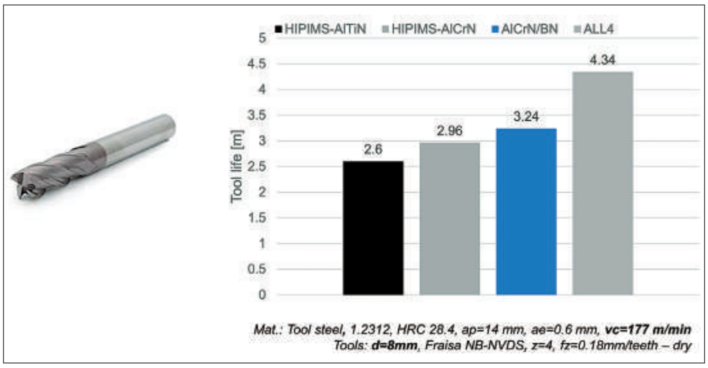


figure 3:
Using LACS®-technology at milling in heat treated steel

There are no “veni, vidi, vici” (came, saw and won) in cutting technology. It takes patience to find and develop the right coatings to their right application fields. Here are two applications where the results are very promising.

- For hard milling, the high hardness of the layer (with a lot of silicon, up to 25 %) is decisive *(figure 5)*. The high toughness (only partly of course, due to the lower residual stress) becomes relevant when the same tool (with the same layer) is also used for other applications. *(e.g., figure 4)*.

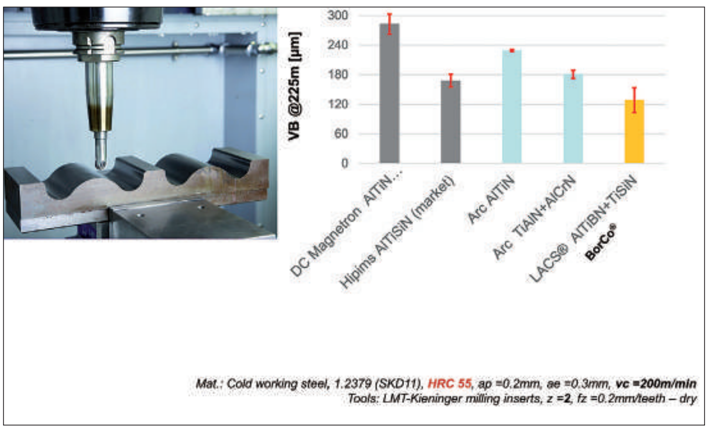


figure 4: Using LACS®-technology
with boron and silicon at hard milling (63 HRC)

- High speed hobbing requires both high hardness and high toughness. This is the area for which the hybrid boron layer is already recognized as the best solution *(figure 5)* and [3], [4], [6]. Alloyed (expensive) cathodes with boron (e.g., in AlCrB) can be arced. Once the optimum alloying ratio has been found using the sputtering cathode (TiB_2 or B_4C), the high productivity layer can go into mass production.
  But you will have lost the flexibility.

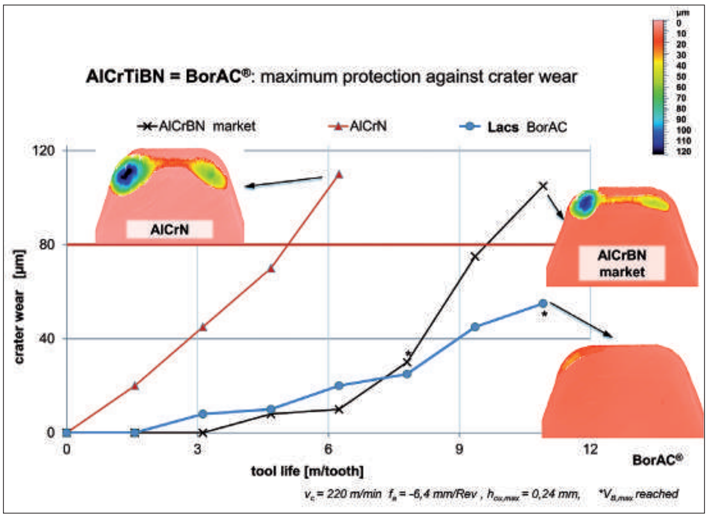


figure 5:
Using LACS®-technology for hobbing

How to find the optimal ratio between chromium, aluminum and boron: if you must buy the alloyed targets for every composition, the development becomes expensive and slow. If you can program the material shares independently from the unalloyed targets by means of a coating program [1], it is much faster and less expensive.

Flexible coating system for hybrid technology

Why the flexibility? It is vital for an SME. Much more is possible with a system that has a modular design and can gradually be expanded with options *(figure 6)* [1]:

The deposition of all standard layers (which are on the market today) is already possible in a very economical way with the 3 ARC cathodes of the eco version. Today, the DLC option is primarily used to create lubrication coatings as a top layer.

If the production capacity with the eco machine is no longer sufficient, the turbo option can deposit 1-2 additional batches per day.

Inserts are usually coated with alumina-based coatings using the CVD process. The small and medium sized company cannot afford a CVD system. The OXI option solves this problem.

For certain tools one needs simple sputtered (smooth) layers, e.g. TiN, TiCN for taps and deep hole drills.

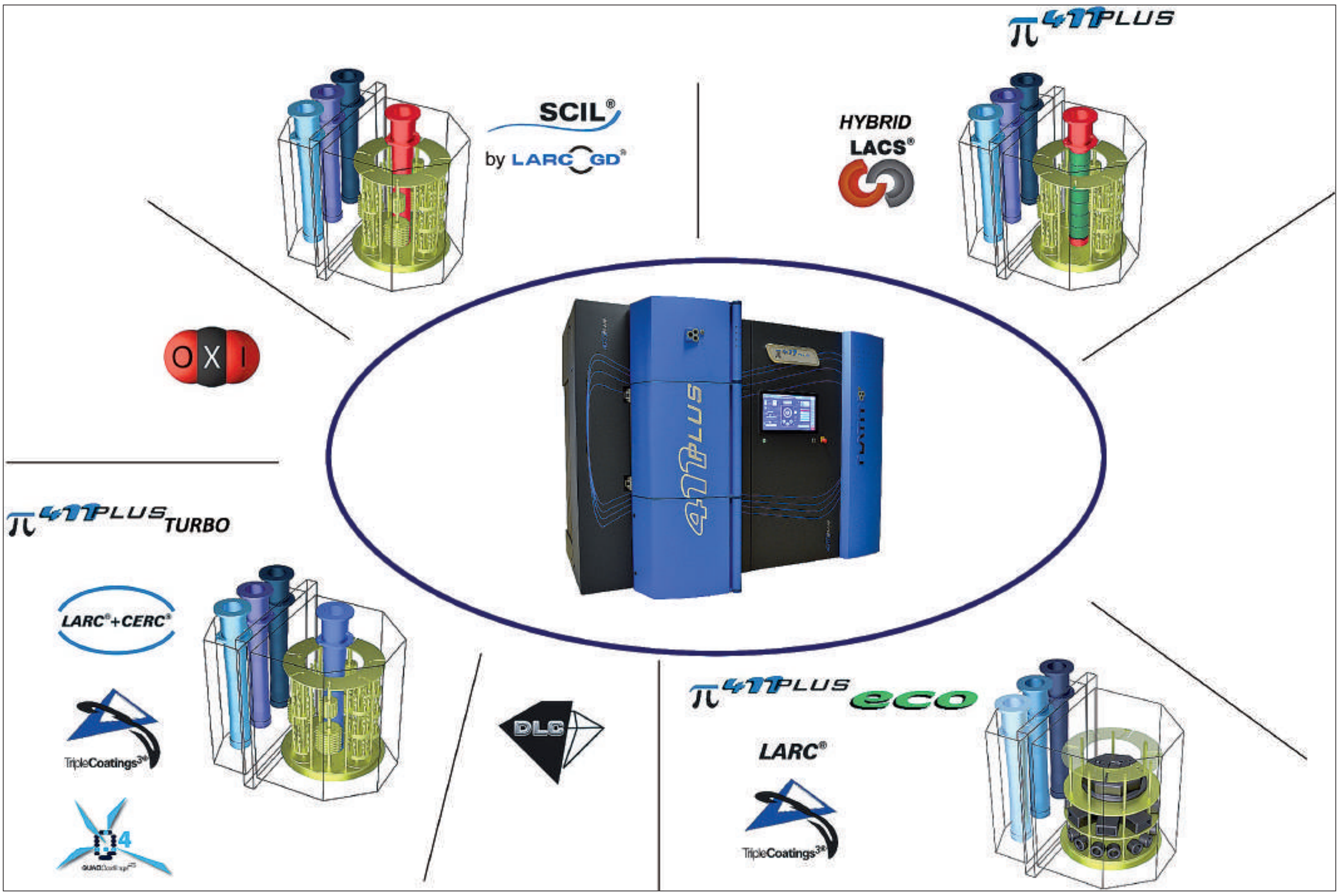


figure 6: The options of the hybrid coating unit Pi411

The SCIL® option offers significant benefits when incorporated into the LACS® option and benefits from the high ionization rate of the LGD of the ARC cathodes (without droplet formation). This increases the performance of conventional sputtering layers, such as TiB_2, WC / C.

The LACS® option can also be used to make conventional coatings such as AlCrN. Good adhesion is guaranteed by the LGD®. The smooth layers are produced by the simultaneous SCIL® cathode with high ionization of the LGD®.

The LACS® technology becomes exciting, when including thermally poorly conductive "doping" from the SCIL® cathode, such as boron from TiB_2 or B_4C and Si from SiC.

Outlook

Technologically the hybrid technology promises a lot. Whether the opportunities are used, depends on the developers and their managers, whether they will find the time and ways to target the right areas of applications.The culmination of flexibility is the next step that is still in development. The SCIL cathode is made of carbon and uses the LACS support to produce hard DLC, also ta:C layers [1]. These layers extend the application horizon of the plant further, towards coating of machine components.

EMO 2019, hall 5, booth E12

References

[1] ***Compendium, 61st edition***
PLATIT AG, Selzach, 2019

[2] *Cselle, T., Lümkemann, A., Jilek, M.:*
From Start-up to Hybrid Revolution
WerkzeugTechnik, no. 162, August 2017

[3] *Lümkemann, A., a.o.:*
Introduction of LACS® Technology
ICMCTF, B1-2-MoA5, San Diego, May/2019

[4] *Zemlicka, R., a.o.:*
The New Hybrid LACS® Technology
PSE, Garmisch-Partenkirchen, September 2018

[5] *Tritremmel, C.:*
Microstructure and mechanical properties of nanocrystalline Al-Cr-B-N thin films Surface & Coatings Technology
213, 2012, page 1-7

[6] *Jungblut, F., o.a.:*
Beyond HiPIMS – glatte und defektfreie Schichten für besondere Zerspanungsherausforderungen
VDI-Schneidstoffausschuss, Dortmund, Februar 2019