

DLC COATINGS

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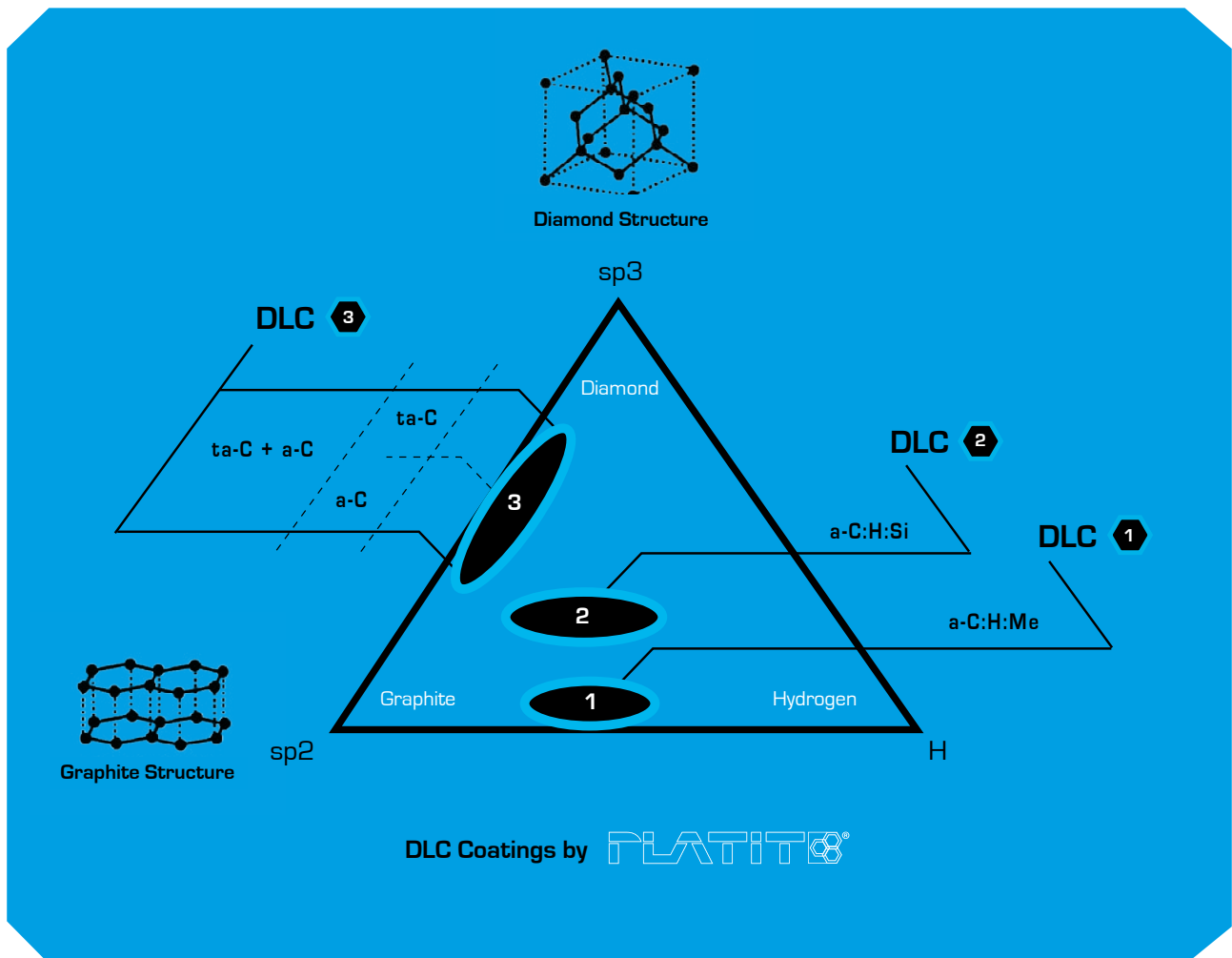
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Three types in PLATIT's coating portfolio

PLATIT's coating portfolio comprises three DLC (diamond-like carbon) coating types which are aimed and fine-tuned to address specific market and application needs. The coatings consist of a mixture of sp^3 (diamond) and sp^2 (graphite) bonds.

DLC1 and DLC2 are hydrogen containing and DLC3 is the hydrogen free coating generation. DLC1 and DLC2 are specifically aimed to address application challenges in components and sliding contacts. DLC3 with the highest sp^3 content, is fine-tuned mainly for tools and particular components.



Highlights:

- Smooth surface
- High mechanical hardness
- Chemical and corrosion resistance
- Low coefficient of friction between the tool and the workpiece
- Non-reflective surface
- Resistance to bacterial colonization
- Suitability for biocompatible products

Comparison of PLATIT DLC coatings

	DLC 1	DLC 2	DLC 3	
PLATIT Coating units	Pi111 Pi411 PL1011	Pi411 PL711	Pi411	PL711
Composition	a-C:H:Me	a-C:H:Si	ta-C + a-C (over 50% ta-C)	ta-C + a-C (up to 50% ta-C)
Process	ARC in C ₂ H ₂ atmosphere	PECVD	SPUTTERING	SPUTTERING
Coating architecture	As top layer	As stand-alone or as top layer	As stand-alone	As stand-alone
Doping	Ti or Cr	Si	None	None
Color	Anthracite	Anthracite	From rainbow colors to anthracite	Anthracite
Coating thickness [μm]	< 1*	< 3	0.3–1	0.3–1
Young's modulus [GPa]	200*	250	350–450	350–450
Nano-hardness [GPa]	< 20*	> 25	35–55	> 32
Roughness	Ra ~ 0.1 μm* Rz ~ coating thickness*	Ra ~ 0.03 μm Rz ~ coating thickness	Ra ~ 0.06 μm Rz ~ coating thickness	Ra ~ 0.02 μm Rz ~ coating thickness
Coefficient of friction [μ] PoD (at RT, 50% humidity)	~ 0.15*	~ 0.1–0.2	~ 0.1	~ 0.1
Max. service temperature [°C]	400	400	450	450
Coating temperature [°C]	< 400	< 220	< 100	< 100
Main application	Improvement of the run-in proces of a tool, lubrication by formation of transfer films	Components, punches and dies	Tools	Components

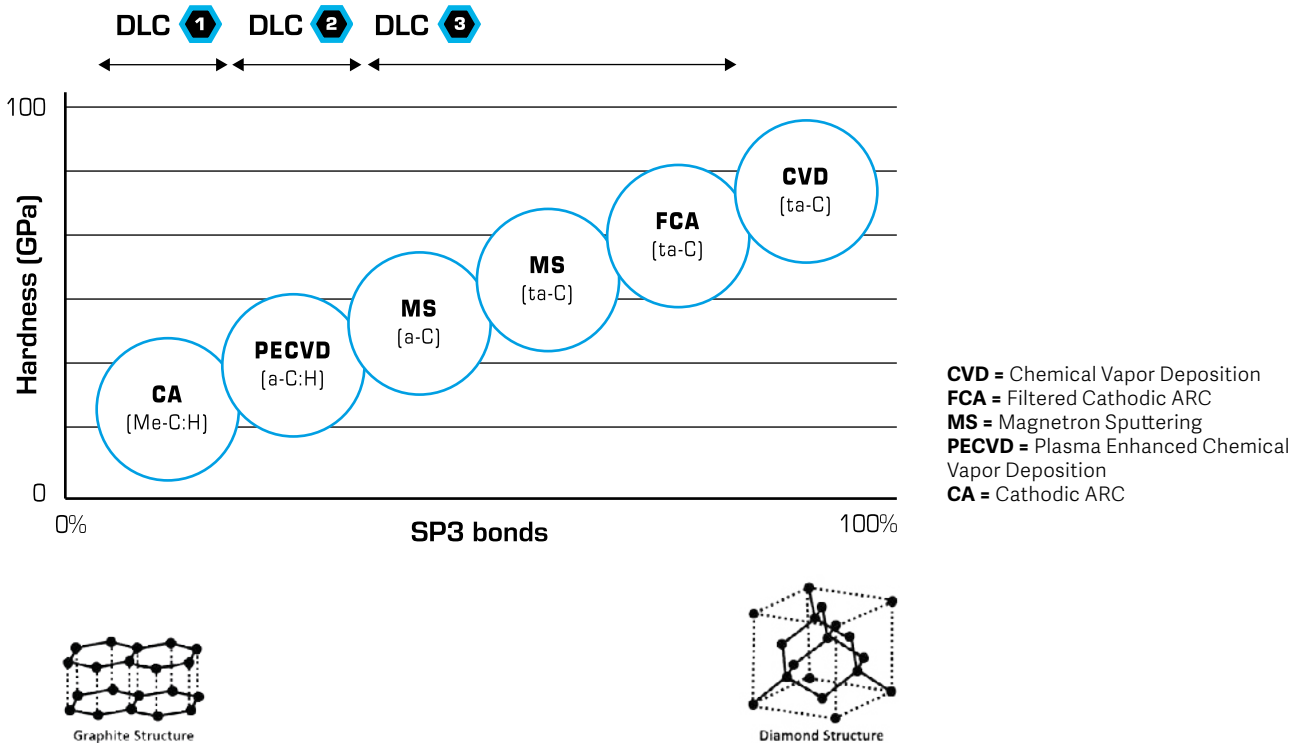
* As a top layer

Categories

DLC coatings are divided into the following categories:

- a-C = hydrogen-free amorphous carbon
- ta-C = tetrahedrally bound hydrogen-free amorphous carbon
- a-C:Me = metal-doped hydrogen-free amorphous carbon (Me = Ti)
- a-C:H = amorphous carbon with hydrogen
- ta-C:H = tetrahedrally bound amorphous carbon with hydrogen
- a-C:H:Si = Si-doped amorphous carbon with hydrogen
- a-C:H:Me = metal-doped amorphous carbon with hydrogen (Me = W, Ti)

Hardness comparison of DLC technologies

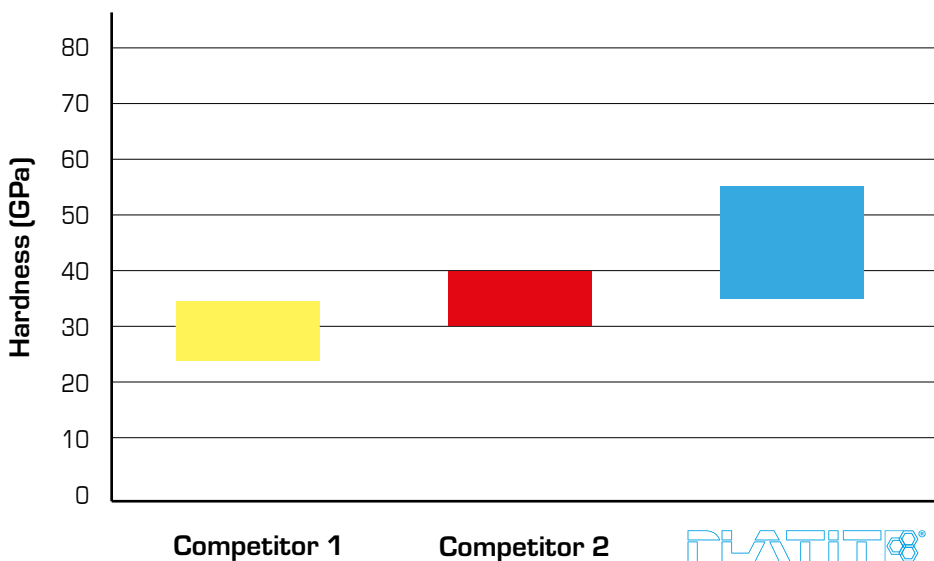


Super hard sputtered ta-C coating

Even though PLATIT has developed coating units also with DLC1, DLC2 (PECVD) and FCA processes, Magnetron Sputtering ta-C is the selected technology for PLATIT diamond-like carbon coatings for the following reasons:

- Over 50% sp³ content
- High coating density and hardness
- High residual stress
- Lowest roughness compared with all DLC technologies
- High thermal stability
- Low risk of substrate overheating during deposition
- High abrasive resistance
- Low chemical affinity to counterpart
- Stable deposition processes and low maintenance intervals; only few cleaning intervals needed
- Ultra Flexible Unit Pi411 allows the deposition of regular nitride as well as DLC coatings with the same hardware setup
- In Pi411 no cleaning between two DLC batches necessary

Hardness comparison of available sputtered ta-C on the market



ta-C belongs to the PLATIT DLC3 hydrogen-free coating generation with over 50% sp³ content. The high sp³ bond fraction results in a higher density, hardness (at ambient and elevated temperature),

thermal stability, oxidation resistance, residual stress and lower thermal conductivity. Thus, ta-C has great potential in cutting and forming applications, dealing with nonferrous, plastics and organic materials.

Applications

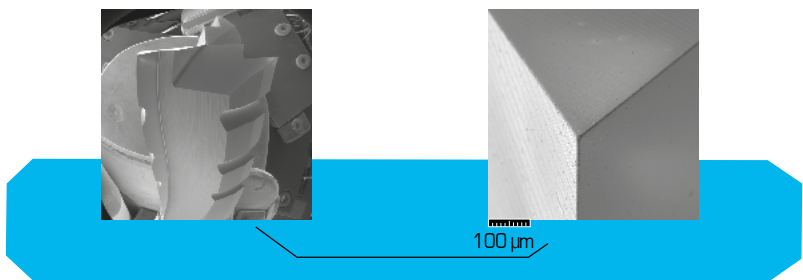
ta-C recommended applications:

Depending on the application from micro-tools to components, ta-C can be deposited by the PLATIT Pi411 or PL711 coating units in rainbow as well as in

black color. ta-C from PLATIT is also recommended for medical applications since the coating is anti-reflective and energetically unfavorable for bacterial adhesion.

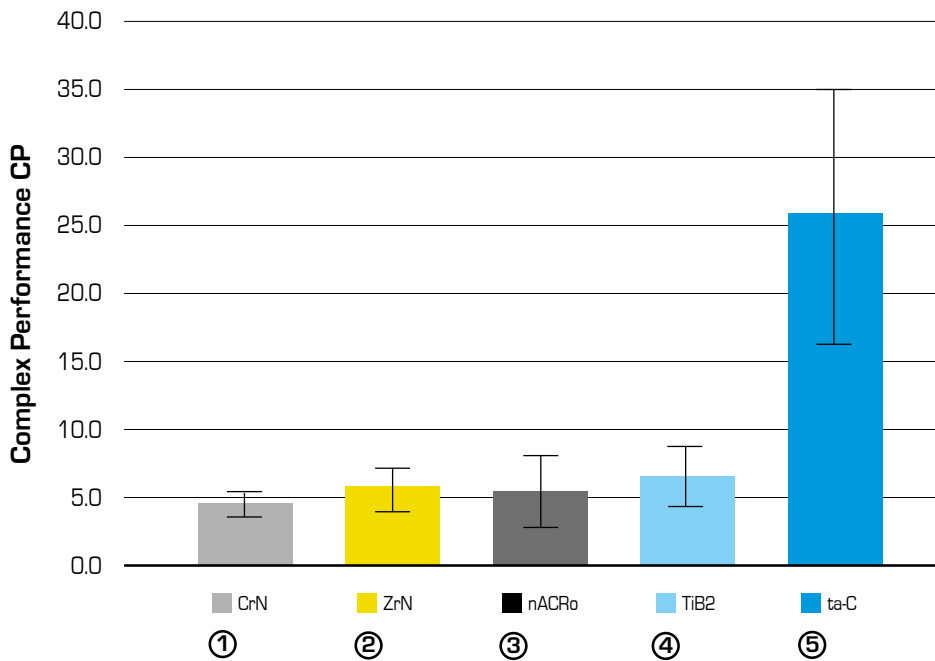
- Cutting and forming tools
- Industrial machinery
- Medical
- Decorative
- Automotive
- Optics
- Gas barrier
- Data storage

DLC3 coated end mill under scanning electron microscope:



Machining Al alloys with Si content to 10–14%:

ta-C with Pi411 PLUS LACS® features higher performance and the least torque value measured



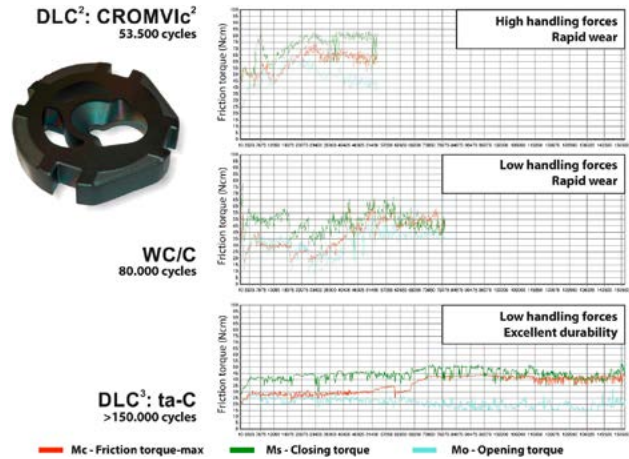
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Tool: aluminum step drill; GIW/PCG
 Workpiece material: GD- $AlSi9Cu3(Fe)$; 9.3% Si
 Source: PLATIT AG and PannonPLATIT, Budapest, HU

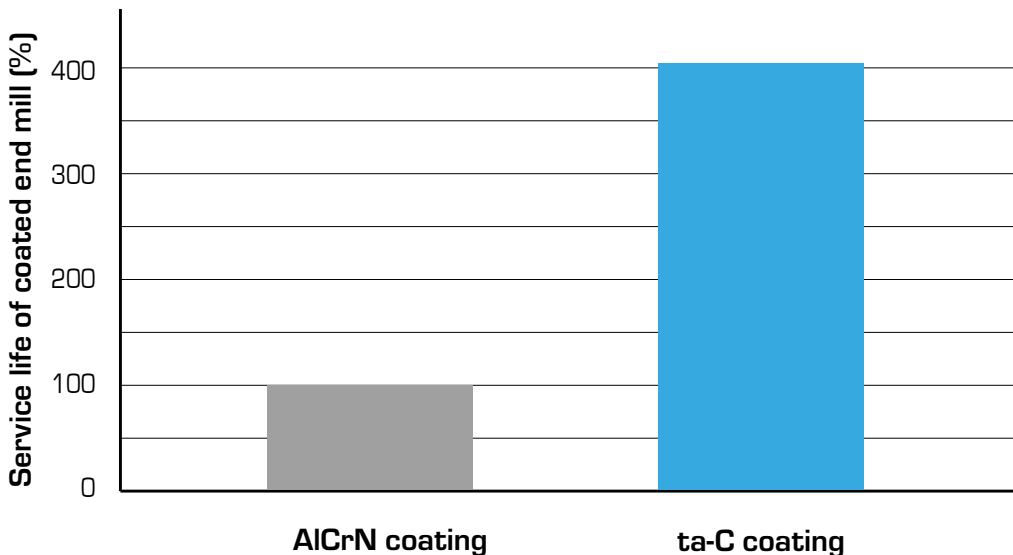
Comparison of the frictional torque of different DLC coatings on a ceramic closure wear element in a water tap:

Coated on a moving ceramic water closure element, ta-C coatings from PLATIT show superiority, combining high hardness and low friction. This allows for much higher service life, which is the number of opening and closing cycles, at a lower and stable friction torque.



Source: PLATIT AG and PLATIT Pannon

Up to four times increased end mill service life with PLATIT's ta-C coating compared to AlCrN in Molybdenum machining:



Source: PLATIT AG and PLATIT Pannon



Owing to its broad range of properties, PLATIT consistently employs ta-C in new applications. Our customers confirm the excellence of our ta-C coatings

with significant improvement of their tools, resulting in a performance increase for many applications, including inserts, drills, end mills, taps, molds and dies.

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