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## DLC Coatings

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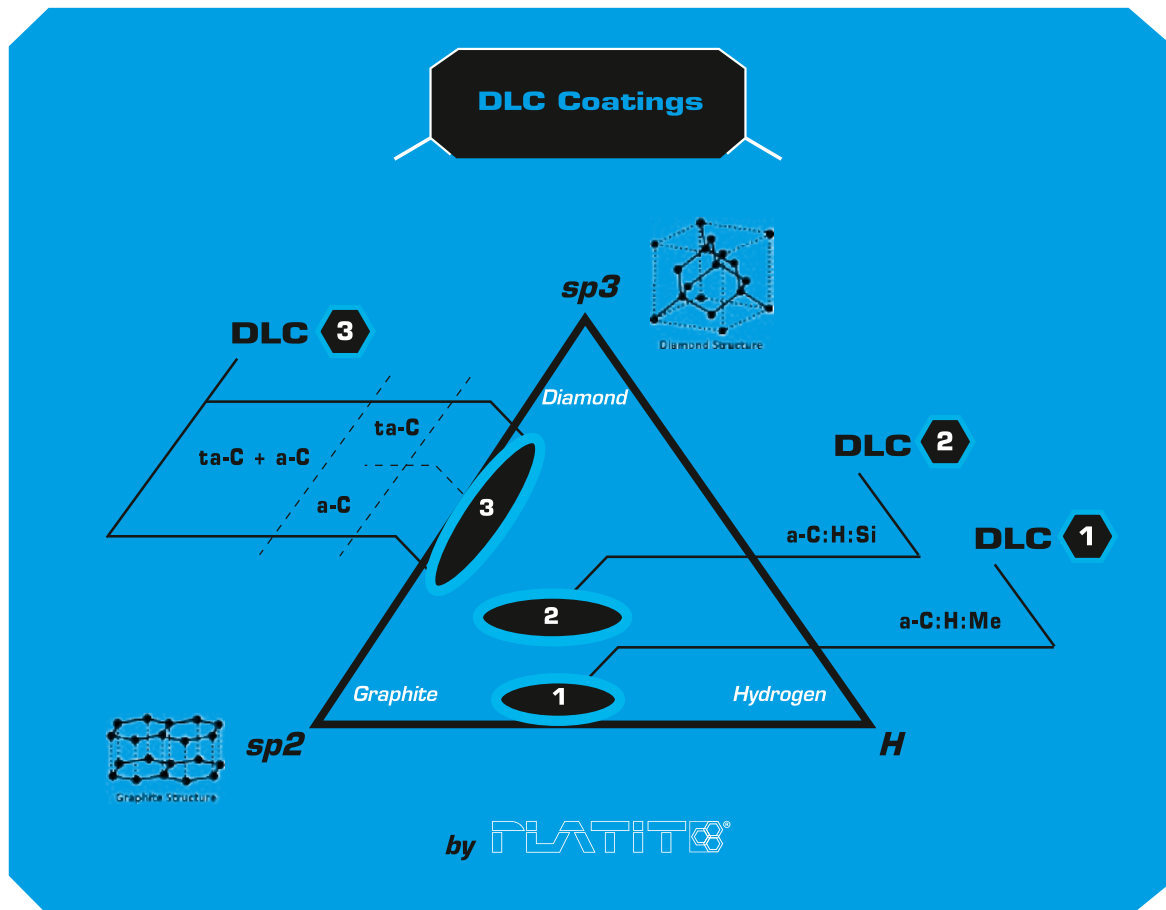
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# DLC Coatings

## 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.


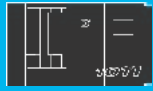




DLC1 and DLC2 are hydrogen containing and DLC3 is the hydrogen free coating generation. DLC1 and DLC2 are specifically aimed to address application challenges in components and sliding contacts. DLC3 with the highest  $sp^3$  content, is fine-tuned mainly for tools and particular components.



### 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	
<b>PLATIT® 11 - Series Coating Units</b>	 <b>411</b>  <b>1011</b>	 <b>411</b>  <b>711</b>	 <b>411</b>	 <b>711</b>
<b>Composition</b>	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)
<b>Main application</b>	Improvement of the run-in process of a tool, lubrication by formation of transfer films	Components, punches and dies	Tools	Components
<b>Process</b>	ARC in C <sub>2</sub> H <sub>2</sub> atmosphere	PECVD	SPUTTERING	
<b>Coating architecture</b>	As top layer	As stand-alone or as top layer	As stand-alone or as top layer	
<b>Doping</b>	Ti or Cr	Si	None	
<b>Color</b>	Anthracite	Anthracite	From rainbow colors to anthracite	Anthracite
<b>Coating thickness [µm]</b>	< 1 *	< 3	0,3 - 1	
<b>Young's modulus [GPa]</b>	200*	250	350 - 450	
<b>Nano-hardness [GPa]</b>	< 20*	> 35	35 - 55	> 32
<b>Roughness</b>	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
<b>Coefficient of friction [µ] PoD (at RT, 50 % humidity)</b>	~ 0.15*	~ 0.1 - 0.2	~ 0.1	
<b>Max. service temperature [°C]</b>	400	400	450	
<b>Coating temperature [°C]</b>	< 400	< 220	< 150	

\* As top layer

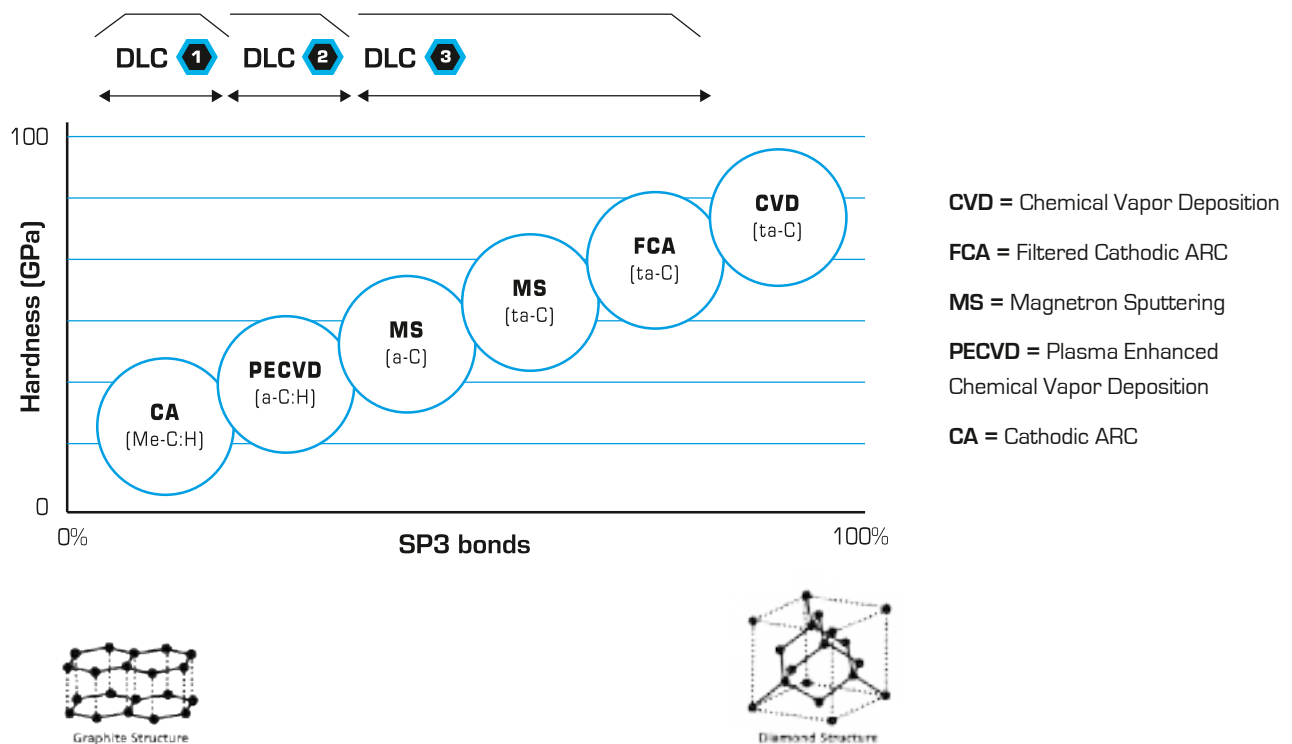
# DLC Coatings

## 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:



**CVD** = Chemical Vapor Deposition

**FCA** = Filtered Cathodic ARC

**MS** = Magnetron Sputtering

**PECVD** = Plasma Enhanced Chemical Vapor Deposition

**CA** = Cathodic ARC

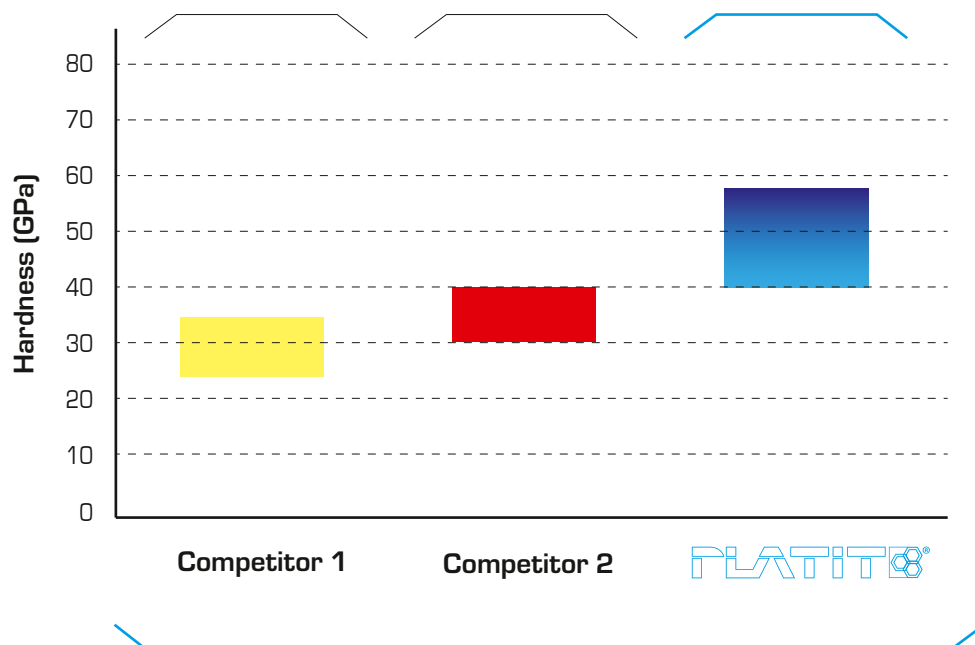
# Super hard sputtered ta-C coating

SOLUTION FOR GRAPHITE MACHINING AND FOR NON-FERROUS METALS

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% sp<sup>3</sup> 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% sp<sup>3</sup> content. The high sp<sup>3</sup> 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.

# Super hard sputtered ta-C coating

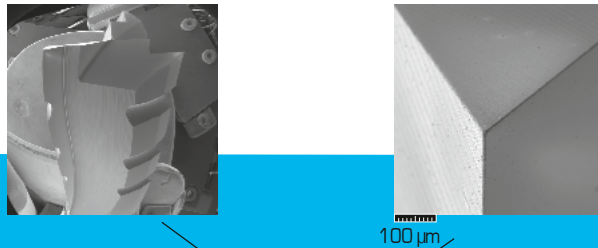
## APPLICATIONS

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.

### ta-C recommended applications:

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

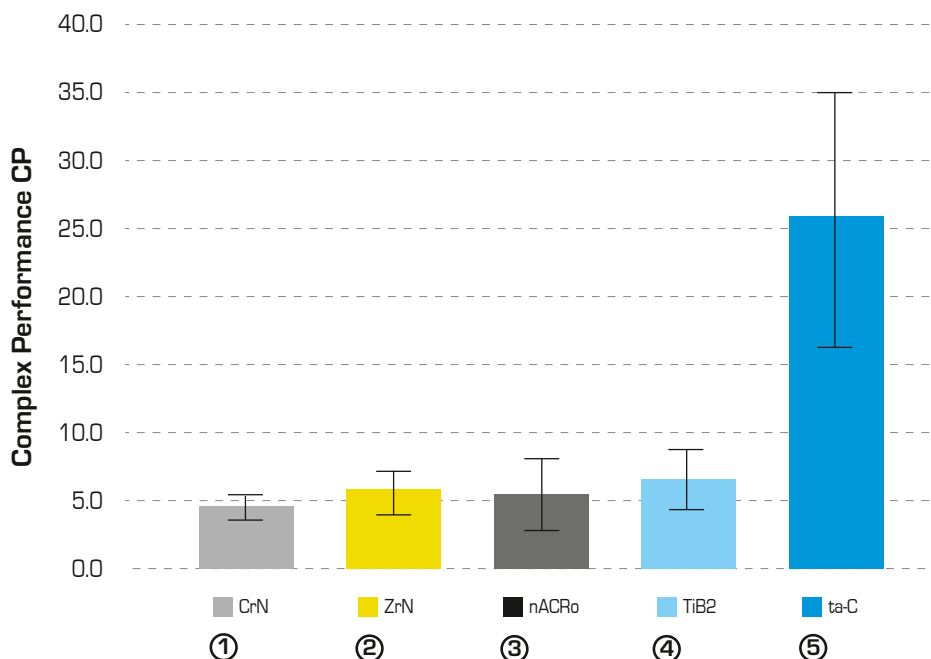
DLC3 coated end mill under scanning electron microscope:



### Machining Al alloys with Si content to 10 - 14 %:

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

# 411

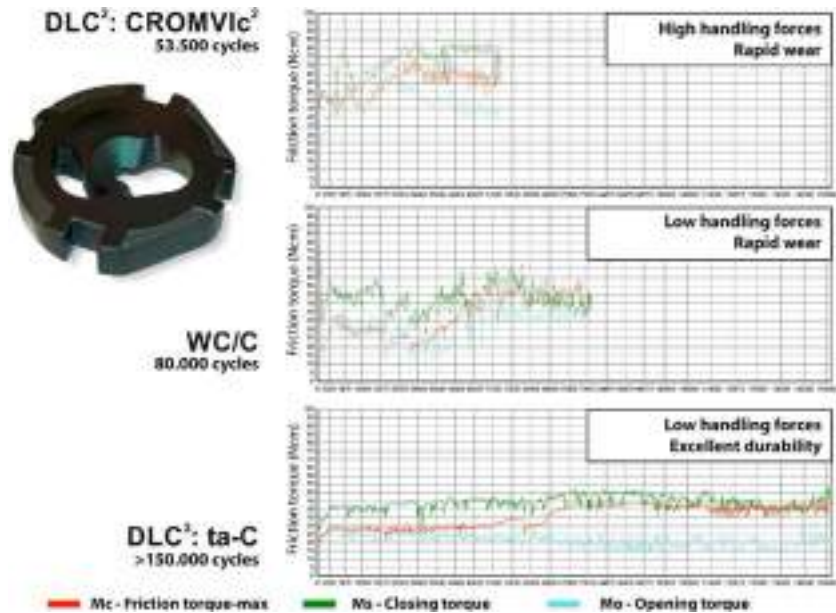


Tool: aluminum step drill; GIW/PCG  
 Workpiece material:  
 GD-AlSi9Cu3(Fe); 9.3 % Si  
 Source: PLATIT AG and PannonPLATIT,  
 Budapest, HU

## APPLICATIONS

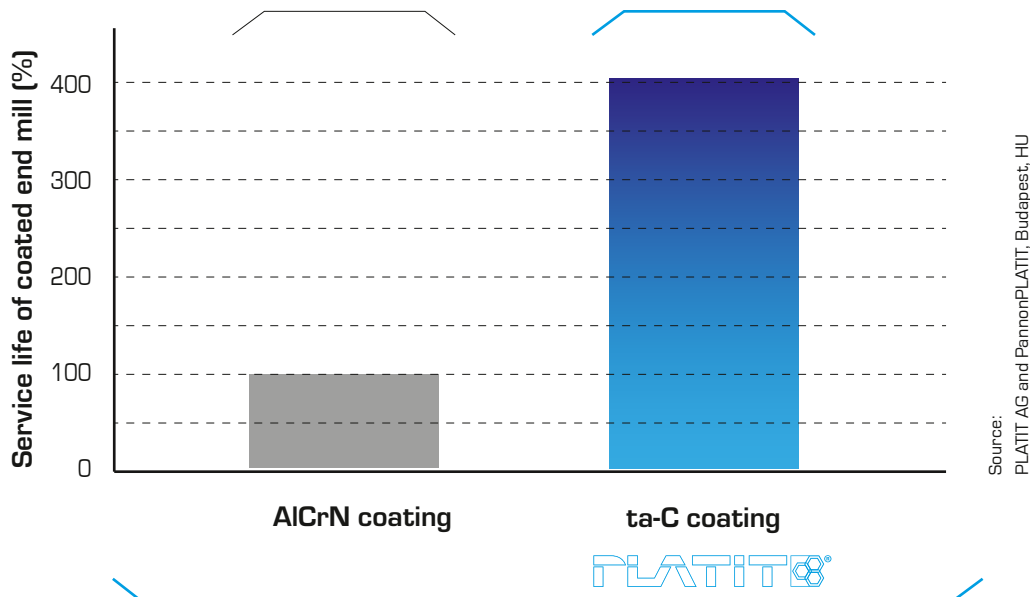
### Comparison of the frictional torque of different DLC coatings on a ceramic closure wear element in a water tap:

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: PannonPLATIT, Budapest, HU

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



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.

## PLATIT CONTACT INFORMATION

### PLATIT AG

Headquarters  
Eichholzstrasse 9  
CH-2545 Selzach  
info@platit.com  
+41 32 544 6200

### PLATIT AG

Custom Coating Solutions (CCS)  
Champ-Paccot 21  
CH-1627 Vaulruz  
info@platit.com  
+41 32 544 6290

### Subsidiaries:

#### PLATIT a.s.

Production, R&D, Service, CEC  
Průmyslová 3020/3  
CZ-78701 Šumperk  
info@platit.com  
+420 583 241 588

#### PLATIT Advanced Coating Systems (Shanghai) Co., Ltd

Sales, Service, CEC  
No. 161 Rijing Road (Shanghai) PFTZ  
CN-200131 Pudong Shanghai  
china@platit.com  
+86 2158 6739 76

#### PLATIT Inc.

Sales, Service, CEC  
1840 Industrial Drive, Suite 220  
Libertyville, IL 60048, US  
usa@platit.com  
+1 847 680 5270  
Fax: +1 847 680 5271

#### PLATIT Scandinavia ApS

Sales  
Rabalderstraede 7  
DK-4000 Roskilde  
scandinavia@platit.com  
+45 46 74 02 38