PLATIT®

Compendium

61st Edition

PLATIT COMPENDIUM ev61

Content

PLATIT and Its 10 Commandments

The Spirit of a Family

60 years of experience in coating business give us the competence to develop, produce and install genuine Turnkey Coating Systems.

The PLATIT Support Center of PLATIT in Selzach / SO, Switzerland
Operational Headquarters & Project Engineering & R&D & Test Center & Logistics & Marketing

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PLATIT CCS Building Vaulruz / FR, Switzerland
Customized coating systems according to special demands

PLATIT a.s. Building in Sumperk, Czech Republic
Standard machines of the Series

The 10 Commandments for PLATIT

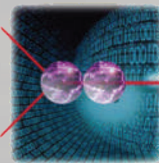
Core competence: Development and production of high-tech PVD coating equipment & coatings

1. **Independence from large enterprises**
   Main marketing targets:
   SME companies
2. **Headquarters in Switzerland**
   Tradition, image, infrastructure, financing and tax system
3. **Worldwide distributed intelligence**
   Global cooperation with institutes, suppliers, coaters and users
4. **Balanced distribution of sales**
   More than 500 installations in 38 countries
5. **Flat, lean company structure**
   No hierarchies, focus on development, not on logistics
6. **Team spirit**
   Innovation and performance count, not origins and ties
7. **Blue Ocean Strategy**
   Products and markets ahead of and without competition
   • min. 1 new coating every year
   • new coating unit every 2nd year
8. **Win-Win with customers**
   Not discount but price/performance decides competitiveness
9. **No job coating**
   Avoiding competition between customers and PLATIT
10. **Turnkey Systems**
    For integration into the production

Milestones of PLATIT's History

PLATIT was founded by W. Blösch AG in 1992.
The Blösch AG is member of the BCI Blösch Corporation Group, started in 1947 as a supplier to the Swiss watch industry. It is now a powerhouse for high-tech funcional and decorative coatings.

Walter Blösch
Founder of W. Blösch AG

2002 

Acquisition of Vilab AG in 1997.
Vilab PCT (Profitcenter Technology) develops special coatings for the optical and watch industry.

Vilab

1995 BCI: Innovative coatings for the watch industry:

1987 PLATIT® Start of the PLATIT project.

1985

New construction for the production of hard coatings.

2001

2000

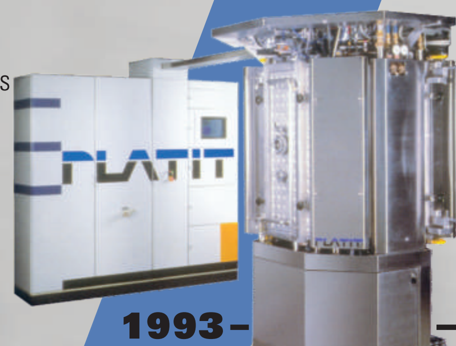
LISS

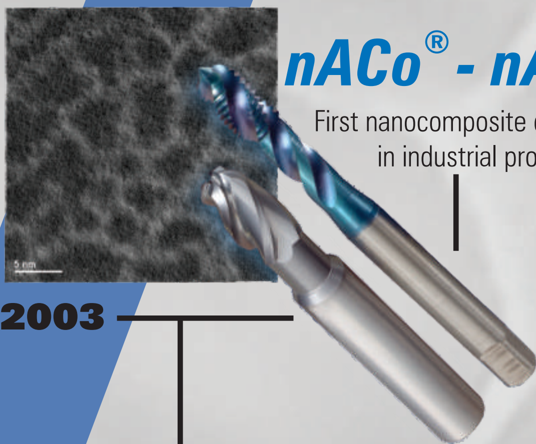
1957 Liss AG is founded for the production of watch dials and jewelry. First plant for the electroplating of precious metals is built.

BLÖSCH

1947 W. BLÖSCH AG is founded by Walter Blösch for heavy gold plating of watch cases and jewelry.

1993





nACo® - nACRo®

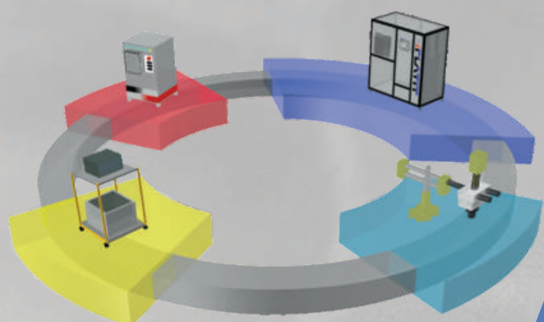
First nanocomposite coatings in industrial production.

2003

π80

Research in nano-structured coatings leads to the introduction of the revolutionary π^{80} coating unit with LARC® technology.

PIVOT – PLATIT establishes PIVOT in a joint venture with SHM in the Czech Republic.



Development of turnkey systems for flexible coating, based on the *i*PL50 coating unit.

PLATIT AG was founded. Assembly of first PLATIT hard coating equipment.

2008 – π80+

2007

200

200th PLATIT installation.

TripleCoatings3®

2006 – **nACVIc®** 1st generation DLC-coatings based on Nanocomposites

π300

2005 – The combination of LARC® and CERC® technology allows enormously high productivity and flexibility.

2004

100

100th PLATIT installation.

PL1001 COMPACT

Introduction of the plug & play workhorse for conventional coatings.

Developments

LARC GD®

320

320th PLATIT installation.

PL1401-HUT

Dedicated for broaches

Nanosphere

Dedicated coating for hobbing
(LMT-PLATIT patent)

2011

π311 +OXI

π311 +DLC

π311

2010

π111+DLC

π111

OXI

DLC²

2009

TripleCoatings3®

380

380th PLATIT Installation.

Forming of **PLATIT a.s.** Sumperk, CZ
by fully integrating PIVOT into PLATIT®

π211
For DLC³-Coatings

Due to the possible upgrades for standard machines, users can participate in the benefits of the new technologies.
E.g. LARC-GD-, OXI-, and DLC²-upgrades.

2013

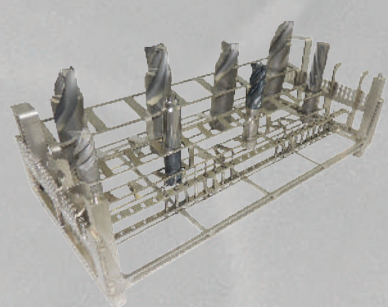
SCIL®
Sputtered **C**oatings **I**nduced by LARC GD®

QUADCoatings4®
for π411

π411

2012

CleX®
Modular holding system
for cleaning and stripping

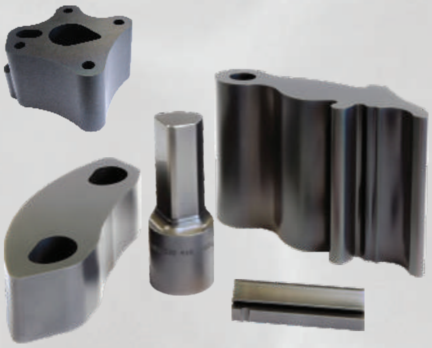


Developments

2015

FeinAl

Dedicated coating for fine blanking
Partner: Feintool, Lyss, CH



QUADCoatings4®
for π^{1511}

π^{1511}

CEC-System
=
Lifetime Warranty
for Cathodes

420

420th PLATIT
Installation

2014

ALL4®:
AlCrTiN4® +
CrCN optional

CT 40
ultra fast decoating system

TripleCoatings3®
eco

1993 - 2018
25
platit.com

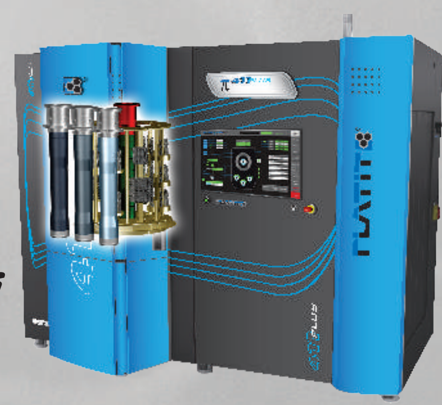
520

520th PLATIT Installation

2018

LACS® Lateral ARC & Central Sputtering

BorAC®



π411PLUS

2017

Integrating PLANAR S.A. into PLATIT®

PL1011

ALL4® eco

2016

π111PLUS

Developments

550 500th PLATIT Installation

New PLATIT facility in Vaulruz, FR, Switzerland for the production of dedicated coating units

ta:C

PL711

BorCo®

2019

CT20
ultra fast decoating system

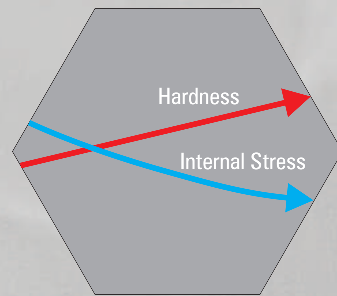
PLATIT®

Milestones of PLATIT's Coatings

LACS®

BorCO®
BorAC®

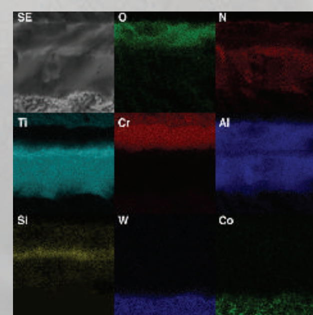
2019
2017



QUADCoatings4®

ALL4®-Tribo
nACoX4®

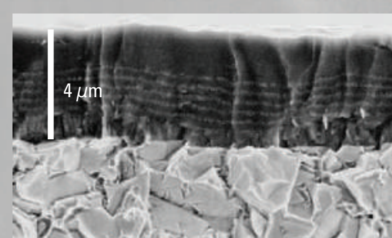
2012



TripleCoatings3®

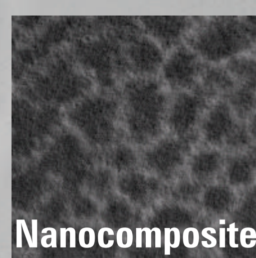
TiXCo3®
nACo3®

2007



nACo®
nACRo®

2003



UniversAl®
UniCut®

1994

PLATIT Coating Systems in 39 Countries of the World

Europe

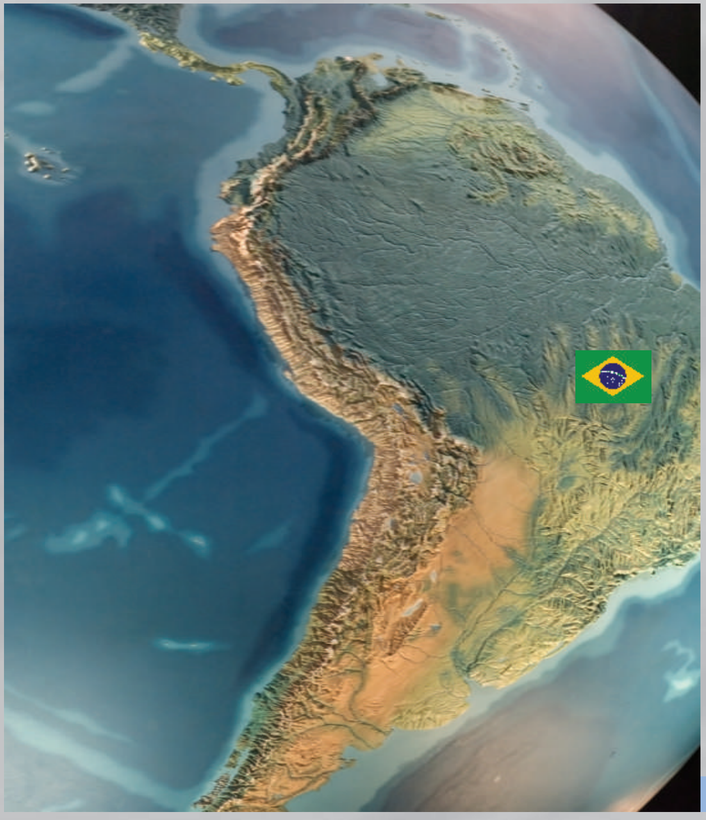
- Austria
- Belarus
- Bulgaria
- Czech Republic
- Denmark
- Estonia
- France
- Finland
- Germany
- Hungary
- Italy
- Netherlands
- Norway
- Poland
- Romania
- Russia
- Slovakia
- Slovenia
- Spain
- Sweden
- Switzerland
- United Kingdom

Asia

- China
- Hong Kong
- India
- Israel
- Japan
- Pakistan
- Philippines
- Singapore
- South Korea
- Taiwan
- Thailand
- Turkey
- United Arab Emirates

Americas

- Brazil
- Canada
- Mexico
- USA



Coating Advantages

PLATIT develops and produces coating equipment for plasma-generating PVD (Physical Vapor Deposition). Our products are based on:

- *Conventional cathodic ARC technology PL1011, π1511*
- *The unique LARC® technology (LAteral Rotating Cathodes) π111, π1511*
- *The unique LARC® and CERC® (CEntral Rotating Cathodes) technologies π411*
- *High performance sputtering technologies*
  - *π411 SCIL®: Sputtering induced by LGD® (LAteral Glow Discharge)*
  - *PL711 HIPIMS: High Performance Impuls Magnetron Sputtering*
- *LACS®: Hybrid technology π411 (LAteral Arcing with Central Sputtering)*

We hold a significant number of patents related to coatings, coating technologies, and processes.

PLATIT coatings offer the highest standard of modern coating technology for tool steels (cold / hot work steel, high speed steel; HSS, HSCO, M42, ...) and tungsten carbides (WC). All work pieces can be coated with a programmable coating thickness between 1 and 18 µm. All batches are coated with high uniformity, ensuring the repeatability of the coating quality.

Cutting

The PLATIT hard coatings reduce the abrasive, adhesive and crater wear on the tools for conventional wet, dry and high speed machining.

All carbide tipped tooling must be manufactured with brazing material that contains no cadmium and no zinc. Cadmium and zinc are not stable under the high vacuum at the coating process temperatures. Braze outgassing will ruin the strength of the joint, contaminate the tooling surface and the vacuum chamber.

Punching, Fine Blanking

PLATIT technology ensures an increase in tool life through special structures and by reducing friction on punches and on fine blanking tools.

Forming

For forming applications such as extrusion, molding, deep-drawing, coining, PLATIT hard coatings reduce friction, wear, built-up edges and striation. Repolishing of functional surfaces is recommended.

The PLATIT hard coatings increase productivity for plastic forming and forming machine components with better release and lower wear. Low roughness and excellent surface texture improve part release and influence injection forces in the mold to allow shorter cycle times. For parts with a mirror finish, repolishing after coating is recommended. Due to physical limitations, deep holes and slots are seldom coatable.

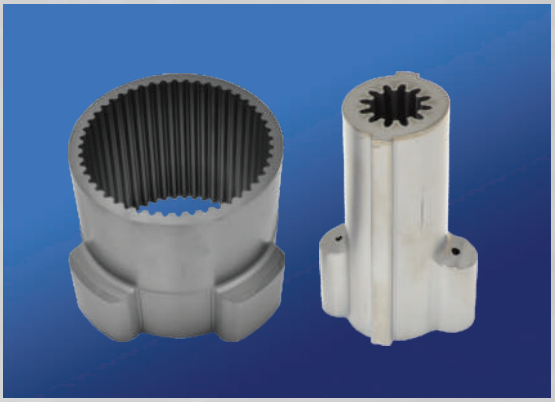
Tribology

PLATIT hard coatings solve tribological problems with machine components that can be coated at temperatures of 200-600°C. Due to the hardness (up to 45 GPa), abrasive wear is reduced. This leads to higher reliability for dry operations, and environmentally damaging lubricants can be replaced.

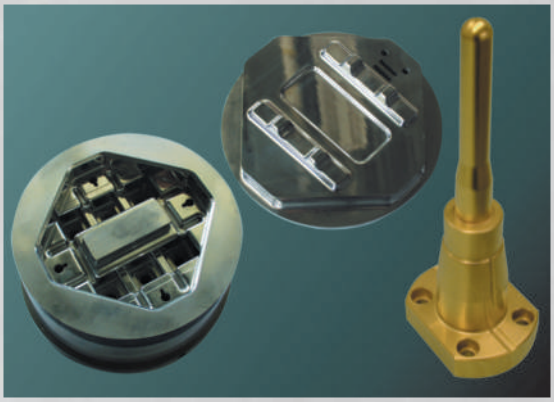
Basic Application Fields

Cutting

Punching / Fine Blanking



Injection Molding



Forming

Tribology

Flexible Coating

Application Oriented
Different objects (e.g. tools) are not coated with one universal coating, but in separate batches with the optimal coating for their individual applications.

User Oriented
Large and small part quantities can be coated according to the customer's specifications.
Users can create new coating brands to coat special parts for highest performance and their own marketing.

Highly Reproducible
All customer-dedicated batches can be repeated with the same exact parameters and under the same conditions.

Fast
The collection of similar pieces to be coated in one batch can be minimized. No waiting times.

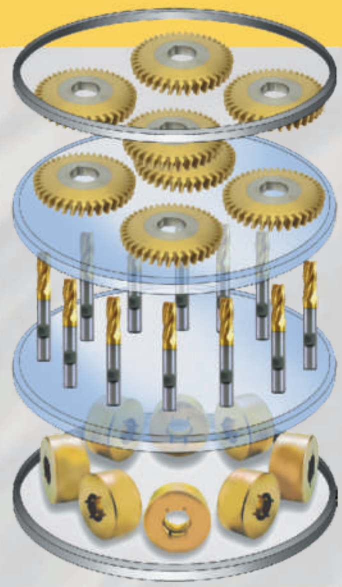
Economical
The system's payback is ensured even at just a few batches per day, since coating times are much shorter than with conventional units.

Large Volume Coating

Standard Coating for All Pieces

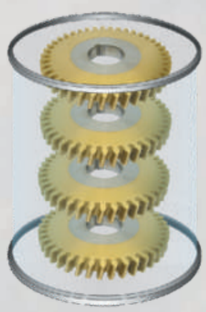
In industrial mass coating, different types of substrates are often coated together. While high volumes may raise profitability, coating performance often suffers. Also, process times are typically much longer than with smaller quantities.

The PL^{711}, PL^{1011}, and π^{1511} units make traditional high-volume coating flexible. They offer high-quality coatings and short cycle times. Different substrate types and sizes can be mixed without sacrificing coating quality.



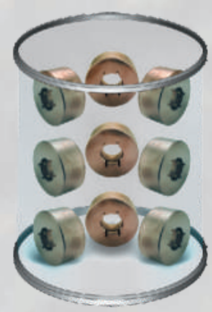
Dedicated Coating

The π^{111}, π^{411} units make specially tailored coatings possible and economical, even for small and medium-sized batches.



Dedicated TiN
for milling cutters

Dedicated TiAlN
for end mills



Dedicated TiCN
for punches and dies

Large volume job coating load with different mixed substrates

Small batch with dedicated coating

Integrated Coating

PLATIT's coating units are suitable for integration into the manufacturing process. This creates the opportunity to

- generate new coatings (such as nanocomposites) and coating brands
- reduce logistics, transport, and storage costs
- operate with own pretreatments, tool geometries and keep them confidential
- manage the quality and timeline for entire production internally
- create earnings through coating

Insourcing the coating process does not require more staff than that for logistics, packaging, shipping and cooperating with the job coater. The break-even of PLATIT coating systems is typically achieved in less than 2 years.

With the high flexibility of the PLATIT units, coatings can be applied

- for the cutting and forming tools used in production and
- for own products, including machine parts

The example below is taken from Madern B.V., Vlaardingen, NL (Madern built up the system with the predecessor of the π^{111}, with π^{80})

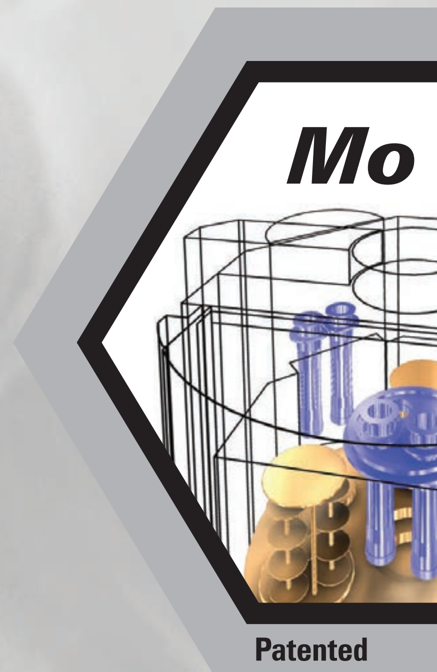
MoDeC® Innovations

PLATIT's coating concept - Modular Dedicated Coating - allows the configuration of the number of cathodes, type, and position according to the coating task. MoDeC® is the driving force behind PLATIT innovations. New coatings and units are developed bearing this principle in mind.

π111 PLUS

Small coating unit with 2 LARC® + cathodes
LARC® technology: LAteral Rotating Cathodes

- The new generation of the first industrial coating unit for Nanocomposite coatings
- The heart of Turnkey Coating Systems for small and medium enterprises
- Selected Triple**Coatings3®**
- Coatable volume: ø355 x H420 mm
- Loading with ø10mm end mills: 288 pcs
- 5 batches / day



PL711

Compact machine for machine components and tools

- 2 planar (DUO) cathodes (standard size of the PL1011)
- DC or HIPIMS sputtering with PA3D module
- TiN, CrN with sputtering
  - +DLC^2 (SCILVIc$^{2®}$) in PECVD mode
  - +DLC^3 (ta-C)
- Coatable volume ø500 x H450 mm
- Loading with ø10mm end mills: 432 pcs
- Extremly high coating surface quality

PL1011

- High volume compact unit
- The "workhorse" for coating centers
- 4 planar cathodes with ARC technology
- Conventional and selected Triple**Coatings3®**
- Coatable volume: ø600 x H680 mm
- Loading with ø10mm end mills: 1080 pcs
- 3 batches / day

π Series

PLATIT's entire product line consists of "compact" coating units. These units come in one piece, with the coating chamber in the same cabinet as the electronics. This eliminates the need of costly and time consuming on-site assembly.

π411 PLUS

Compact coating unit with highest flexibility

- π411 eco is the basic machine
  - 3 LARC® cathodes

Modular upgradeable with options:

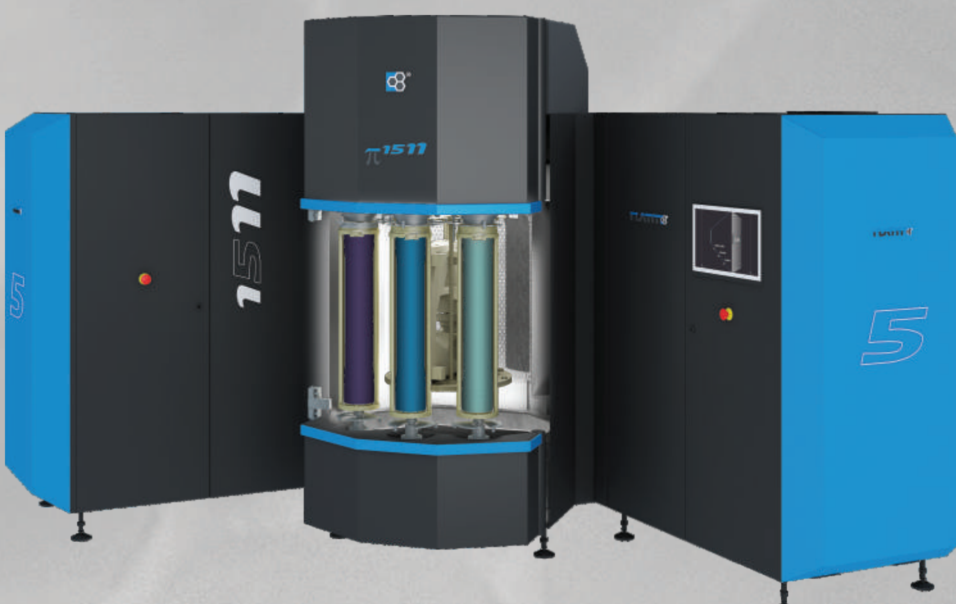
- DLC² option
- π411 TURBO option
  - 3 LARC® cathodes and 1 CERC® cathode
  - high productivity with CERC® booster

- OXI option
- SCIL® option: high performance sputtering
  - 3 LARC® cathodes and 1 central SCIL® cathode
- LACS® option: Simultaneous LAteral ARCing + CEntral sputtering
- For conventional and Nanocomposite coatings
- All Triple**Coatings³®** and QUAD**Coatings⁴®**
- Coatable volume: ø500 x H420 mm
- Loading with ø10mm end mills: 504 pcs
- 5 (up to 6) batches / day

π1511

Combination of LARC® and planar ARC technologies

- High volume compact unit
- 3 LARC®-XL rotating cathodes in the door
- 2 planar cathodes in the back as boosters
- All 5 cathodes can deposit simultaneously
- For conventional and Nanocomposite coatings
- Most Triple**Coatings³®** and QUAD**Coatings⁴®**
- Coatable volume: ø600 x H680 mm
- Loading with ø10mm end mills: 1080 pcs
- 3 batches / day



PLATIT π111 PLUS

The Startup Machine

General Information

- Compact hardcoating unit
- Based on PLATIT LARC® technology (LAteral Rotating Cathodes)
- Coating on tool steels (TS) above 230 °C, high speed steels (HSS) 350 - 500 °C and on tungsten carbide (WC) between 350 - 550 °C

Hard Coatings

- Monolayers, Multilayers, Nanogradients, Nanolayers, Nanocomposites, and their combinations
- Main standard coatings: AlTiN^2-Multilayer, nACo^2®, nACRo^2®, AlCrN^3
- Selected Triple**Coatings^3®** available

Hardware

- Footprint: W1890 x D1500 x H2120 mm
- Vacuum chamber with internal sizes of: W450 x D320(460) x H615 mm
- Loading volume: ø353 x H494 mm
- Coatable volume: ø353 x H420 mm
- Max. load: 100 kg
- Turbo molecular pump
- Revolutionary rotating (tubular) cathode system with 2 LARC®+ cathodes:
  - LARC® target size: ø96 x 510 mm
  - Magnetic Coil Confinement (MACC) for ARC control
  - Double wall, stainless steel, water cooled chamber and cathodes
  - Changing time for skilled operator: approx. 15 min / cathode
- VIRTUAL SHUTTER® and TUBE SHUTTER®
- LGD®: LARC® Glow Discharge
- Ionic plasma cleaning:
  - etching with gas (Ar/H_2); glow discharge,
  - metal ion etching (Ti, Cr)
- Pulsed BIAS supply 30 kHz (optional 350 kHz)
- Air conditioning for the electric cabinet
- Up to 6 gas channels, 5 MFC controlled
- Special dust filters for heaters (10 kW)
- Electrical connection: 3x400V, 100A external fuse 50-60 Hz, 30 kVA
- Carousel drive with high loadability (>150kg)
- Chamber preheating
- Changeable door shields
- Pulsed ARC supplies with low frequency
- LARC+ cathodes

Electronics and Software

- Control system with touch-screen menu driven concept
- No programming knowledge is required for control
- Data logging and real-time viewing of process parameters
- Remote diagnostics and control
- Insite operator's manual and on CD-ROM
- Enhanced operating software compatible to π411

Optimal Cycle Times*

• Shank tools (2 μm):	ø 10 x 70	mm,	288 pcs:	4 h
• Inserts (3 μm):	ø 20 x 6	mm,	1680 pcs:	4.5 h
• Hobs (4 μm):	ø 80 x 180	mm,	20 pcs:	6 h

*: The cycle times can be achieved under the following conditions:

- solid carbide tools (no outgassing necessary)
- high quality cleaning before the coating process (short etching)
- continuous operation (pre-heated chamber)
- 2-cathode processes
- use of fast cooling (e.g. with helium, opening the chamber at 200°C)
- 5 processes / day

π Advantages with LARC & LARC+ Technology

1. LARC Technology
Low target costs due to the cylindrical rotating cathodes
- Large effective target surface: d * π * h
- Highly ionized plasma
- Target life: ~200 batches
- Low target costs/tool: ~0.07 CHF/tool

π111

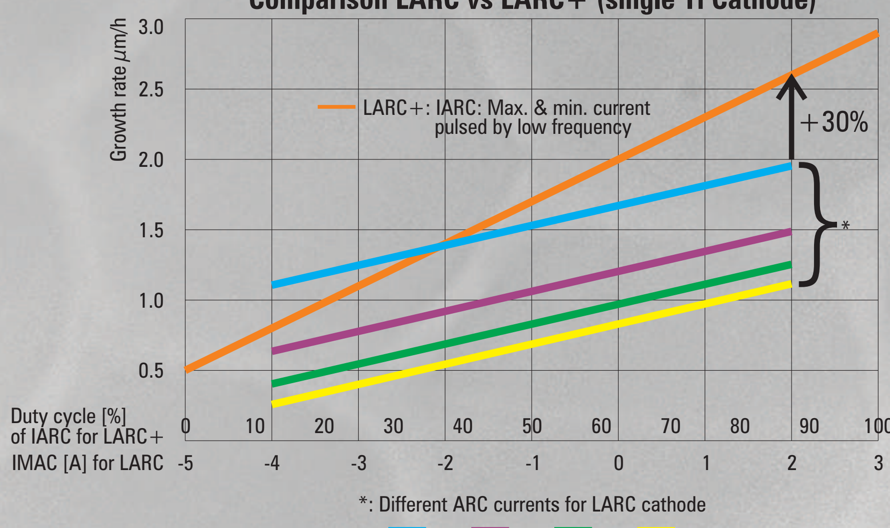
2. LARC+ Technology
Additional cost reduction
- New magnetic field system (LARC+)
- Low frequency pulsed ARC
- Increased target life by ~30%
- Low target costs/tool: ~0.05 CHF/tool

π111 PLUS

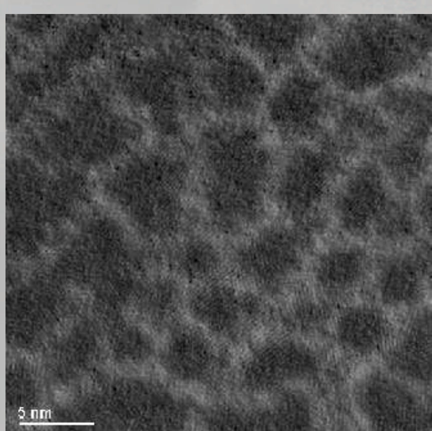
3. LARC+ Very consistent target erosion
LARC+: Targets at end of life

4. High deposition rate further increased with LARC+
Due to:
- Chamber preheating with water
- Focused magnetic field
- Increasing of deposition rate by ~30%

Comparison LARC vs LARC+ (single Ti Cathode)



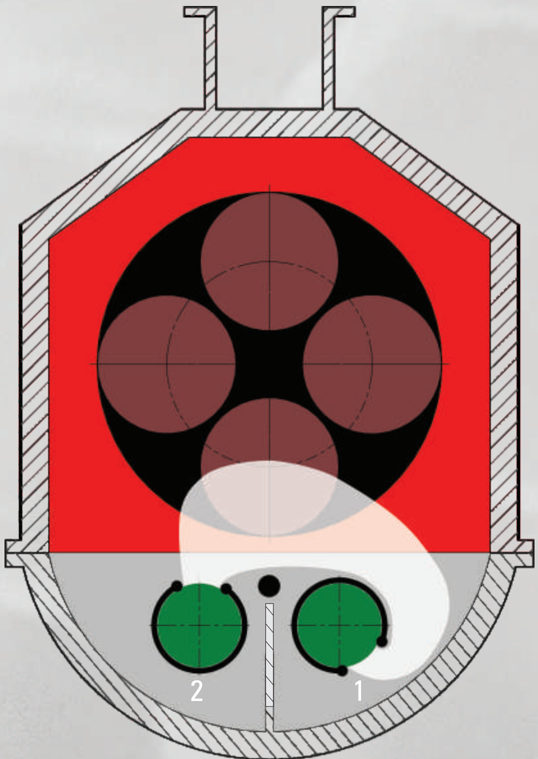
5. Programmable stoichiometry
- Due to minimum distance between 2 targets, deposition of:
  - Multi- and Nanolayers, gradient coatings
  - Without changing the unalloyed targets; Ti, Cr, Al, Al(Si), Zr
  - Nanocomposites:
    - Segregation into 2 phases, e.g. (nc-TiAlN)/(a-SiN)



6. Optimum adhesion
With LGD®, VIRTUAL SHUTTER®, and TUBE SHUTTER® due to:
- Burning with the magnetic field
  - to the back for fast target cleaning
  - to the substrates for deposition
- Permanent presence of pure Ti or Cr target
- LARC+: Enhanced LGD plasma cleaning efficiency

LGD® and Double Shuttering

LARC GD® LARC® Glow Discharge



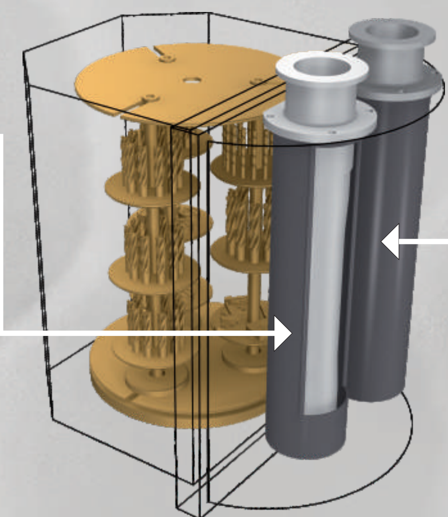
- LARC GD® is a new patented method, that works with the LARC cathodes in combination with the VIRTUAL SHUTTER® and TUBE SHUTTER®
- LARC GD® generates a highly efficient argon etching for special substrates with difficult surfaces (e.g. hobs, mold and dies)
- The electron stream between cathodes 1 and 2 creates high ion density plasma, which "cleans" substrates, even with complicated surfaces
- Pulsing of LGD source ensures high LGD-process stability and suppresses micro-arcs (hard-arcs) generation

Double Shuttering

VIRTUAL SHUTTER®

Target cleaning before coating

- TUBE SHUTTER® is closed
  - to protect the substrates from dust of the previous process
- ARC is burning towards the back
  - VIRTUAL SHUTTER® is on
- ARC works as getter pump and substantially improves vacuum
- Target is cleaned before deposition
  - without contaminating the substrates



TUBE SHUTTER®

Deposition (coating)

- TUBE SHUTTER® is open
- ARC is burning towards the substrates
  - VIRTUAL SHUTTER® is off
- Smooth deposition with clean target

Advantages of the double shutters

- Adhesion layer is always deposited with clean targets
- Shuttering of all cathode types possible
- Simple handling, setting and maintenance of the shields and ceramic insulators
- Higher ARC current -> higher deposition rate possible (~+20-30%)

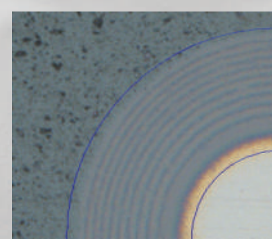
The Main Coatings of the π^{111} PLUS

$CrTiN^2$: For Forming

Stoichiometry: TiN - Cr/TiN-ML
π^{111} PLUS: 1: Cr – 2: Ti

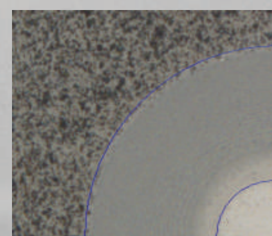
$AlTiN^2$: For Universal Use

Stoichiometry: TiN - Al/TiN-ML
π^{111} PLUS: 1: Al – 2: Ti



$AlCrN^{3®}$: For Dry Cutting Abrasive Materials

Stoichiometry: CrN - Al/CrN-NL - AlCrN
π^{111} PLUS: 1: Al – 2: Cr

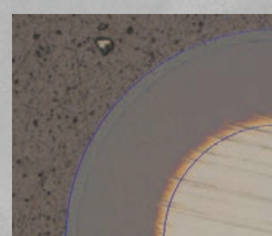


$ALL^{3®}$ - $AlCrTiN^{3®}$: Universal for Cutting and Forming

Stoichiometry: Cr(Ti)N - Al/CrTiN-NL - AlCrTiN
π^{111} PLUS: 1: Al – 2: $CrTi_{15}$

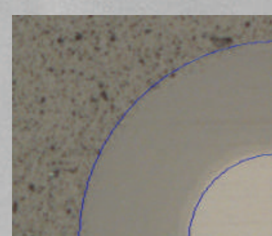
$nACo^{2®}$: For Universal Use, Turning, Drilling

Stoichiometry: TiN - AlTiN/SiN
π^{111} PLUS: 1: $AlSi_{12}$ – 2: Ti



$nACRo^{2®}$: For Superalloys, Milling, Hobbing

Stoichiometry: TiN - AlCrN/SiN
π^{111} PLUS: 1: $AlSi_{12}$ – 2: Cr



$TiXCo^{3®}$: For Superhard Machining, Milling, Drilling

Stoichiometry: TiN - nACo - TiSiN
π^{111} PLUS: 1: Al – 2: $TiSi_{20}$

PLATIT π411PLUS

The High Flexibility Machine

General Information

- Compact hard coating unit
- Based on PLATIT LARC®, CERC® and SCIL® technologies LAteral Rotating Cathodes, CEntral Rotating Cathodes and Sputtered Coatings induced by LARC-GD®
- Coating on tool steels (TS) above 230 °C, high speed steels (HSS) 350 - 500 °C and on tungsten carbide (WC) between 350 - 550 °C
- Reconfigurable by the user into different cathode setups:
  A: 3 LARC® cathodes (π411eco)
  B: 3 LARC® cathodes and 1 CERC® cathode
  C: 3 LARC® cathodes and 1 SCIL® cathode

Coatings

- Monolayers, Multilayers, Nanogradients, Nanolayers, Nanocomposites, TripleCoatings3®, QuadCoatings4®, SCIL®-Coatings and their combinations
- Main standard coatings: AlCrN3®, nACRo4®, ALL4®
- All Triple**Coatings3®** and QUAD**Coatings4®**
- All SCIL® and LACS®-Coatings available

Hardware

- Footprint: W2720 x D1721 x H2149 mm
- Vacuum chamber, internal sizes: W650 x D670 x H675 mm
- Loading volume: ø500 x H494 mm
- Coatable volume: ø500 x H420 mm
- Max. load: 265 kg
- System with turbo molecular pump
- Revolutionary rotating (tubular) cathode system with 3 LARC® / 1 CERC® cathodes:
  - Magnetic Coil Confinement (MACC) for ARC control
  - LARC®: Up to 200A ARC current
    - Changing time for skilled operator: approx. 15-30 min/cathode
  - CERC®: Up to 300A ARC current
  - SCIL®: Up to 30 kW sputtering power
- VIRTUAL SHUTTER® and TUBE SHUTTER® with door shielding
- Ionic plasma cleaning:
  - etching with gas (Ar/H_2); glow discharge
  - metal ion etching (Ti, Cr)
- LGD®: LARC® Glow Discharge
- Pulsed BIAS supply 30 kHz (optional 350 kHz)
- 6 (+1) gas channels, 6 MFC controlled
- Special dust filters for heaters (24 kW)
- Preheater
- Electrical connection: 3x400 V, 160 A, 50-60 Hz, 76 kVA
- Upgradeable with DLC², CERC®, OXI, SCIL®, LACS® options and to all at user's site

Electronics and Software

- New HMI (Human Machine Interface)
- Control system with touch-screen menu driven concept
- No programming knowledge is required for control
- Data logging and real-time viewing of process parameters
- Remote diagnostics and control
- Insite operator's manual and on CD-ROM
- Enhanced operating software compatible to π111

Optimal Cycle Times*

• Shank tools (2 µm):	ø 10 x 70 mm,	504 pcs:	4	h
• Inserts (3 µm):	ø 20 x 6 mm,	2940 pcs:	4.5	h
• Hobs (4 µm):	ø 80 x 180 mm,	28 pcs:	6	h

* The cycle times can be achieved under the following conditions:
- solid carbide tools (no outgassing necessary)
- high quality cleaning before the coating process (short etching)
- continuous operation (pre-heated chamber)
- 4-cathode processes
- use of fast cooling (e.g. with helium, opening the chamber at 200°C)
- 5 (up to 6) batches / day

Coating Technologies of π411PLUS

ARC Technology with Rotating Cathodes

- LARC® LAteral Rotating Cathodes

LARC® → π411 eco

DLC2® Option

- PVD/PECVD process for deposition of a-C:H:X coatings

CERC® Option

- CERC® CEntral Rotating Cathode as booster

+ CERC® → π411TURBO

OXI Option

- For deposition of oxide and oxynitride coatings

SCIL® Option

- Sputtered Coatings Induced by LARC GD®
- DC or pulsed

LACS® Option

- Lateral ARC & Central Sputtering simultaneously
- Hybrid coating

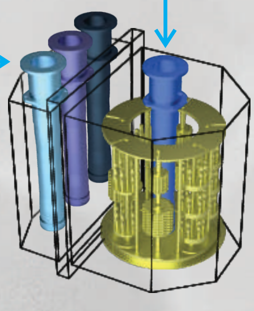
Technologies and Coatings of π411PLUS

ARC-Evaporation
- High ionization degree
- High coating density, high coating hardness
- Excellent adhesion
- High productivity
- Droplets cause rougher surface

High Performance Sputtering SCIL®
- Lower ionization degree
- Lower coating density and hardness
- Moderate adhesion
- Lower deposition rate
- Few droplets, smooth surface

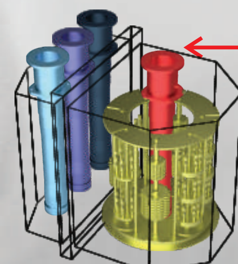
ARC-Technology:
LARC®:
LAteral Rotating Cathodes

CERC®:
CEntral Rotating Cathode



LARC®+CERC®

Sputter-Technology: SCIL® :
Sputter Coatings
Induced by LGD®
LGD® : Lateral Glow Discharge



LACS®

Options:
- **ARC-Technology** for ~85% of the coatings for cutting tools
  - 4 generations of coatings
  - For milling, hobbing, drilling, sawing, fine blanking, etc.
- **PECVD-Technology** for DLC^{2} coating
  - For cutting of sticky materials with lubricating top coating
- **SCIL®: High performance sputtering** for smooth coatings
  - For cutting, components, molds and dies
- **LACS® Hybrid-Technology**
  - LAteral ARC and Central Sputtering simultaneously

Main Coatings of the π411PLUS Options

Options	Machines \ Coatings	Conventional Coatings	Nanocomposite Coatings	TripleCoatings3®	QUADCoatings4®
	π411 eco	TiN, TiCN, CrN, CrTiN, ZrN, AlTiN, AlCrN	nACo$^{2®}$, nACRo$^{2®}$	AlCrN$^{3®}$, TiXCo$^{3®}$, ALL$^{3®}$	ALL$^{4®}$ eco
DLC	π411DLC	X-VIc®	nACVIc$^{2®}$		
	π411TURBO	AlTiN, AlCrN	nACo$^{2®}$, nACRo$^{2®}$	nACo$^{3®}$, nACRo$^{3®}$, AlCrN$^{3®}$, TiXCo$^{3®}$, ALL$^{3®}$	nACo$^{4®}$, nACRo$^{4®}$, TiXCo$^{4®}$, ALL$^{4®}$
OXI	π411OXI				nACoX$^{4®}$
	π411SCIL	TiB$_2$-SCIL®, WC/C, AlTiN-SCIL®, X-SCILVIc$^{2®}$, ta:C*			
	π411LACS	AlCrN-LACS®		BorAC®	BorCO®

*: In development.

PLATIT®

Cathode Configurations of π⁴¹¹PLUS

Typical Cathode Configurations

eco

ECO: 3 – Cr, 2 – Al, 1 – Ti

ECO-TiXCo®: 3 – TiSi, 2 – Al, 1 – Ti

TURBO

Default: 3 – Cr, 2 – Al, 1 – Ti, 4 – AlTi

Universal: 3 – Cr, 2 – AlSi, 1 – Ti, 4 – AlTi

ALL4®: 3 – Cr, 2 – Al, 1 – Ti, 4 – AlCr

TiXCo®: 3 – TiSi, 2 – Al, 1 – Ti, 4 – AlTi / AlCr

SCIL® and LACS®

BorAC®: 3 – Cr, 2 – Al, 1 – Ti, 4 – TiB_2-SCIL

BorCO®: 3 – Cr, 2 – Al, 1 – TiSi, 4 – TiB_2-SCIL

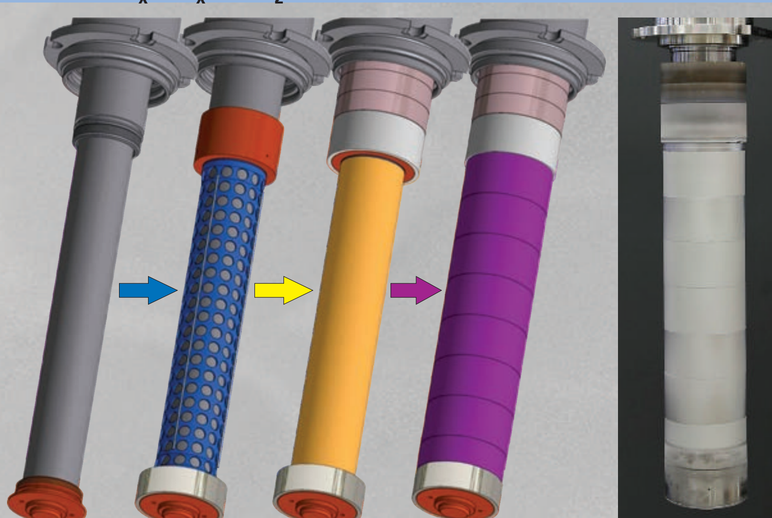
SCIL®: 3 – Cr, 2 – Al, 1 – Ti, 4 – AlCr-SCIL, AlTi-SCIL

Ring Cathodes* for SCIL® with Ti, Cr, AlCr, AlTi, B_x, Si_x, TiB_2, ...W

The Main Parts of the SCIL® Cathodes with Rings

1. Cathode body, incl. magnetic & electronic systems
2. Holed pipe for coolant inlet
3. Membrane pipe, tensed by inside cooling water for good conduction to the rings
4. Target rings

The non alloyed cathode allows the flexible programming and deposition of the coating stoichiometry.



PL711 for Tools and Machine Components

Source: Fullandi, Shenzen, China

Machines with 2 sputtering cathodes, DC and HIPIMS modes ø550x500 mm coatable volume.
Many moving parts in the machinery and automotive industries do not need extra hard coatings.
The most important requirements are:

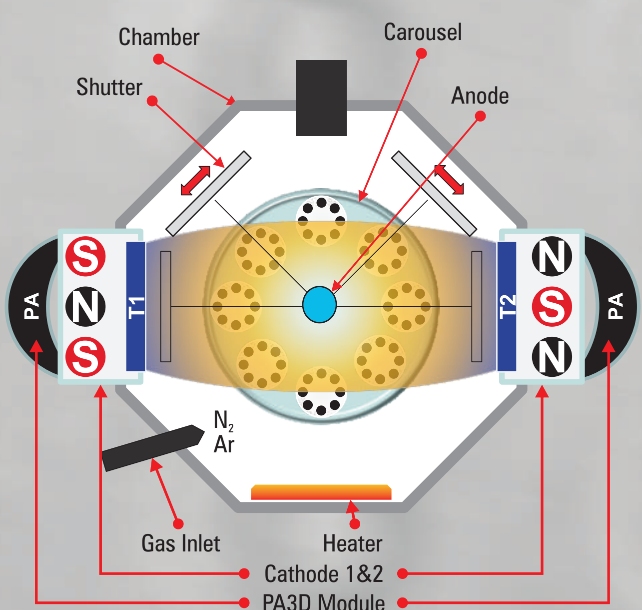
- Extremely high smoothness, and
- very low coefficients of friction.

Work Modes

- Monoblock sputtered (DC or HIPIMS) coatings (TiN, CrN) with very low roughness (S_a < 20 nm)
- DLC (Diamond Like Coating) coatings with a very thin sputtered CrN or TiN adhesion layer (~200 nm) plus
  - DLC² (SCILVIc²®)
    - with silicon doped amorphous carbon with hydrogen (a-C:H:Si)
    - by a PECVD process from gases
  - or DLC³ (ta:C®)
    - by a sputtering process (DC or HIPIMS)
    - from carbon targets

Hardware

- Footprint: W3300 x D2300 x H2400 mm
- Internal chamber size: W820 x D820 x H1100 mm
- Loading volume: ø500 x H500 mm
- Coatable volume: ø500 x H450 mm
- Max. load: 400 kg



Advanced Sputtering Technology

- PA3D Module to generate an ionizeded focus plasma into the carousel
- Two planar cathodes (with the standard sizes of the PL1011)
- DC or HIPIMS sputtering

Top quality coating

- good hardness (24 - 40 GPa)
- excellent surface finish (S_a down to 20 nm)
- excellent adhesion

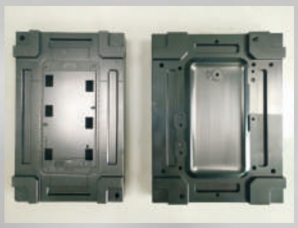
Industry targeting

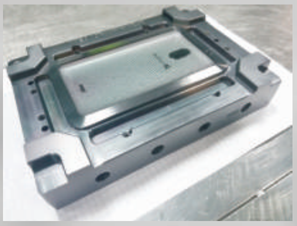
- cutting tools for non-ferrous machining application
- molds and dies, general engineering parts
- protection of cavities
  - against corrosion
  - against scratches
- sliding parts
  - reduction of friction coefficient (~0.1 against steel)
  - running dry

Applications with High Surface Quality

Mold Inserts & Optical Mold Inserts

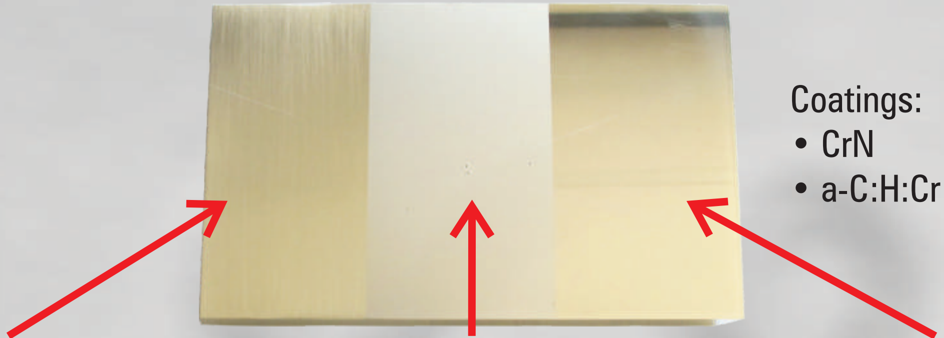
These applications are only possible, because of the excellent surface quality of the coating deposited by the PL711






Mold Surfaces with Three Different Treatments

The high surface quality of three common used polishing treatment won't be reduced by the coating of the PL711



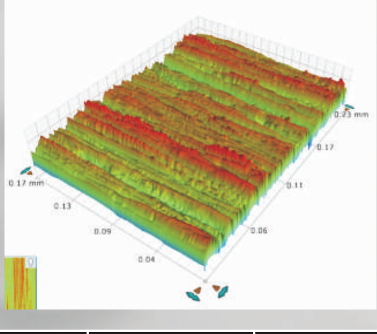
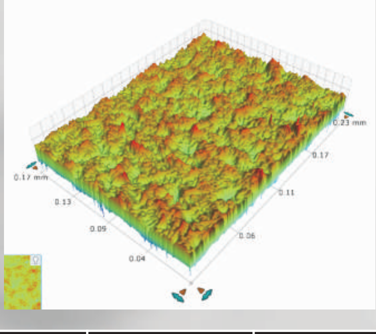
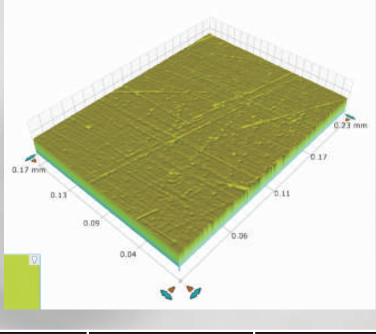
Coatings:
- CrN
- a-C:H:Cr

Surface after fine sanding with emery paper

Textured surface by laser or electro-erosion

Mirror surface finish by diamond paste polishing

Surface Finish Before Coating

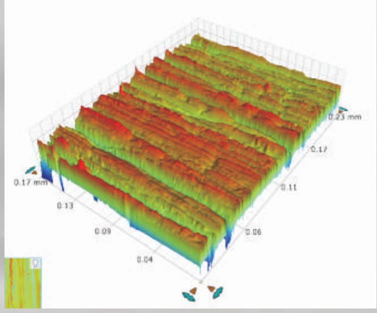
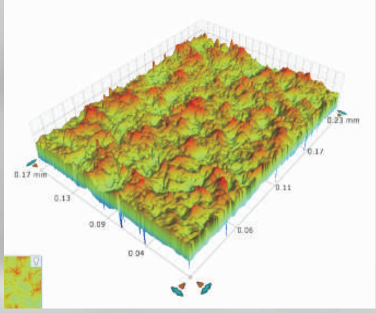
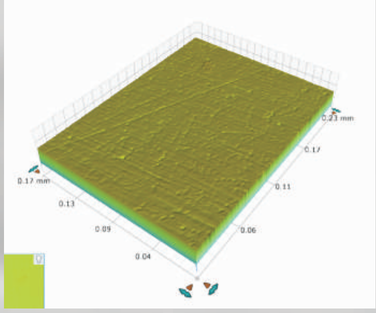
	Sa (µm)	Sz (µm)
Before	0.25 ±0.03	2.4 ±0.53
Coated	0.24 ±0.045	3.2 ±0.4

	Sa (µm)	Sz (µm)
Before	0.15 ±0.01	2.4 ±0.4
Coated	0.14 ±0.07	2.4 ±0.12

	Sa (µm)	Sz (µm)
Before	0.012 ±0.001	0.37 ±0.03
Coated	0.011 ±0.001	0.31 ±0.06

Surface Finish After Coating

Keeping High Surface Quality after Coating

PLATIT PL1011

The Workhorse of Job Coating Centers

General Information

- High capacity hardcoating unit
- Based on PLATIT planar ARC technology
- Coatings on HSS and WC (T ≤ 500°C)

Electronics and Software

- Control system with touch-screen menu driven concept
- No programming knowledge is required for control
- Data logging and real-time viewing of process parameters
- Remote diagnostics and control
- Insite operator's manual

Hard Coatings

- Monolayers, Multilayers, and Nanolayers
- Main standard coatings: TiN, TiCN-grey, AlTiN-G
- Available Triple**Coatings³®**:
  - TiN, AlTiN², ALL³: Universal use, forming, hobbing, milling

Options

- ARC in DC and pulsed mode
- DLC² in PECVD mode

Hardware

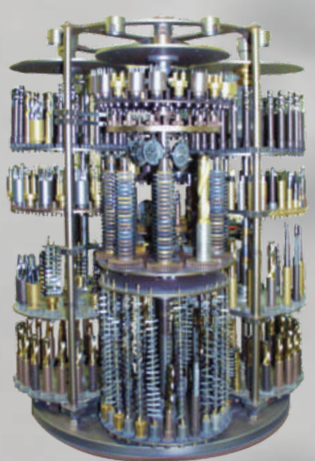
- Foot print: W3880 x D1950 x H2220 mm
- Internal chamber size: W1000 x D1000 x H1100 mm
- Loading volume: ø600-H780 mm
- Coatable volume: ø600-H680 mm
- Max. load: 400 kg
- Standard BIAS: 15kW DC, 1000V, optional: 20 kW, 250 kHz, 700V
- Double wall, stainless steel, water cooled chamber
- Front door loading, excellent access
- 4 planar cathodes with quick-exchange system
- Storage of 4 spare cathodes inside the cabinet
- Electrical connection: 3x400 V, 50-60 Hz, 95 kVA
- Modular carousel system with 2, 4, 8, and 12 as well as 3, 6, and 9 satellites

Cycle Times*

• Shank tools (2 μm):	ø10 x 70	mm,	1080 pcs:	6.25 h
• Inserts (3 μm):	ø20 x 6	mm,	8700 pcs:	6.5 h
• Hobs (4 μm):	ø80 x 180	mm,	48 pcs:	7.0 h

*: The cycle times can be achieved under the following conditions:

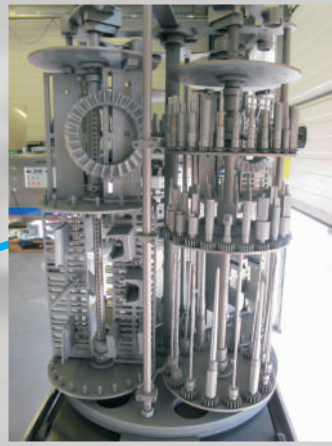
- solid carbide tools (no outgassing necessary)
- high quality cleaning before the coating process (short etching)
- continuous operation (pre-heated chamber)
- 4-cathode processes
- use of fast cooling (e.g. with helium, opening the chamber at 200°C)
- 3 batches / day

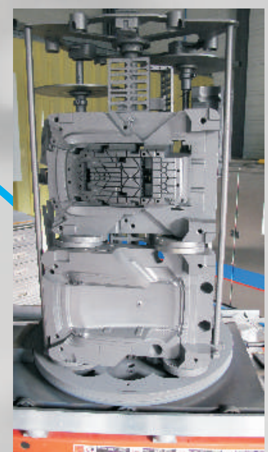


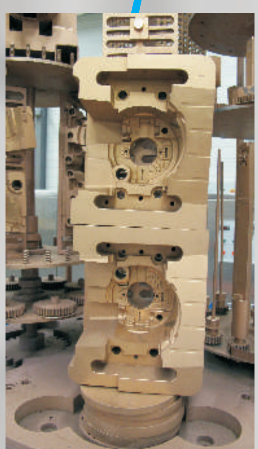
With easy loading, different tool types and sizes can be mixed and coated in one batch.

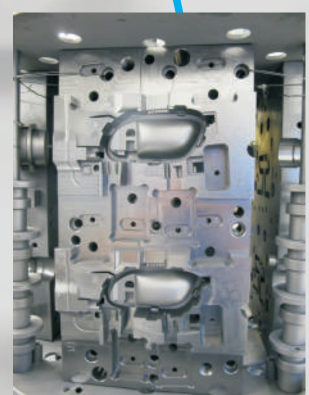
Typical Substrates Coated by PL1011

Parts for Cutting Tools, Injection Molding, and Die Casting









PLATIT π1511

The High Volume Machine with Rotating and Planar Cathodes

General Information

- High capacity hardcoating unit
- Based on PLATIT rotating (LARC®) and planar-cathodic-ARC-technology
- Coatings on HSS and WC (T ≤ 500°C)

Hard Coatings

- Monolayers, Multilayers, and Nanolayers
- Nanocomposites, Triple**Coatings³®** and QUAD**Coatings⁴®**
- Main Standard Coatings: AlCrN³, AlCrTiN⁴, TiXCo⁴

Hardware

- Foot print: W4882 x D2181 x H3354 mm
- Internal chamber size: W1000 x D1000 x H1100 mm
- Loading volume: ø600 x H780 mm
- Coatable volume: ø600 - H680 mm
- Max. load: 400 kg
- BIAS: 20 kW, 350 kHz, 750 V
- Double wall, stainless steel, water cooled chamber
- Front door loading, excellent access
- 3 LARC®-XL rotating cathodes in the door
- 2 planar cathodes in the back as boosters, with quick exchange system
- All 5 cathodes controlled by pulsed ARC supplies
- Electrical connection: 3x400 V, 50-60 Hz, 100 kVA
- Modular carousels with 2, 4, 8, 12 satellites

Electronics and Software

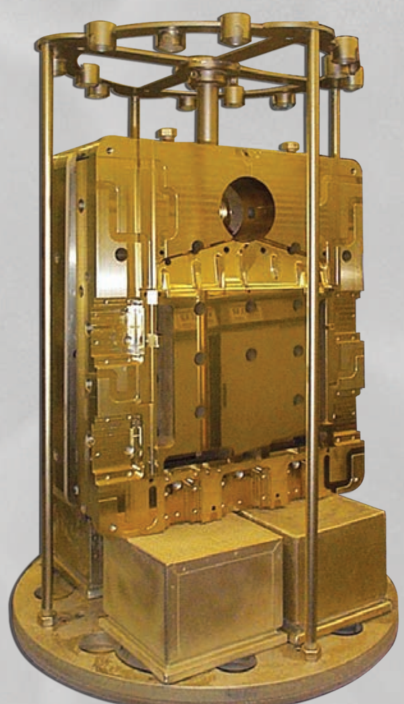
- Control system with touch-screen menu driven concept
- No programming knowledge is required for control
- Data logging and real-time viewing of process parameters
- Remote diagnostics and control
- Insite operator's manual

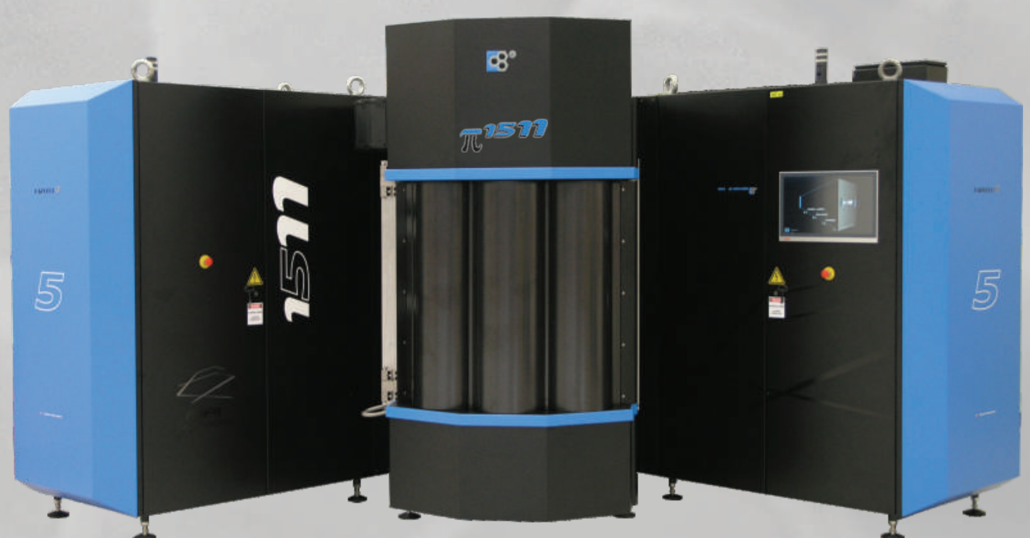
Cycle Times*

• Shank tools (2 μm):	ø10 x 70	mm,	1080 pcs:	7.0 h
• Inserts (3 μm):	ø20 x 6	mm,	8700 pcs:	7.5 h
• Hobs (4 μm):	ø80 x 180	mm,	48 pcs:	8.0 h

*: The cycle times can be achieved under the following conditions:

- solid carbide tools (no outgassing necessary)
- high quality cleaning before the coating process (short etching)
- continuous operation (pre-heated chamber)
- 5-cathode processes
- use of fast cooling (e.g. with helium, opening the chamber at 200°C)
- 3 batches / day

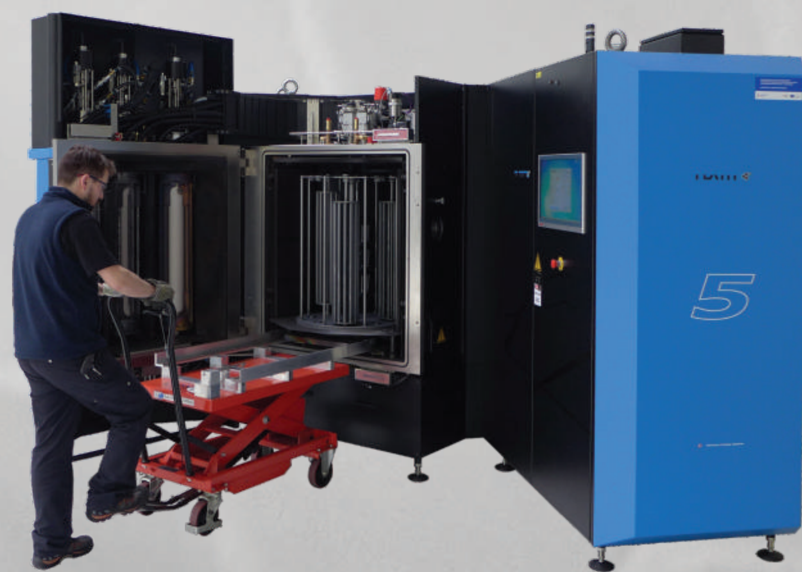




Most Important Features

High Capacity Coating Unit

- 5 cathodes can run simultaneously
  3x LARC®-XL LAteral Rotating Cathodes
  - Main cathodes: Ti, Al, AlSi+, Cr, TiSi
  2x planar ARC Cathodes
  - Main cathodes: AlCr, AlTi, Ti
- Deposition of TripleCoatings3® and QuadCoatings4®
- Up to 3 batches / day,
  even with 3 different coatings



High Loadability

- Robust and easy change of loads

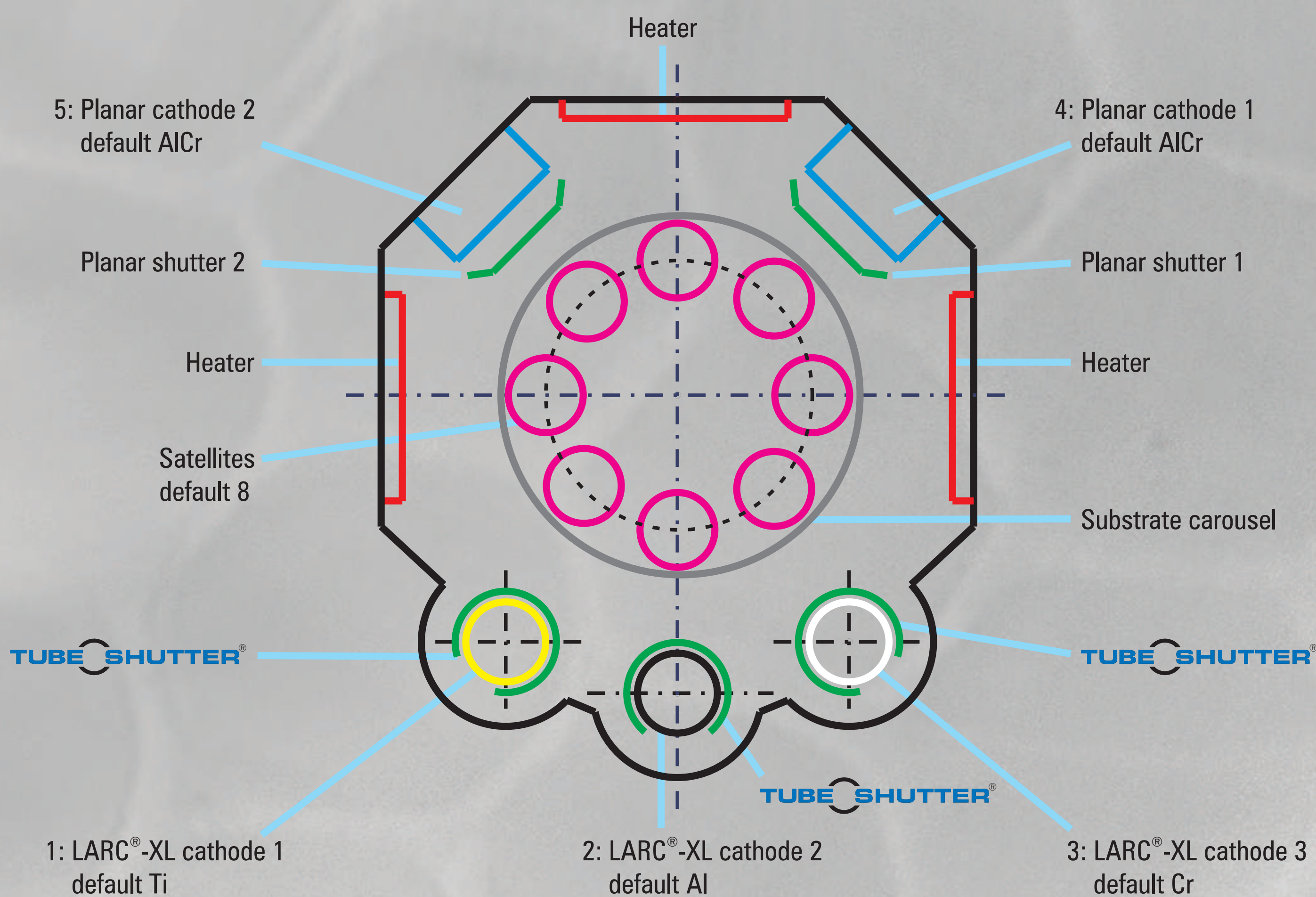
Optimal Adhesion due to

- VIRTUAL SHUTTER® and
- TUBE SHUTTER®
- LARC GD®
- Planar shutters for the planar cathodes

Main Application Fields

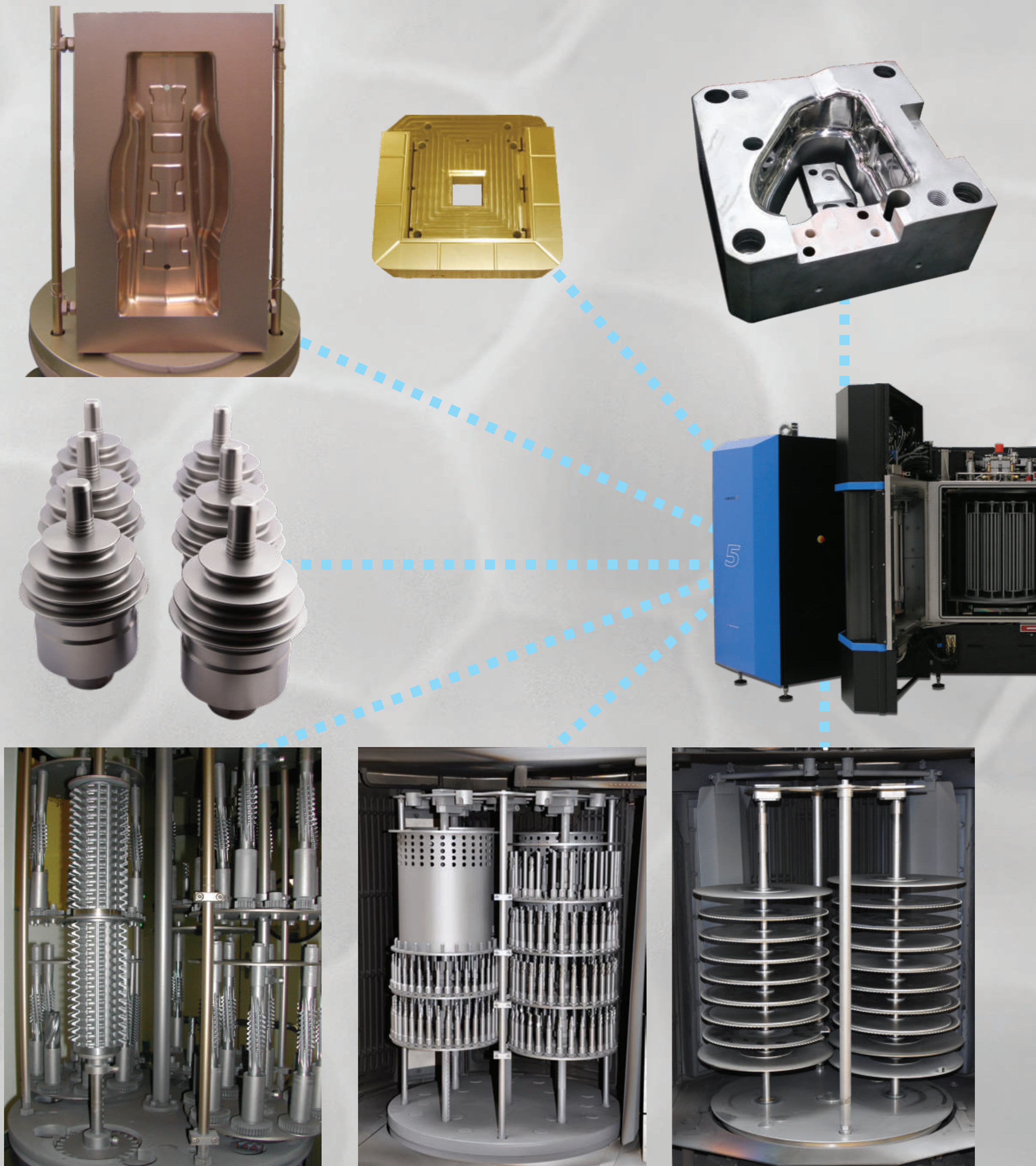
- Molds and dies with small and large dimensions (for forging, fine blanking, stamping, bending, etc.)
- Cutting tools, especially with larger dimensions (saw blades, hobs, broaches)
- Job coating services

Combination of 2 PLATIT Technologies



Application Fields of the π1511

Tools for Forming, Cutting, Molds & Dies, Forging



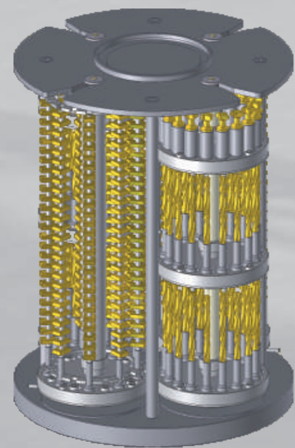
Cutting tools with larger dimensions and quantities (saw blades, hobs, broaches)

Deep Drawing, Casting, Bending, Fine Blanking

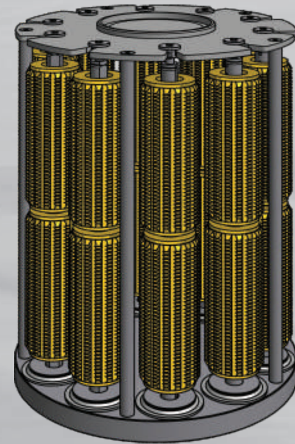
Carousels for π111 and π1511

π111

Carousel for single rotation
D ≤ 355mm

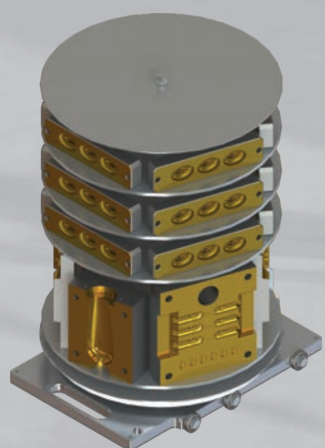


4 axis carousel for continuous
triple rotation with gearboxes
D ≤ 143mm

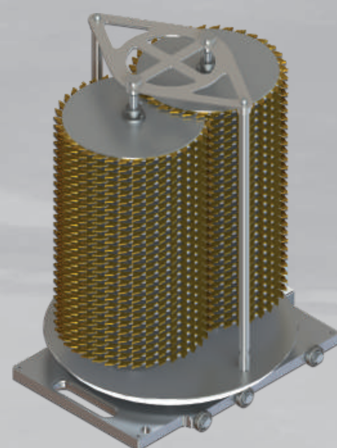


10 axis carousel for continuous
double rotation
D ≤ 82 mm

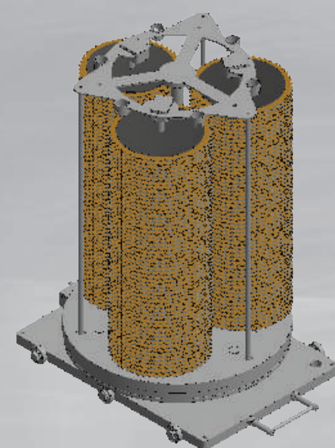
PL1011/π1511



Single rotation carousel for
molds, dies and saw blades with
D ≤ 700mm

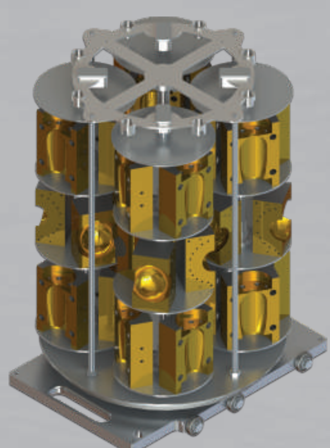


2 axis carousel for saw
blades with overlapping
D ≤ 450 mm

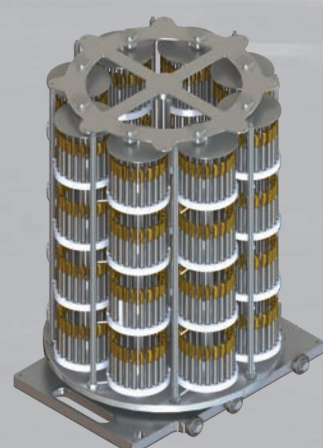


3 axis carousel for saw blades
D ≤ 420 mm with overlapping
D ≤ 250 mm without overlapping

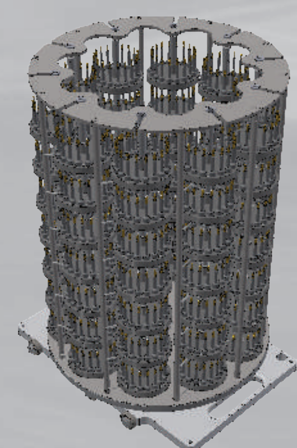
PL1011/π1511



4 axis carousel for molds
and dies - D ≤ 270 mm

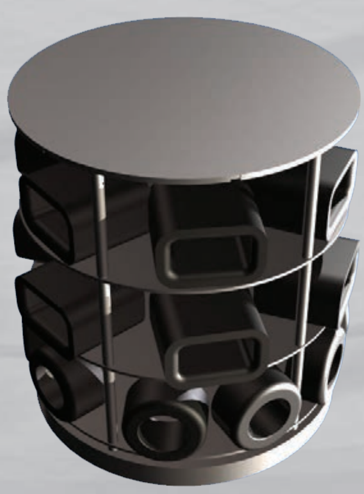


Multiple carousel with
changeable 4, 8, 12 axes
for gearboxes D=170 mm

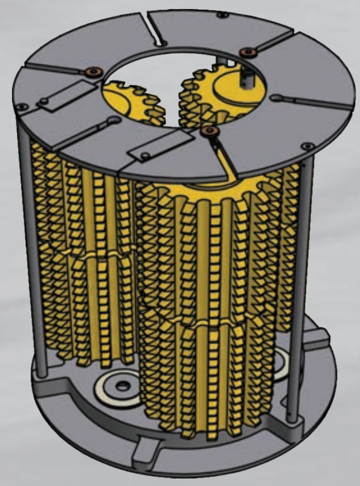


10 axis carousel for hobs and
gearboxes D=143 mm

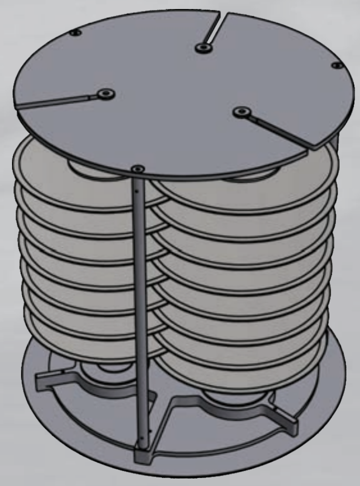
Lightweight Carousels for π411PLUS



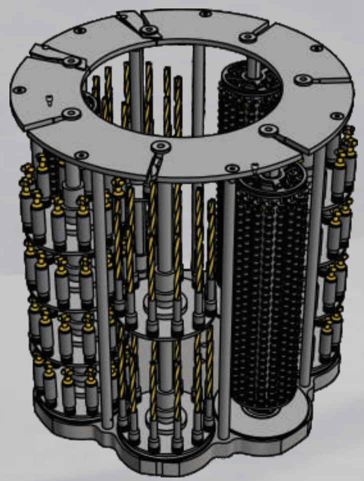
Single rotation carousel
D1=500 mm for saw blades
D1=460 mm for molds and dies



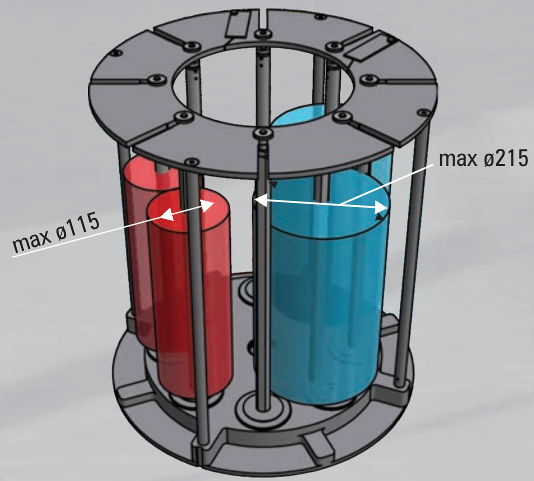
3 (6) axis carousel
D3=220 mm / D6=150 mm



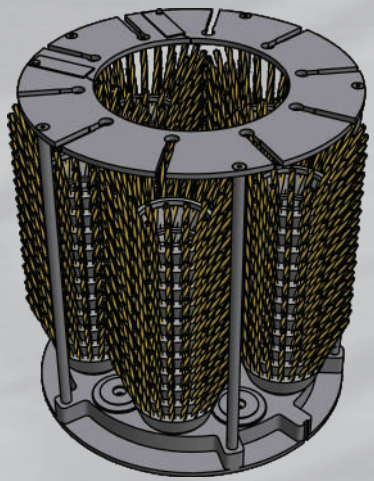
3 axis carousel for saw blades
with overlap
Max. saw blade D=285 mm



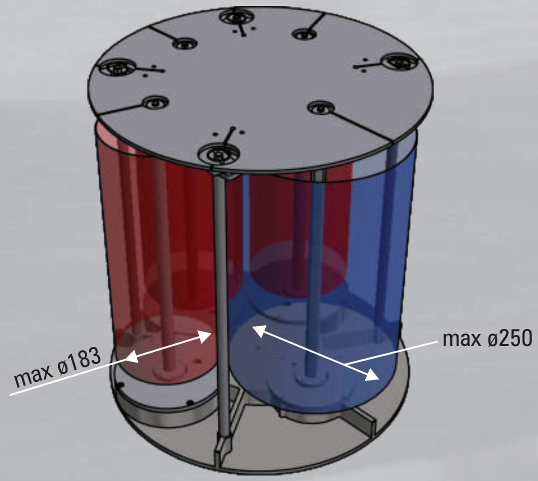
7 axis carousel
D7=143 mm



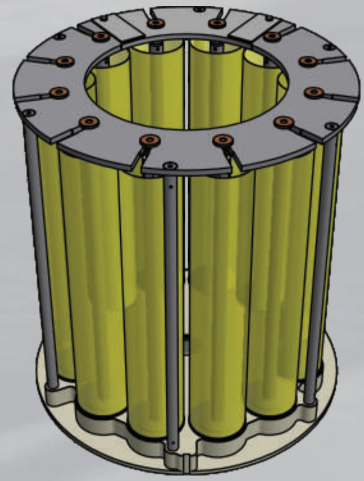
4 (8) axis carousel
D4=215 mm / D8=115 mm



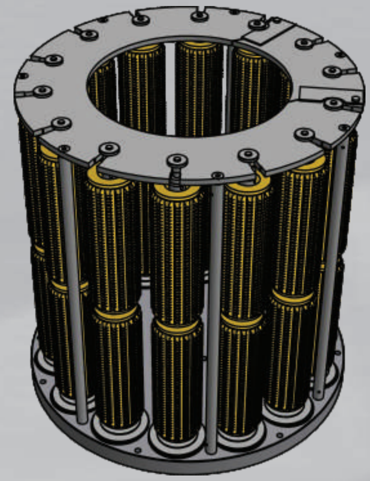
5 (10) axis carousel
D5=175 mm / D10= 94 mm



4 axis dedicated asymmetric carousel
D3=183 mm / D1=250 mm

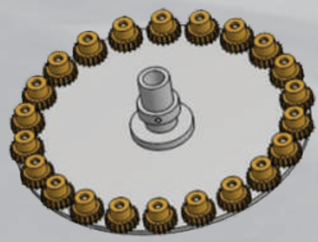
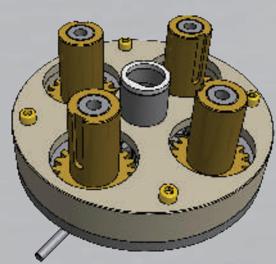
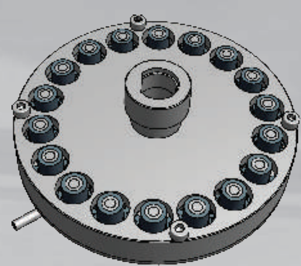
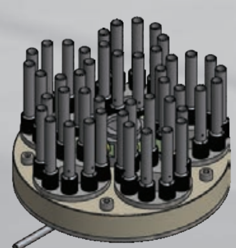
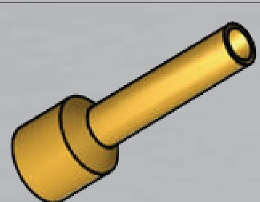
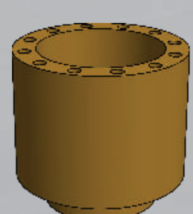


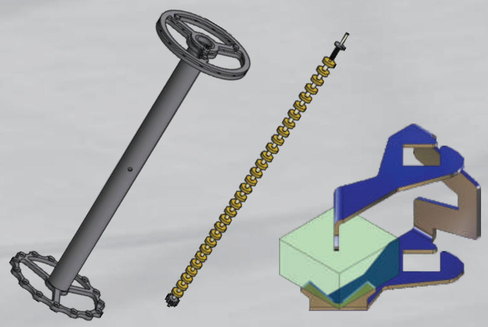
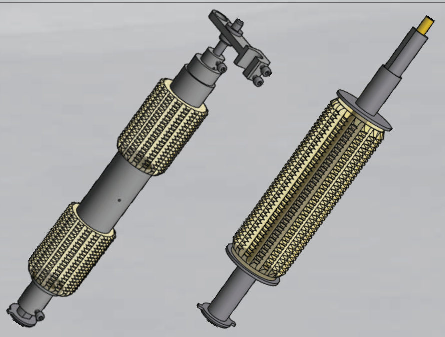
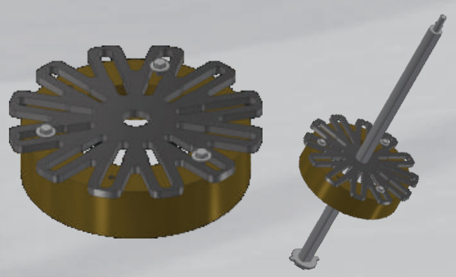
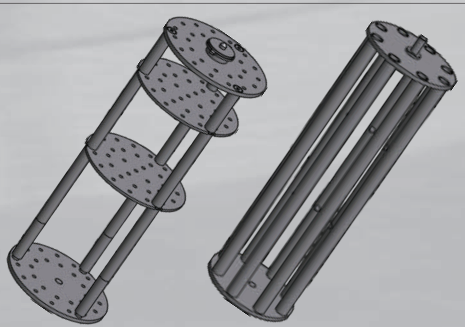
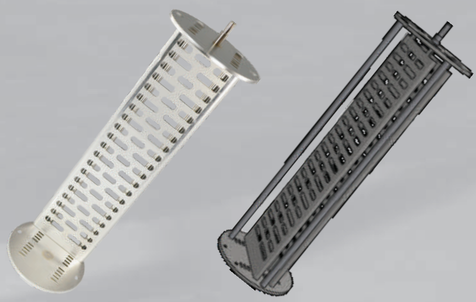
12 (6) axis carousel
D12=100 mm / D6=145 mm



14 axis carousel
D14= 85 mm

Holders for Cutting Tools

Holders		Application
Plates with gears, as holders for sleeves		The gears are rotating stepwise, driven by kickers from the side. Plates and gears are available for the different standard diameters of shank tools in the range of d = 2.2 - 52 mm
Gearboxes for triple rotation for shank tools with shank diameter D and with gear positions #N		For special big shank tools D ≤ 52 mm (2") - N= 4 Special sleeves are necessary
Gearboxes for triple rotation for shank tools with shank diameter D and with gear positions #N		For rotating sleeves Gearbox 1: D=143 mm - Gearbox 2: D=170 mm D ≤ 40mm - N=6 D ≤ 25mm - N=8 - N=10 D ≤ 20mm - N=12 D ≤ 14mm - N=18 - N=22 The tools are rotating uninterruptedly around the own axes. It allows very homogeneous coating around the tools. Gearboxes make loading of batches significantly easier.
Quad-Gearboxes (4-fold rotation)		For holding big quantities of shank tools D=1 mm - 1/8": 5 x 14 positions = 70 tools D=4 - 8 mm: 5 x 9 positions = 45 tools The whole batch usually contains the same tools. They are rotating around their own axes.
Sleeves		For standard shank tools. Diameters: [mm] 6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 32 and 1/8", 3/16", 1/4", 3/8", 1/2",4/7", 5/8", 3/4", 7/8", 1" Special diameters on request
Revolvers for shank tools with shank diameter D and with positions #N		D=2.2 mm - N=12 D=1/8" (3.4mm) - N= 9 D=4.1 mm - N= 6 D=5 mm - N= 6 D=6 mm - N= 4 The tools are not rotating around the own axes.

Holders		Application
Insert holders with satellites and rods		Satellites for inserts with diameter / edge length [mm] d / ☐ : 8.5, 12, 14, 19, 20, 27, 29.5, 42 Satellites positions: 6, 9, 15, 18 Support ring for rods of small inserts. Rods according to the hole diameters of the inserts: d > 2.4, 3.7, 4.2, 5.2, 6.2 mm TongS keep the inserts without holes, spindled on special rods. TongS are products of 4pvd, Aachen, Germany.
Hob holders for shank hobs and bore hobs		The parts of hob satellites are set together according to the sizes and dimensions of the different hobs.
Holders deep drawing dies (rings)		The deep drawing rings are fixed by screws, hanging on "fork" holders.
Cage for double rotation Dummy cage		Cages for simple flat shapes, which can be laid down, like certain molds, dies, and inserts. Dummy cages have to fill the empty places in the carousels.
Vertical holders for fine blanking tools, punches and components		Flat parts, punches, and fine blanking tools should be coated on one side only. Therefore only double rotation is necessary. The vertical holders with slots enable flexible clamping of the tools by screws or magnets.

Loading Capacities

π111PLUS / π411PLUS

π111PLUS

	Tool Diameter	Tool Length	Satellites	Discs / Satellite	Holders / Disc	Tools / Holder	Tools / Disc	Tools / Batch
End mills	2 mm	50 mm	4	5	8	12	96	1920
	6 mm	50 mm	1	5	52	1	52	260
	6 mm	50 mm	4	4	5	9	45	720
	6 mm	50 mm	4	5	18	1	18	360
	8 mm	60 mm	4	4	18	1	18	288
	10 mm	70 mm	4	4	18	1	18	288
	16 mm	75 mm	4	3	12	1	12	144
	20 mm	100 mm	4	3	8	1	8	96
	32 mm	133 mm	4	2	6	1	6	48
Drills	3 mm	46 mm	4	5	5	14	70	1400
	4.2 mm	55 mm	4	5	5	9	45	900
	6.8 mm	74 mm	4	4	8	4	32	512
	8.5 mm	79 mm	4	4	18	1	18	288
	10.2 mm	102 mm	4	3	18	1	18	216
	16 mm	115 mm	4	3	12	1	12	144
	20 mm	131 mm	4	2	12	1	12	96
	25 mm	170 mm	4	2	8	1	8	64
Inserts	20 mm	6 mm	4	1	15	28	420	1680
Hobs	120 mm	200 mm	4	2	1	1	1	8
	80 mm	180 mm	10	2	1	1	1	20
							Average number of tools / batch	473

π411PLUS

	Tool Diameter	Tool Length	Satellites	Discs / Satellite	Holders / Disc	Tools / Holder	Tools / Disc	Tools / Batch
End mills	2 mm	50 mm	7	5	8	12	96	3360
	6 mm	50 mm	7	4	5	9	45	1260
	6 mm	60 mm	7	4	18	1	18	504
	8 mm	60 mm	7	4	18	1	18	504
	10 mm	70 mm	7	4	18	1	18	504
	16 mm	75 mm	7	3	12	1	12	252
	20 mm	100 mm	7	3	8	1	8	168
	32 mm	133 mm	7	2	6	1	6	84
Drills	3 mm	46 mm	7	5	5	14	70	2450
	4.2 mm	55 mm	7	5	5	9	45	1575
	6.8 mm	74 mm	7	4	8	4	32	896
	8.5 mm	79 mm	7	4	18	1	18	504
	10.2 mm	102 mm	7	3	18	1	18	378
	16 mm	115 mm	7	3	12	1	12	252
	20 mm	131 mm	7	2	12	1	12	168
	25 mm	170 mm	7	2	8	1	8	112
Inserts	20 mm	6 mm	7	1	15	28	420	2940
Hobs	120 mm	200 mm	7	2	1	1	1	14
	80 mm	180 mm	14	2	1	1	1	28
							Average number of tools / batch	840

Only standard holders were used for capacity calculations. Capacity can be increased with dedicated holders.

- tools in sleeves driven by kickers
- tools in sleeves driven by gearboxes
- tools in revolvers driven by kickers
- tools in revolvers driven by gearboxes
- tools in sleeves driven by quad-gearboxes
- inserts with holes fixed on rods
- hobs on satellites

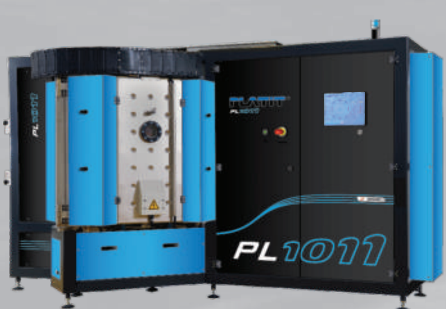
PL711 / PL1011 / π1511

PL711

	Tool Diameter	Tool Length	Satellites	Discs / Satellite	Holders / Disc	Tools / Holder	Tools / Disc	Tools / Batch
End mills	2 mm	50 mm	6	5	8	12	96	2880
	6 mm	50 mm	6	5	8	4	32	960
	6 mm	60 mm	6	5	18	1	18	540
	8 mm	60 mm	6	5	18	1	18	540
	10 mm	70 mm	6	4	18	1	18	432
	16 mm	75 mm	6	4	18	1	18	432
	20 mm	100 mm	6	3	18	1	18	324
	32 mm	133 mm	6	2	14	1	14	168
Drills	3 mm	46 mm	6	5	8	6	48	1440
	4.2 mm	55 mm	6	5	8	6	48	1440
	6.8 mm	74 mm	6	4	8	4	32	768
	8.5 mm	79 mm	6	4	18	1	18	432
	10.2 mm	102 mm	6	3	18	1	18	324
	16 mm	115 mm	6	3	18	1	18	324
	20 mm	131 mm	6	2	18	1	18	216
	25 mm	170 mm	6	2	12	1	12	144
Inserts	20 mm	6 mm	6	33	15	1	198	2970
Hobs	120 mm	200 mm	6	3		1	1	18
	80 mm	180 mm	6	4		1	1	24
					Average number of tools / batch			757

PL1011 / π1511

	Tool Diameter	Tool Length	Satellites	Discs / Satellite	Holders / Disc	Tools / Holder	Tools / Disc	Tools / Batch
End mills	2 mm	50 mm	10	8	8	12	96	7680
	6 mm	50 mm	10	7	5	14	70	4900
	6 mm	60 mm	10	7	18	1	18	1260
	8 mm	60 mm	10	7	18	1	18	1260
	10 mm	70 mm	10	6	18	1	18	1080
	16 mm	75 mm	10	6	12	1	12	720
	20 mm	100 mm	10	5	12	1	12	600
	32 mm	133 mm	10	4	6	1	6	240
Drills	3 mm	46 mm	10	7	5	14	70	4900
	4.2 mm	55 mm	10	7	5	14	70	4900
	6.8 mm	74 mm	10	6	8	4	32	1920
	8.5 mm	79 mm	10	6	18	1	18	1080
	10.2 mm	102 mm	10	5	18	1	18	900
	16 mm	115 mm	10	4	12	1	12	480
	20 mm	131 mm	10	4	12	1	12	480
	25 mm	170 mm	10	3	12	1	12	360
Inserts	20 mm	6 mm	10	58	15	1	580	8700
Hobs	120 mm	200 mm	12	3		1	1	36
	80 mm	180 mm	12	4		1	1	48
					Average number of tools / batch			2187



Only standard holders were used for capacity calculations.
Capacity can be increased with dedicated holders.

- tools in sleeves driven by kickers
- tools in sleeves driven by gearboxes
- tools in revolvers driven by kickers
- tools in revolvers driven by gearboxes
- tools in sleeves driven by quad-gearboxes
- inserts with holes fixed on rods
- hobs on satellites

Customized Coating Units for Special Applications

During the last two decades PLATIT successfully grew a large worldwide network of customers, who came to PLATIT with their special demands. Due to the increase of these special demands, PLATIT decided to specialize its team in Vaulruz, Switzerland to engineer and produce special machines.

The engineers and technicians are specialized in:

- concept development
- advice & consultation
- mechanical & electrical equipment design
- customer specific programming
- manufacturing with a local network of Swiss companies
- factory acceptance test and commissioning at customers' facilities
- machine and process support & spare parts.

Systems developed, produced and delivered to the following sectors:

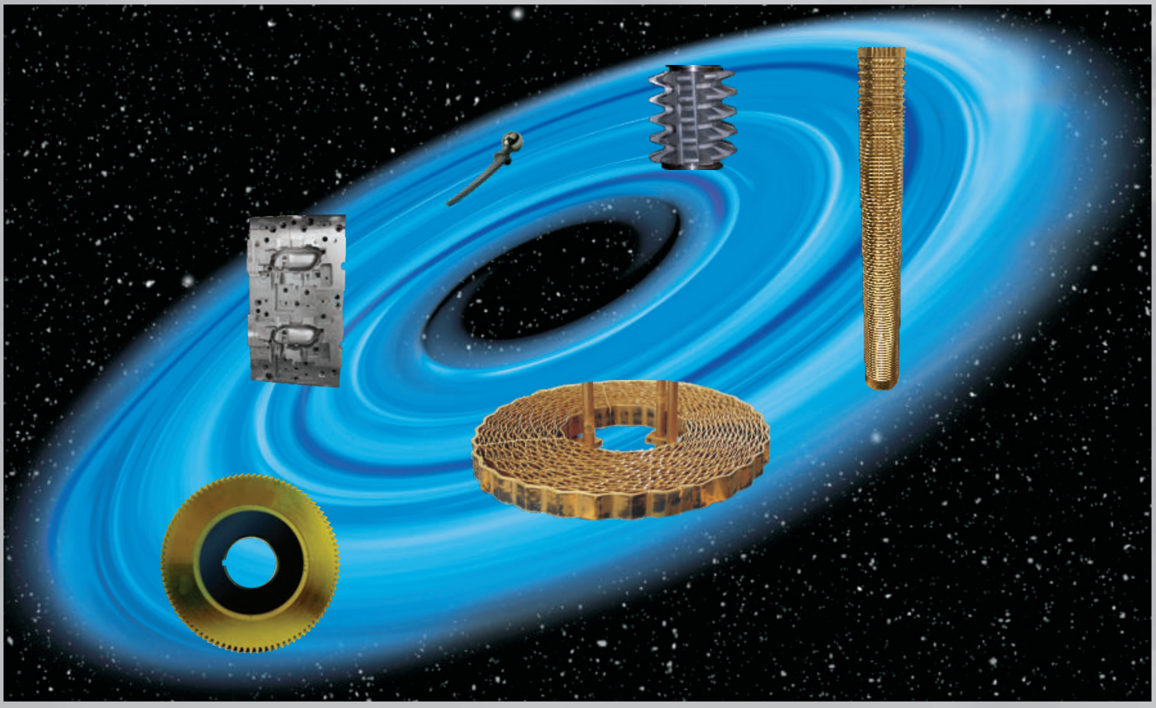
- Cutting tools: manufacturers of large cutting tools like broaches & saw blades
- Aerospace: anti-abrasion, anti-erosion hard coatings, scratch resistance coatings
- Plastic injection: extra smooth coatings for corrosion and scratch protection & lubricant films for moving elements with minimum lubrication and tight tolerances
- Medical industries: bio compatible coatings for dental components and medical devices

Technologies implemented and delivered:

- ARC – in DC & pulsed modes
- Sputtering – in DC, pulsed & HiPIMS (High-Power Impulse Magnetron Sputtering) modes and
- PECVD (Plasma Enhanced Chemical Vapor Deposition) mode

Sophisticated special systems, requiring special machine designs, holders, handlings and coatings:

- machine and medical components
- saw bands
- saw blades, and
- broaches



π^{603} for Coating of Saw Bands

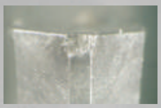
Saw band up to 200 mm height can be coated. The tool holder table is inclined to achieve constant thickness distribution.

Three rotating cathodes for flexible deposition

Saw band coils up to 1.4 m diameter can be coated. The back side of the saw band is deposited with a help of a planar target.

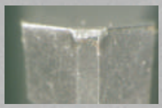
Development of Dedicated Coatings for Saw Bands

uncoated at 1.8 m^2

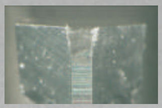


AlTiN[2] at 2.12 m^2

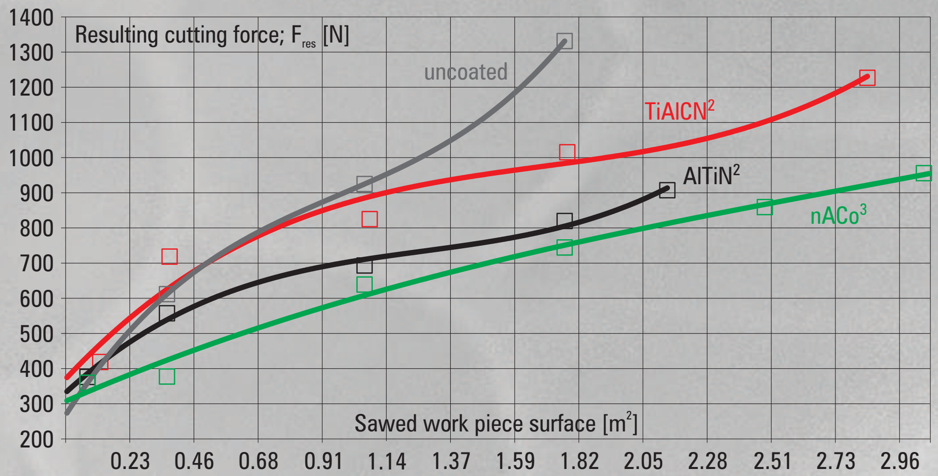
TiAlCN[2] at 2.8 m^2



nACo[3] at 4.04 m^2



Source: Wikus, Spangenberg, Germany



Dedicated Units for Saw Blades

Source: Tru-Cut, Brunswick, OH, USA

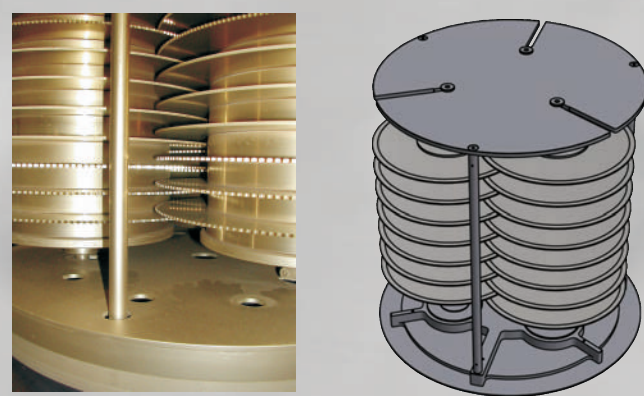
PL2001 for saw blades

- Extremely high capacity hardcoating unit for large tools and substrates
- Based on PLATIT planar-cathodic-ARC-technology
- Coatings on HSS and WC (T ≤ 500°C)

Hardware

- Foot print: W3880 x D2350 x H2220 mm
- Internal chamber size: W1700 x D1700 x H1100 mm
- Coatable volume: up to Ø1200 x H700 mm
- Max. substrate load: 800 kg
- 4 PLATIT cathodes with quick-exchange system fully compatible with the PL1001 COMPACT cathodes
- Electrical connection: 3x400 V, 50-60 Hz, 110 kVA
- Modular carousel system with 1, 2, 3, 4, 6, 8 satellites

Single loading



Loading with overlapping

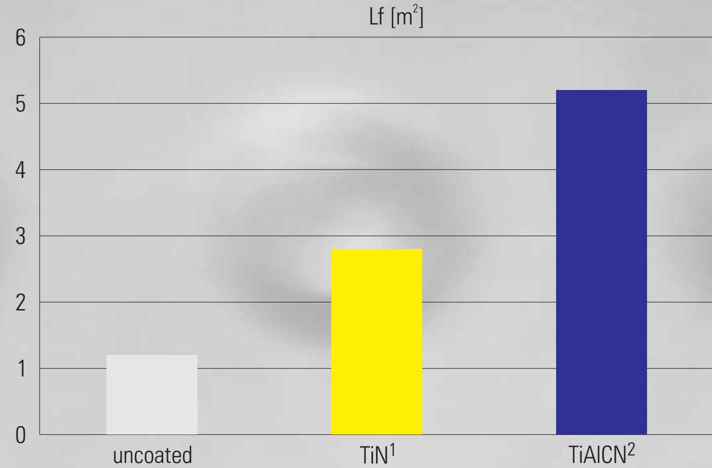
Loading capacities

Saw sizes [mm]	Saw sizes ["]	blade thickness	spacing between	π411 # of satellites	PL1011 # of satellites	PL2011 # of satellites	π411 # of blades per load	PL1011 # of blades per load	PL2011 # of blades per load
100	3.94	1.5	7	10	12	24	518	988	1976
120	4.72	1.5	7	8	12	20	414	988	1647
160	6.30	1.5	7	6	8	14	311	659	1153
200	7.87	2	10	4	4	10	147	233	583
225	8.86	2	10	3	4	8	110	233	467
250	9.84	2	10	2	4	8	73	233	467
275	10.83	2	10	1	4	6	37	233	350
300	11.81	2	10	1	3	6	37	175	350
315	12.40	2	10	1	3	6	37	175	350
325	12.80	2	10	1	3	5	37	175	292
350	13.78	2.2	10	1	2	5	36	115	287
360	14.17	2.2	10	1	2	5	36	115	287
400	15.75	2.2	10	1	1	4	36	57	230
450	17.72	2.2	10	1	1	3	36	57	172
500	19.69	2.2	10	1	1	1	36	57	57
550	21.65	3	14	0	1	1	0	41	41
560	22.05	3	14	0	1	1	0	41	41
620	24.41	3	14	0	1	1	0	41	41
830	32.68	3.5	16	0	0	1	0	0	36
965	37.99	4	19	0	0	1	0	0	30
1066	41.97	4	19	0	0	1	0	0	30

Applications

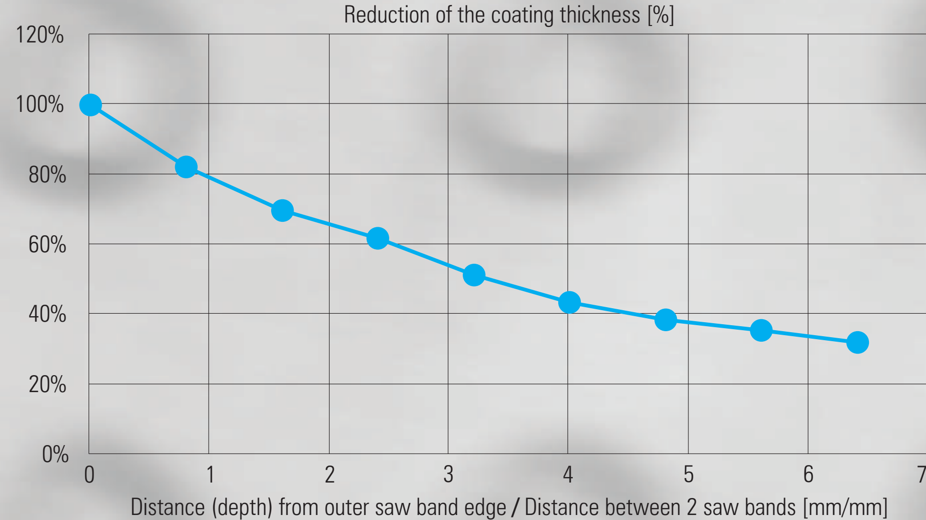
Tool Life Comparison at Sawing

Setting the distance holder for big saw blades before coating

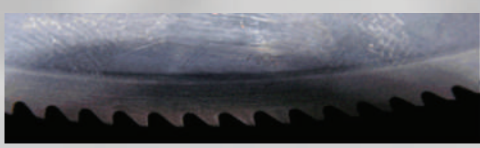


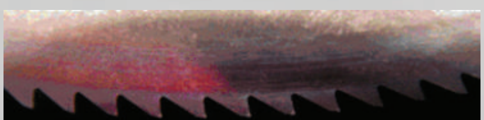
Material: 42CrMo4 – Outer Coolant: emulsion
Tool: 250 mm – v_c=100m/min – f_z=0.06 mm/z

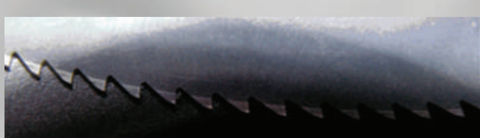
Thickness Reduction at "Depth" at Overlapped Coating of Saw Blades



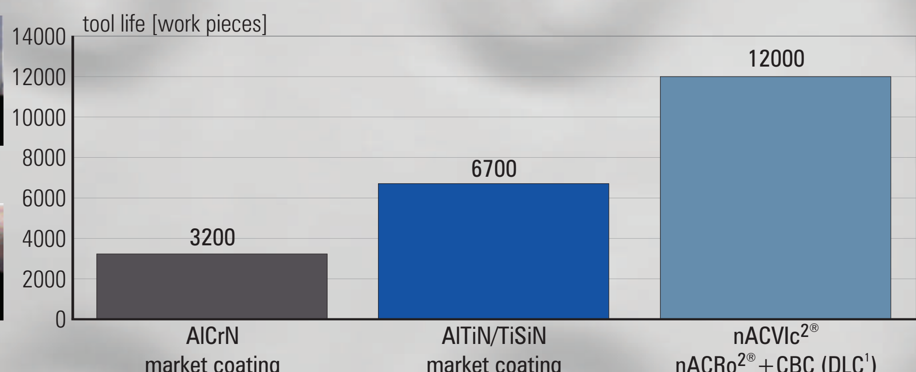
Sawing







Tool Life Comparison



Precision cutting of 3 mm profiles, stainless steel 904L
Tool: carbide circular sawblade Ø 160mm x 0,8mm, z=200
Cutting conditions: n=400 rev/min, v_f=64 mm/min, lubrication: oil
Life time criterion: Burr formation on work piece
Source: Swiss watch industry

Dedicated Units for Broaches

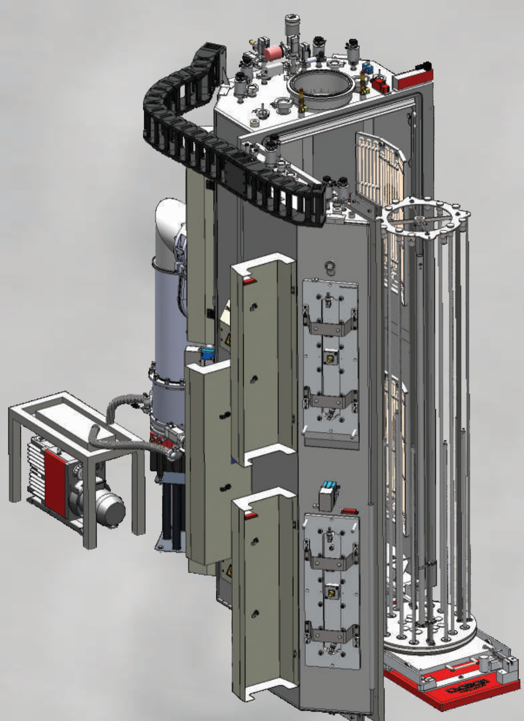
PL1401-HUT for Broaches

- Based on PLATIT planar-cathodic-ARC-technology
- After coating the first half, the broaches must be turned to coat the other half in a second batch

Hardware

- Coatable volume: ø700 x H700 mm + ø150 x H700 mm
- Max. length of broaches: 2000 mm
- Max. coatable lengths on broaches: 2 x 700 mm
- Max. substrate load: 400 kg
- 4 PLATIT cathodes with quick-exchange system fully compatible with the PL1001 COMPACT cathodes
- Modular carousel system with 1, 2, 3, 4, 6, 8 satellites

Source: Metallestalki, Bilbao, ES



PL2511 for Extra Long Broaches

- Based on PLATIT planar-cathodic-ARC-technology
- The extra long broaches are coated in 1 batch

Hardware

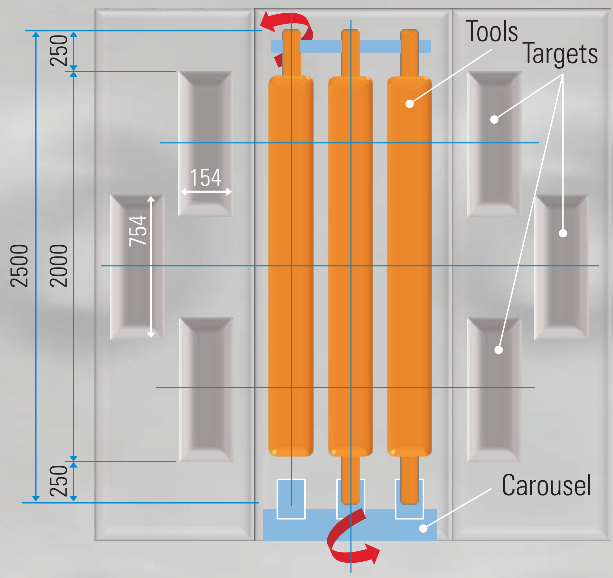
- Coatable volume: ø700x700 - 2'000 mm
- Max. length of a broach: 2'500 mm
- Max. substrate load: 600 kg
- 6 PLATIT cathodes with quick-exchange system, fully compatible with the PL1001 compact cathodes
- Modular carousel system with 1, 2, 4, 6, 8 satellites
- The coating unit and the loading system are to be embedded into the special fundament of the work floor

Dedicated 1-Chamber Cleaning System for Broaches

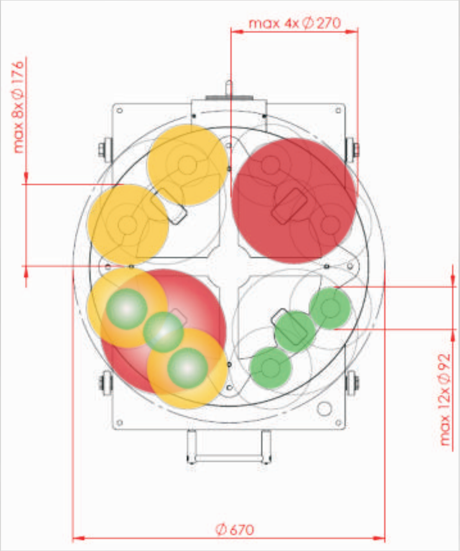
- Max. broach length: 2'500 mm
- Max. broach load: 600 kg
- Cycle time < 1h

PL^{2511} Cathodes & Targets & Carousel

Cathode Configuration



- Coating range 2000 mm with excellent thickness distribution across height: ±10%
- ø700 and H = 2500 mm maximum tool size
- 600 kg maximum loading capacity; higher loads on demand
- Smart carousel design solution offering 1fold, 2fold and 3fold rotation on one platform
- Loading availability for broaches, hobs and any other kind of shank type tools, even molds & dies parts



Caroussels

- Smart and flexible carousel design
  - 4 satellites - max. 4x ø270 mm
  - 8 satellites - max. 8x ø176 mm
  - 12 satellites - max. 12x ø 92 mm
- Highest flexibility offered to accommodate dedicated loads but also mixed loads

Loading Table

	Broaches - Length [mm]			
	0 - 600	601 - 1100	1100 - 2500	Carousel configuration
	pcs./plate x plate/spindle x number of spindles			
	ø Round Broaches [mm]			
0 < ø < 30	96	64	32	Standard 4 spindles, 8 position plates
	8 x 3 x 4	8 x 2 x 4	8 x 1 x 4	
30 < ø < 50	48	32	16	Standard 4 spindles, 4 position plates
	4 x 3 x 4	4 x 2 x 4	4 x 1 x 4	
50 < ø < 80	36	24	12	12 spindle carousel, no plates
	1 x 3 x 12	1 x 2 x 12	1 x 1 x 12	
80 < ø < 100	24	16	8	8 spindle carousel, no plates
	1 x 3 x 8	1 x 2 x 8	1 x 1 x 8	
100 < ø < 250	12	8	4	4 spindle carousel, no plates
	3 x 4	2 x 4	1 x 4	
	Square Broaches [mm]			
20 x 50	120	80	40	4 spindle carousel, flat plates
	10 x 3 x 4	10 x 2 x 4	10 x 1 x 4	
30 x 30	96	64	32	4 spindle carousel, flat plates
	8 x 3 x 4	8 x 2 x 4	8 x 1 x 4	
40 x 60	72	48	24	4 spindle carousel, flat plates
	6 x 3 x 4	6 x 2 x 4	6 x 1 x 4	
50 x 100	36	24	12	4 spindle carousel, flat plates
	3 x 3 x 4	3 x 2 x 4	3 x 1 x 4	
60 x 200	24	16	8	4 spindle carousel, flat plates
	2 x 3 x 4	2 x 2 x 4	2 x 4	

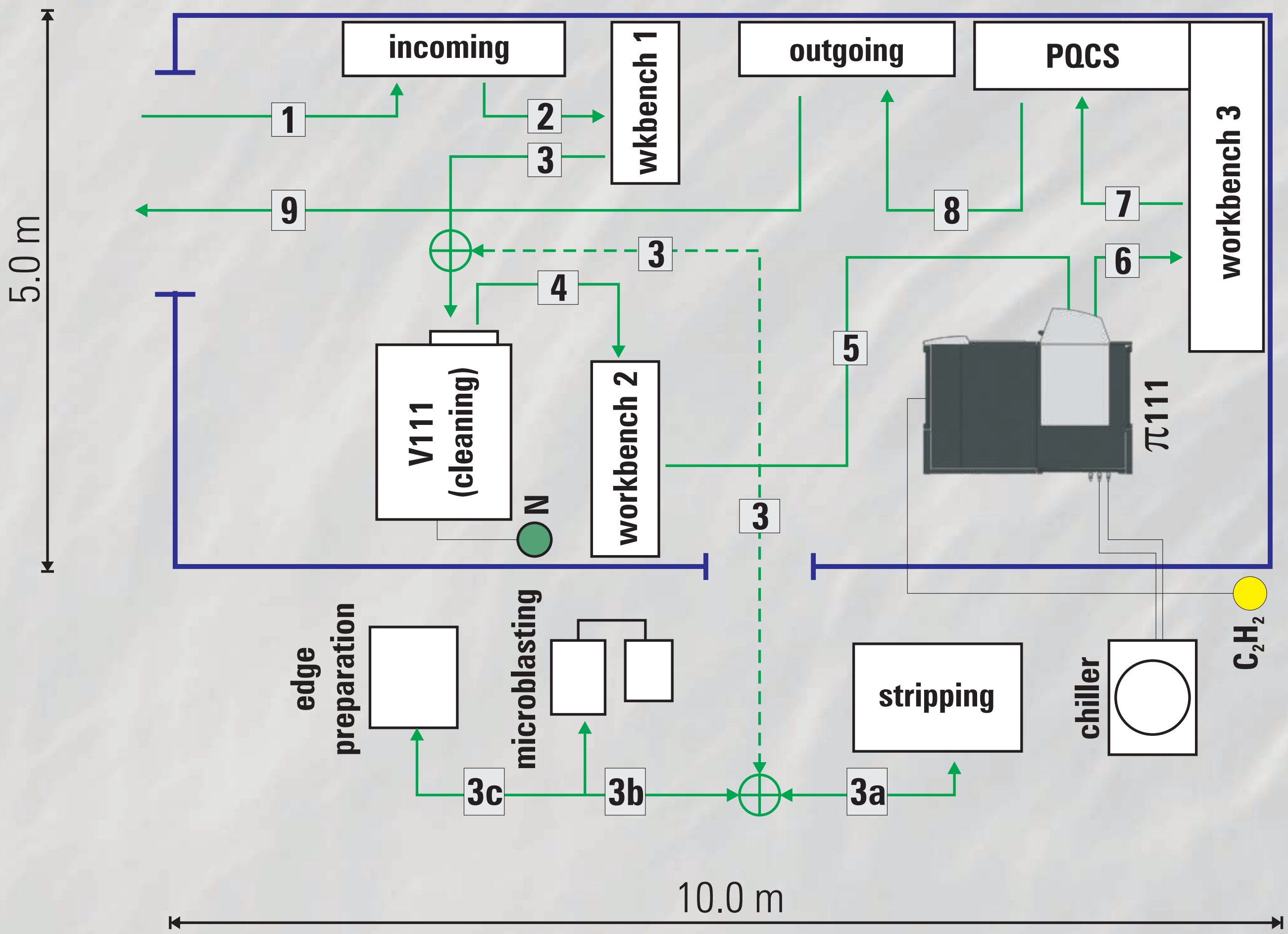
Turnkey Solutions

The integration of flexible coating into the manufacturing production requires complete turnkey solutions.

PLATIT offers complete coating systems including all necessary peripheral equipment and technologies for:

- surface pretreatment by polishing, brushing and/or micro blasting,
- one-chamber vacuum cleaning with "start-and-forget" operation,
- stripping of coatings from HSS and carbides,
- handling for loading and unloading of substrates and cathodes,
- and quality control systems according to ISO 9001.

Work Flow in a Small Coating Center



Work Flow in Minimal Coating Center

1. Incoming goods
2. Preparations for cleaning (e.g. microblasting)
3. Cleaning

3a. Optionally: stripping
3b. Optionally: edge preparation (e.g. brushing, micro blasting, etc.)
3c. Optionally: post treatment (e.g. micro blasting, polishing, etc.)
3d. Optionally: cleaning after pre or post treatment

4. Preparations for coating (e.g. loading carousels)
5. Coating
6. Unload charge
   Optionally post surface treatment
7. Check quality with PQCS
8. Packing for shipping
9. Outgoing goods / shipping

Some equipment (chiller, stripping, microblasting, edge preparation) should be set up in a different room, apart from the coating area. The chiller can be placed outside.

Source: Müller Präzisionswerkzeuge, Sien, Germany

Stripping and its Ways

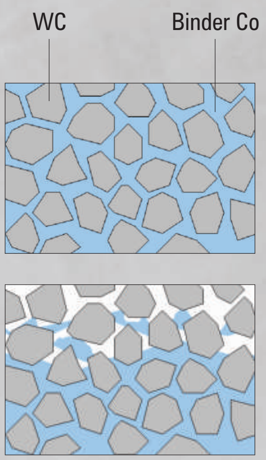
Under optimum conditions the electro-chemical stripping can be carried out without damaging the substrates. However, normally it damages the substrates, especially carbides with cobalt leaching.

What is Cobalt-Leaching?

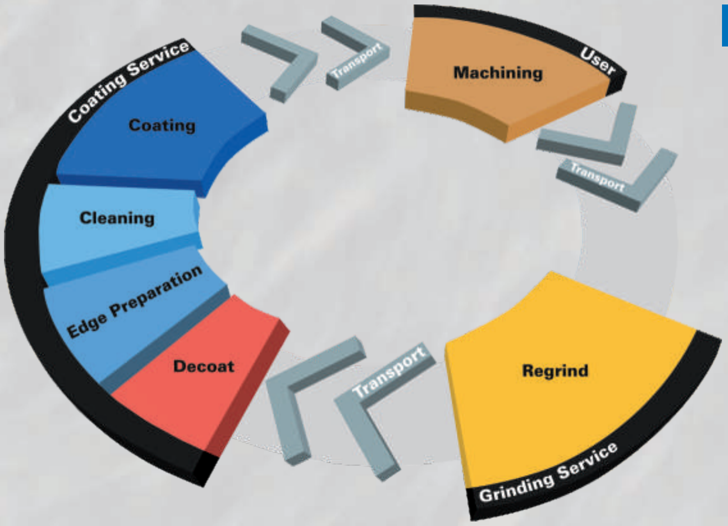
Removal of some cobalt from the top surface of the composite material tungsten carbide consisting of WC (grains) and cobalt (matrix).
Reason: Removal of cobalt by oxidation, mainly by contact with water:

- Water cooled grinding
- Too fast grinding with blunt grinding wheel (even when cooling with oil)
- Water based stripping

Coating of cobalt-leached carbide is useless. The coating has in fact a good adhesion to the top WC layer, but both peel off together at the first cut because the binding cobalt is missing.

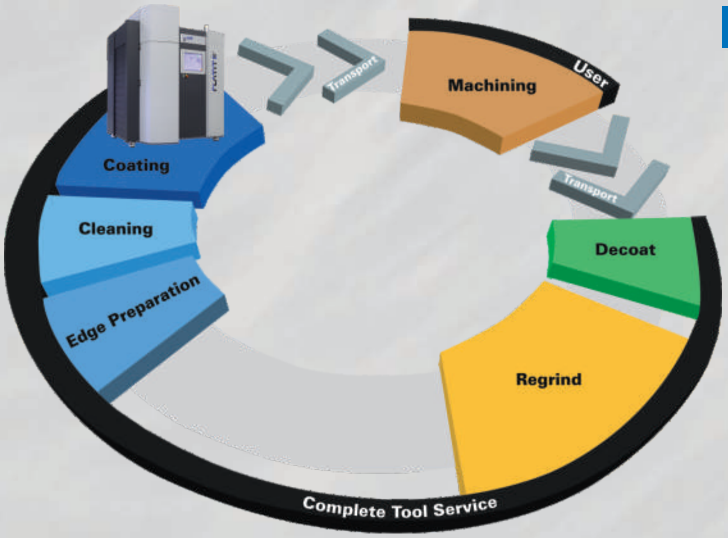


Stripping at conventional and integrated coating service



The conventional way

The risk of bad adhesion is very high. The stripping takes place after regrinding and damages the final geometry of the tool. The edge preparation after stripping can reduce the damage only. Additionally, packing, transport, and repackaging increase the risk of tool damaging enormously.



The integrated way

The stripping can be done prior to the regrinding. This creates a lot of advantages for your production:

- Less transport and packaging, less damages by handling
- No chemical destruction after regrinding, the edge preparation unfolds to its full effect (regularly)
- Optimum adhesion
- The performance is close to a new tool.

Stripping of PLATIT Coatings

Conventional Decoating Modules (ST Series)

Solid carbide drill coated with AlTiN

Stripped solid carbide drill

Machine	Description	Max. Tool Dimensions (WxDxH)
1. ST-40 HM	Decoating Ti, Al based coatings from carbide	160 x 330 x 160 mm
2. ST-40 CR	Decoating Cr based coatings from carbide and HSS	330 x 330 x 300 mm
3. ST-40 HSS	Decoating Ti, Al, Cr based coatings from HSS	330 x 240 x 200 mm
4. ST-40 R	Rinsing module	330 x 330 x 300 mm
5. ST-40 P	Corrosion protection module	330 x 330 x 300 mm
6. ST-170-CR	Decoating Cr based coatings from carbide and HSS	330 x 1100 x 200 mm (for 7 hobs with ø80 x 180 mm)
7. ST-170 HSS	Decoating Ti, Al based coatings from HSS	330 x 1100 x 200 mm (for 7 hobs with ø80 x 180 mm)
8. ST-500 HSS	Decoating Ti, Al, Cr based coatings from HSS	500 x 500 x 400 mm
9. ST-500 CR	Decoating Cr based coatings from carbide and HSS	500 x 500 x 400 mm
10. ST-500 R	Rinsing module	500 x 500 x 400 mm
11. ST-500 P	Corrosion protection module	500 x 500 x 400 mm

Super Fast Decoating System CT20/CT40 (Patented)

- Free programmable computer controlled decoating unit
- The decoating process is supplied by pulsed signal
- Automatic process end detection possible
- Max. tool dimensions: ø200 x 300 mm

1. Stripping of coatings with TiN adhesion layer
    - Ultra fast stripping down to TiN
    - Recoating on TiN or
    - Stripping of the TiN adhesion layer with ST-40 modules
    - No cobalt leaching
2. Stripping of coatings without TiN adhesion layer
    - Ultrafast stripping down to the substrate material
    - Post treatment needed

Special insulated holders are available for shank tools, hobs and inserts.
Decoating-chemicals available through the worldwide distribution network of Borer AG, Zuchwil, Switzerland.

CT20: with 1+1 baths
CT40: with 2+2 baths

Decoating Processes

Conventional Decoating Processes

Carbide Shank Tools										HSS Hobs									
				Chemicals									Chemicals						
Coating	Decoating Time for 2 μm, Ø10 mm	Decoating Recipe	Module	Galvanic Support	Decoat 100	Decoat H	Decoat K	Decoat C	Decoat 301	Decoating Time for 4 μm, Ø80x180 mm	Decoating Recipe	Module	Galvanic Support	Decoat H	Decoat 231	Decoat K	Decoat C	Decoat AlZiRo+	Decoat 301
TiN	4 - 5 h	T-HM	HM	x	x	x	x		x	~ 1 h	T-HSS	HSS		x				x	
TiCN-grey	6 - 8 h	T-HM	HM	x	x	x	x		x	~ 2 h	T-HSS	HSS		x				x	
TiAlN	10 - 18 h	T-HM	HM	x	x	x	x		x	1 - 2 h	T-HSS	HSS		x				x	
AlTiN	10 - 18 h	T-HM	HM	x	x	x	x		x	1 - 2 h	T-HSS	HSS		x				x	
CrN	0.5 - 3 h	C	Cr				x	x	x	0.5 - 3 h	C	Cr			x	x	x		x
AlCrN	0.5 - 2 h	C	Cr				x	x	x	0.5 - 2 h	C	Cr			x	x	x		x
TiN/AlCrN	0.5 - 2 h	C/T-HM	Cr/HM	x	x	x	x	x	x	0.5 - 2 h	C/T-HSS	Cr/HSS		x	x	x	x	x	x
nACo	9 - 11 h	T-HM	HM	x	x	x	x		x	0.5 - 2 h	T-HSS	HSS		x				x	
nACRo	0.5 - 2 h	C	Cr				x	x	x	0.5 - 2 h	C	Cr			x	x	x		x
TiXCo	5 - 9 h	T-HM	HM	x	x	x	x		x	1 - 3 h	T-HSS	HSS		x				x	

Fast Decoating Processes

Carbide Shank Tools										HSS Hobs							
							Chemicals				Chem				Chemicals		
Coating	Module CT-40 Time for 2 μm, Ø10 mm	Decoat S	Module ST-40 HM Time	Decoating Recipe	Posttreatment	Galvanic Support	Decoat 100	Decoat H	Decoat K	Module CT-40 Time for 4 μm, Ø80x180 mm	Decoat K	Decoat C	Module ST-40 HSS Time	Decoating Recipe	Posttreatment	Decoat AlZiRo+	Decoat H
TiN			4 - 5 h	T-HM		x	x	x	x				1 h	T-HSS		x	x
TiCN-grey			6 - 8 h	T-HM		x	x	x	x				2 h	T-HSS		x	x
TiAlN	2 min	x	15 min	T-HM		x	x	x	x				1 - 2 h	T-HSS		x	x
AlTiN	2 min	x	15 min	T-HM		x	x	x	x				1 - 2 h	T-HSS		x	x
CrN	2 min	x			x					10 min	x	x			x		
CrTiN-ML	2 min	x	15 min	T-HM		x	x	x	x	10 min	x	x	10 min	T-HSS		x	x
AlCrN	2 min	x			x					10 min	x	x			x		
TiN/AlCrN	2 min	x	15 min	T-HM		x	x	x	x	5 min	x	x	10 min	T-HSS		x	x
AlTiCrN	2 min	x	15 min	T-HM		x	x	x	x	10 min	x	x	10 min	T-HSS		x	x
nACo	2 min	x	15 min	T-HM		x	x	x	x				0.5 - 2 h	T-HSS		x	x
nACRo	2 min	x			x					10 min	x	x			x		
TiXCo	2 min	x	1 h	T-HM		x	x	x	x				1 - 3 h	T-HSS		x	x

Dedicated coating processes for TripleCoatings and QuadCoatings are also available - De-coat chemicals are products of Borer Chemie AG, Zuchwil, Switzerland

Cleaning Units

V111, V411, V1511

Industrial single chamber cleaning units for fully automatic cleaning and vacuum drying of:

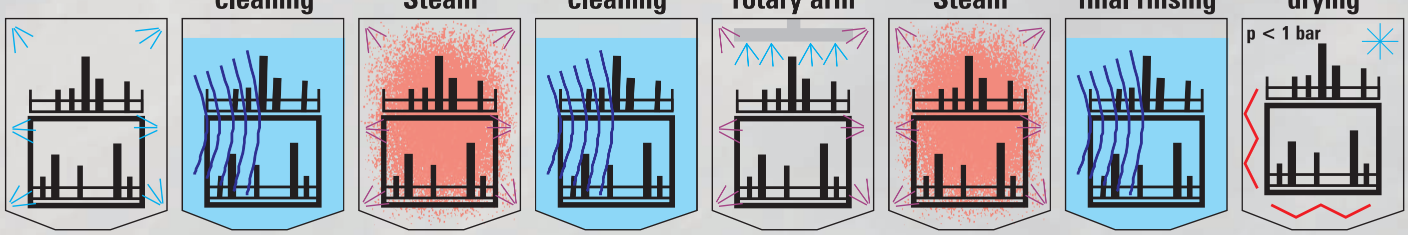
- Cutting tools, molds and dies, machine components
- Also for difficult to clean parts with cavities
- Developed in cooperation with Eurocold, Italy

These products include:

- Single chamber cleaning unit with detergent (alkaline) tank, demineralized water tank, vacuum drying system
- Water preparation: water softener, reverse osmosis, demi water
- Detergent, salt (to be ordered in user's country)
- Easy to understand touch screen for programming and handling like on the PLATIT coating units
- CleX® modular holder system for carrying shank tools, inserts and hobs

Max. dimensions of substrates to be cleaned: WxDxH [mm]:		
V111	**V411**	**V1511**
355 x 390 x 480	500 x 500 x 500	700 x 700 x 750

Washing Cycle (~45 min)



	Pre-Rinsing	Ultrasound cleaning	Rinsing & Steam	Ultrasound cleaning	Rinsing & rotary arm	Rinsing & Steam	Ultrasound final rinsing	Vacuum drying
	Detergent 1	Detergent 1	City water/ demi water with Corr.inh.	Detergent 2	Demi water with corr.inh.	Demi water	Demi water	
Step by:	V111, V411, V1511	V111, V411, V1511	V1511	V1511	V411, V1511	V111, V411, V1511	V1511	V111, V411, V1511

Consider wastewater regulations of your country!

Cleaning and its Control

Modular Manual Cleaning Unit

- CL - 40 EL: Module for electrolytic cleaning
- CL - 40 US: Module for ultrasonic treatment
- CL - 40 R: Module for rinsing
- CL - 40 D: Oven for drying

Cleaning unit for laboratories and institutes, which do not need automatic cleaning of higher substrate quantities.
The substrates are carried in special baskets by hand from module to module.

1. Rinsing away the raw dust using tap water
2. Precleaning the substrates using ultrasonic in demineralized water or in detergent
3. Rinsing using demineralized water
4. Fine cleaning using electrolytic treatment
5. Rinsing using demineralized water

See basket sizes on pages 56-57.

Cleanness - Coatability Evaluation by Measuring Surface Tension

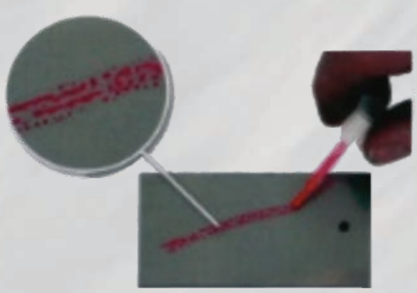
Only a metallic clean surface leads to good adhesion of the coating.
The surface tension (energy) on the substrate is one decisive criterion for the adhesion of coatings.
The higher the surface tension of the substrate, the better the adhesion of the coating.
Contaminations like grease, oil, finger prints, or dust decrease the surface energy.

The minimum surface energy should be 42 mN/m on the cleaned substrates before coating.

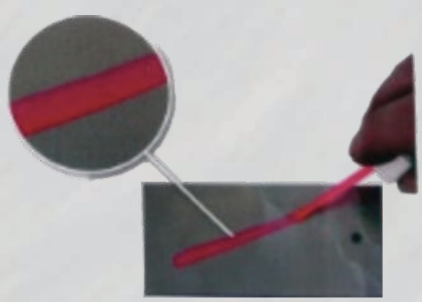
Bad wettability on oily part because of the low surface energy

The drop method can characterize the surface energy of the substrate on an easy way:
The measuring set contains a series of pens or inks. The testing fluid is applied by pens or inks to the surface of the substrate.
Every pen or ink is marked to recognize a surface energy value;
32, 34, 36, 40, 42, 44 mN/m

Good wettability without oil because of high surface energy



The ink generates droplets because its surface tension is higher than the surface tension of the substrate.
Bad wettability - plate is not clean enough and needs more cleaning.



The ink does not generate droplets because its surface tension of the substrate is higher than this of the ink.
Good wettability - plate is clean for coating.

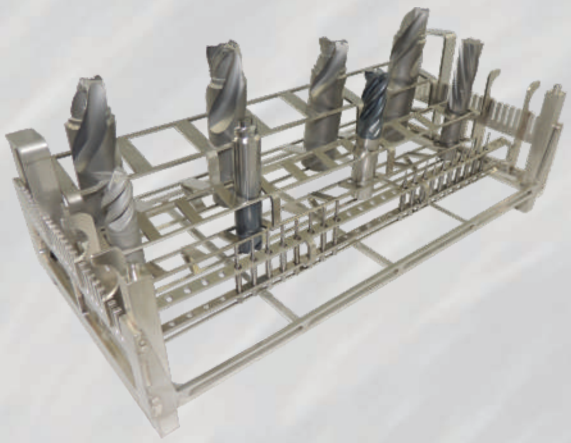
CleX®: Clean Flexible

Modular Holder System for Cleaning and Stripping

CleX® for Shank Tools

Flexible holder system for cleaning and stripping of shank tools.

Advantages:
- Different tool-diameters can be held together
- Up to 150% more tools per foot print in comparison to conventional systems
- CleX® carriers can be handled even with tools loaded
- CleX® baskets are stackable
- Smart light design ➔ Low shadowing
- Minor contact surfaces ➔ Hardly cleaning spots
- Inclined surfaces ➔ Good water draining
- Stainless steel construction ➔ High temperature resistance ➔ High durability



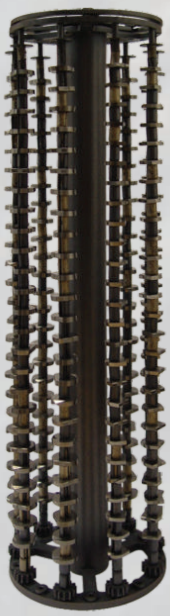
CleX® for Inserts

Flexible insert-holder for minimal handling at pre-, post-treatment and coating.

Advantages:
- Different insert-types can be held together
- For inserts with holes
- **Without reloading**, up to 500 inserts can sequentially run through **all** these processes:
  - Cleaning
  - Edge structuring by wet- / dry-microblasting
  - Coating
  - Polishing by wet- / dry-microblasting

At wet- / dry-microblasting, all sides of the inserts are treated.

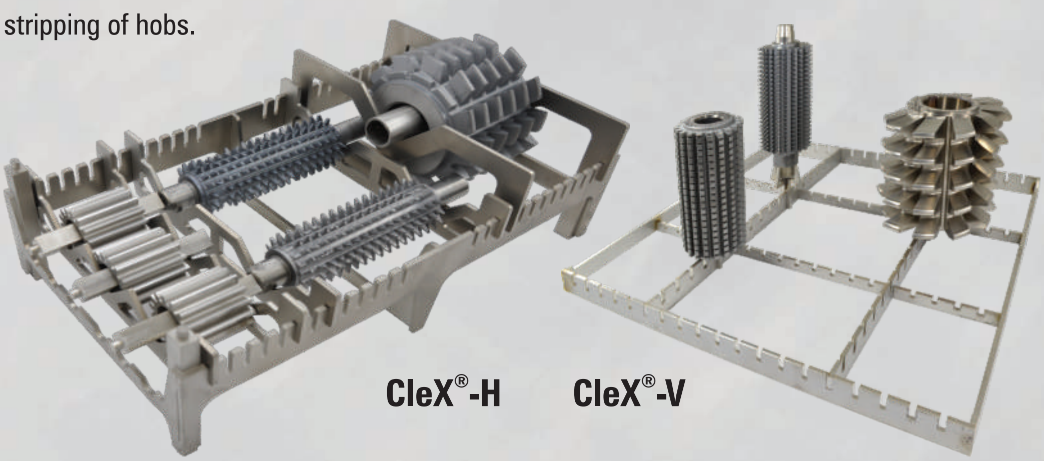
For inserts without holes the system can be used with the TongS system (see page 39) for coating only.



CleX® for Hobs

Flexible holder for cleaning and stripping of hobs.

Advantages:
- Hobs of different diameters and lengths can be held
- CleX® baskets are stackable



CleX®-H CleX®-V

CleX®: Clean Flexible

CleX® for Shank Tools

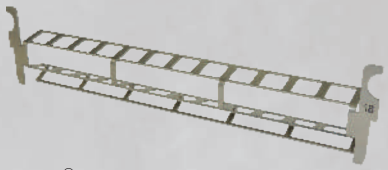
CleX® Basket 330x160 mm	V111 2 pcs/level	V411 4 pcs/level	V1511 8 pcs/level

CleX® Carrier	ø-Shank mm	Tools/CleX® Carrier	Tools/CleX® Basket
CleX®-S-3	ø3	30	270
CleX®-S-5	ø5	26	234
CleX®-S-6	ø6	24	168
CleX®-S-8	ø8	20	140
CleX®-S-10	ø10	18	126
CleX®-S-12	ø12	16	112
CleX®-S-14	ø14	15	75
CleX®-S-16	ø16	13	52
CleX®-S-18	ø18	12	48
CleX®-S-20	ø20	11	44
CleX®-S-25	ø25	9	36
CleX®-S-32	ø32	7	28

Inch sizes are available on request


CleX basket


CleX®-S-3 carrier for ø3 mm


CleX®-S-18 carrier for ø18 mm

CleX® for Inserts

For satellites ø143x380mm	Positions	Optimized for Edge Length □ mm	For minimum Insert-Hole ø mm
CleX®-I-15R	15 with support ring	14	2.4
CleX®-I-15	15	14	3.7 4.2 5.2 6.2
CleX®-I-18	18	18 x 8.5 9 x 19.0 6 x 29.5	3.7 4.2 5.2 6.2

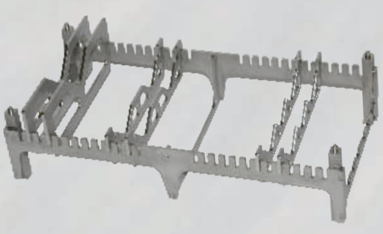

CleX®-I-15R

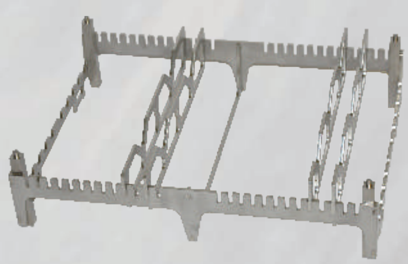

CleX®-I-15


CleX®-I-18

CleX® for Hobs

CleX holders	Optimized for
CleX-H: 330x160 mm	1 x ø130 2 x ø 65 3 x ø 38
CleX-H-XL: 330x240 mm	1 x ø170 2 x ø108 3 x ø 70
CleX-V: 500x500 mm	flexible


CleX®-H hob basket

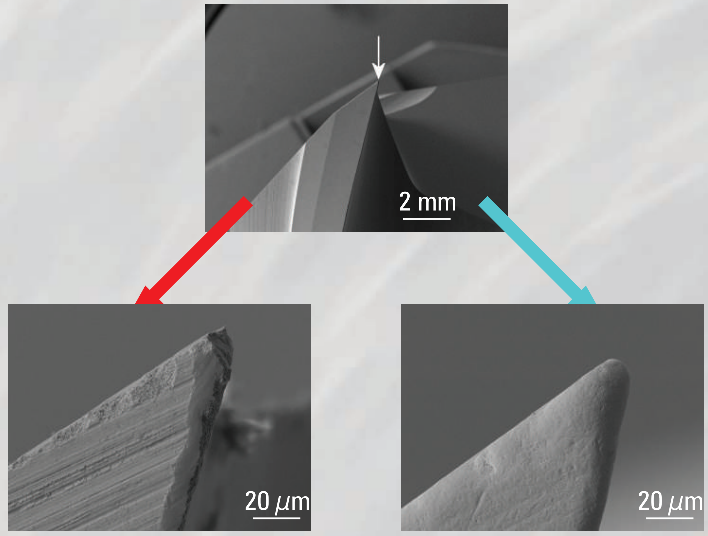

CleX®-H-XL hob basket

Micro Structuring of Cutting Edges

Why Edge Preparation?

1. Main goal: Increasing the edge stability
   a. Stable edge form:
      to avoid the edge's chipping
   b. Stable, low edge surface roughness:
      to decrease friction between tool and workpiece
   c. Stable material:
      e.g. to avoid cobalt leaching
2. Without edge preparation:
   - low performance
3. Different work piece materials need:
   - different edge preparation
4. Over the optimum edge preparation:
   - performance drops down abruptly
5. Optimum edge preparation can:
   - increase performance enormously

Typical Edge Images from High End Tool Manufacturers

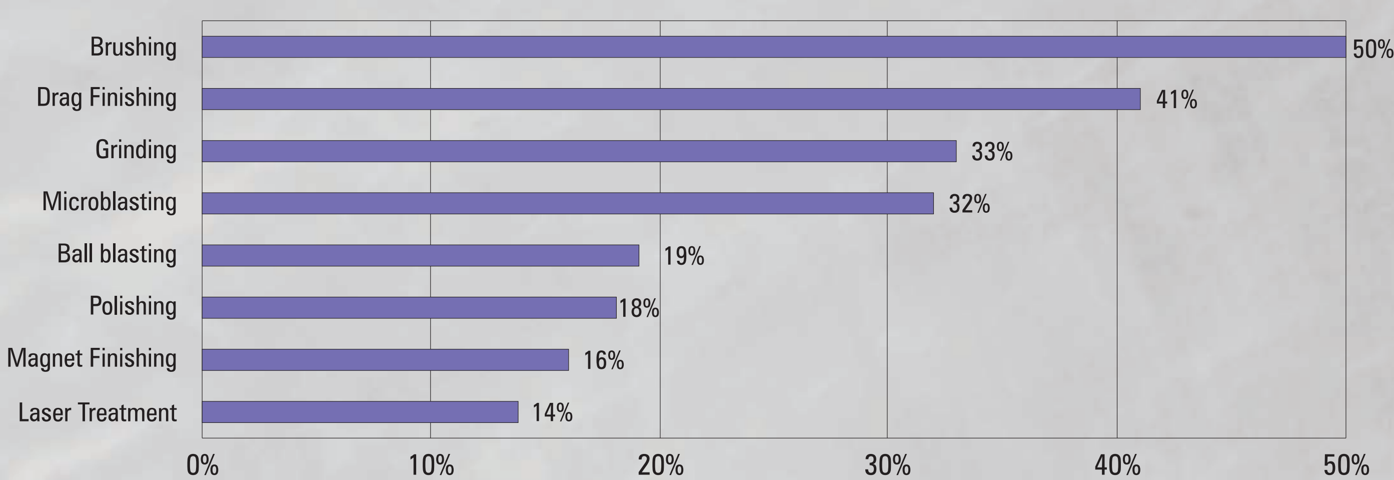


General Evaluation of Edge Treatment Methods

Criteria / Features	Brushing	Drag Finishing	Dry Micro Blasting	Wet Micro Blasting	Magnet Finishing
Quality	good	good	medium	good	good
Constancy	good	good	medium	good	good
Flexibility	high	medium	good	good	medium
Productivity	good	medium	medium	high	good
Price	high	medium	medium	high	high
Standard machines available	yes	yes	yes	yes	yes
Flute polishing possible	yes	yes	yes	yes	limited in depth
Droplet removal possible	yes	yes	yes	yes	yes
Special features	Independent treatment for all edges possible	Difficult for micro and very large tools	Residual materials on the surface	No residual material, high air consumption	Especially for micro tools, demagnetizing necessary

Microstructuring: Why and How?

Which Methods are Used and How Often?



Source: IWF, Berlin, Germany

Comparison of Different Micro Structuring Methods for Treatment of Cutting Tools

Tool	**Brushing** MET-6	**Drag Finishing** 4-Tools (3-rot.)	**Dry blasting** TR110	**Wet blasting** Compact II+	**Magnet Finish** MF 62CA
Drill					
Tip only	A1	C	B3	B2	A1
Tip and Flank	A1	A1	A3	A2	A1
Step	A1	A1	A3	A2	C
Flute	A1	A1	A3	A2	C
All individual	A1	C	C	C	C
Endmill					
Flank only	A1	C	C	C	A1
Tip and Flank	A1	A1	A3	A2	A1
Ball nose	A1	A1	A3	A2	B1
Insert					
With Bore	B1	B1	A3	A2	B1
Without Bore	B1	C	A3	B2	C
Hob					
With Bore	B1	B1	A3	A2	C
Without Bore	B1	C	A3	A2	C
Biggest Advantage	High flexibility	Smooth surface	Easy loading	Easy loading	Flexibility for shank tools
Biggest Limitation	Long set up	Manual clamping	Rough surface	Maintenance	Price

Possible:

A	yes
B	with difficulty
C	no

Surface:

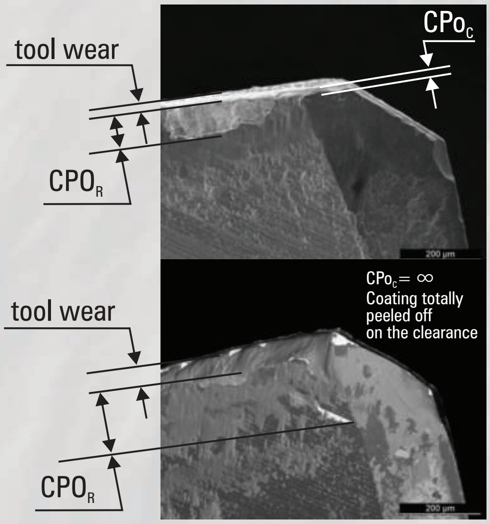
1	smooth
2	rough
3	very rough

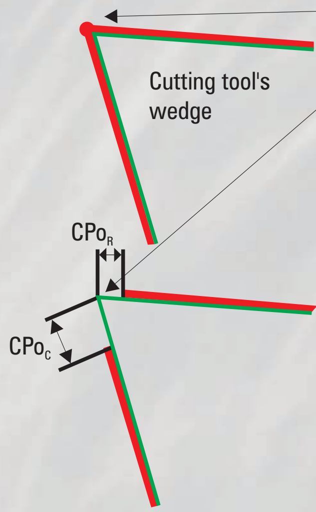
Recommendation:

	best
	alternative
	not recommended

Applications

The Aim of Edge Preparation





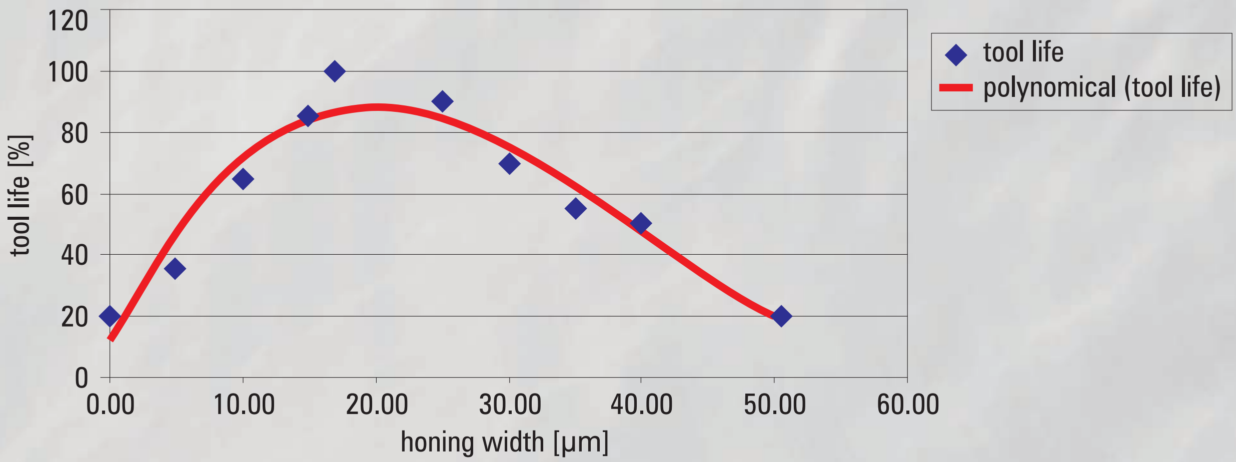
1. Sharp edge: High internal stress of the PVD coating
2. Shortly after starting cutting, the coating breaks away

   CPo$_R$: Coating's flaking
   on the tool's rake surface

   CPo$_C$: Coating's flaking
   on the tool's clearance surface

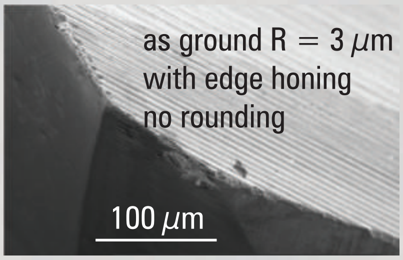
3. Good coating -> CPo$_r$ and CPo$_c$ grow slowly
4. **The aims of the edge preparation:**
   - **Deburring the cutting edges**
   - **Smooth transition between rake and clearance**
   - **Reducing internal stress, but**
   - **without making the edge blunt**

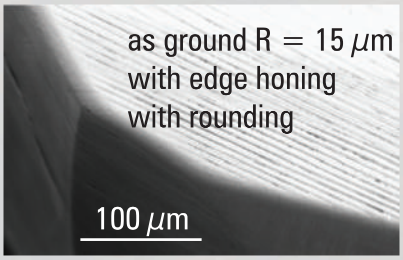
Influence of Edge Preparation at Milling in High Alloyed Steel



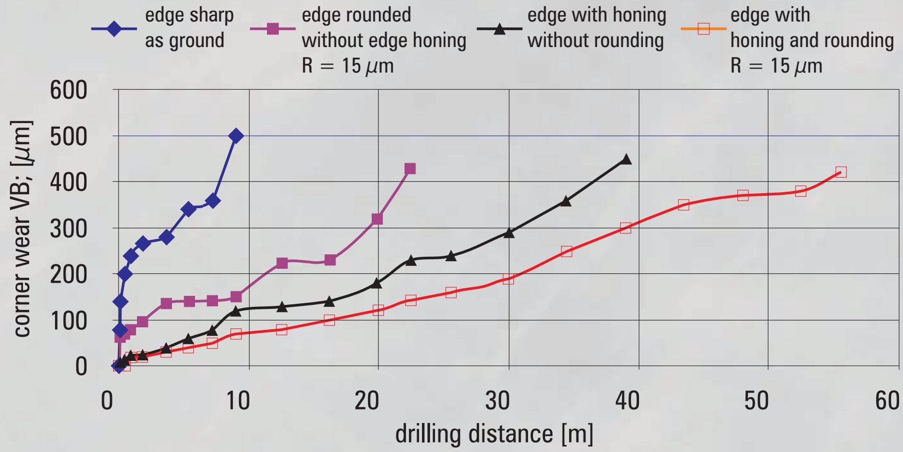
Material: 1.2379 - X155CrVMo12-1 - End mill: nACRo coated - d=10mm,
z=4, ae=0.25 x d – ap=1.5 x d – vc=150 m/min – fz=0.05 mm/z – Measured: GFE, Schmalkalden, Germany

Drilling





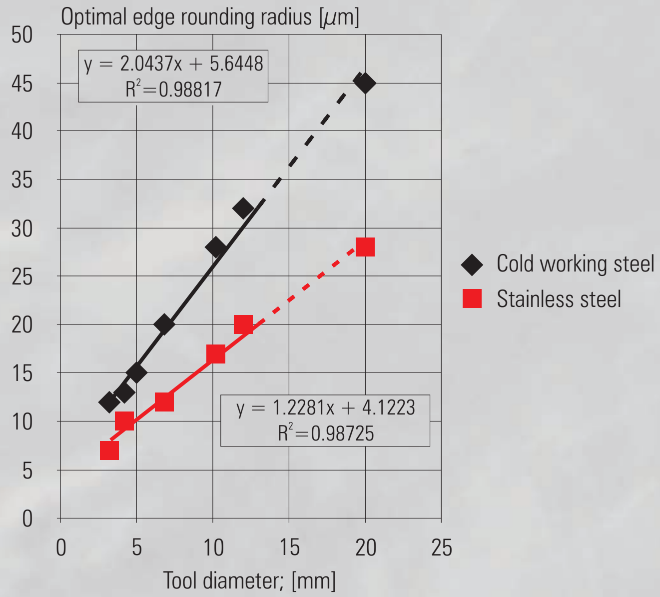
Influence of Corner Edge Preparation on the Performance of Drills



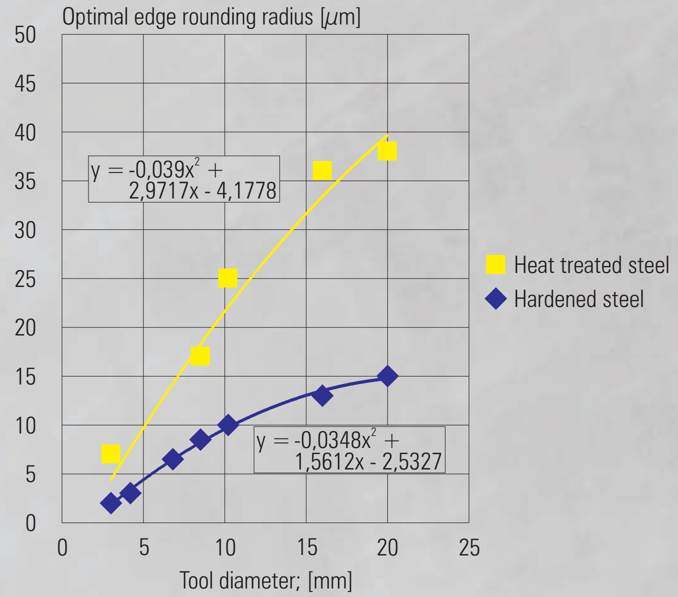
Work piece material: cold working steel - 1.2379 - X155CrVMo12-1 - HRC22 - blind holes
Solid carbide drills with nACo coating: d=5 mm - vc=75 m/min - fz=0.15 mm/z - ap=15mm - dry air coolant

Optimum Edge Rounding

Edge Preparation for Drills



Edge Preparation for End Mills



The optimal edge rounding values were elaborated in cooperation with GFE, Schmalkalden, Germany

Edge Preparation after Coating

- The edges are rounded after coating
- The coating is removed around the edge
- The edge is "set free"

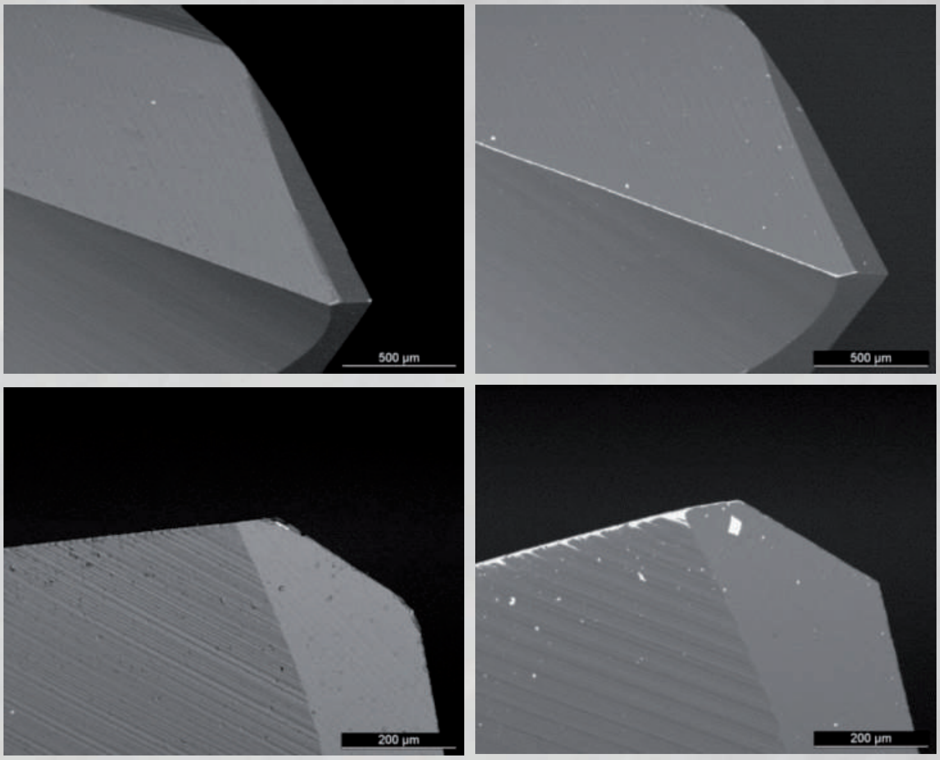
Advantages of edge preparation after coating:

- Edge rounding and
- Droplets removing in one step
- Combined break outs of coating+carbide can be avoided
- Elimination of antenna effect

Disadvantages of edge preparation after coating:

- Interruption of coating structure on long surface line
- Immediately full and direct contact of cutting and work piece material
- Lower heat and chemical insulation
- Low coating thickness near to the edge
- Full coating structure begins far from cutting edge
- Bigger edge radius (e.g. for roughing) results in larger surfaces without coating
- Gives the impression of bad coating

As coated — Edges are "set free" treated after coating



Brushing

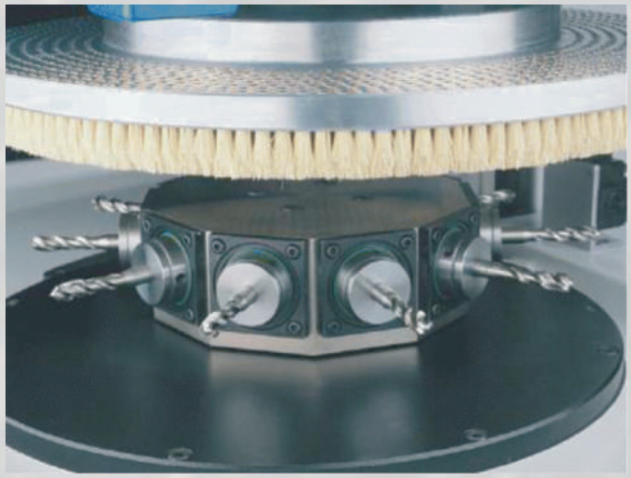
For Pre- and Post-Treatment of Cutting Tool Edges

Brushing with 5 axis CNC machine

For flexible use

Source: MET, Cleveland, USA

Brushing with 2 axis machine



Use for series production

Source: Gerber, Lyss, Switzerland

The 5 axes

Tool:
1. X-axis: Horizontal move
2. A-axis: Rotation around tools, rotating axis

Brush:

3. Y-axis: Transverse axis (offset)
4. Z-axis: Vertical move (setting to tool)
5. C-axis: Swivel axis (around Z)

Advantages

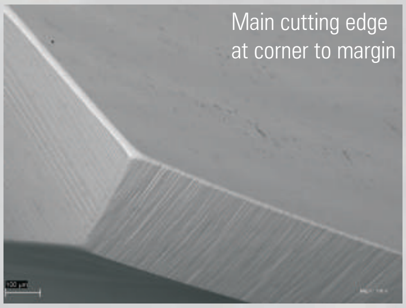
- Flexibility
- Individual and independent edge treatment for
  - rake face / clearance
  - chisel edge
  - corner chamfer
  - step drill edges
  - margin
- Different (dedicated) edge treatment geometries
  - round
  - waterfall
  - reverse waterfall (trumpet)
- Flute detection and tool orientation
- Explicit flute polishing
- Optional magazine for automatic loading

Limitations

- First setup for a new tool requires more time

Carbide step drill after grinding

After brushing

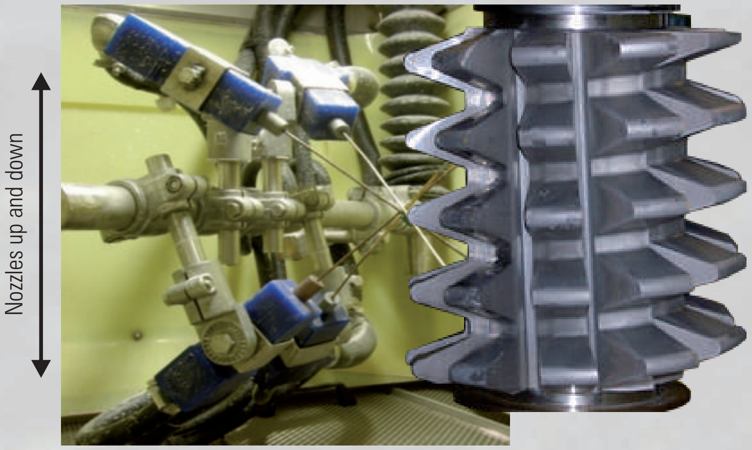


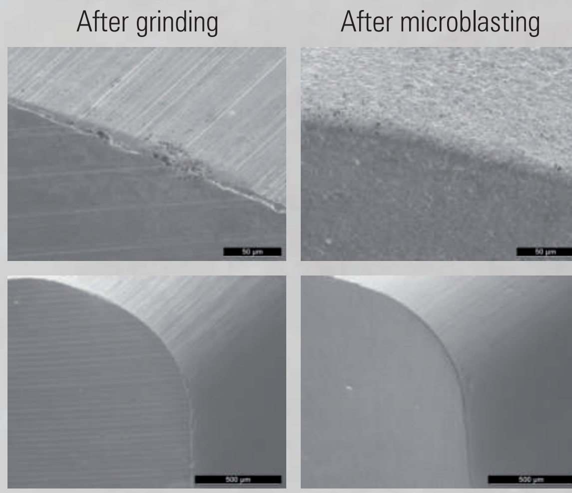
Modular software routines and tool holders

For:
- drills, step drills
- reamers
- end mills, ball nose end mills
- hobs
- inserts
- taps

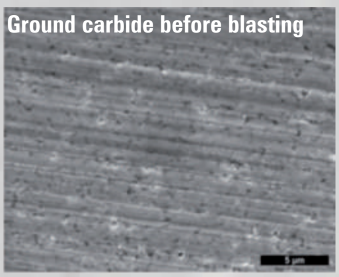
Microblasting

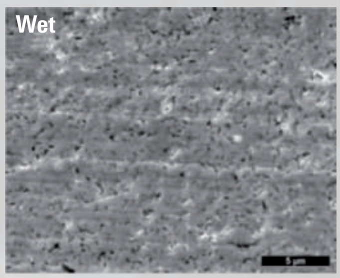
Working Principle and Results

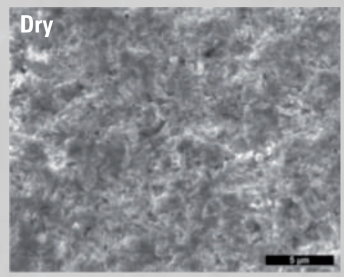


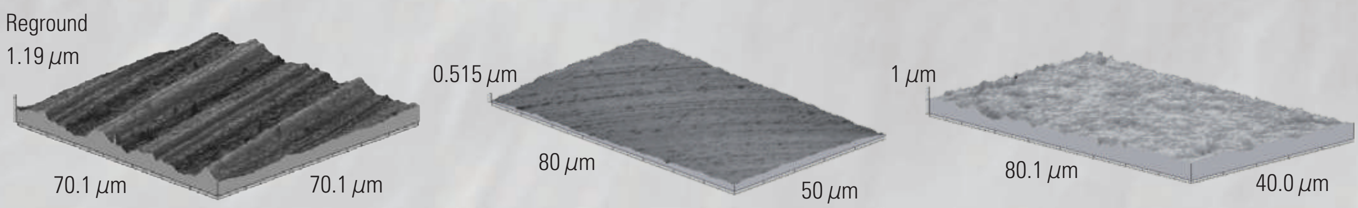


Comparison of Wet and Dry Microblasting







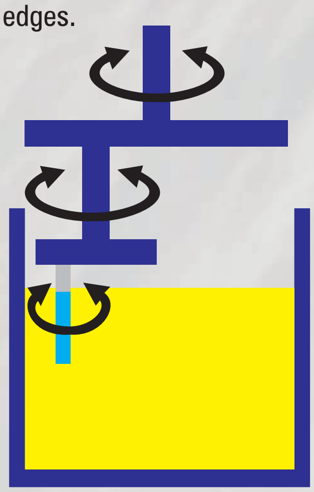


Comparison	WET	DRY
Surface roughness	Sa=0.05 µm - Sz=0.32 µm slightly shiny surface	Sa=0.11 µm - Sz=1.14 µm
Rest material after blasting	Danger of cobalt leaching because of water	Smearing of residual material
Coating adhesion	HF1	HF1
Edge rounding	Better to control	Difficult to control
Grain size	Mesh 320 (50 µm) coarse, for edge rounding Mesh 400 (37 µm) middle, for surface activation Mesh 500 (30 µm) fine, for polishing	
Typical micro blasting time [min] for hob ø80 mm - R=10 µm	3	6
Main features	• Pre cleaning not needed • Drying after blasting needed • Difficult cleaning at interrupted work • Higher price – huge air consumption	• Pre cleaning needed • No drying needed after blasting • Easy handling at interrupted work • Lower price – high air consumption

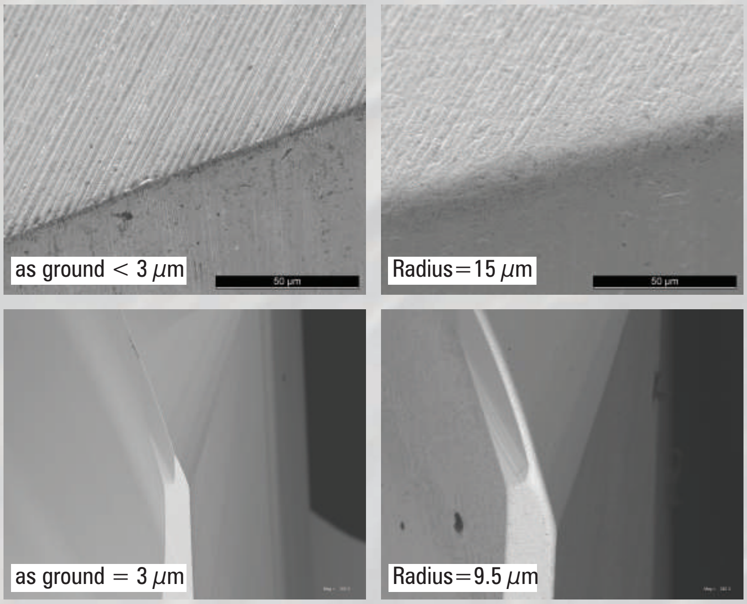
Drag Grinding

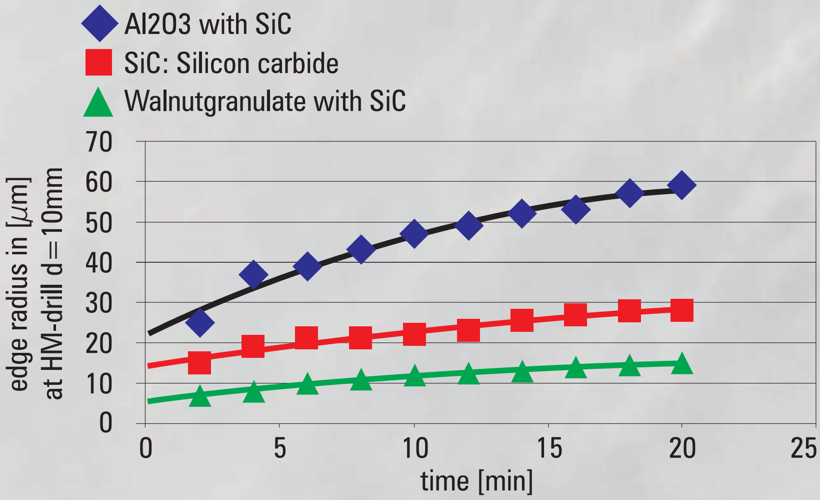
Working Principle and Results

The tools are clamped in a planetary drive. The tools are dragged in the process media. The auto rotation of the tools guarantees a homogeneous edge rounding of all cutting edges.



BEFORE AFTER





Advantages

- Reliable process
- High reproducibility
- Flute polishing

Process Media

Composition	Edge rounding	Polishing
Walnut + SiC	Carbide (+HSS)	Standard coatings
Ceramic 1 + SiC	Carbide (+HSS)	Super hard coatings

Source: OTEC, Straubenhardt, Germany

Limitations

- Inflexible clamping system
- Clamping head must be full for homogeneous treatment
- Relatively long process time

Stream Grinding

Extending loading carriage can be set up directly beside the wall

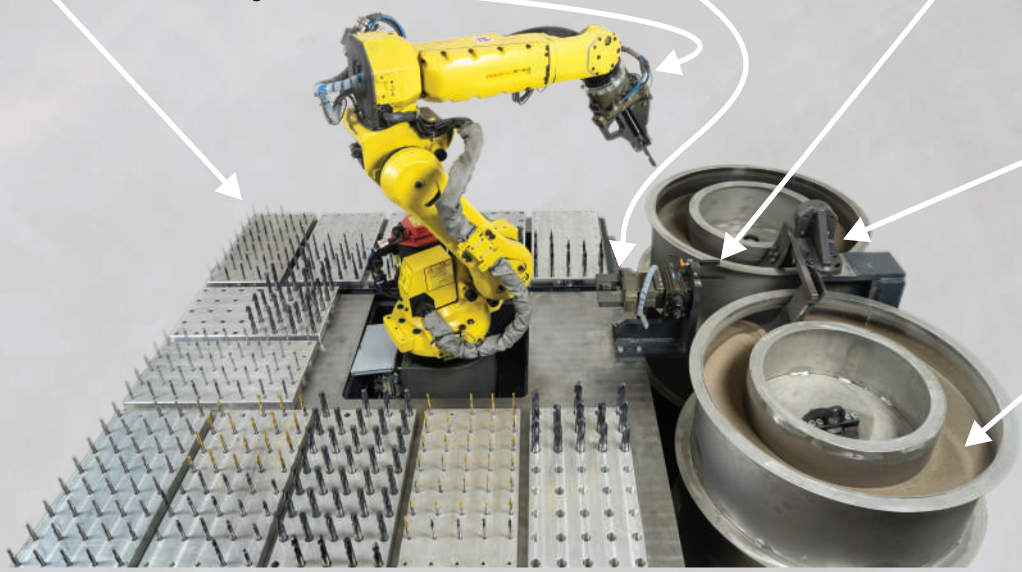
3-jaw gripper for Ø 3 - 20 mm with automatic Ø recognition max. length 200 mm

Parallel gripper with swivel unit for embracing the different Ø in different prisms

Sensor for checking immersion depth and tool breakage

Container 1: With granulate for smoothing

Container 2: Edge honing or polishing



- Interchangeable locked pallets ø3 - 20 mm
- Automatic switching to the next pallet even at partly loaded pallets or at tool quantity of 1
- Simple programming over the Fanuc robot panel
- Adjustable speed, duration and immersion depth per pallet

- Infinitely variable controlled drive right / left
- Processing time: ~ 2 min / tool
- Automatic edge rounding and polishing ~2 min / tools

Options:

- Special pallets
- Special grippers
- Special software

Source: Gabo-Tec GmbH, Böbingen, Germany

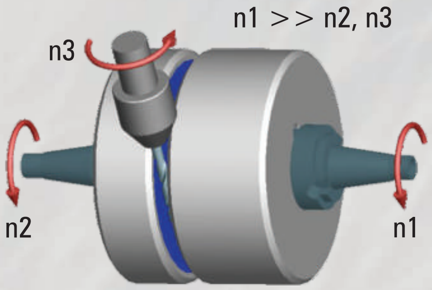
Pulsing Finish by OTEC

The SF stream finishing technology offers deburring, rounding and smoothing in a single processing stage.It can optionally be equipped with pulse finishing. It means the rotating direction of the substrate will be periodacally changed.Depending on the requirement profile, the machines can be pre-equipped automatic loading or optionally equipped with integrated automatic loading. Typical applications are the treatment of machine components with complex geometries such as taps, dies and fuel injectors.

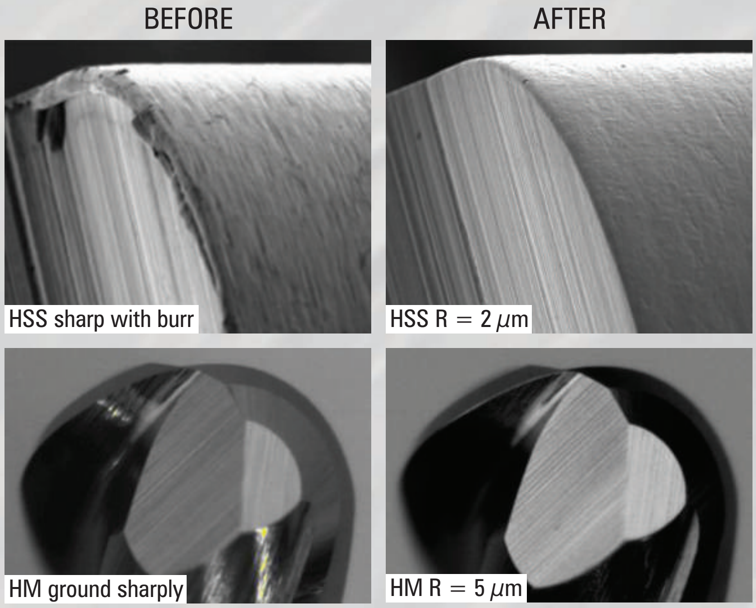
Source: OTEC GmbH, Straubenhardt, Germany

Magnet Finish

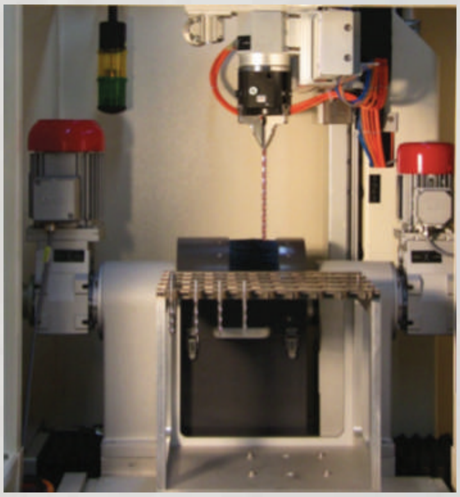
Working Principle and Results



The magnetfinish process bases on two rotating disks with an adhered magnetic abrasive. This abrasive sticks on the flat side of the magnetic disks and operates as a thick elastic mass adapting to the shape of the tool. Rotation results in a movement of the abrasive mass against the tool surface. Due to the high velocity of this movement, the surface treatment is very intense.

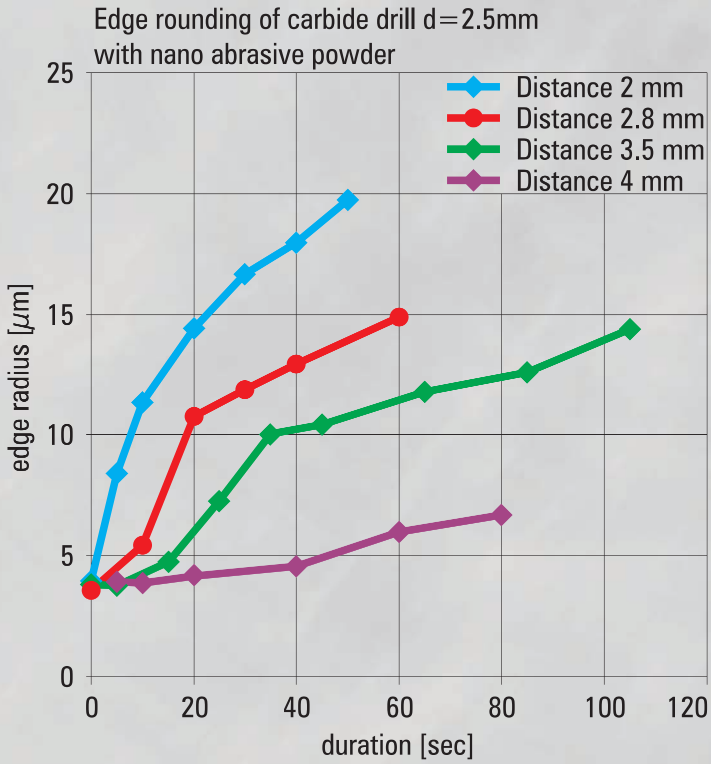


Source: Magnetfinish GmbH, Switzerland



Process Media

Name	Edge rounding	Polishing
Middle Grain Abrasive	HSS	Standard Coatings
Big Grain Abrasive	Carbide	
Nano Abrasive	Carbide, PCD, CBN	Superhard and DLC coatings



Advantages

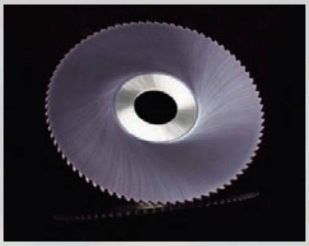
- Easy automatic processing
- Good for small quantities, no dummies needed
- Short process time
- Cooling channels on drills stay clean
- Deburring possible without edge rounding
- Consistent quality over tool length
- High repeatability due to constant abrasivity

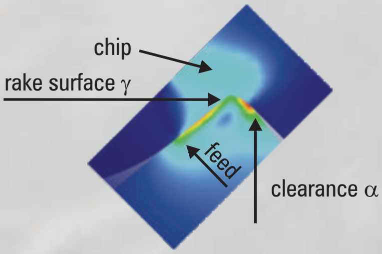
Limitations

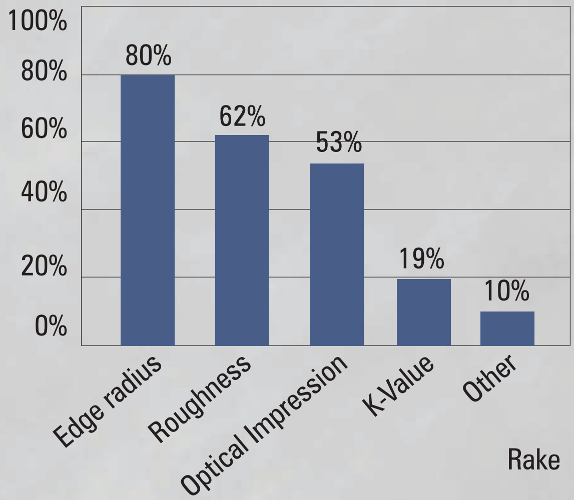
- Tool range: 0.1 – 25 mm
- Flute on drill polishing up the Ø 12 mm
- After magnet finishing, demagnetization of the tools is necessary

Influence of the Edge Shape

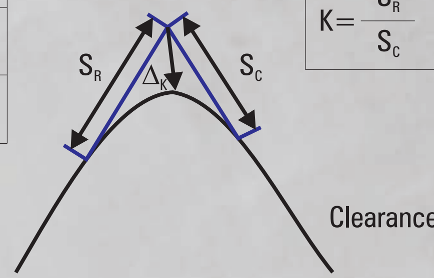
Importance of the Geometric Edge Parameters





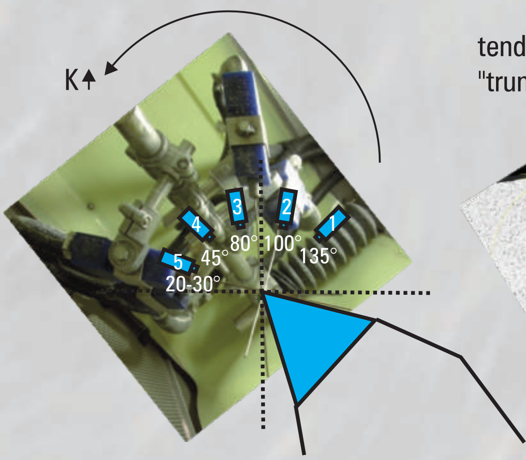


$$K = \frac{S_R}{S_C}$$

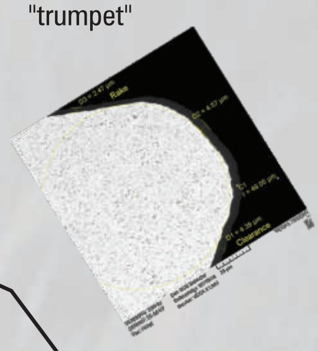


Source: IWF, Berlin, Germany

K-Factor and its Influence on the Application

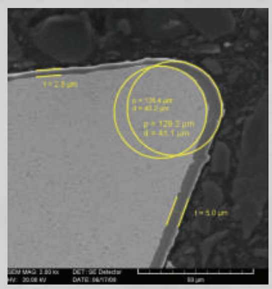


tends to rake K > 1
"trumpet"

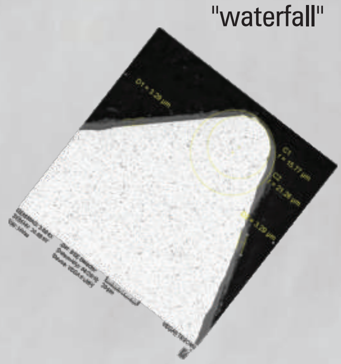


for high depth of cuts, for roughing

Symmetrical K=1

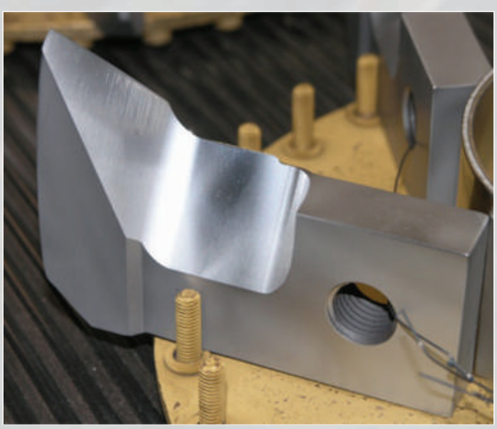


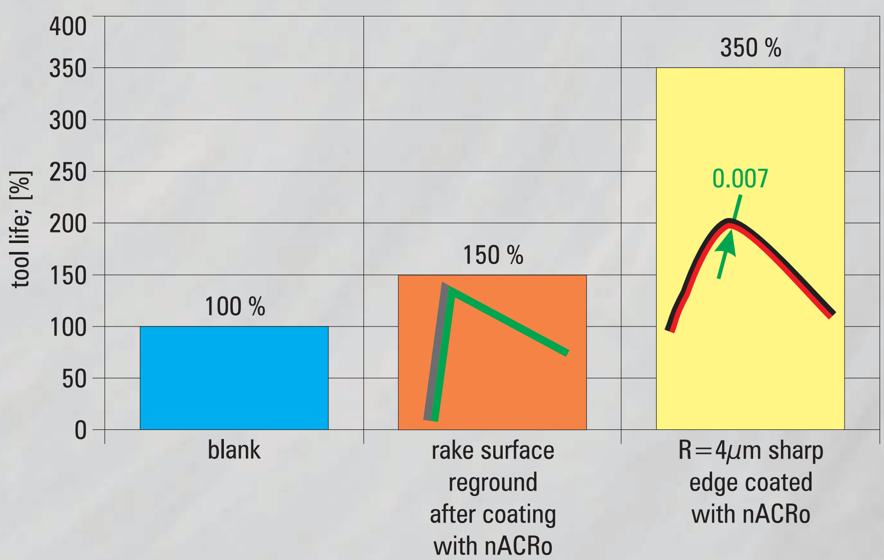
tends to clearance K < 1
"waterfall"



for low depth of cuts, for finishing

Edge Preparation Increases Tool Performance even for WOOD CUTTERS



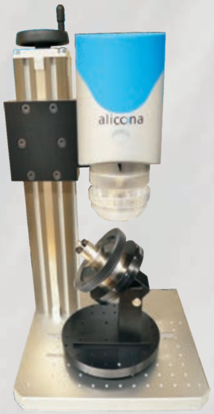


Optical 3D Measurement of Cutting Edges

Two different methods for contactless and destruction-free measurement of cutting edges.

Alicona Measuring-Systems

Focus-Variation:
A surface-based process with high-resolution combines functionalities of a roughness and 3D-coordinate system. The applied technology provides high stability against extraneous lights and vibrations.



Alicona EdgeMaster with special holder from PLATIT
Source: Alicona, Graz, Austria

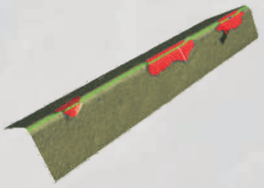
LMI-GFM Measuring-Systems

Stripe-light-projection:
Aligned, sectional planes of light are projected on the cutting edge. These are captured by a CCD camera and compared with the emitted light to calculate the edge radii.

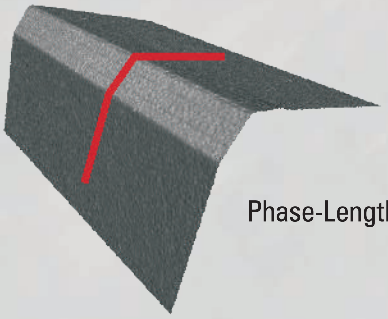
LMI MicroCAD
Source: LMI, Vancouver, Canada

2 x 2 x 25 mm^3*	Measuring Volume	1.6 x 1.2 x 0.8 mm^3*
3 μm*	Min. Edge Radius	5 μm
Yes	K-Factor	Yes
Ra, Rz, Rq, Rp, Rv	Chipping	Ra
Simple and Repeatable	Tool Positioning	Limited
Wedge-, Clearance-, and Rake-Angle, Phase-Length etc.	Tool Geometry	No
Possible	User-Definied Parameters	No
Automatic	Break-Outs and Wear	No
Yes	Shape Deviation	Yes
Ra, Rz, etc. + Sa, Sz, etc.	Surface Roughness	Not possible

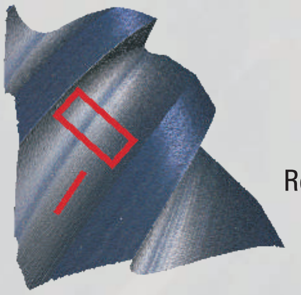
*depending on lens



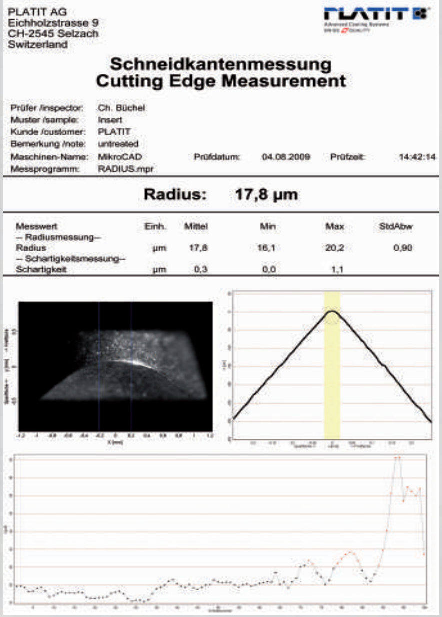
Chipping and Break-Outs



Phase-Length



Roughness



PLATIT AG
Eichholzstrasse 9
CH-2545 Selzach
Switzerland

Schneidkantenmessung
Cutting Edge Measurement

Prüfer /inspector: Ch. Büchel
Muster /sample: Insert
Kunde /customer: PLATIT
Bemerkung /note: untreated
Maschinen-Name: MikroCAD Prüfdatum: 04.08.2009 Prüfzeit: 14:42:14
Messprogramm: RADIUS.mpr

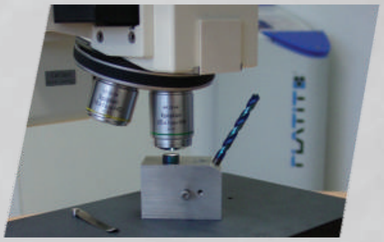
Radius: 17,8 µm

Messwert	Einh.	Mittel	Min	Max	StdAbw
-- Radiusmessung--					
Radius	µm	17,8	16,1	20,2	0,90
-- Schartigkeitsmessung--					
Schartigkeit	µm	0,3	0,0	1,1	

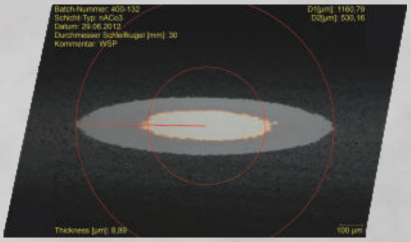
Quality Control PQCS

Image Processing System

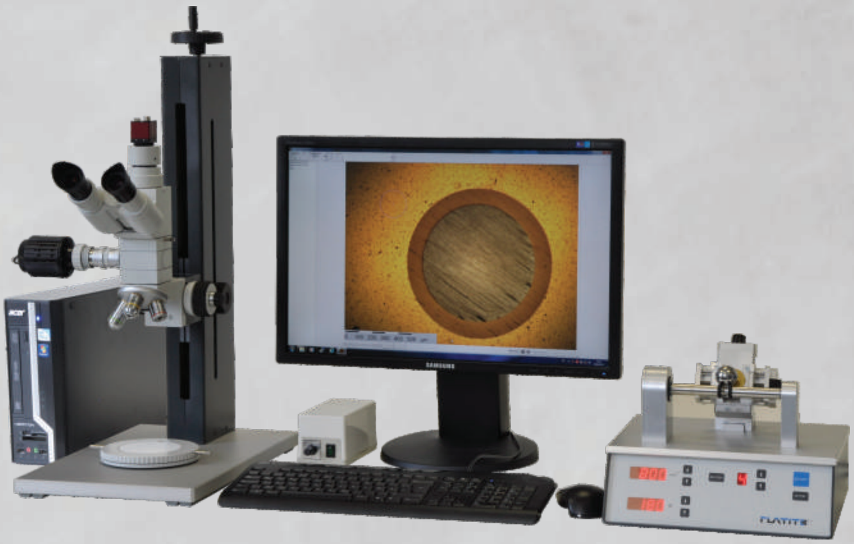
- Microscopical analysis of test plates and coated tools
- Thickness measurement by Calotest on test place and real tools
- Adhesion evaluation using Rockwell test



Measurement

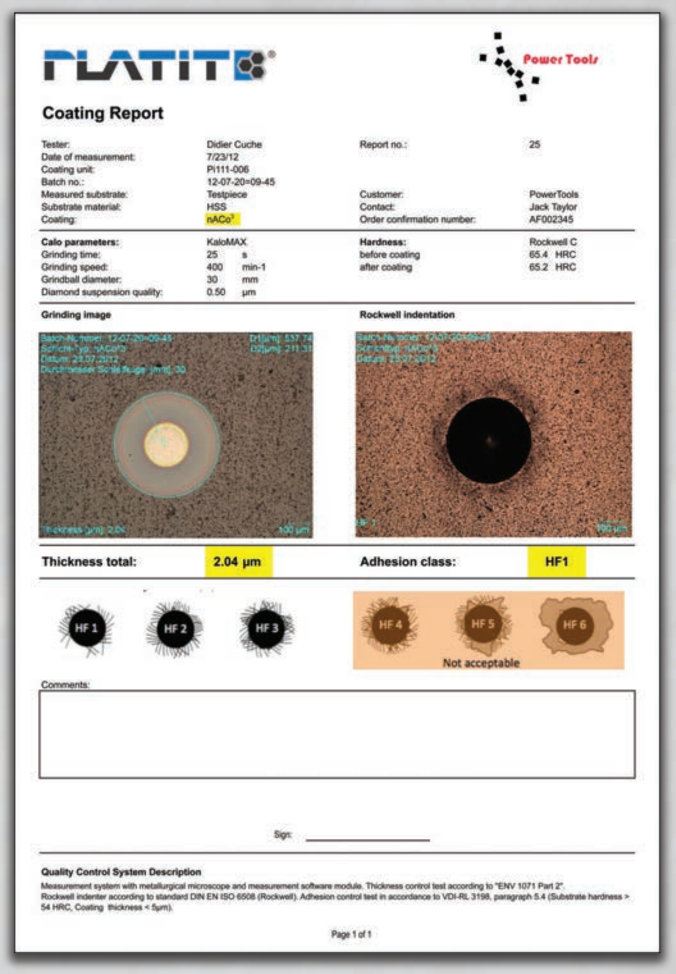


Calo, measured on tool



Platit Quality Control System (PQCS)

- Easy user interface
- Step by step "Coating Report" generation
- Automatic database entries after "Coating Report" generation and links to:
  - Batch photo
  - Calo image
  - Rockwell image
  - Coating Report
- Report no. (with link to report)
- Tester, Date, Coating unit
- Batch no. (with link to batch photo)
- Measured substrate, substrate material
- Coating
- Hardness before and after coating [HRC]
- Thickness [µm] (with link to Calo image)
- Adhesion class [HF] (with link to Rockwell image)
- Customer, contact
- 5 user defined text fields e.g.
  - pretreatment
  - posttreatment
  - used holders
  - ...
- 5 user defined number fields e.g.
  - positions of special substrates on carousel
  - ...



Power Tools

Coating Report

Tester:	Didier Cuche	Report no.:	25
Date of measurement:	7/23/12		
Coating unit:	Pi111-006		
Batch no.:	12-07-20=09-45		
Measured substrate:	Testpiece	Customer:	PowerTools
Substrate material:	HSS	Contact:	Jack Taylor
Coating:	nACo³	Order confirmation number:	AF002345

Calo parameters:	KaloMAX	**Hardness:**	Rockwell C
Grinding time:	25 s	before coating	65.4 HRC
Grinding speed:	400 min-1	after coating	65.2 HRC
Grindball diameter:	30 mm		
Diamond suspension quality:	0.50 µm		

Grinding image **Rockwell indentation**

Thickness total: 2.04 µm **Adhesion class:** HF1

HF 1 HF 2 HF 3 HF 4 HF 5 HF 6

Not acceptable

Comments:

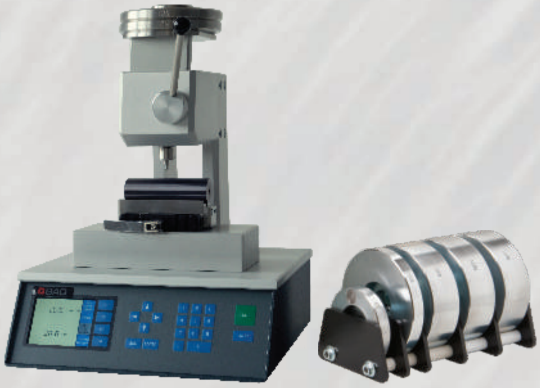
Sign:

Quality Control System Description

Measurement system with metallurgical microscope and measurement software module. Thickness control test according to "ENV 1071 Part 2". Rockwell indenter according to standard DIN EN ISO 6508 (Rockwell). Adhesion control test in accordance to VDI-RL 3198, paragraph 5.4 (Substrate hardness > 54 HRC, Coating thickness < 5µm).

Page 1 of 1

Scratch Tester

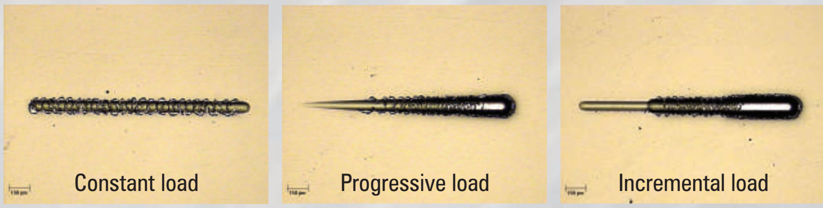


Scratch tester with constant loads
for testing in production (go or not go)
Source: BAQ, Braunschweig, Germany

Scratch tester for lab analysis
Source: Anton Paar, Graz, Austria

Method

- Linear scratching of an indenter with an applied load to characterize the coating adhesion
- The diamond of the scratch test is the same as the diamond of a Rockwell indenter
- The scratch tester allows three ways to apply the load:

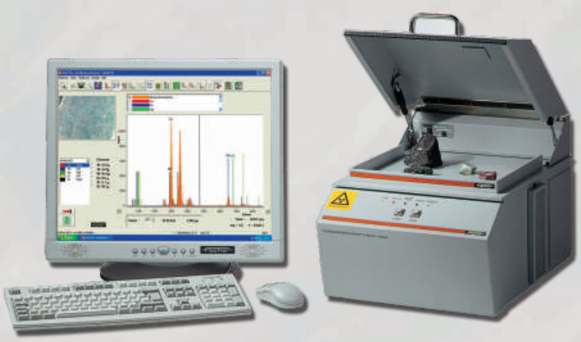


Source: CSM Instruments, Peseux, Switzerland

Limitations

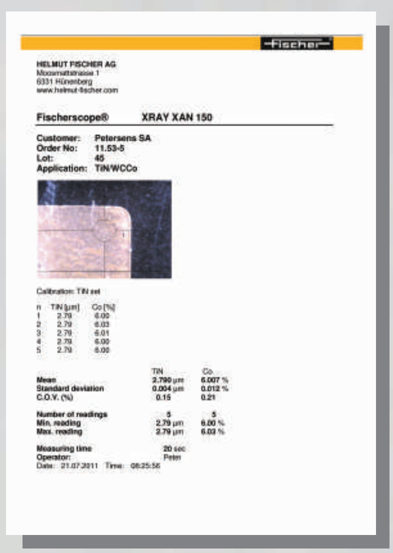
- Analysis of the scratch on an external microscope
- Flat surface required
- Length of scratch: 0 – 30 mm
- Load range: 0 – 200 N (for hard coatings)

X-Ray Spectrometer



Method

- X-rays excite the substrate to emit X-ray fluorescence
- The analysis is focused on a small spot of 0.3 μm
- The penetration depth is about 40 - 50 μm (for HSS)



Fischer

HELMUT FISCHER AG
Moosmattstrasse 1
6331 Hünenberg
www.helmut-fischer.com

Fischerscope® **XRAY XAN 150**

Customer: Petersens SA
Order No: 11.53-5
Lot: 45
Application: TiN/WCCo

Calibration: TiN set

n	TiN [µm]	Co [%]
1	2.79	6.00
2	2.79	6.03
3	2.79	6.01
4	2.79	6.00
5	2.79	6.00

	TiN	Co
Mean	2.790 µm	6.007 %
Standard deviation	0.004 µm	0.012 %
C.O.V. (%)	0.15	0.21
Number of readings	5	5
Min. reading	2.79 µm	6.00 %
Max. reading	2.79 µm	6.03 %
Measuring time	20 sec	
Operator:	Peter	

Date: 21.07.2011 Time: 08:25:56

Source: Fischer, Sindelfingen, Germany

Advantages

- Non-destructive coating thickness measurement
- Non-destructive composition measurement
- Non-destructive cobalt leaching measurement

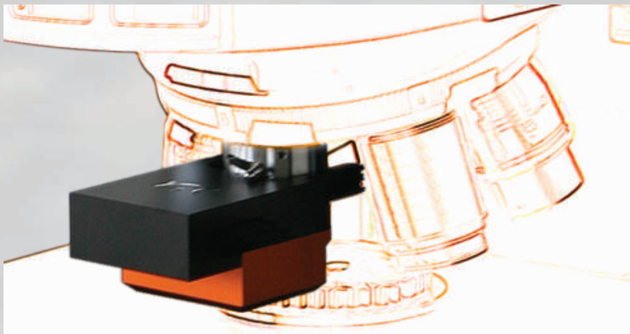
Limitations

- Al (element 13) and Si (element 14) detectable
- Measuring chamber size (L x W x H): 360 x 380 x 240 mm

Surface Analysis by AFM

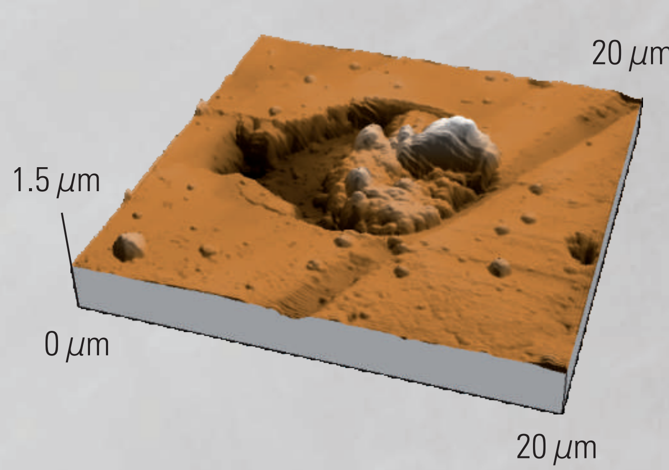
Method

- Atomic Force Microscopy (AFM)
- Static and dynamic measuring modes
- Attached to optical microscope (e.g. to the PLATIT Quality Control System PQCS) or as a stand-alone equipment



Manufacturer: Nanosurf AG, Liestal, Switzerland

Defect Analysis on Hard Coated Surface by AFM



Advantages

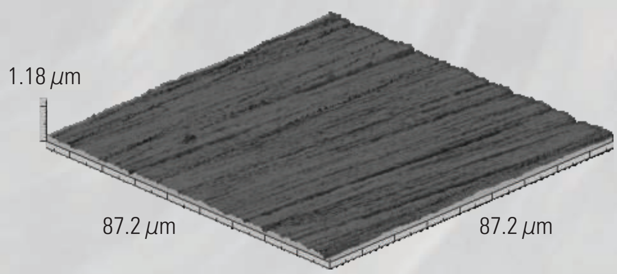
- High-resolution 3D data of the coated surface
- Integrates seamlessly with your optical analysis
- Easy to use and robust scanner
- Automated reports and sample acceptance/rejection rules

Limitations

- Max. scan range (XY): 70 / 110 µm
- Max. height range (Z): 22 µm
- Resolution (XY / Z): 1.7 nm / 0.34 nm
- Typical noise levels: 0.4 nm (0.55 nm max.)

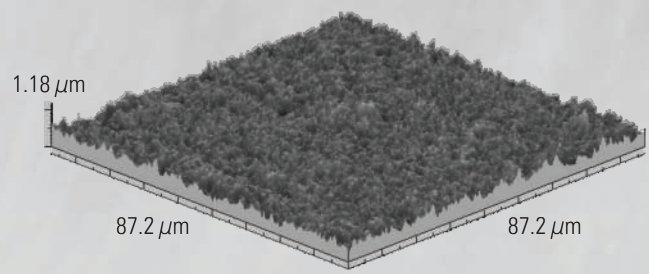
Typical Surface Structures and Roughnesses Measured by AFM

After grinding



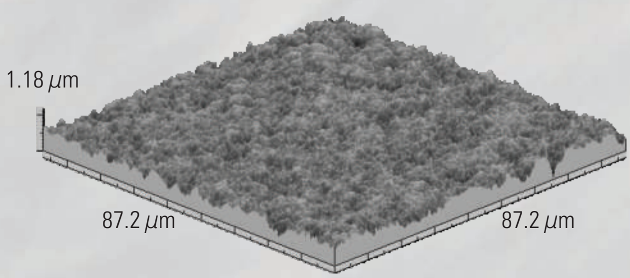
Sa = 0.019 µm - Sz = 0.28 µm

After EDM



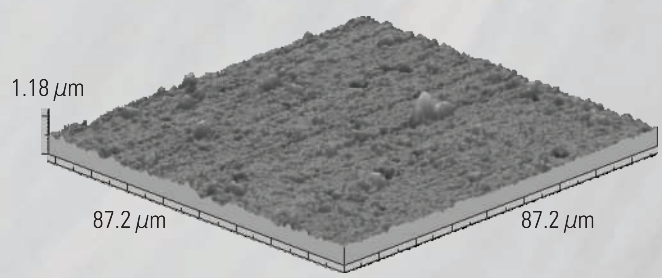
Sa = 0.073 µm - Sz = 0.86 µm

After (grinding + wetblasting)



Sa = 0.076 µm - Sz = 0.76 µm

After (AlCrN coating + wetblasting)



Sa = 0.039 µm - Sz = 0.10 µm

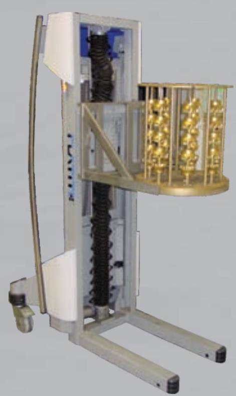
Additional Equipment for Handling

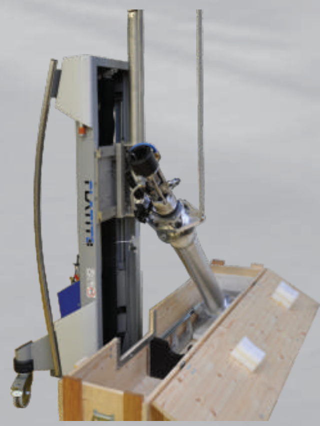
FL380 Fork Lift

Carousel exchange

Cathode exchange

Fork lift for easy transportation of loaded carousels and cathodes to and from the coating unit. Compatible with the machines of the π series.





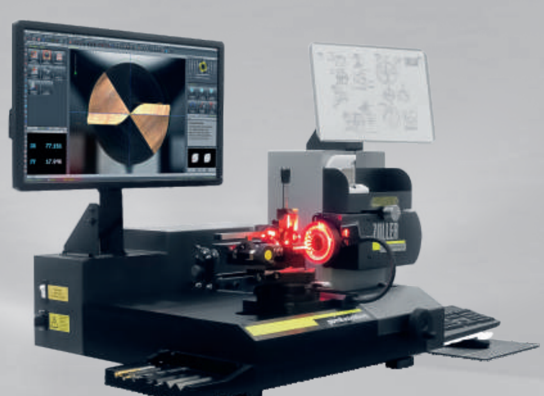
Taking out the π^{1511} cathode for exchange from the wooden box

Cathode Tables

For correct vertical holding and stocking of LARC and CERC cathodes.

3+1 tower 4+4 tower
for π^{1511} cathodes

Tool Inspection Equipment



- Tool inspection and measuring before and after coating
- Automatic edge identification
- Automatic measuring processes according to tool geometry
- Wear measurements at tool testing
- Complete tool logs

Source: Zoller GmbH, Pleidelsheim, Germany

for Extended PVD Production

Cooling Boxes

CB411 and CB1011
For π^{411}, π^{1511}, and PL^{1011}

Safe cooling of the tools immediately after coating.
To accelerate the cooling and to move away the dust and coating rests. The tools and the carousels are blasted by compressed air.

Polishing for Extreme Shiny Surfaces

The PolishPeen 770 equipment is a vacuum blasting cabin with an injector in the blasting pistol. A special media is used as polishing powder.
The operation enables mirror finishing for irregular shapes of tools, punches, dies, pins and small-sized molds.

Source: Iepco AG, Höri, Switzerland

Degasing Ovens

DE400
For $\pi^{411PLUS}$

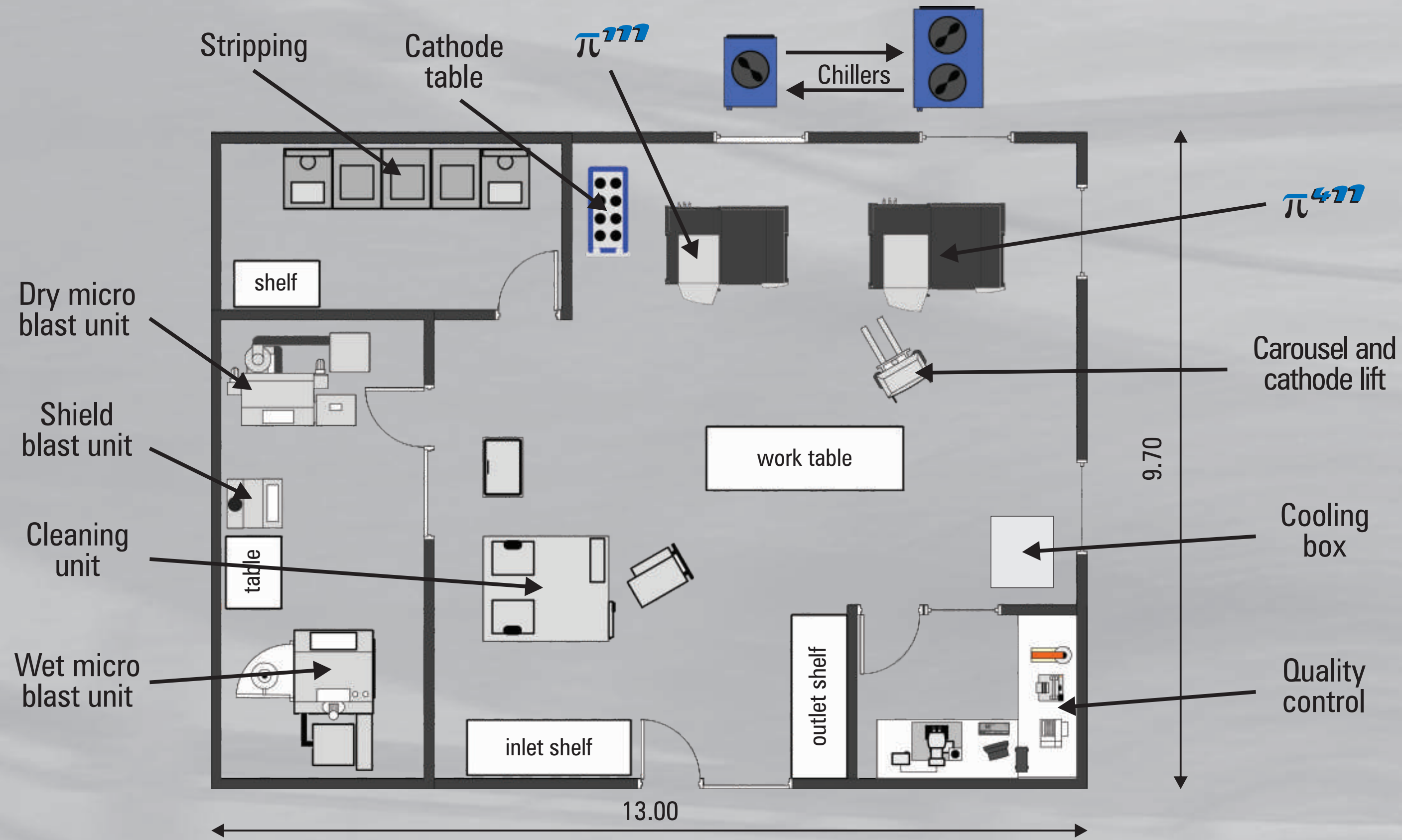
Brazed tools in the compound, machine components, mold and dies manufactured from simplier steels can contain elements their outgassing would damage the coating chamber. The evaporate pressures of the most «dangerous» elements, zinc, and cadmium, are higher than the coating process pressure. The cadmium and zinc will begin to evaporate at very low temperatures during the deposition process. This can lead to voids in the brazed joint, and cause poor adhesion of the coating.
Therefore, this kind of substrates should be outgassed in a separated outgassing oven before coating in a PVD unit. The outgassing oven heat-treat the substrates at higher temperature than the highest temperature will be in the coating chamber. The outgassed materials are collected on the cold trap of the door, which can be cleaned mechanically after the outgassing process.

Oilfree Mini Steam Jet

Steam jet
- for cleaning of subtrates surfaces
- especially the internal cooling ducts of rotating shank tools

Equipment Layout

In-House Coating Center



Source: PV-Tech, Pforzheim, Germany

Connection Data

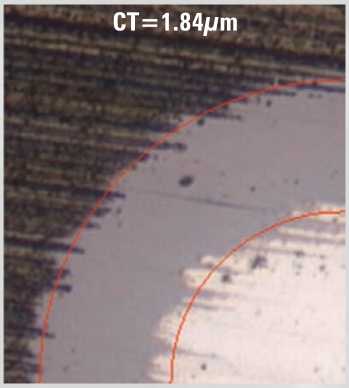
Name	Description	Dimension WxDxHxRH [mm]	Weight [kg]	Power supply [V / Hz]	Electrical connection [kVA]	Fuse [A]	Water [bar]	Air [bar]	Gas
π1511	Coating unit	4882 x 2181 x 3354 x 4200	5000	3x400 / 50 - 60	100	200	2 - 4	8	N_2, Ar, C_2H_2, He
PL1011	Coating unit	3880 x 1950 x 2220		3x400 / 50 - 60	90	200	2 - 4	8	N_2, Ar, C_2H_2, He
C1511	Chiller π1511	1000 x 1000 x 2055	370	3x400 / 50 - 60	20.7	40	3 - 6	-	-
C1011	Chiller PL1011	1000 x 1000 x 2055	370	3x400 / 50 - 60	20.7	40	3 - 6	-	-
π411PLUS	Coating unit	2730 x 1776 x 2215 x 3200	2650	3x400 / 50 - 60	110	160	2 - 4	-	N_2, Ar, C_2H_2, He
C411	Chiller for π411	1680 x 790 x 1410	750	3x400 / 50	20.5	40	-	-	-
C411	Chiller for π411	1680 x 790 x 1410	750	3x460 / 60	20.5	40	-	-	-
π111PLUS	Coating unit	1881 x 1185 x 2213 x 3200	1400	3x400 / 50 - 60	42	100	2 - 4	-	N_2, Ar, C_2H_2, He
C111	Chiller for π111	1230 x 790 x 1410	600	3x400 / 50	12.3	16	-	-	-
C111	Chiller for π111	1230 x 790 x 1410	600	3x460 / 60	12.3	16	-	-	-
FL381	Fork lift	841 x 1330 x 1947	400	115-230 / 50 - 60	0.75	10	-	-	-
V111	Cleaning unit	1570 x 1370 x 2410	1200	3x400 / 50 - 60	10	16	3 - 4	6 - 8	N_2
V411	Cleaning unit	1830 x 1980 x 2500	1650	3x400 / 50 - 60	24	40	3 - 4	6 - 8	N_2, CO_2
V1511	Cleaning unit	4200 x 1800 x 2450	4500	3x400 / 50 - 60	58	100	3 - 6	6 - 8	N_2
DE411	Degasing oven	1950 x 1500 x 2250	1400	3x400 / 50 - 60	28	40	2 - 3	6 - 8	Ar, He
ST-40 HM	Stripping unit	625 x 825 x 1200	127	230 / 50 - 60	1.1	16	-	-	-
ST-40 HSS	Stripping unit	625 x 825 x 1200	88	230 / 50 - 60	2.5	16	2 - 6	6 - 8	-
DF-4 HD	Drag finish unit	1150 x 970 x 2260	370	3x400 / 50 - 60	7.5	32	-	-	-
115N	Dry sand blasting unit	1315 x 1200 x 1885	360	230 / 50 - 60	0.8	16	-	6 - 10	-
TR110	Dry micro blast unit	2100 x 1450 x 2430	480	3x400 / 50 - 60	2	16	-	3 - 10	-
C-II	Wet micro blast unit	2100 x 2050 x 2950	1200	3x400 / 50 - 60	7	32	2 - 4	2 - 5	-
CT-20	Stripping unit	1860 x 822 x 1460	350	3x400 / 50 - 60	6.5	16	2 - 6	3 - 6	-
PP770	Polish blast unit	845 x 840 x 1740	205	230 / 50 - 60	0.15	10	-	3 - 10	-
PQCS	Microscope + PC	1500 x 650 x 800	40	230 / 50 - 60	0.4	10	-	-	-

The data are approximate values only. For detailed data see PLATIT's periphery handbook.

In - House coating center of eft-Pannon, Budaörs, Hungary

Coating Generations and their Structures

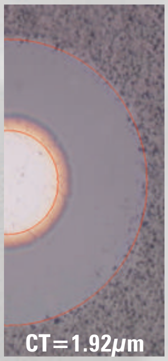
1. Generation — Monoblock Structure Without Adhesion Layer



The **monoblock structure without adhesion layer** can be produced by the fastest, most economical process. All targets are the same and run during the whole deposition process. Example coatings TiN, CrN

2. Generation — Conventional Structures With Adhesion Layer

Monoblock

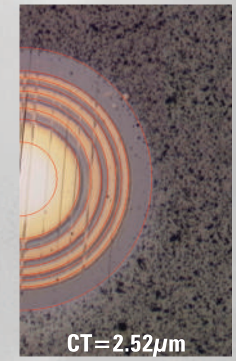


Especially at high aluminum content the **monoblock** coating should be started with adhesion layer TiN, CrN. Typical coating: AlTiN.

Gradient (G)

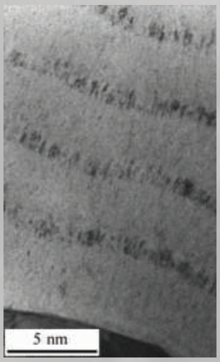
At **gradient structure** the ratio of components (e.g. C) will continuosly be changed. Typical coating: TiAlCN[2]

Multilayer (ML) Period > 20 nm



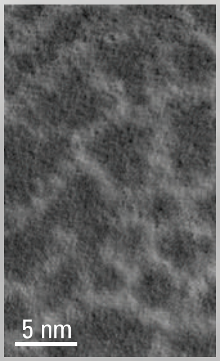
Multilayer structures have higher toughness at lower hardness than comparable monoblock coatings. The "sandwich" structure absorbs the cracks by the sublayers. Typical coating: AlTiN[2]

Nanolayer (NL) Period < 20 nm



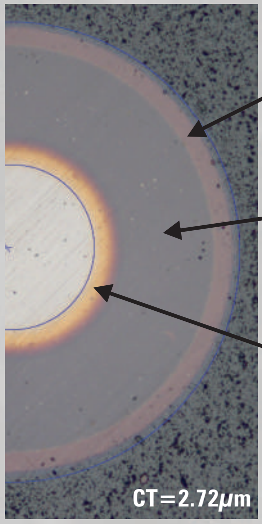
Nanolayer is the conventional structure for the so called Nanocoatings. It is a finer version of multilayers with a period of < 20 nm. Typical coating: CrTiN[2]

Nanocomposite (NC)



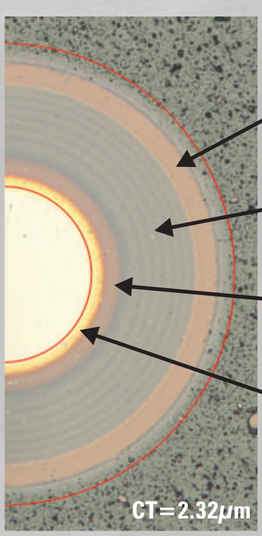
At depositing **Nanocomposites** the hard nanocrystalline grains (TiAlN or AlCrN) become embedded in an amorphous SiN-Matrix. Typical coating: nACo[2]

3. Generation: TripleCoatings3®



Typical coatings: AlCrN[3], TiXCo[3]

4. Generation: QUAD Coatings4®

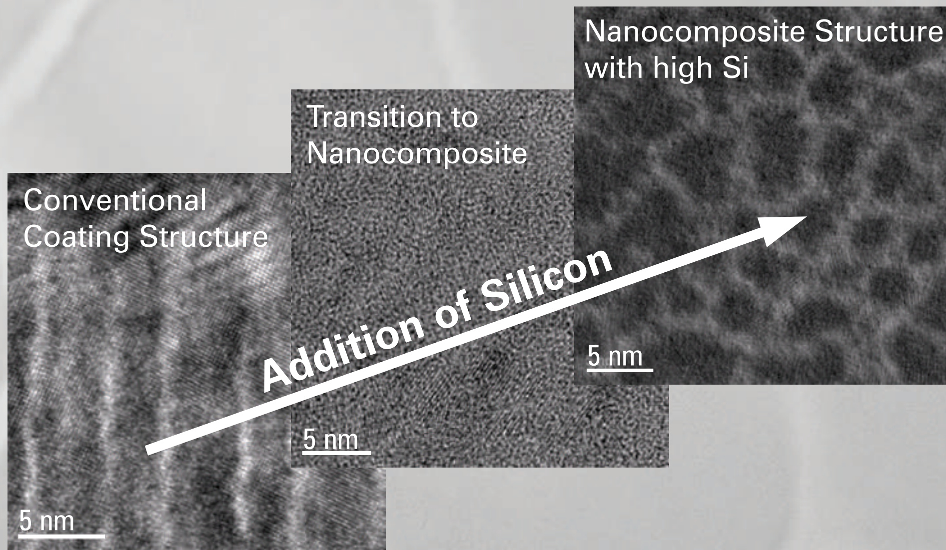


Typical coatings: ALL[4], TiXCo[4], nACoX[4]

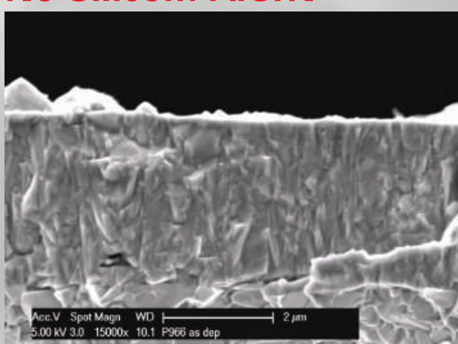
Comparison of Coating Structures

By deposition of very different kinds of materials, the components (like Ti, Cr, Al in the first group, and Si in the other) are not mixed completely, and 2 phases are created. The nanocrystalline TiAlN- or AlCrN-grains become embedded in the amorphous Si_3N_4-matrix and the nanocomposite structure develops.

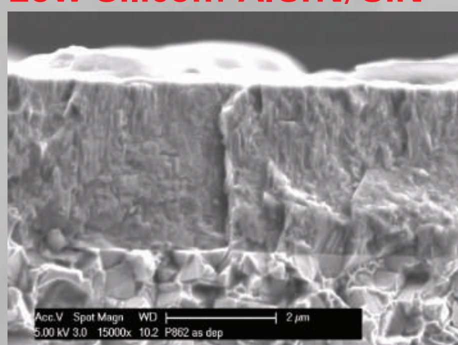
Silicon increases the toughness and decreases the internal residual stress of the coating. The increasing of the hardness is generated by the structure only, the SiN matrix enwraps the hard grains and avoids growing of their size.



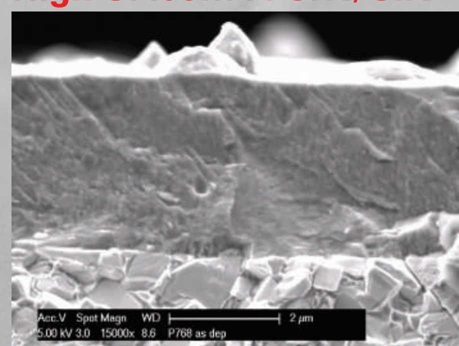
No Silicon: AlCrN



Low Silicon: AlCrN/SiN

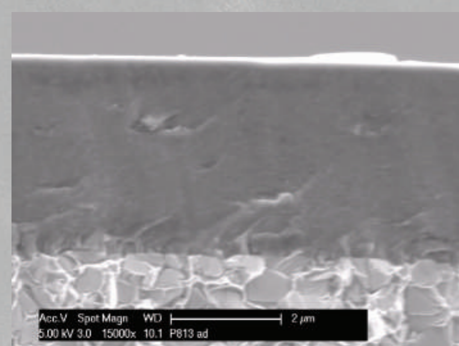


High Silicon: AlCrN/SiN

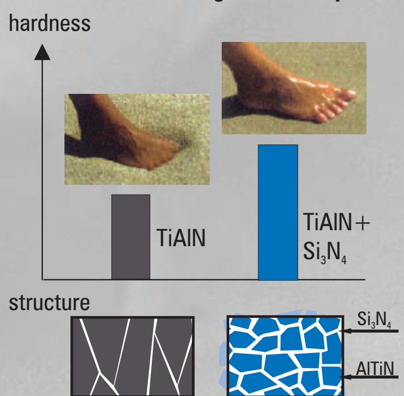


- Si addition changes microstructure from columnar to isotropic
- Effect is analog to the Ti-based system
- In TiAlN/SiN less Si is needed to reach glassy structure

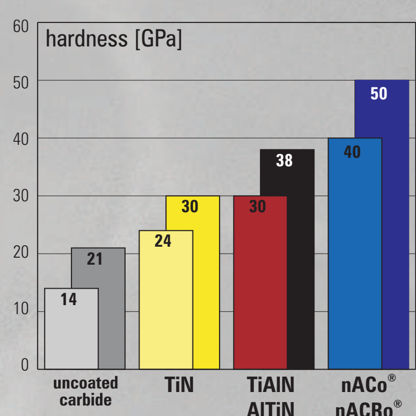
High Silicon: AlTiN/SiN: nACo®



Hardness Increase through Nanocomposites

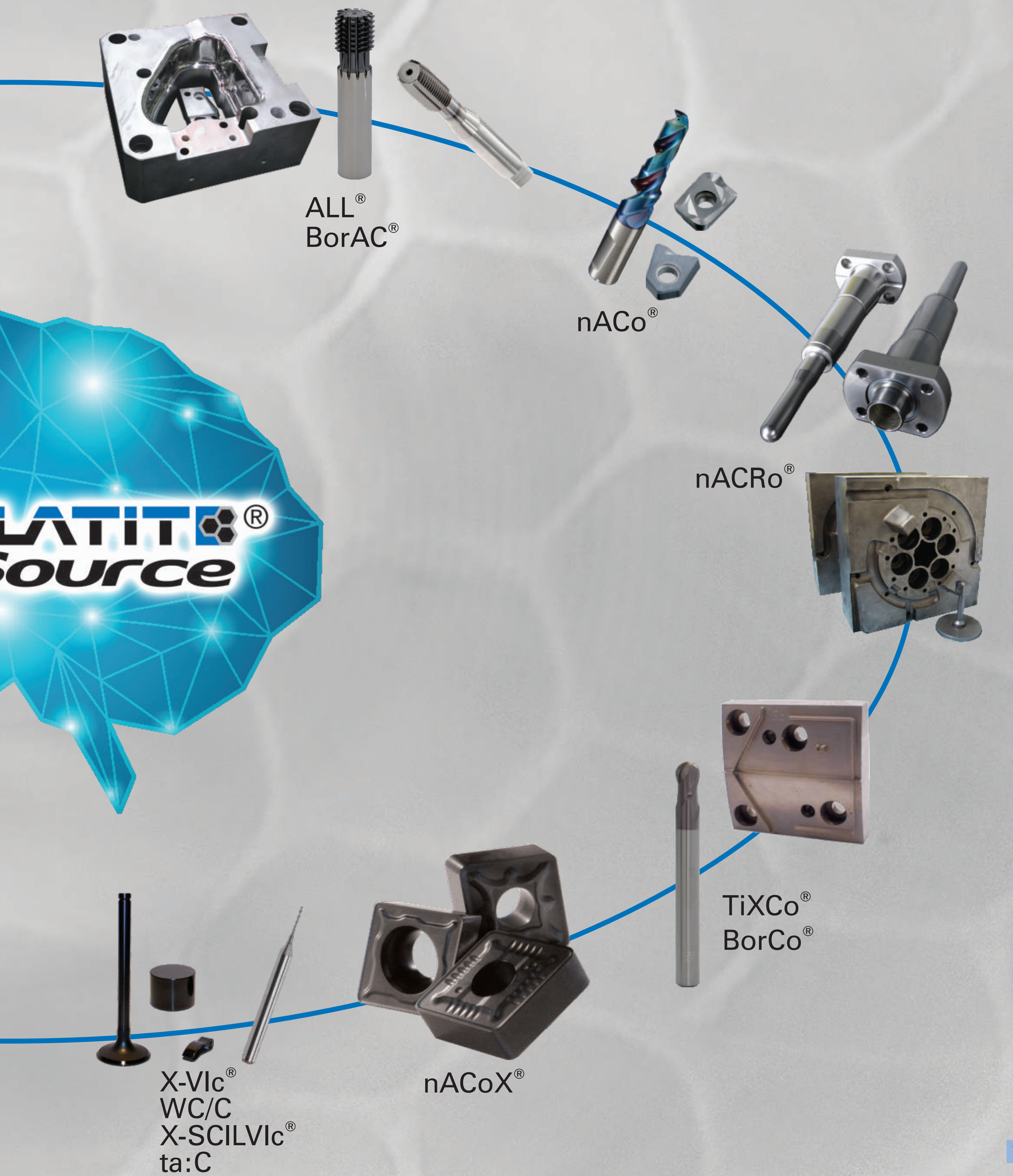


Source: J. Patscheider, EMPA, CH



The beach comparison illustrates the hardness increase made possible by using a nanocomposite structure. Usually, the foot sinks into dry sand. In wet sand, the foot does not sink in or not as far, because the space between sand grains is filled with water. The surface has a higher resistance, so it is harder.

PLATITs Main Coatings


ALL®
BorAC®
nACo®
nACRo®
TiXCo®
BorCo®
nACoX®
X-VIc®
WC/C
X-SCILVIc®
ta:C

Coating Properties

Process	Type	No.	Coating	LT	π111	π411	PL1011	PL711	π1511	Color		Nano-hardness up to [GPa]	Thickness [µm]	Friction- (fretting) coefficient	Max. usage temperature [°C]	
ARCing	Nitrides	1	TiN	*	√	√	√		√	gold		26	1 - 7	0.4	600	
ARCing	Nitrides	2	TiCN-grey	*	√	√	√		√	violet		38	1 - 4	0.25	400	
ARCing	Nitrides	3	TiAlN		√	√	√			violet-black		36	1 - 4	0.5	700	
ARCing	Nitrides	4	AlTiN		√	√	√		√	black		32	1 - 4	0.6	900	
ARCing	Nitrides	5	TiAlCN		√	√	√			violet-reddish		36	1 - 4	0.25	500	
ARCing	Nitrides	6	CrN	*	√	√	√		√	metal-silver		20	1 - 7	0.5	700	
ARCing	Nitrides	7	CrTiN	*	√	√	√		√	metal-silver / gold		30	1 - 7	0.40	600	
ARCing	Nitrides	8	ZrN	*	√	√	√			white-gold		22	1 - 4	0.40	550	
ARCing	Nitrides	9	AlCrN		√	√	√		√	blue-grey		36	1 - 7	0.5	900	
ARCing	Nitrides	10	ALL3®		√	√	√		√	blue-grey		37	1 - 4	0.5	850	
ARCing	Nitrides	11	ALL4®			√			√	blue-grey		37	1 - 5	0.45	850	
ARCing	Nitrides	12	nACo®		√	√	√		√	violet-blue		41	1 - 4	0.4	1200	
ARCing	Nitrides	13	nACRo®		√	√	√		√	blue-grey		40	1 - 7	0.45	1100	
ARCing	Nitrides	14	TiXCo®		√	√	√		√	copper		44	1 - 4	0.35	900	
ARCing	Nitrides	15	BorAC®-ARC			√	√			blue-grey	B	38	1 - 4	0.5	900	
ARCing	OXI	16	nACoX®			√			√	black		30 - 42	4 - 15	0.40	1200	
ARCing	DLC	17	X-VIc®	*	√	√	√			grey	DLC	20 - 38	1 - 4	0.15	400	DLC
Sputtering	SCIL®	18	X-SCILVIc®			√		√		blue-grey	DLC	20 - 30	1 - 4	0.15	400	DLC
Sputtering	SCIL®	19	WC/C			√				grey	W	16 - 20	1 - 4	0.1	400	DLC
Sputtering	SCIL®	20	X-SCIL®	*		√		√		varies		26	1 - 7	0.35	600	
Sputtering	SCIL®	21	TiB_2			√				light-grey	B	30 - 40	0.5 -1.5	0.35	600	
Sputtering	HS	22	ta:C	*		#		√		grey	DLC	>35	1 - 2	0.15	400	DLC
Hybrid	LACS®	23	BorAC-LACS®			√				blue-grey	B	30 - 50	1 - 7	0.5	900	
Hybrid	LACS®	24	BorCO-LACS®			√				copper	B	44	1 - 7	0.35	900	
Hybrid	LACS®	25	AlCrN-LACS®			√				blue-grey		36	1 - 5	0.5	900	

***LT:** Low temperature processes possible. **VIc®**: DLC (Diamond Like Coating)
The given physical values may vary at different coating structures (gradient, mono-, multi- and nanolayers).

#: In development.

DLC: The toplayer DLC^2 coatings are deposited by PECVD method (Plasma Enhanced Chemical Vapor Deposition).

HS: HIPIMS (High Performance Impuls Magnetron Sputtering)

Main Application Fields

		Cutting	Forming	Machine Component	
1	TiN	universal use	molds and dies	universal use, also for decorative purposes	
2	TiCN-grey	tapping, milling for HSS and HM with coolant	molds and dies, punching		
3	TiAlN	drilling and universal use, also for weak machines			
4	AlTiN	milling, hobbing, high performance machining, also dry			
5	TiAlCN	sawing, milling, tapping, also with MQL	molds and dies, punching		
6	CrN	cutting wood, light metals like copper, and Al alloys with low Si	molds and dies		
7	CrTiN	cutting and forming high alloyed materials with HSS tools	molds and dies with higher hardness, extrusion	tool holders, corrosion prot., medical tools	
8	ZrN	machining aluminum, magnesium, titanium alloys		for decorative purposes	
9	AlCrN	dry milling, hobbing, sawing	fine blanking, punching		
10	ALL3®	universal; wet and dry cutting	molds and dies, stamping, deep drawing, bending, fine punching		
11	ALL4®	universal, cutting of abrasive materials	molds and dies, forging, fine blanking		
12	nACo®	turning, hard machining on stable machine, drilling, reaming, grooving	punching, fine blanking		
13	nACRo®	tough wet cutting of difficult materials (superalloys), micro tools	friction welding, extrusion, die casting		
14	TiXCo®	for superhard cutting			
15	BorAC®-ARC	for milling, hobbing	fine blanking, punching		
16	nACoX®	HSC dry turning and milling		for components with highly abrasive load	
17	X-VIc®	cutting light metals, wood	mold and dies with low friction coefficient	car parts, blisks, sawing parts, copper parts	DLC
18	X-SCILVIc®	cutting non-ferrous materials, if extreme low roughness on tools required	molds and dies if extremely low roughness required on the surface	car parts, blisks, saving parts, copper parts, if extremely low roughness required	DLC
19	WC/C	reducing friction at run-in	molds and dies if extremely low roughness required on the surface	car parts, blisks, saving parts, copper parts, if extremely low roughness required	DLC
20	X-SCIL®	tapping, thread forming, gun drilling, reaming			
21	TiB_2	cutting light metals especially aluminum with low Si	mold and dies with easy release	clamping elements with low friction and high wear resistance	
22	ta:C	cutting non ferrous materials, composite materials, graphite, microtools	for forming tools with high wear load	for components with high wear load	DLC
23	BorAC-LACS®	dry milling, hobbing, sawing, reaming	fine blanking, punching		
24	BorCO-LACS®	universal, especially for hard machining			
25	AlCrN-LACS®	micro machining	fine blanking, punching		

The main application fields of the coating components:

- Ti: general component, for wet machining, drilling, turning
- C: for forming and cutting of sticky materials at low temperature, for machine components as DLC
- Al: for universal use, for abrasive materials, for dry machining
- Cr: for abrasive and high alloyed materials, also at dry machining, for wood
- Si: general and hard machining as Nanocomposites for rigid machines, for finishing
- B: universal use of coating with low internal stress
- O: for high temperature machining, for turning, milling
- C: increasing hardness with low friction coefficient, limited heat resistance

Coating Guide

Coating Usage Recommendations

	Cutting				Fine Blanking Punching Stamping	Chipless Forming		Tribology
	Turning	Milling - Hobbing Gear Cutting Sawing	Drilling Reaming Broaching	Tapping		Injection molding	Forming Deep Drawing Extrusion	
Steels unalloyed < 1000 N/mm^2	nACo® AlTiN	ALL^{3}® nACRo®	nACo® AlTiN	ALL^{3}® SCILVIc^{2}®	AlCrN nACVIc®	nACVIc® CrTiN	ALL^{3}®-Tribo nACRo®	
Steels unalloyed > 1000 N/mm^2	nACo® AlTiN	ALL^{4}® nACRo®	nACo® AlTiN	ALL^{3}® SCILVIc^{2}®	AlCrN ALL^{4}®	nACVIc® CrN	ALL^{3}®-Tribo nACRo®	
Steels hardened < 55 HRC	nACo® TiXCo^{3}®	nACo® TiXCo^{4}®	nACo® TiXCo^{3}®	nACo® SCILVIc^{2}®	AlCrN ALL^{4}®			
Steels hardened > 55 HRC	TiXCo^{3}® nACo®	TiXCo^{4}® nACo®	TiXCo^{3}® nACo®	TiXCo^{4}® nACo®	AlCrN TiXCo^{4}®			
Stainless steel	nACo® nACoX®	ALL^{4}® nACRo®	nACo® TiXCo^{3}®	ALL^{4}® SCILVIc^{2}®	ALL^{4}®-Tribo CrTi-VIc^{2}®	ALL^{3}®-Tribo CrTi-VIc^{2}®	ALL^{3}®-Tribo CrTi-VIc^{2}®	
Superalloys Ni-based	nACoX® nACo®	nACoX® ALL^{4}®	TiXCo^{3}® nACoX®	nACVIc® SCILVIc^{2}®	nACVIc® CrTi-VIc^{2}®	nACVIc® CrTi-VIc^{2}®	nACVIc® CrTi-VIc^{2}®	
Superalloys Ti-based	ALL^{3}® nACo®	nACRo® ALL^{4}®	ALL^{4}® nACo®	CrTi-VIc^{2}® SCILVIc^{2}®	nACVIc® CrTi-VIc^{2}®	nACVIc® CrTi-VIc^{2}®	nACVIc® CrTi-VIc^{2}®	
Cast iron	nACo® AlTiN	nACo® AlTiN	nACo® AlTiN	nACRo® ALL^{4}®				
Aluminum Si > 12%	nACRo® TiCN	nACRo® TiCN	nACRo® TiCN	nACRo® SCILVIc^{2}®	AlCrN ALL^{4}®-Tribo	nACRo® TiCN	nACVIc® CrTi-VIc^{2}®	X-VIc^{2}® - WC/C ta:C
Aluminum Si < 12%	TiB_2 ZrN	TiB_2 ZrN	TiB_2 ZrN	TiB_2 ZrN	TiB_2 ZrN	TiB_2 ZrN	TiB_2 ZrN	
Copper	ta:C CrN	ta:C CrN	ta:C CrN	ta:C CrN	ta:C CrN	ta:C CrN	ta:C CrN	
Bronze, Brass, Plastic	TiCN ta:C	TiCN ta:C	TiCN ta:C	SCILVIc^{2}® ta:C	TiCN ta:C	TiCN ta:C	TiCN ta:C	
Graphite	ta:C TiXCo®	ta:C TiXCo®	ta:C TiXCo®	ta:C TiXCo®				
Carbon-fibre composites	ta:C TiXCo®	ta:C TiXCo®	ta:C TiXCo®	ta:C TiXCo®				
Wood	CROMTIVIc® nACVIc®	CROMTIVIc® nACVIc®	CROMTIVIc® nACVIc®	CROMTIVIc® nACVIc®				

Primary Recommendation: If available, use this coating for the application. — coating A

coating B — Alternate Recommendation: Use this coating when the primary recommendation is not available.

- Thickness and structure can and should be different according to the different application processes even for the same coating.
- If the exponent x (coating^{x}) is not defined, the available machine determines the coating.

The Coating Spectrum for the Standard Machines

				π111PLUS	π411PLUS eco	π411PLUS with CERC® or SCIL®	PL711	PL1011	π1511
ARCing	Nitrides	1	**TiN**	TiN^1	TiN^1			TiN^1	TiN^1
ARCing	Nitrides	2	**TiCN-grey**	TiCN^2-grey	TiCN^2-grey			TiCN^2-grey	
ARCing	Nitrides	3	**TiAlN**	TiAlN^2-ML	TiAlN^2			TiAlN^2-ML	
ARCing	Nitrides	4	**AlTiN**	AlTiN^2	AlTiN^2			AlTiN^2-ML	AlTiN$^{2®}$
ARCing	Nitrides	5	**TiAlCN**	TiAlCN^2	TiAlCN^2			TiAlCN^2	
ARCing	Nitrides	6	**CrN**	CrN^1	CrN^1			CrN^1	
ARCing	Nitrides	7	**CrTiN**	CrTiN^2-ML	CrTiN^2			CrTiN^2	
ARCing	Nitrides	8	**ZrN**	ZrN^2	ZrN^2			ZrN^2	
ARCing	Nitrides	9	**AlCrN**	AlCrN$^{3®}$	AlCrN$^{3®}$	AlCrN$^{3®}$+		AlCrN^2	AlCrN$^{3®}$
ARCing	Nitrides	10	**ALL$^{3®}$**		ALL$^{3®}$			ALL$^{3®}$	ALL$^{3®}$
ARCing	Nitrides	11	**ALL$^{4®}$**		ALL$^{4®}$ eco	ALL$^{4®}$			ALL$^{4®}$
ARCing	Nitrides	12	**nACo®**	nACo$^{2®}$	nACo$^{2®}$	nACo$^{4®}$		nACo$^{3®}$	nACo$^{4®}$
ARCing	Nitrides	13	**nACRo®**	nACRo$^{2®}$	nACRo$^{2®}$	nACRo$^{4®}$		nACRo$^{3®}$	nACRo$^{4®}$
ARCing	Nitrides	14	**TiXCo®**	TiXCo$^{3®}$ eco	TiXCo$^{3®}$ eco	TiXCo$^{4®}$		TiXCo$^{3®}$	TiXCo$^{4®}$
ARCing	Nitrides	15	**BorAC-ARC®**		BorAC$^{3®}$-ARC			BorAC$^{3®}$-ARC	
ARCing	OXI	16	**nACoX®**			nACoX$^{4®}$			
ARCing	DLC	17	**X-VIc®**	(Ti, AlTi, Cr, CrTi, Zr)NVIc$^{2®}$					
Sputtering	SCIL®	18	**X-SCILVIc®**			(Ti, Cr, CrTi)-SCILVIc$^{2®}$	(Ti, Cr)-SCILVIc$^{2®}$		
Sputtering	SCIL®	19	**WC/C**			WC/C			
Sputtering	SCIL®	20	**X-SCIL®**			TiN^1-SCIL®	TiN/CrN-SCIL$^{1®}$		
Sputtering	SCIL®	21	**TiB_2**			TiB_2-SCIL®			
Sputtering	HS	22	**ta:C**			**ta:C #**	**ta:C**		
Hybrid	LACS®	23	**BorAC®-LACS**			BorAC$^{3®}$			
Hybrid	LACS®	24	**BorCO®-LACS**			BorCO$^{4®}$			
Hybrid	LACS®	25	**AlCrN-LACS®**			AlCrN-LACS$^{2®}$			

DLC (rows 17–19) · DLC (row 22)

Coating^x: The exponent x defines the generation of the coating (according to page 76):

1: 1st generation coating: Monobblock coating; the adhesion layer is the same like the whole coating (e.g. TiN^1)

2: 2nd generation coating = Adhesion layer + Core layer (e.g. AlTiN^2)

3: TripleCoatings: 3rd generation coatings = Adhesion layer + Core layer + Toplayer (e.g. nACo^3)

4: QuadCoatings: 4th generation coating = TripleCoating + Additional layerblock (e.g. TiXCo^4)

If there is no exponent to the coating, the coating family is assumed. The achievable generation depends on the available machine.

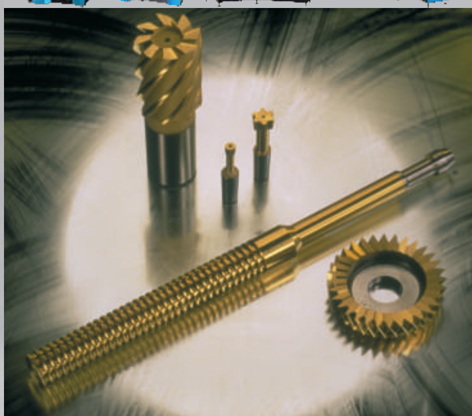
#: In development.

HS: HIPIMS (High Performance Impuls Sputtering)

Coating Types
Conventional Coatings

The machine symbols show which machine the coating can be deposited by.
The coatable stoichiometries can be different depending on the machine used.

TiN



The general-purpose coating for:

- cutting
- forming, injection molding
- tribological applications (for machine components)
- available process with 1, 2 or 4 cathodes

TiAlN

Universal coatings

Monoblock (MB) and gradient (G): for stable cut
Multilayer (ML): for interrupted cut

%-Ratio Al/Ti:

TiAlN-F (ML): ~50/50
TiAlN-G: ~50/50
TiAlN-MB: ~50/50

AlTiN

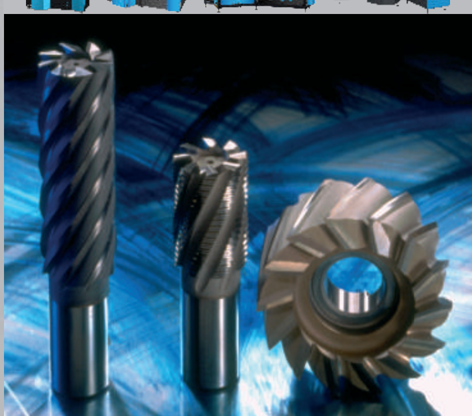
Universal high performance coatings

Monoblock (MB) and gradient (G): for stable cut
Multilayer (ML): for interrupted cut

%-Ratio Al/Ti:

AlTiN-ML: ≥60/40
AlTiN-G: ≥60/40
AlTiN-T (MB): ≥60/40
AlTiN-C (MB): ≥67/33

TiCN-grey



Conventional carbonitride coating (grey):

- for milling and tapping
- for stamping, punching and forming

TiAlCN

***Gradient* coating for universal use:**

- with high hardness
- at low friction coefficient
- for milling and tapping
- for stamping and punching

and their Main Applications Fields

X-VIc®: a:C:H:Me; metal doped Carbon Based Diamond Like Coating (CBC)
X-VIc2®: a:C:H:Si metal free silicon doped Carbon Based Diamond Like Coating (DLC²)

The CBC and DLC² coatings can be deposited as top layers only.

CrN

The standard coating for non-cutting applications

- for molds and dies
- for machine parts
- for optimal release of molds and dies
- low deposition temperature possible (above 220 °C)
- CrCN (Tribo) can be used as a top layer on all coating as a tribological lubricant

CrTiN

Multilayer coating for universal use

- improved economy by using Ti
- outstanding chemical resistance and toughness due to fine multilayer structure
- for molds, dies and machine parts
- for HSS cutting tools in high alloyed materials
- lower deposition temperature possible

ZrN

Monolayer coating with Ti- or Cr- based adhesion layer

- effectively reduces the built-up edges when machining aluminum and titanium alloys
- for medical application
- for forming application with optimum release
- fancy color
- also available as top layer as ZrCN

CBC + DLC²

Hard lubricant

All coatings + VIc2®

Duplex coating with nanogradient structure
Basic layer + DLC top layer

- for components
- to avoid built-up edges
- for machining aluminum and titanium alloys
- for forming applications with optimum release

TiN¹ + CBC = cVIc®

TiN¹ + DLC² = cVIc2®

CrN¹ + DLC² = CROMVIc2®

CrTiN¹ + DLC² = CROMTIVIc2®

ZrN² + DLC² = ZIRVIc2

AlTiN² + DLC² = ALLVIc2®

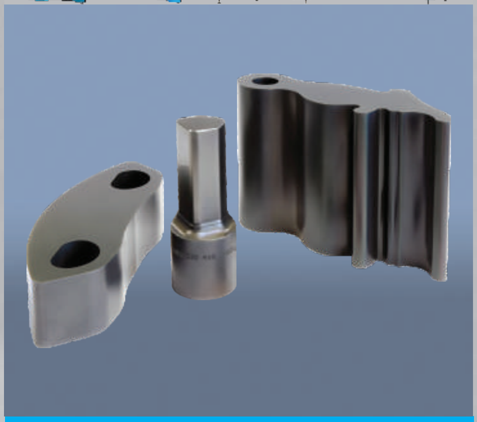
nACRo² + DLC² = nACVIc2®

*Explanation of different DLC types see page 124

Multi Components Coatings (Ti, Al, Cr, B, C, B) without Silicon

The machine symbols show which machine the coating can be deposited by.
The coatable stoichiometries can be different depending on the machine used.

AlCrN

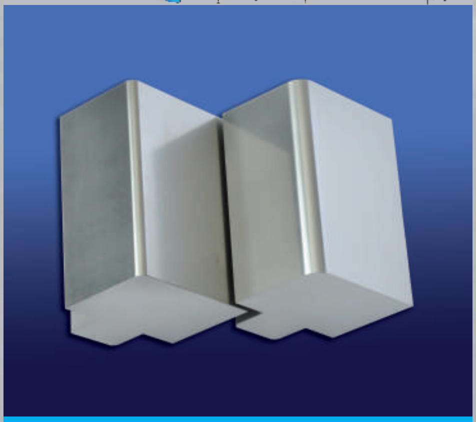


Classic coating for universal use

Stoichiometry:
AlCrN: CrN - AlCrN-MB
AlCrN^3: CrN - AlCrN-NL - AlCrN-MB

- for milling, hobbing
- for fine blanking
- standard version of FeinAl and Nanosphere

ALL^3® = AlTiCrN^3

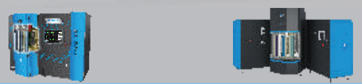


All-in-One, AlTi based coating for universal use

Stoichiometry:
CrTiN - AlCrN-NL - AlTiCrN

- for forming
- for injection molding
- for wet cutting

ALL^4® = AlCrTiN^4



All-in-One, AlCr based coating for universal use

Stoichiometry:
CrTiN - AlCrTiN-G - AlCrN-NL - AlCrTiN

- for wet and dry machining
- for forming and punching
- for hobbing and milling
- for fine blanking
- for injection molding

AlCrN+

Coating for milling of molds & dies

Cathodes: Ti-LARC - Al-LARC - Cr-LARC - AlTi-CERC

Stoichiometry: CrN - AlTiN-NL - AlCrN-NL

- for inserts and shank tools
- for roughing in hardened materials
- different coloring available
- for flycutters

ALL^4® eco

Coating for hobbing in the eco machines

π^{411} eco cathodes:
CrTi-LARC - Al-LARC - Cr-LARC

Stoichiometry: CrN - AlCrN-G - AlCrTiN-NL

- for hobs with big diameters
- for cutting abrasive materials

BorAC^3-ARC NEW B

Boron doped AlCrN coating

Cathodes:
π^{411} : Al-LARC - AlCrB-LARC - Cr-LARC - non
PL^{1011}: Cr - AlCr - AlCrB - AlCr

Stoichiometry: CrN - AlCrN - AlCrBN

Deposition with boron alloyed targets (AlCrB)

- for hobbing and milling

PLATIT®

Nanocomposite Coatings with Silicon

X-VIc®: a:C:H:Me; metal doped Carbon Based Diamond Like Coating (CBC)
X-VIc2®: a:C:H:Si metal free silicon doped Carbon Based Diamond Like Coating (DLC^2)

The CBC and DLC^2 coatings can be deposited as top layers only.

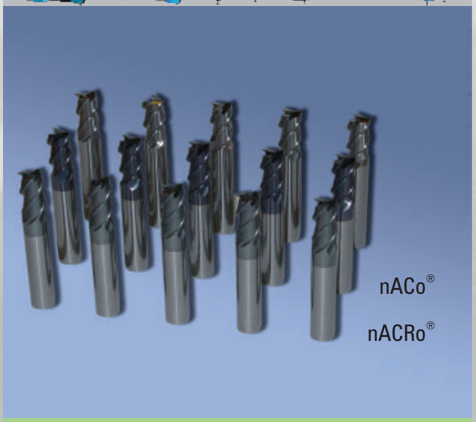
nACo®

Nanocomposite coating based on Ti and silicon

Stoichiometry:
nACo3®: TiN - AlTiN - AlTiN/SiN
nACo4®: TiN - AlTiN-G - AlTiN-NL - AlTiN/SiN
TiAlSiN: TiN / TiAlSiN

- for drilling, turning, hard milling
- also available with decorative blue top layer

nACRo®



Nanocomposite coating based on Cr and silicon

Stoichiometry:
nACRo3: CrN - AlTiCrN - AlCrN/SiN
nACRo4: CrN - AlCrN-G - AlCrN-NL - AlCrN/SiN

- for "difficult to cut" materials, highly alloyed steels, super alloys
- for injection molding

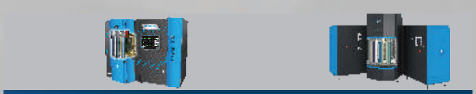
TiXCo®

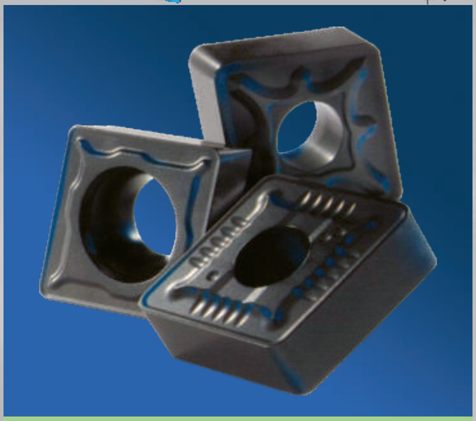
Nanocomposite coating with high silicon content

Stoichiometry:
TiXCo3: TiN - nACo - TiN/SiN
TiXCo4: TiN - nACo - AlCrTiN/SiN - TiN/SiN

- for hard machining, milling, drilling, reaming
- for paper cutting
- for superalloys

nACoX®





Oxide coating

Cathodes: Ti - AlSi - $AlCr_{45}$ - AlTi

Stoichiometry:
nACoX4®: TiN - AlTiN - nACo - AlCrON

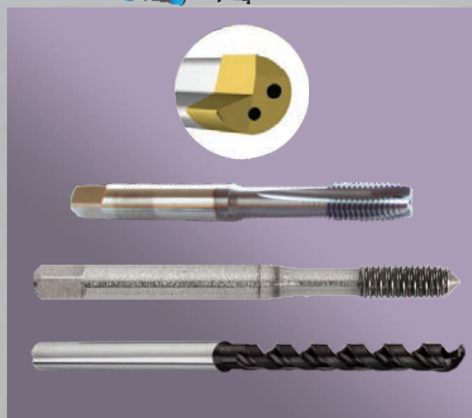
Application fields:
- HSC dry turning and milling

Sputtered Coatings

The machine symbols show which machine the coating can be deposited by.
The coatable stoichiometries can be different depending on the machine used.

TiN-SCIL®
TiCN-SCIL®
CrTiN-SCIL®
AlTiN-SCIL®

XN-SCIL®



Sputtered Monoblock Coating
(CrN and ZrN also common)
Cathodes: X: Ti or Cr or CrTi

Stoichiometry:
LGD – TiN-(CrN, ZrN, CrTiN) SCIL®-MB

- universal use, when smooth coating indispensable

TiB_2-SCIL®

B

Sputtered Coating for Cutting of Non-Ferrous Materials and for Components

Cathodes: Ti-LARC - Al-LARC - TiB_2-SCIL

Stoichiometry:
LGD – TiB_2-SCIL®-MB

- for cutting aluminum, copper, and plastic
- for components with high wear resistance

ta:C

NEW DLC

Carbon Based Coating: ta-C
Stoichiometry: C-MB, $sp^3 > 50\%$
Cathodes: PL711: Cr - C
π411: Ti-LARC - Al-LARC - Cr-LARC - C-SCIL

- hard DLC^3 coating with > 35 Gpa
- for components, bearings
- for medical parts and tools
- smooth surface without polishing
- cleaning batch is necessary after every batch

X-SCILVIc²®

DLC

Sputtered Duplex Coating
Cathodes: X: Ti or Cr or CrTi
Stoichiometry: X-(Ti, Cr, CrTi, AlTi)N-SCILVIc²®

- for components
- for forming applications with optimum release
- for medical parts and tools
- low temperature necessary (<200°C)
- cleaning batch is necessary after every batch

WC/C

W

Sputtered Lubrication Coating with LGD Etching
Cathodes: Ti-LARC - Al-LARC - W-SCIL
Stoichiometry: LGD – WC/C

- for components with very low friction coefficient
- higher temperature allowed at deposition
- cleaning batch after 5 coating batches necessary

Hybrid Coatings Deposited by LACS®-Technology

X-VIc®: a:C:H:Me; metal doped Carbon Based Diamond Like Coating (CBC)
X-VIc[2]®: a:C:H:Si metal free silicon doped Carbon Based Diamond Like Coating (DLC[2])

The CBC and DLC[2] coatings can be deposited as top layers only.

BorAC³®

Cr based LACS®-coating with boron
Simultanous Arcing and Sputtering

Cathodes: Ti-LARC – Al-LARC – Cr-LARC – TiB_2-SCIL

Stoichiometry: CrN – AlCrN-G – AlCrTiN/BN-NL

- for hobbing, milling

BorCO⁴® NEW

Cr, Ti & Si based LACS®-QuadCoating with boron:
Cathodes:
TiSi-LARC – Al-LARC – Cr(Ti)-LARC – TiB_2-SCIL
Stoichiometry:
CrN – AlCr(Ti)N - AlCrTiSiN/BN-NL – TiSiN

- tough core layer with low internal stress
- very hard top layer
- for hard machining and paper cutting
- for machining super alloys

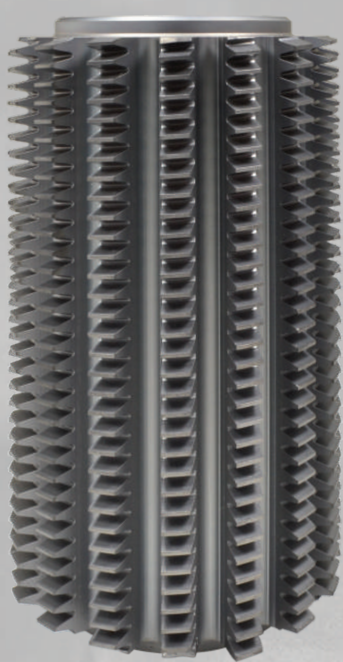
AlCrN®-LACS® NEW

AlCr based LACS®-coating
Simultanous LGD + AlCrN deposition

Cathodes: Al-LARC – Cr-LARC – AlCr-SCIL

Stoichiometry: AlCrN-MB

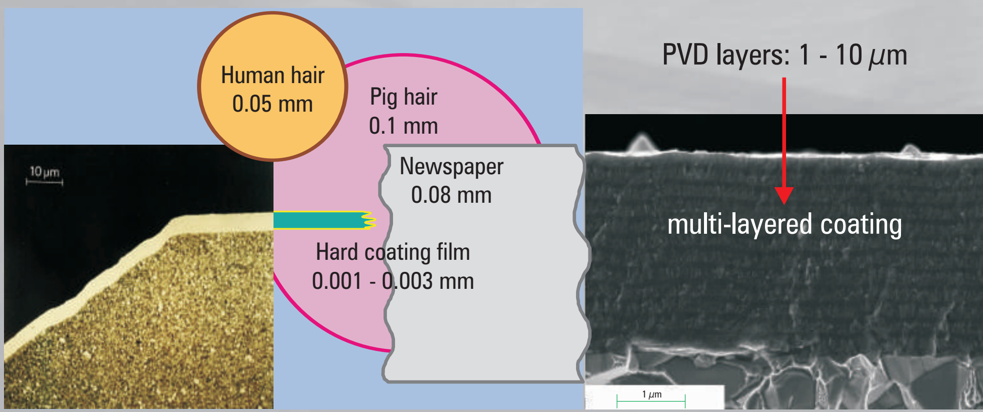
- micro tools
- cutting tools for electronic circuits board
- hobbing
- smooth surface without polishing

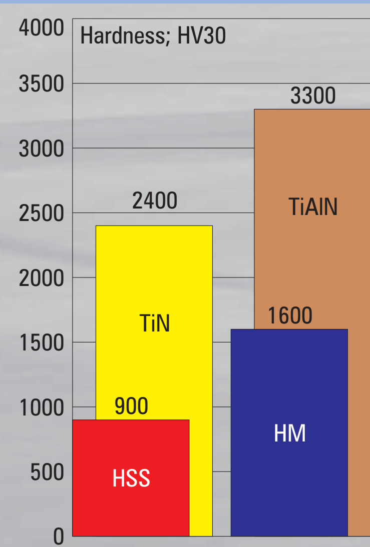


LACS®

Basic Data

What is a Coating? A Thin Hard Film.

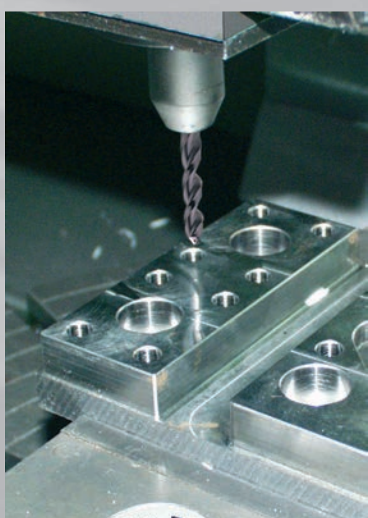




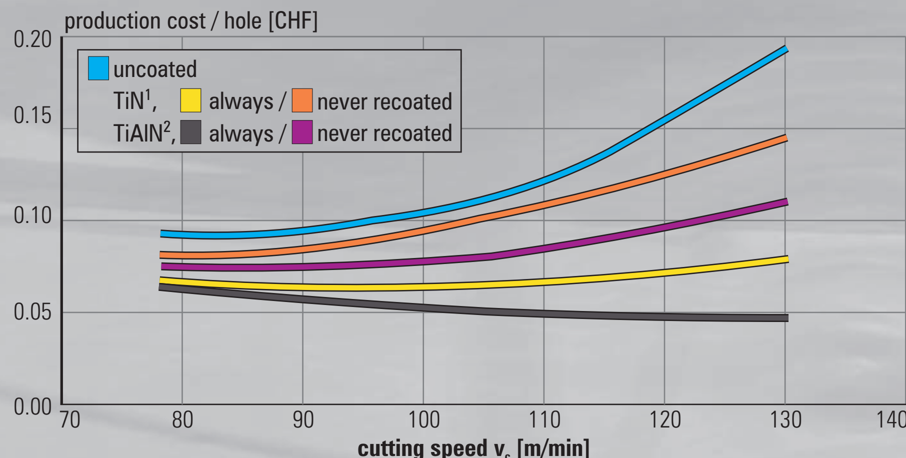
Material in a form of thin protection film on the tool surface improving properties of the basic material, such as

- Hardness
- Oxidation resistance
- Coefficient of friction
- Fracture toughness
- Chemical stability

Cost Advantage



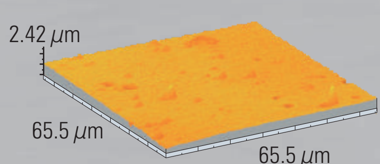
Production Costs with Solid Carbide Drills



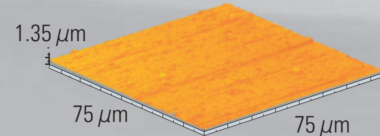
Production costs = machine costs + work costs + tool costs
Tool changing costs are not considered, all tools reground 10x

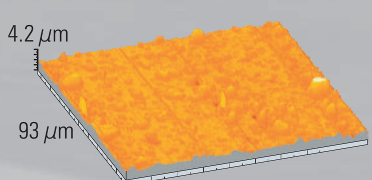
Typical Coating Surfaces

LARC®
S_a = 0.09-0.25 µm

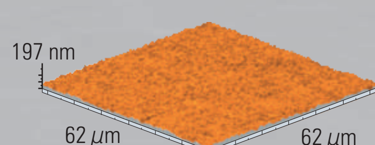


SCIL®
S_a = 0.02-0.08 µm





ARC
S_a = 0.15-0.45 µm



µ-ARC®
S_a = 0.003-0.008 µm
requires post-polishing

Measured by AFM, at 2µm coating thickness

Coating Features

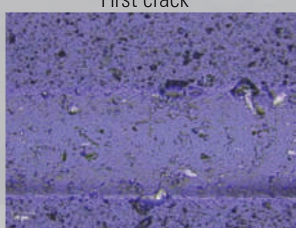
Influence of the Most Important Component Materials on Coating's Features

Coating	+ Component	Grain fineness	Decreasing Internal stress	Hardness	Wear resistance (abrasive)	Wear resistance (oxidation)	Hot hardness	Heat insulation	Max. usage temperature	Possibility of thickness increase	Decreasing friction	Possibility of Nanocomposite	Low target costs with alloyed targets	Low target costs with unalloyed targets LARC
Ti+N=TiN Basic coating	**+N**	0	-	+	+	+	0	0	0	-	0	no	0	0
TiCN	**+C**	0	--	++	++	-	-	--	-	--	++	no	0	0
typically **TiAlCN** with Al~20-25%	**+ Al**	(+)	+	-	-	+	+	+	+	+	-	no	--	0
typically **TiAlN**	**+Al** / (-C)	+	-	+ if Al<X% / - if Al>X%	+	+	+	++	+	-	-	no	-	+
typically **AlTiCrN**	**+Cr**	-	+	+	+	+	+	+	(+)	+	-	no	-	(-)
typically **AlCrN** Cr~30%	**+Cr** / (-Ti)	--	+	(+)	++	(+)	+	+	(+)	+	(-)	no	--	-
typically **TiAlN/SiN CrAlN/SiN, AlCrTiN/SiN**	**+Si**	++	(+)	++	+	++	++	++	++	0	0	yes	--	+

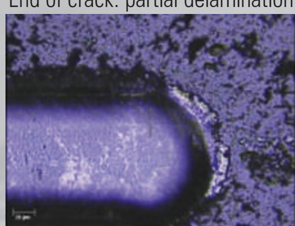
+ means mainly positive change in the user's point of view - means mainly negative change in user's point of view X is approximately around 65%

Adhesion

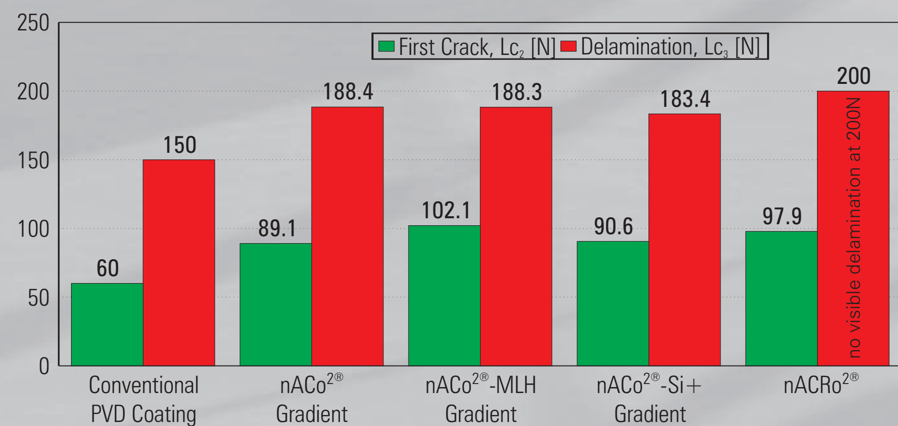
First crack



End of crack: partial delamination

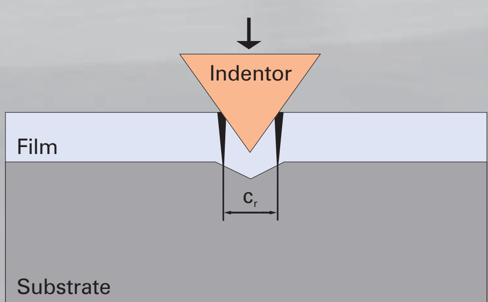


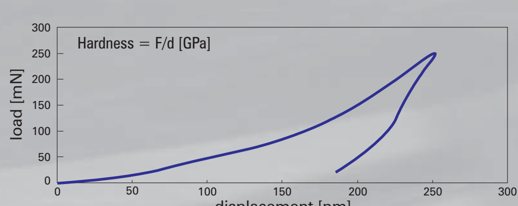
Critical Loads at Scratch Test



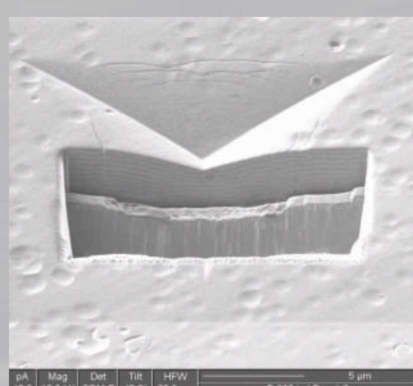
Average values from min. 10 measurements with deviation; <5%
Scratch length: 70 mm - scratch speed: 0.4 - 60 mm/min
Measured on tungsten carbide K40, by CSEM, Neuchâtel, Switzerland

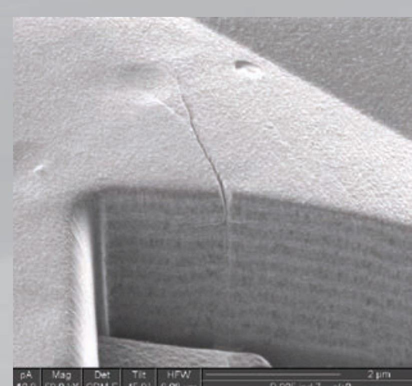
Hardness





Absorption of Cracks by Multilayer Structure





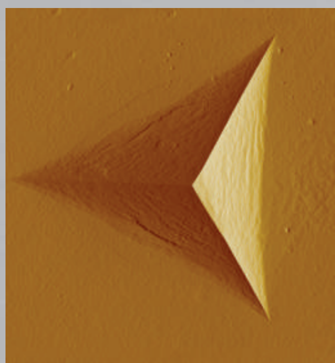
Source: TOPNANO-Project, EPF Lausanne, Switzerland
Measuring hardness by nanoindentation

Nanostructures Coating Features

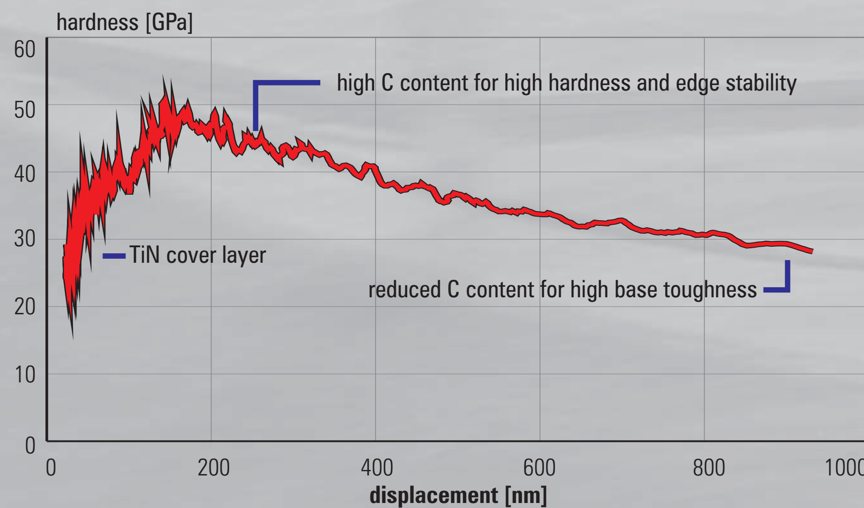
Nanogradients

Variation of Nanohardness by Gas Inlet

The coating structure is continuously changed. The coating composition can be modified by gas inlet or metallic content variation.



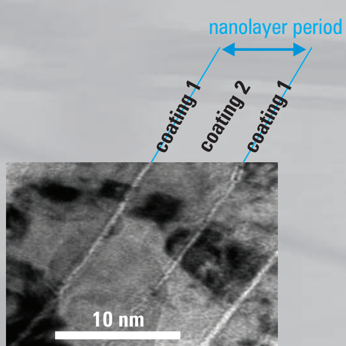
Crack free indentation of nanogradient coating

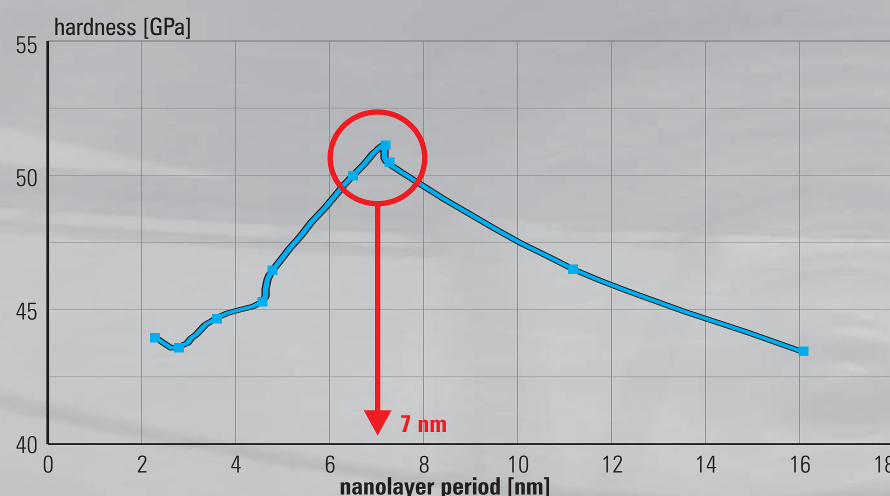


Nanolayers

Hardness of Nanocomposite with Nanolayer Structure

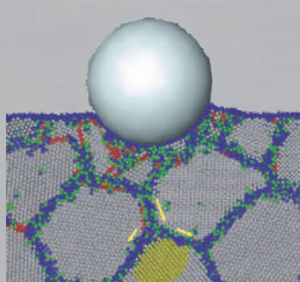
The coating hardness depends on the thickness period of the sublayers. The optimum period of the superlattices increases hardness enormously.





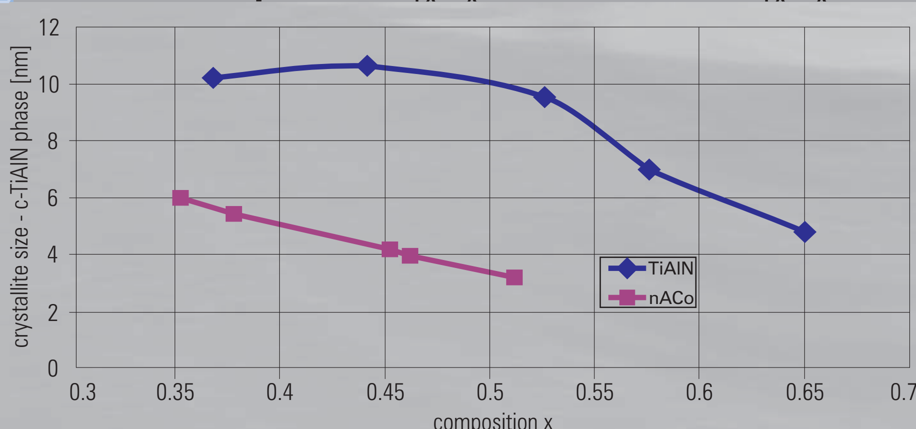
Nanocomposites

Grain Size Comparison: $Ti_{1-x}Al_xN^2$ and $nACo^2 = Ti_{1-x}Al_xN/SiN$



Modelling view of the 5 nm average grain size sample at an indentation depth of 20 Ä.
The Nanocomposite coatings have a higher hardness than conventional coatings. Because the amorphous SiN matrix enwraps (infoldes, covers) the nanocrystalline grains and avoids their growth.

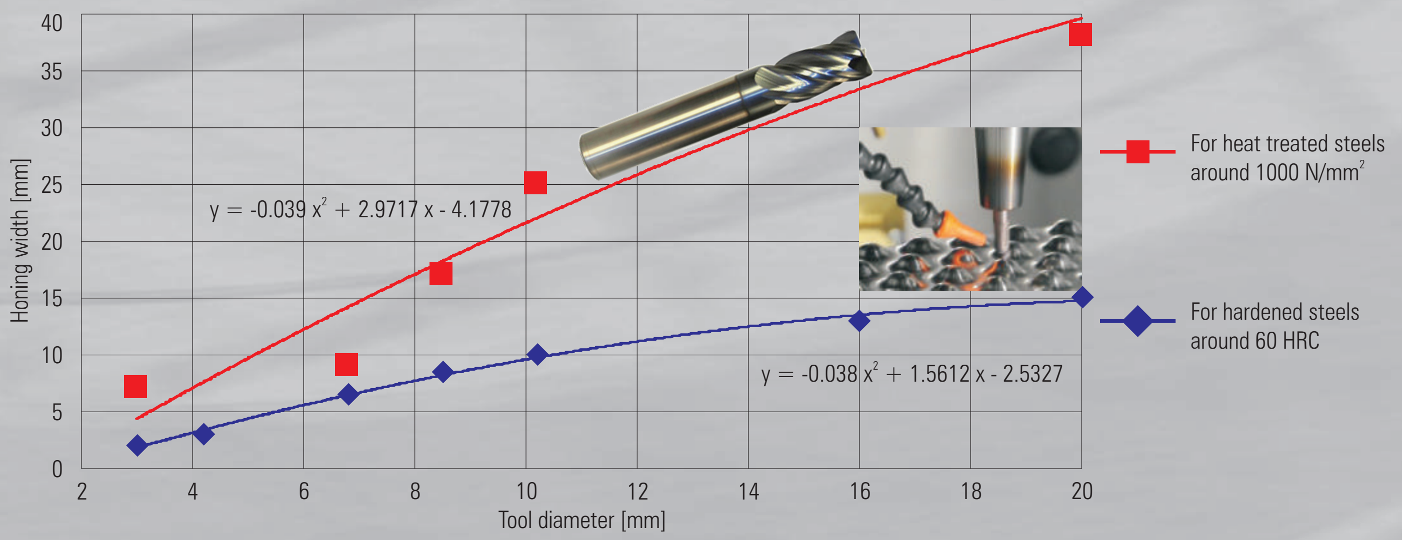
Source: Paul Scherrer Institute, Villigen, Switzerland



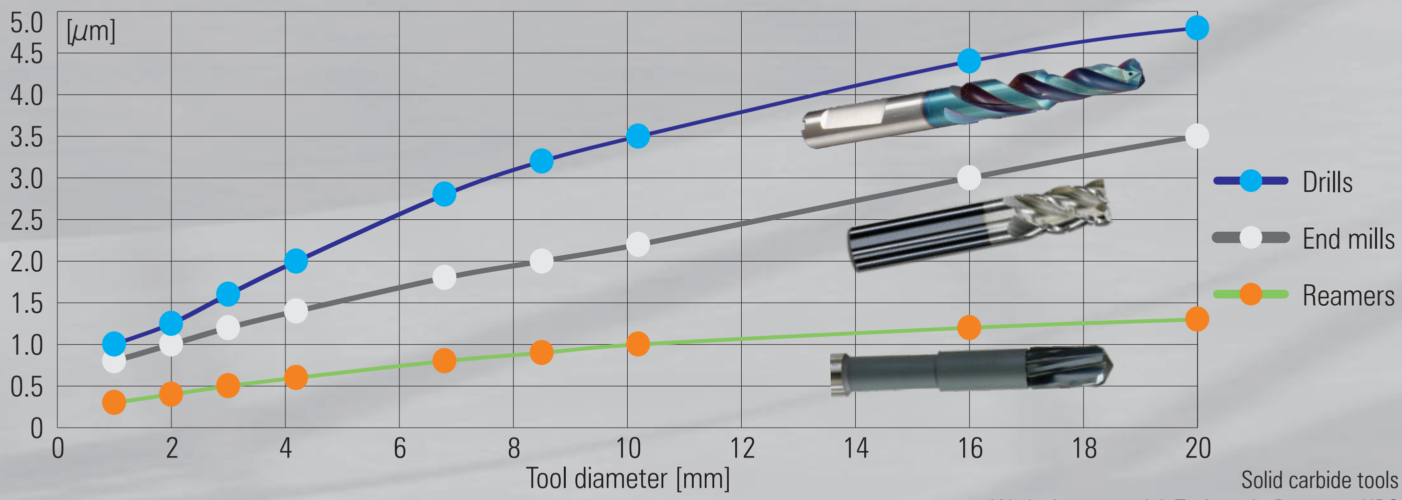
Calculated from XRD data using the Scherrer Equation
Same linear behavior but smaller crystallites than in the Cr-based system

Coating Features

Typical Honing Widths for End Mills for Different Work Piece Materials



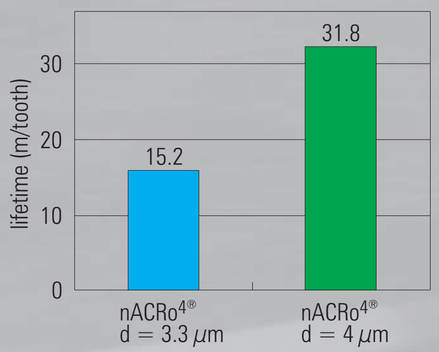
Drilling, Milling, Reaming — Typical Coating Thicknesses

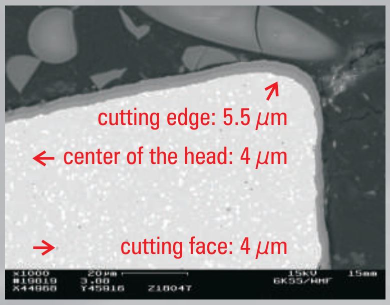


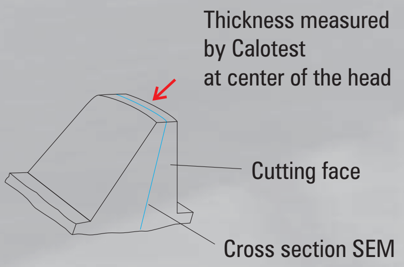
Solid carbide tools
Work piece material: Tool steel - R_m = ~32 HRC

Hobbing — Influence of Coating Thickness

- 3.3μm vs. 4μm (at the center of the fly-cutter's tooth head)
- 20% higher thickness tool life time doubled!
- Higher coating thickness delays crater wear





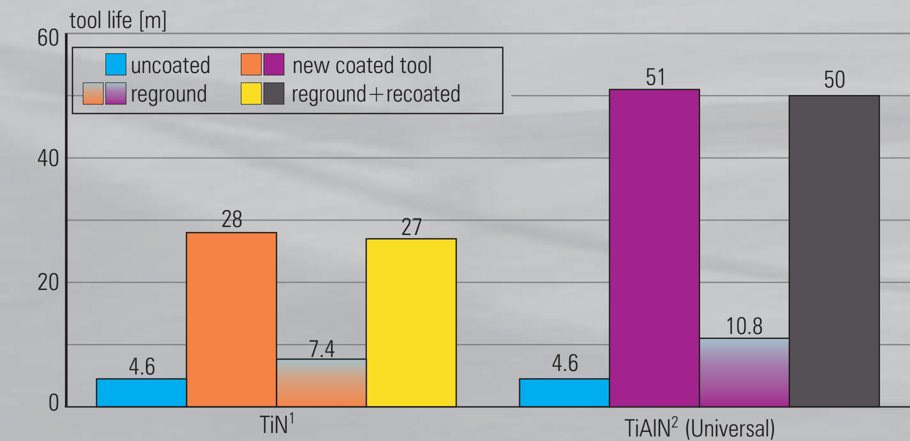


HSS hob (fly cutter), m = 2.5, v_c = 150 m/min, f_a = 1.69 mm/rev, dry

Conventional Coatings

Drilling with Solid Carbide

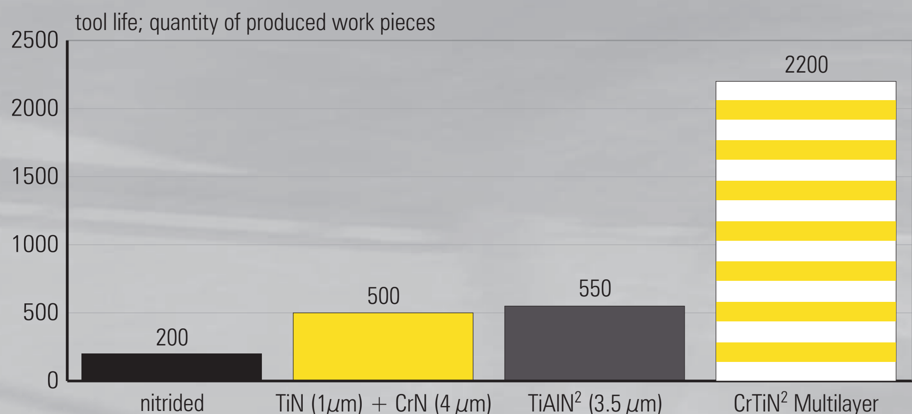
Tool Life Comparison



Work piece: wheel hub, Material: 38MnV35, R_m=800 N/mm^2, Ext. coolant: emulsion 7%, carbide K40UF, d=12.6 mm, a_p=13.5 mm, v_c=78 m/min, f=0.25 mm/rev. - Source: Daimler, Germany

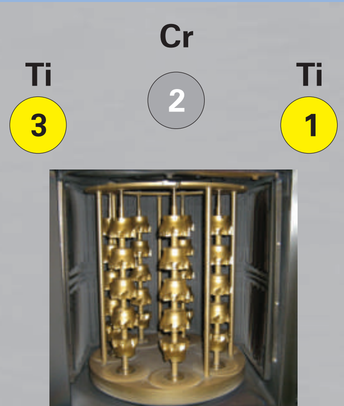
Aluminum Extrusion

Tool Life Comparison



Layer sequence in μm: 1xTiN=1.3 - 9x(TiN=0.25 / CrN=0.4) - 1xCrN=0.35
Mat.: Al 6012; Total coating thickness: 7.5 μm - Source: Metalba, Italy

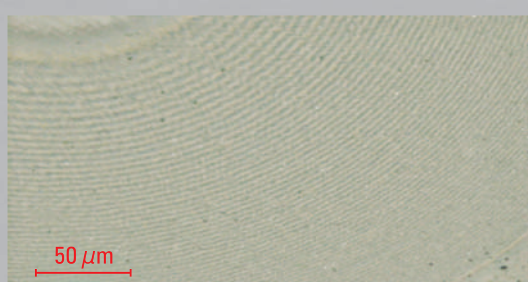
Tool Holders



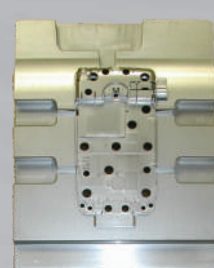
Coating of milling head holders with CrTiN[2] & golden top color by the π^{303} configuration.
Source: Fraisa, Bellach, Switzerland

Coating Tool Holders Against Corrosion

- for molds and dies
- for machine components
- for tool holders
- for aluminum cutting and forming
- with high hardness and toughness
- with very good chemical resistance
- with very fine multilayer structure and surface
- with selectable top color
- deposited by LARC®-technology



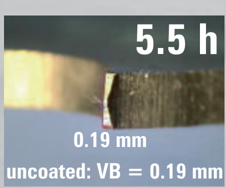
Coating thickness = 4 μm

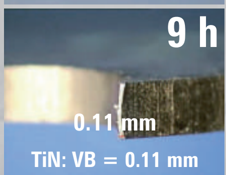


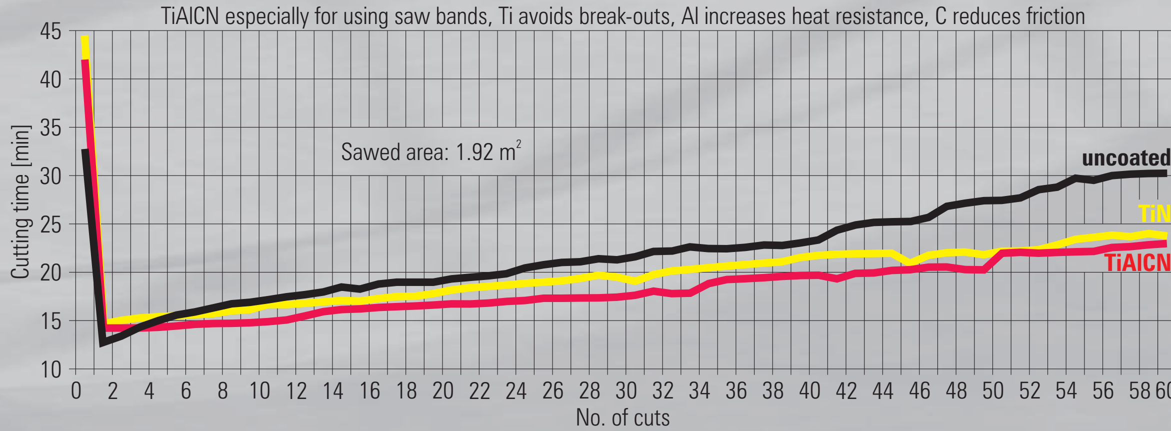
Mold for mobile phone coated by CrN toplayer

Applications

Sawing — High Productivity Increase by Coating of Saw Bands





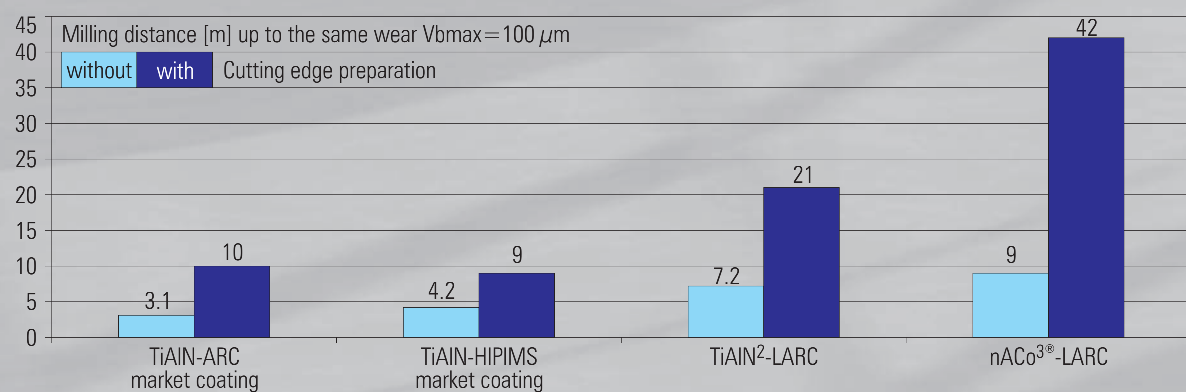


Tool: Bimetal sawband M42 - 41x1.3mm 3-4 ZpZ - Edge preparation: Brushing - Work piece material: Stainless steel 1.4571 - ø200 mm - v_c= 35 m/min - v_f=13 mm/min, P_c=20 cm3/min, f_z=0.0027 mm/tooth - Cooling: Emulsion (4%)

Source: Wikus, Spangenberg, Germany

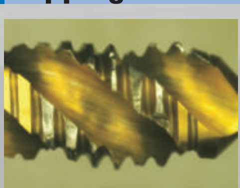
Milling — High Performance Cutting with Optimized Edge Geometries

Impact of edge preperation on coated solid carbide end mills. "The better the coating, the more important the edge preperation."



Work piece material: 1.2379 - X155CrVMo12-1 – FRAISA end mill NX-V – d=10 mm
z=4 – a_e=0.25 x d – a_p=1.5 x d – v_c=150 m/min – f_z=0.05 mm/z – MQL
Measured by GFE, Schmalkalden, Germany

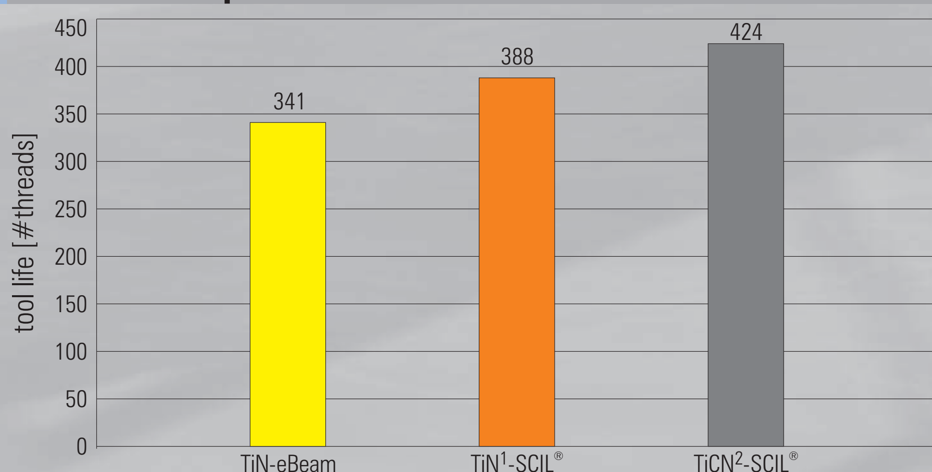
Tapping — Tool Life Comparison



TiN-eBeam
at thread no. 403

TiN¹-SCIL®
at thread no. 527

TiCN²-SCIL®
at thread no. 527

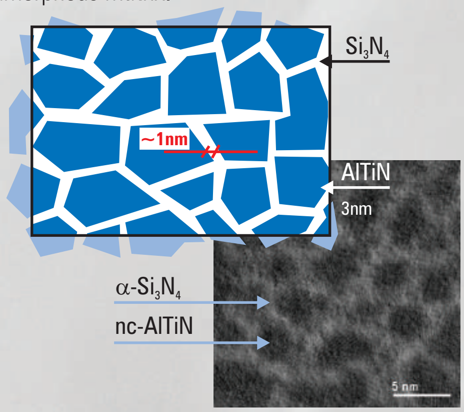


Material: 1.7225 / 42CrMo4 - Coolant: Emulsion
Tools: M6 - PM-HSS-E - v_c= 15 m/min - a_p=12 mm - blind holes

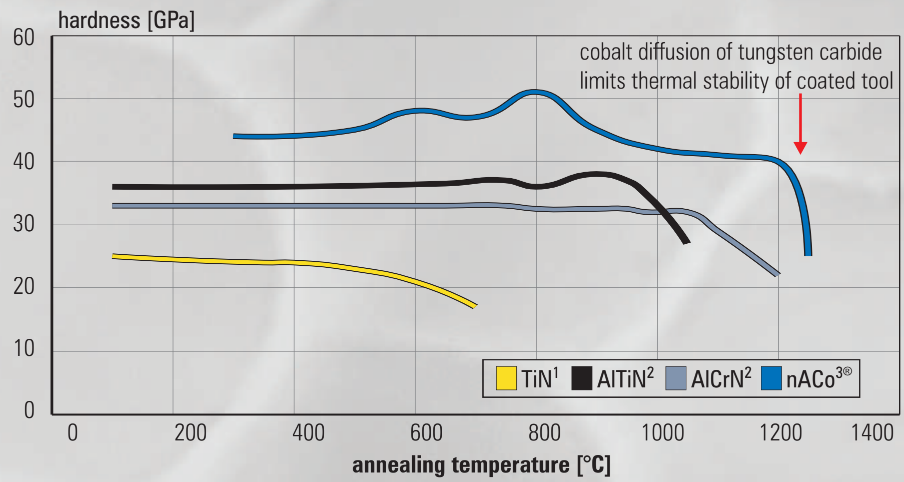
Nanocomposites
nACo®: AlTiN/SiN

Nanocomposites

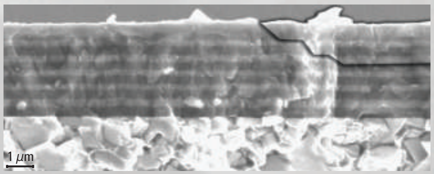
Composite of non-mixable components. Nanocrystalline grains are embedded into an amorphous matrix.



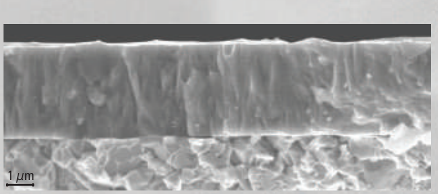
Heat Resistance Comparison



Gear Cutting with Inserts

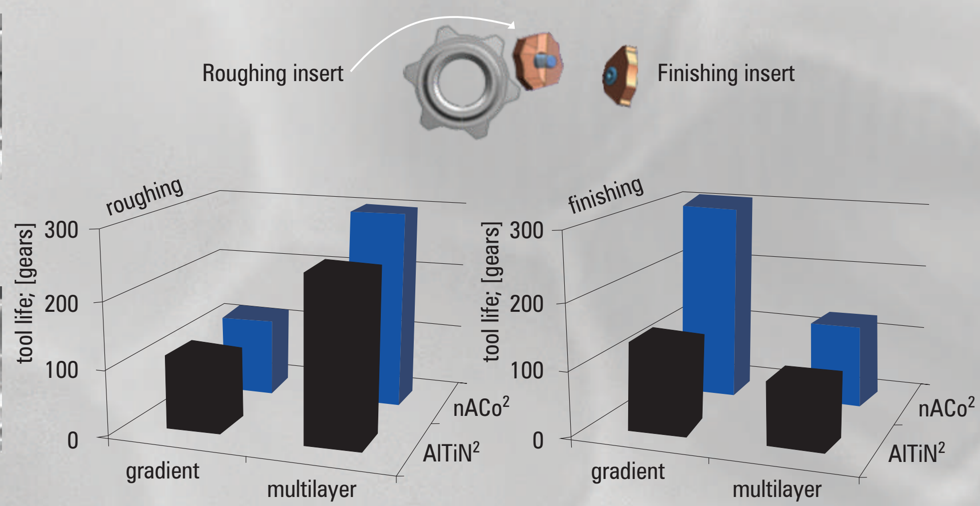


Multilayer for roughing:
At dynamic load the cracks are absorbed at the borders of the sublayers.



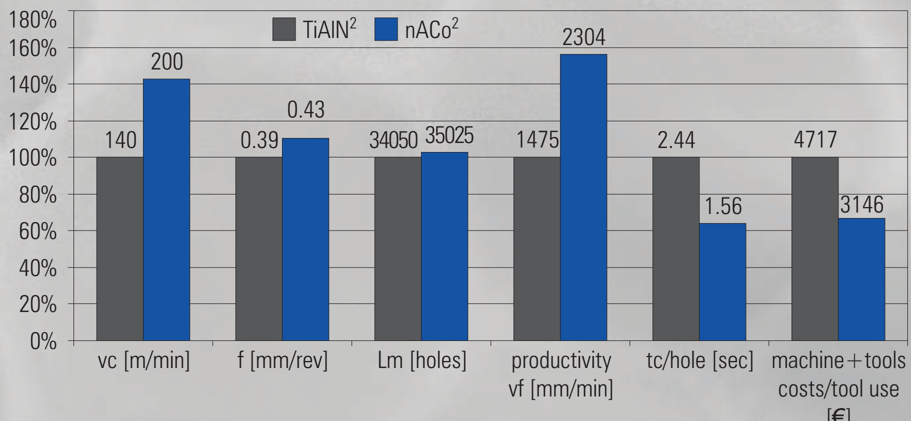
Monolayer for finishing:
Higher hardness increases tool life.

Influence of the Coating Structure



Drilling

Productivity Improvement with Higher Speed and Feed

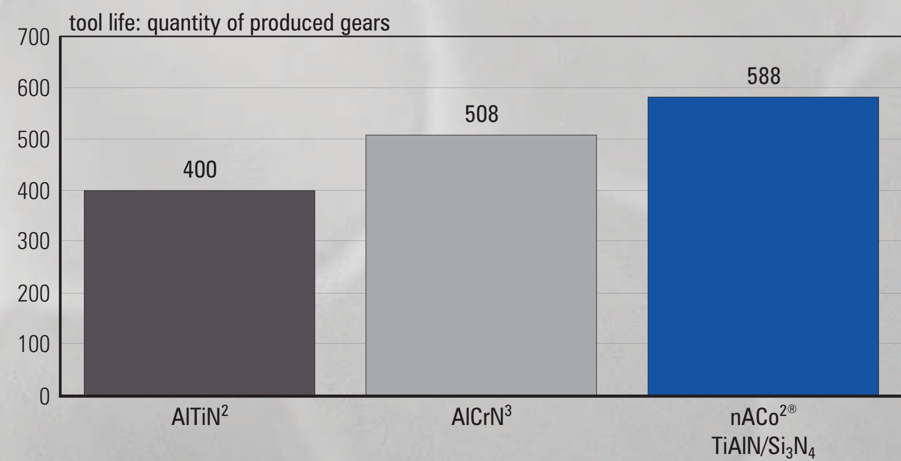


Work piece material: GGG40 – ap=60 mm
Solid carbide step drill: d=7.1/12 mm – Internal cooling with 70 bar - 5 % emulsion
Source: Sauer Danfoss, Steerings, Denmark

Applications

Bevel Gear Hobbing

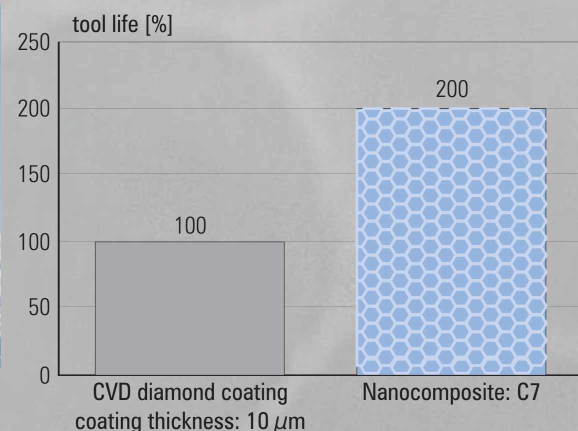
Tool Life Comparison



Milling of Bevel gears with carbide Tri-Ac hobbing cutters
Source: Gleason, Rochester, NY, USA

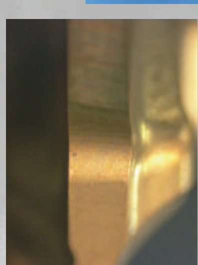
Drilling

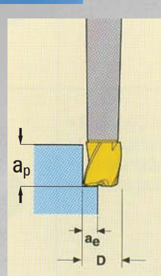
Tool Life Comparison



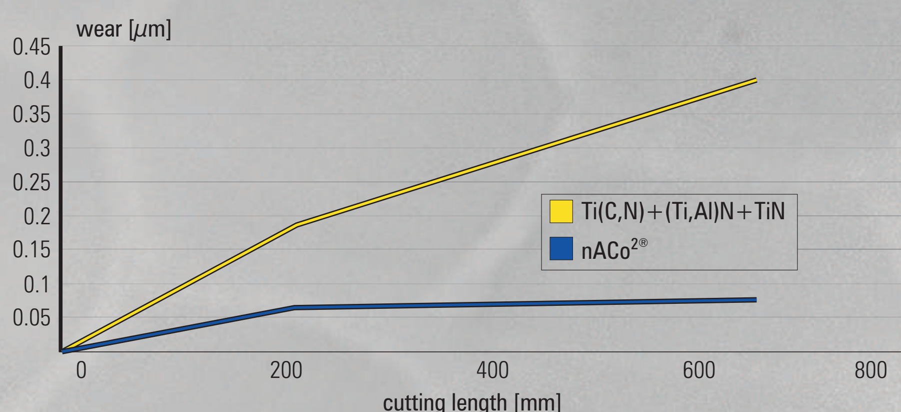
Tool: d=10/12mm solid carbide drill
Material: carbon fiber composite / aluminum
Source: Unimerco, Lichfield, UK

Plunging





Wear Comparison

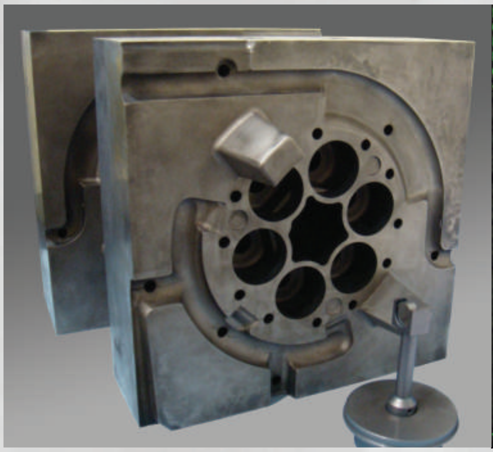


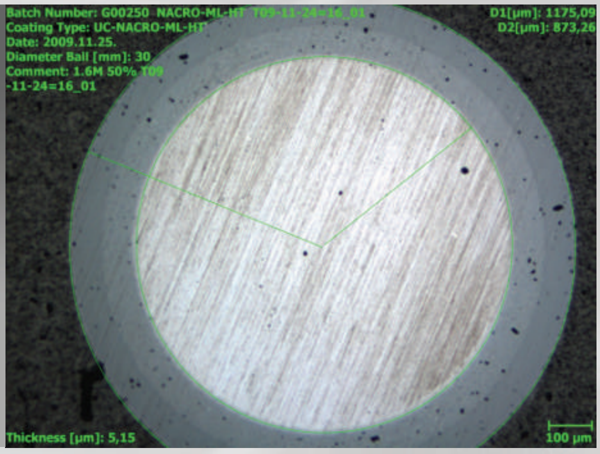
Material: IN100 - Nickel Base - 12Cr-18Co-3.2Mo - 4.3Ti-5.0Al-0.8V-0.02B-0.06Zr
Tool: Carbide insert - Minimaster MM12; D=12 mm, r=2 mm, z=2
v_c= 21 – 30 m/min, fz= 0,05 mm, a_p=20 mm, a_e=3 mm, turbine milling
Source: EU R&D project Macharena - Volvo Aero Norge AS

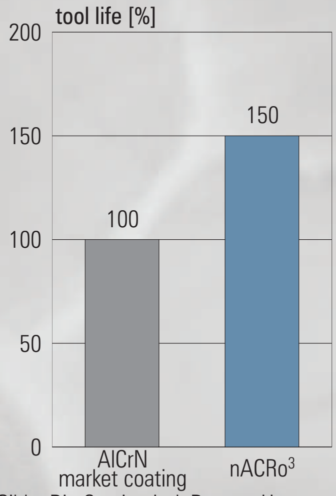
Nanocomposites
nACRo®:AlCrN/SiN

Injection Molding

Aluminum Injection Mold with Dedicated Multilayer-nACRo



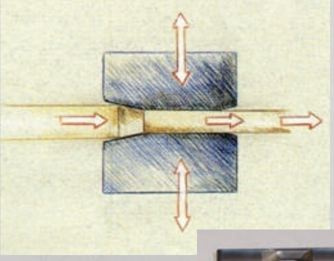


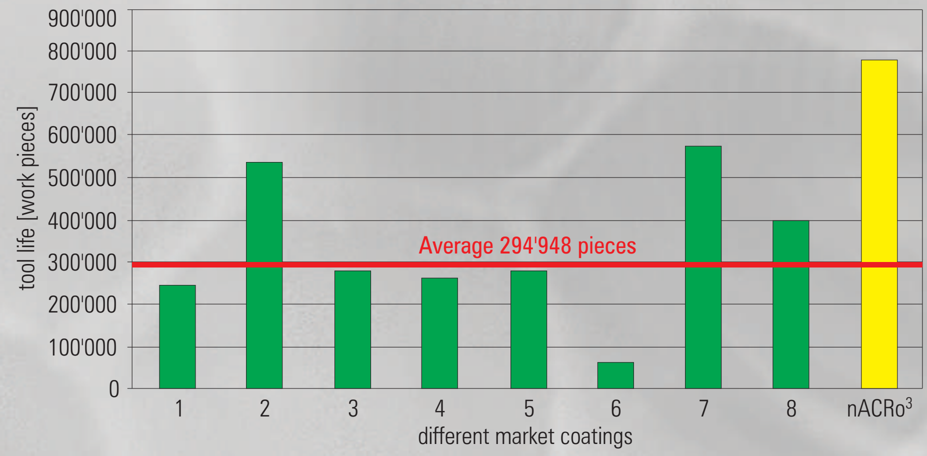


Source: Gibbs Die Casting Ltd. Retsag, Hungary

Rotating Stamping

Tool Life Comparison

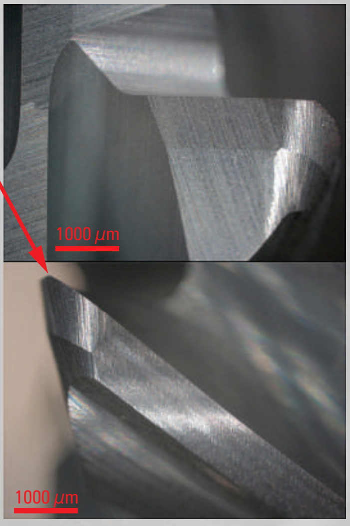


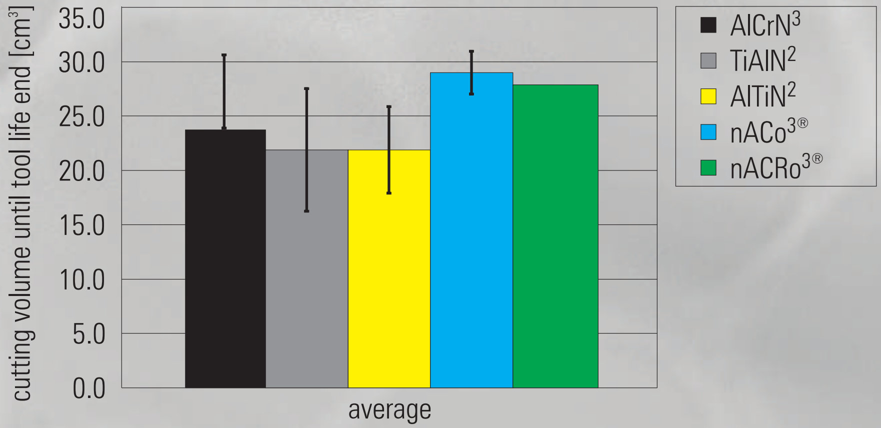


Source; GFE, Schmalkalden, Germany
Fa. Thyssen Krupp Presta Ilsenburg, Germany

Slotting

Tool Life Comparison in Inconel 718



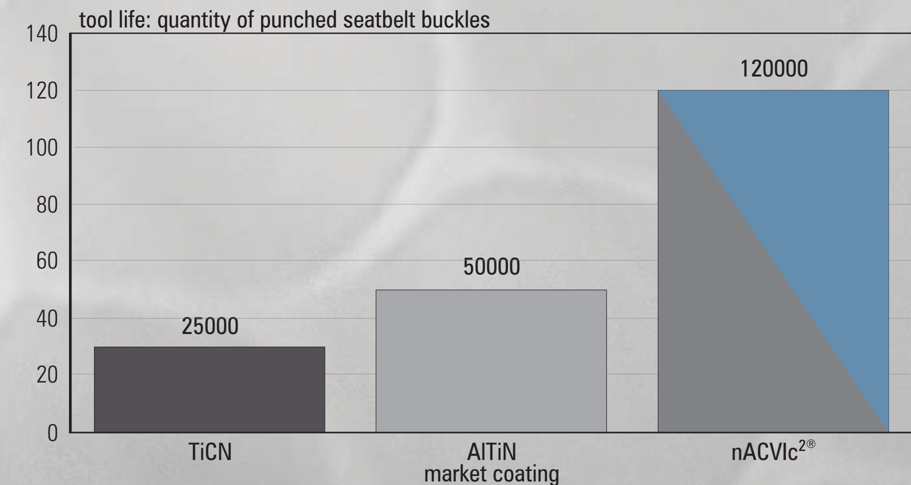


Tools: FRAISA 5325.450 NX-V, Ø10 mm z=4, helix angle 38/41°
Conditions: a_e=10 mm, a_p=2.5 mm, v_c=25m/min, f_z=0.025 mm
Source: EU R&D project MACHERENA

Applications

Punching

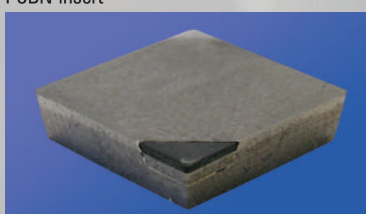
Tool Life Comparison



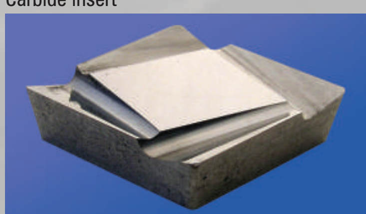
Material: Ck45, 3.0 mm - Source: Brano - Liss, Roznov, CZ

Turning

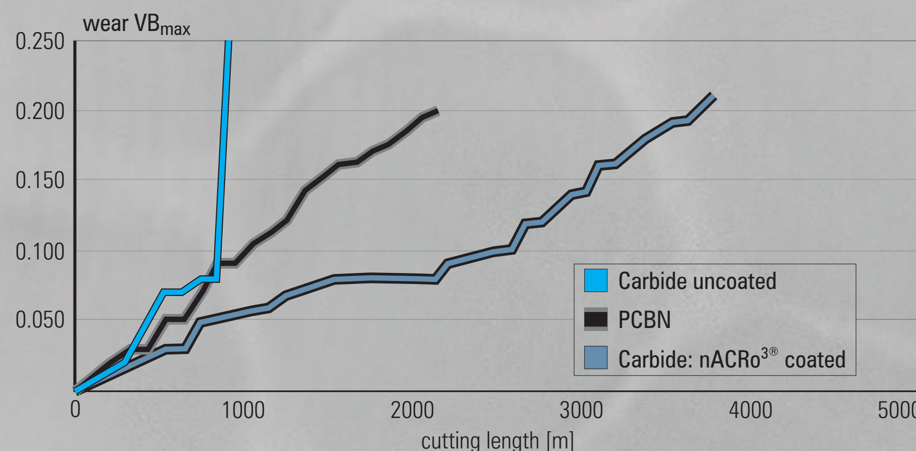
PCBN-insert



Carbide insert

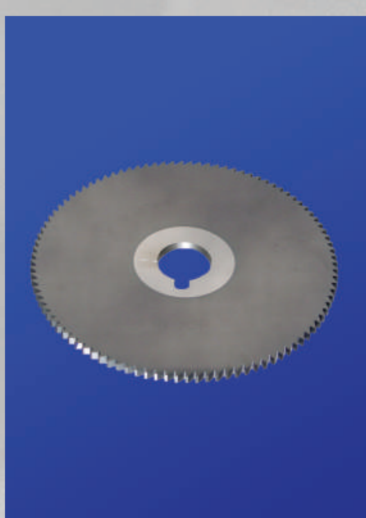


Tool Life Comparison

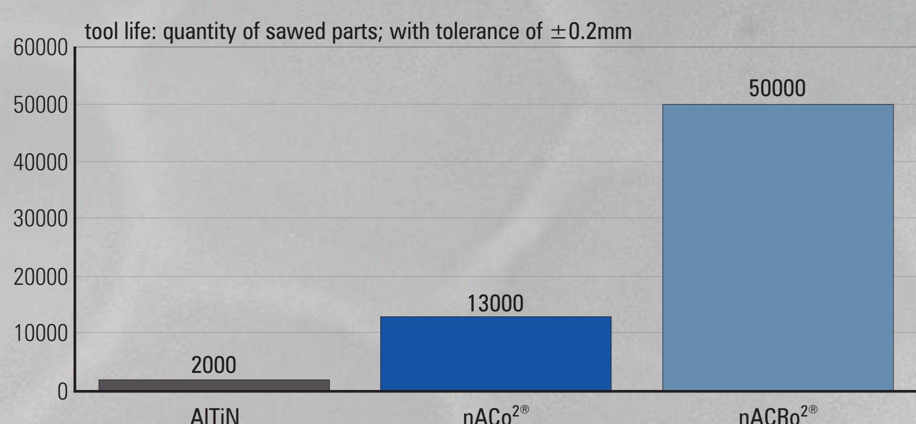


Material: Somaloy SMC550; Soft Magnetic Composites v_c = 700 m/min, f = 0.1 mm/rev - a_p = 0.2 mm
Measured by IWF, TU Berlin, EU R&D project PM-MACH

Sawing



Tool Life Comparison



Solid carbide saw blades, Ø 125 x 3.6 mm, z=100 – sintered workpiece material: Co1
n =300 RPM - v_f=800 mm/min - a_p = 35 mm, coolant: emulsion 7% - Source: Prétat, Selzach, CH

TripleCoatings$^{3®}$

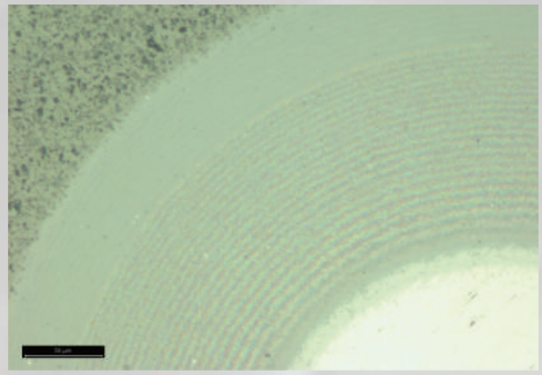
AlCrN^3: For Dry Cutting Abrasive Materials

Stoichiometry: CrN - Al/CrN-ML - AlCrN

π111PLUS	: 1: Al	– 2: Cr		
π411	: 1: none	– 2: Al	– 3: Cr	– 4: $AlCr_{30}$
PL1011	: 1: Cr	– 2: $AlCr_{36}$	– 3: none	– 4: $AlCr_{36}$
π1511	: 1: Ti	– 2: Al	– 3: Cr	– 4: $AlCr_{30}$ – 5: $AlCr_{30}$

AlCrN^3+: AlCrN^3 doped by titanium: TiN - AlTiN - Al/CrN-ML

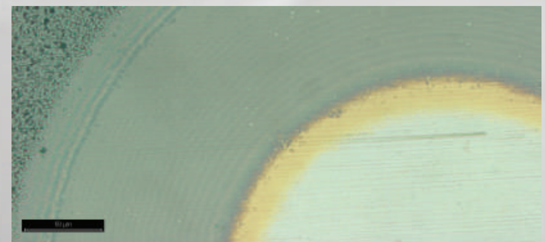
π411	: 1: Ti	– 2: Al	– 3: Cr	– 4: $AlTi_{33}$



ALL$^{3®}$: AlTiCrN^3: Universal for Cutting and Forming

Stoichiometry: Ti(Cr)N - Al/CrN-ML - AlTiCrN

π111PLUS	: 1: Al	– 2: $CrTi_{15}$		
π411	: 1: Ti	– 2: Al	– 3: Cr	– 4: none
PL1011	: 1: Cr	– 2: $AlTi_{33}$	– 3: $AlTi_{33}$	– 4: $AlCr_{36}$ (AlTiCrN-G)
PL1011	: 1: Cr	– 2: $AlTi_{33}$	– 3: Cr	– 4: $AlTi_{33}$ (AlTiCrN-ML)
π1511	: 1: Ti	– 2: Al	– 3: Cr	– 4: $AlTi_{33}$ – 5: AlTi



nACo$^{3®}$: For Universal Use, Turning, Drilling

Stoichiometry: TiN - AlTiN - nACo

π411	: 1: Ti	– 2: $AlSi_{18}$	– 3: none	– 4: $AlTi_{33}$
PL1011	: 1: Ti	– 2: $AlTi_{33}$	– 3: $AlTi_{30}Si_{10}$	– 4: $AlTi_{33}$

nACRo$^{3®}$: For Superalloys, Milling, Hobbing

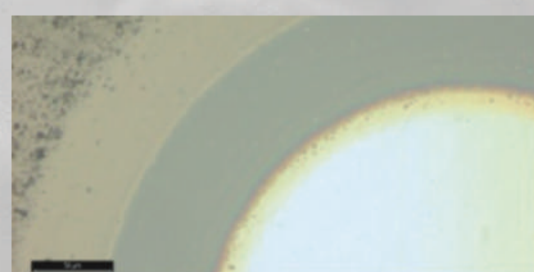
Stoichiometry: CrN - AlTiCrN-ML - nACRo

π411	: 1: Ti	– 2: $AlSi_{18}$	– 3: Cr	– 4: $AlTi_{33}$
PL1011	: 1: Cr	– 2: $AlCr_{30}Si_{10}$	– 3:Cr	– 4:$AlCr_{36}$

TiXCo$^{3®}$: For Superhard Machining, Milling, Drilling

Stoichiometry: TiN - nACo - TiSiN

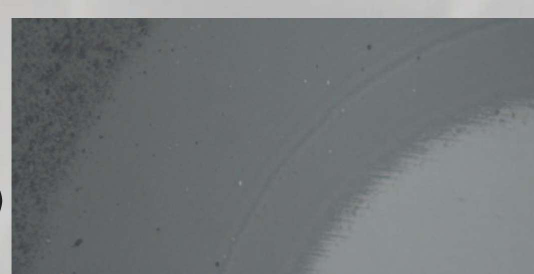
π111PLUS	: 1: Al	– 2: $TiSi_{20}$	(TiXCo$^{3®}$ eco)	
π411 eco	: 1: Ti	– 2: Al	– 3: $TiSi_{20}$	– 4: none
π411	: 1: Ti	– 2: Al	– 3: $TiSi_{20}$	– 4: $AlTi_{33}$
PL1011	: 1: Ti	– 2: $AlTi_{33}$	– 3: $TiSi_{20}$	– 4: $AlTi_{33}$



BorAC$^{3®}$: For Milling and Hobbing

Stoichiometry: CrN - AlCrN - AlCrTiBN

π411 eco	: 1: AlCrB	– 2: Al	– 3: Cr	(BorAC$^{3®}$-ARC)
π411	: 1: Ti	– 2: Al	– 3: Cr	– 4: TiB_2
PL1011	: 1: Ti	– 2: AlCrB	– 3: Cr	– 4: AlCrB (BorAC$^{3®}$-ARC)

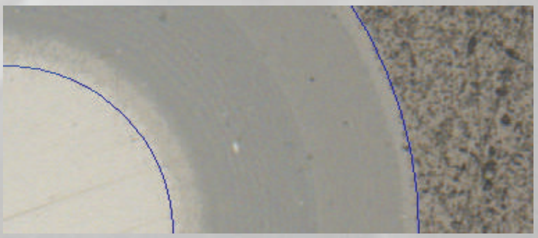


QUAD Coatings4®

ALL4®: AlCrTiN4: Universal for Cutting and Forming

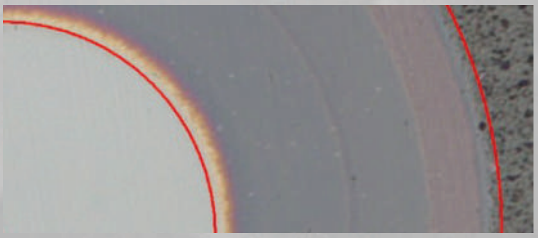
CrTiN - AlCrTiN-G - Al/CrN-ML - AlCrTiN - (CrCN optional)
π^{411} : 1: Ti – 2: Al – 3: Cr – 4: $AlCr_{30}$
π^{1511} : 1: Ti – 2: Al – 3: Cr – 4: $AlCr_{30}$ – 5: $AlCr_{30}$

ALL4® eco : Dedicated for Big Hobs



CrTiN - AlCrTiN-G - Al/CrN-ML - AlCrTiN - (CrCN optional)
π^{411} : 1: $CrTi_{15}$ – 2: Al – 3: Cr – 4: none

nACo4®: For Universal Use, Turning, Drilling



TiN - AlTiN-G - AlTiN-ML - nACo
π^{411} : 1: Ti – 2: Al – 3: $AlSi_{18}$ – 4: $AlTi_{33}$
π^{1511} : 1: Ti – 2: Al – 3: $TiSi_{20}$ – 4: $AlTi_{33}$ – 5: $AlTi_{33}$

nACRo4®: For Superalloys, Milling, Hobbing

CrN - AlCrN-G - AlCrN-ML - nACRo
π^{411} : 1: Cr – 2: $AlSi_{18}$ – 3: Cr – 4: $AlCr_{30}$
π^{1511} : 1: none – 2: $AlSi_{18}$ – 3: Cr – 4: $AlCr_{30}$ – 5: $AlCr_{30}$

TiXCo4®: For Superhard Machining

TiN - nACo-G - AlTiCrN/SiN - TiSiN
π^{411} : 1: Ti – 2: Al – 3: $TiSi_{20}$ – 4: $AlCr_{30}$
π^{1511} : 1: Ti – 2: Al – 3: $TiSi_{20}$ – 4: $AlTi_{33}$ – 5: $AlTi_{33}$

nACoX4®: For HSC Dry Turning and Milling

TiN - AlTiN - nACo - AlCrON
π^{411} : 1: Ti – 2: $AlSi_{18}$ – 3: $AlCr_{45}$ – 4: $AlTi_{33}$

BorCO4®: For Hard Machining and for Superalloys

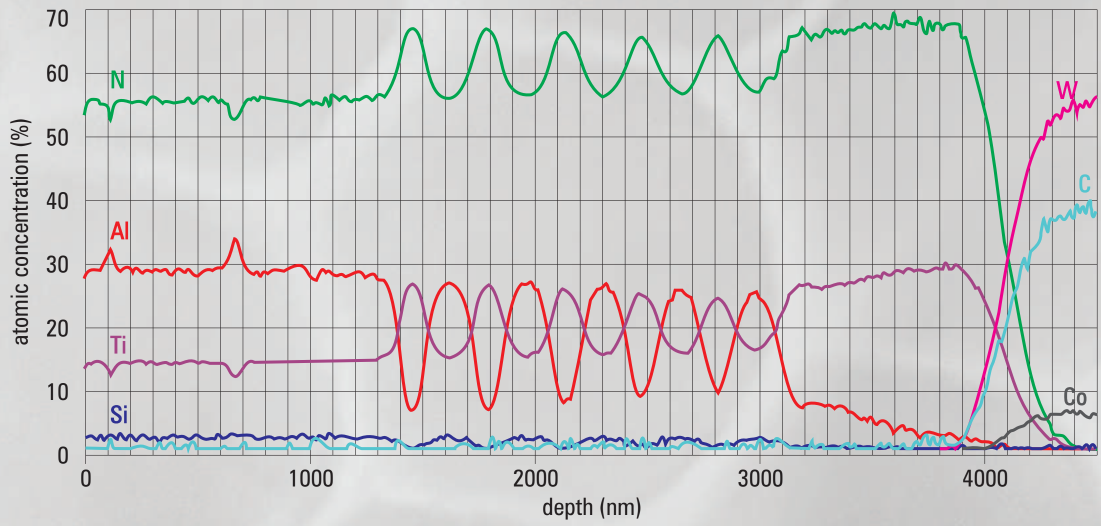
Stoicometry: CrTiSiN - AlCrN - AlCrTiBN - TiSiN
π^{411} : 1: $TiSi_{20}$ – 2:Al – 3:Cr – 4:TiB_2

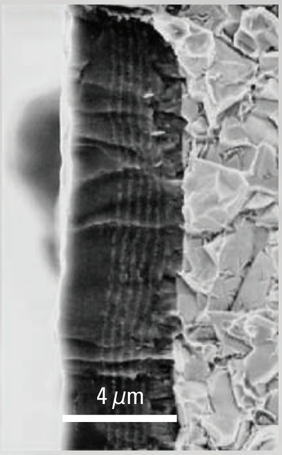
Triple-QUAD

TripleCoatings3®

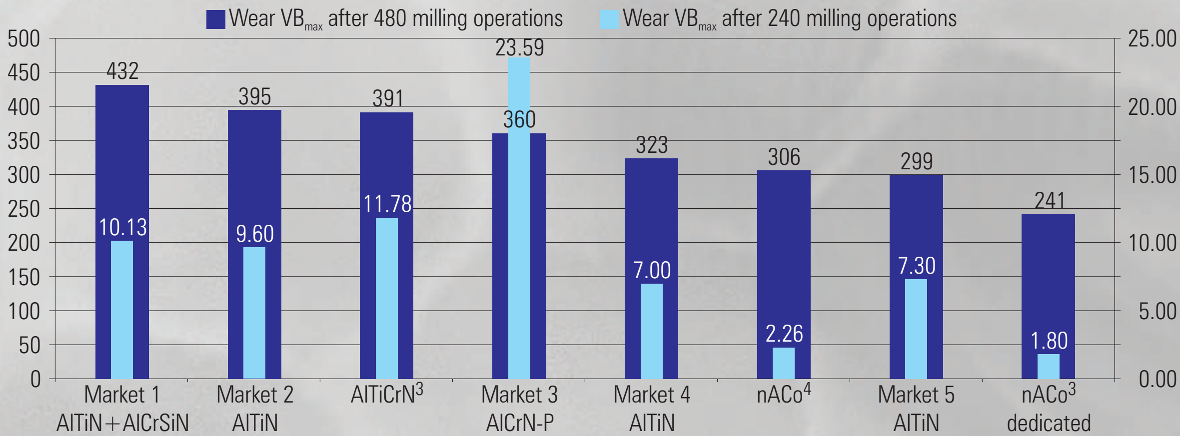
nACo3® & nACRo3®

Triple Coating Structure — Depth Profile of nACo3®



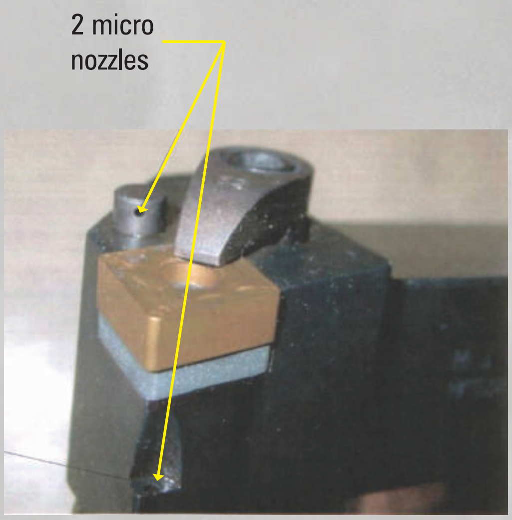


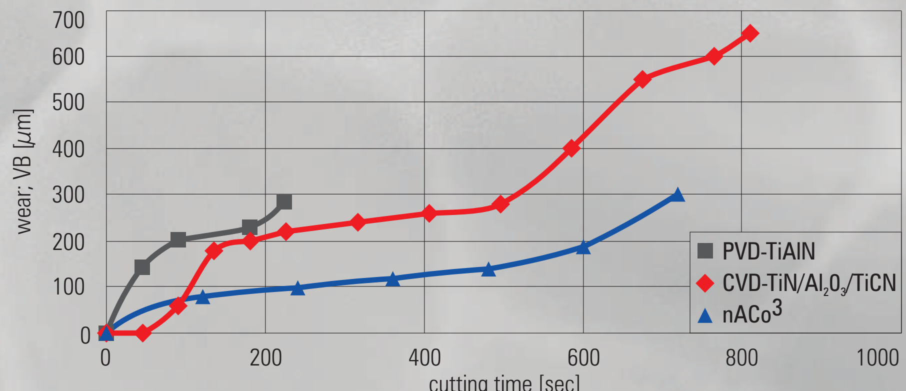
Milling — Benchmarking in High Alloyed Steel



Material: SUS316 mobile phone housing – Solid Carbide End Mill, D4 – z=4 – cutting length 6 mm – a_p=0.1
a_e=4.0 – v_c=100.53 m/min – n=8000 min-1 – f_z=0,0625 mm/z – f=0,2500 mm/rev – v_f=2000 mm/min – Coolant: emulsion
Source: Füllanti, Shenzen, China

Turning — TripleCoatings3® in Tool Life Comparison to CVD-Coating



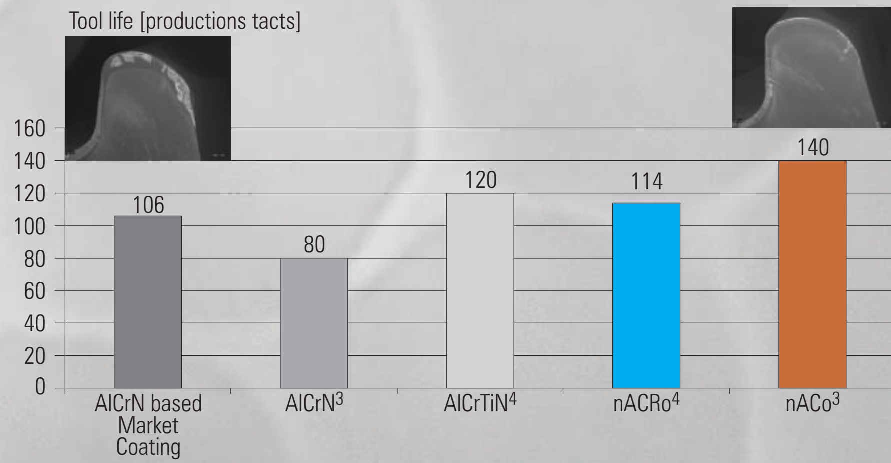


Material: stainless Steel AISI 316L - Inserts:Sandvik CNMG 12 04 08
v_c=290 m/min- ap=0.8 mm - f=0.24 mm/rev - Dry
Tool life criteria: VBmax ≤ 300 µm - KTmax ≤ 130 µm - N8 (Ra<3.2µm – Rz<12.5µm)
Source: EIG, Geneva, Switzerland

Applications

Turning - Grooving

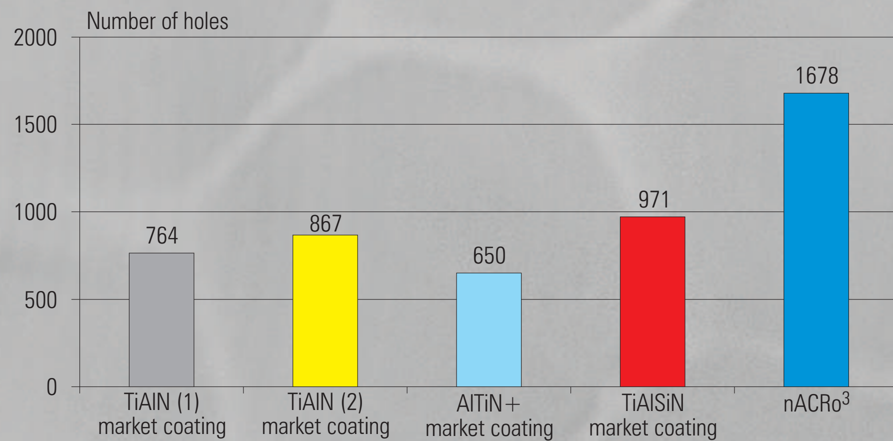
Tool Life Comparison



Material: Turbine housing – cast chrome steel, with reduced Ni content
vc= 63 m/min – f=0.1 mm/rev – Minimum lubrication – Tested by Daimler, Stuttgart, Germany

Drilling

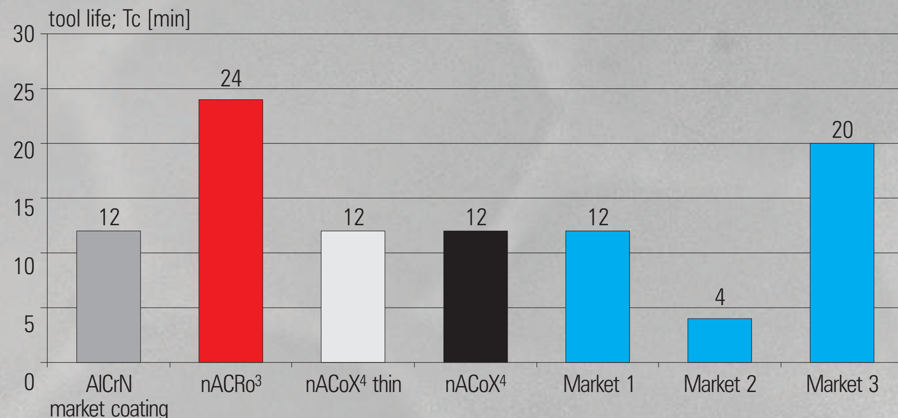
Tool Life Comparison



Solid carbide drill; Ø 8 mm; DIN6539-D8 – Work material 42CrMoV, HRC 30~32
successive cutting; drilling depth a_p=24 mm v_c 150 m/min; 5968 rpm; feed/rotation f=0.15 mm;
feed rate v_f=895 mm/min; coolant 8% – Source: TDC Dalian, China

Cooled Milling in Stainless Steel

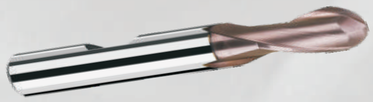
nACRo3®: Highest resistance against temperature changes

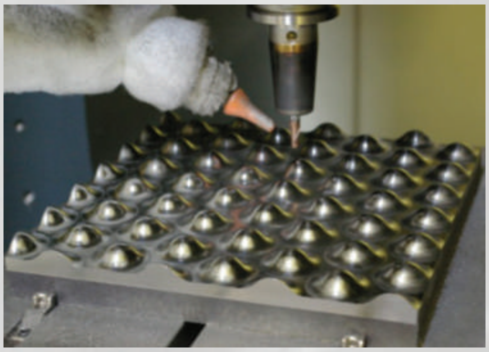


Tool: Milling head with SDMT inserts - Cooling: Emulsion
Material: Stainless steel - A500 = <1.4301> X5CrNi18-10
vc = 200 m / min - n = 1273 U/min - ap = 3 mm - ae= 32 mm - fz = 0,2 mm

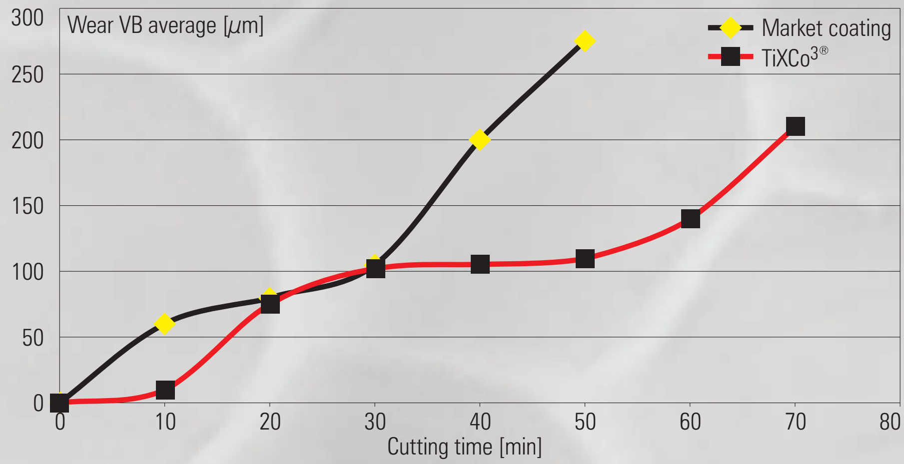
TripleCoatings3®
TiXCo3® for Hard Tasks

Milling with TiXCo3®



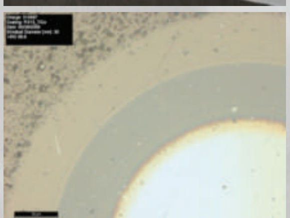


Hardened Steel with 54 HRC

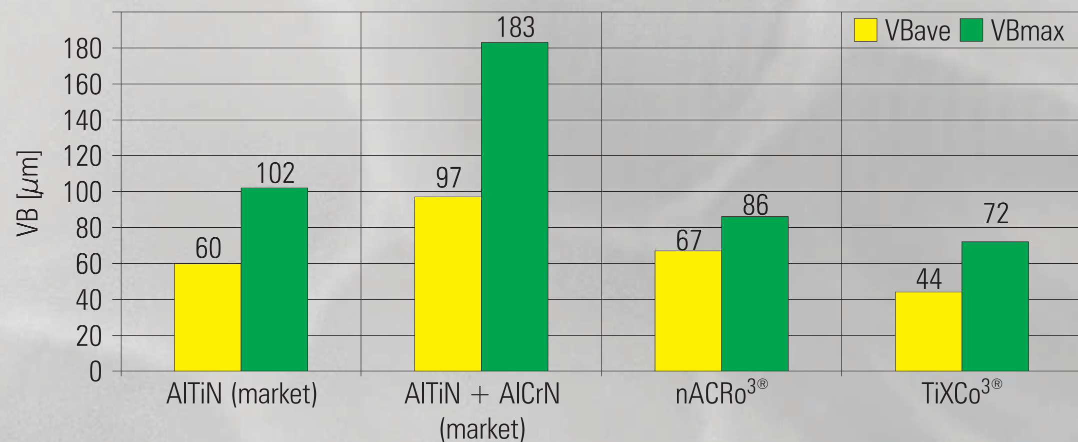


Material: Cold working steel - 1.2379 - SKD11 - Tool: d=10 mm - z=2
v_c=100 m/min - a_p=0.3 mm - a_e=5.5 mm - f_z=0.165 mm - MQL

Super Hard Milling



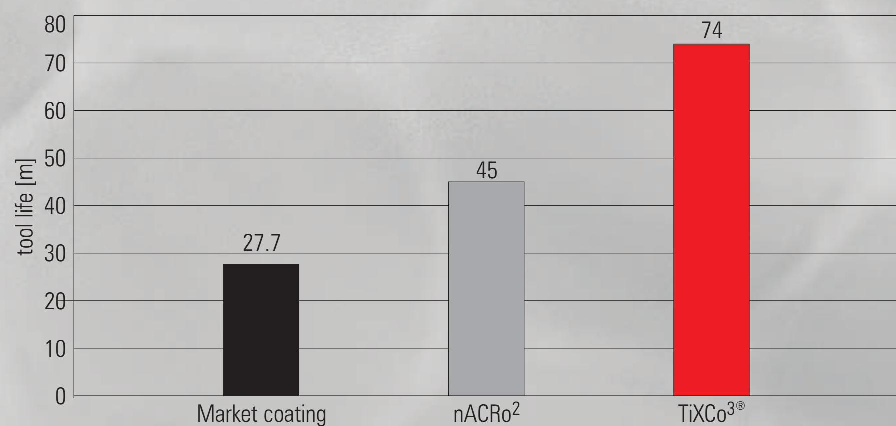
Wear Comparison



Torus end mill in cold-working steel X210Cr12 (1.2080) - 61.5 HRCØ 8 mm - z=4 - ap=0.1mm - ae=3mm vc=100m min-1 - n=4000min-1 - fz=0.2mm - vf=3200mm min-1 - dry - Source: Development project LMT Fette-PLATIT

Milling in Stainless Steel

Tool Life Comparison



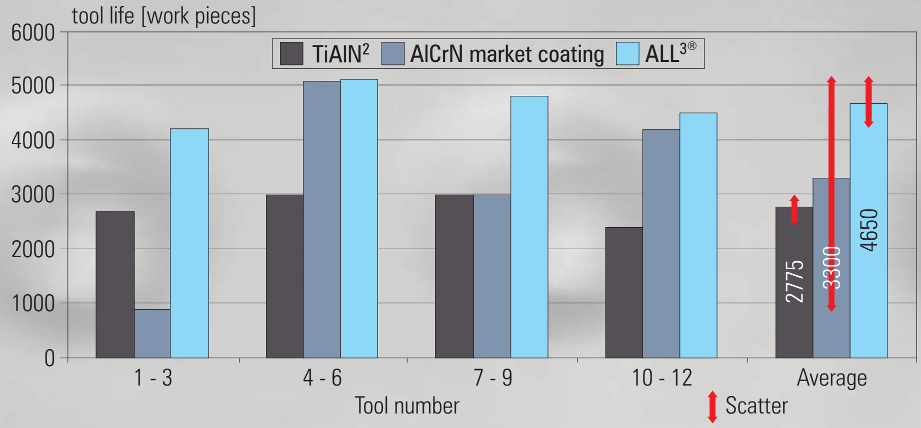
Tool: End mills - d=10 mm - Criteria: wear <= 0.3 mm
Workpiece: stainless steel - X2CrNiMo - Coolant: emulsion
v_c=250 m/min, f=3000 mm/min, a_p=0.3 mm, a_e=4 mm

PLATIT®

TripleCoatings3® *Applications with PL1011*

Hobbing

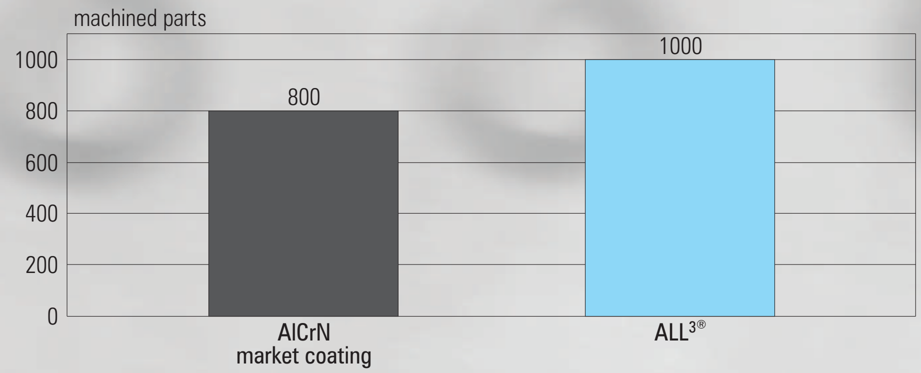
Tool Life Comparison



Work piece material: 34CrNiMo6 (1.6582)
vc=45m/min, fn=0.12 mm/rev, RPM=500
Coolant with oil - Source: Unimerco, Sunds, DK

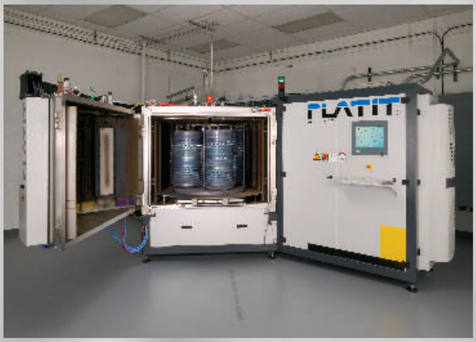
Gear Cutting

Tool Life Comparison

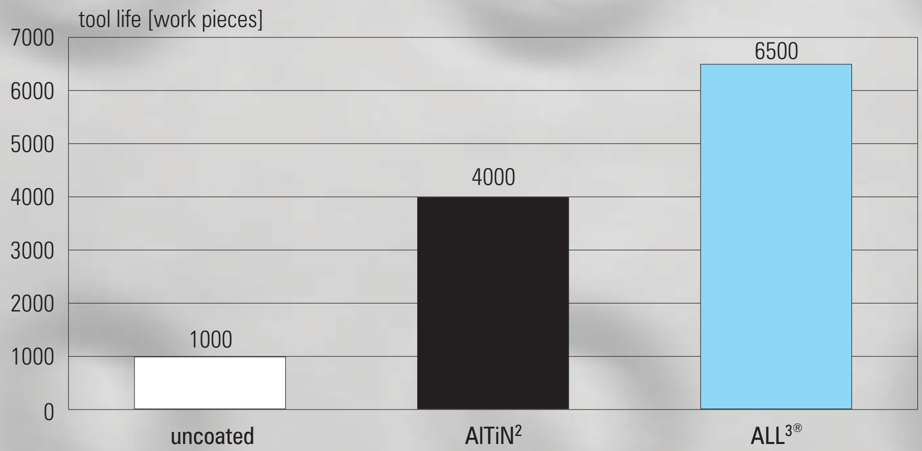


Machining of planet gears; Work piece material: 212 M; Width of work piece: 63 mm
Tools: HHS gear cutter ø95 x 150 mm
Roughing: v_c=120 m/min - f=2 mm/RPM
Finishing: v_c=140 m/min - f=1.5 mm/RPM
Criteria of tool life: Series of 200 parts without profile failure (very tight tolerances)

Sawing



Tool Life Comparison



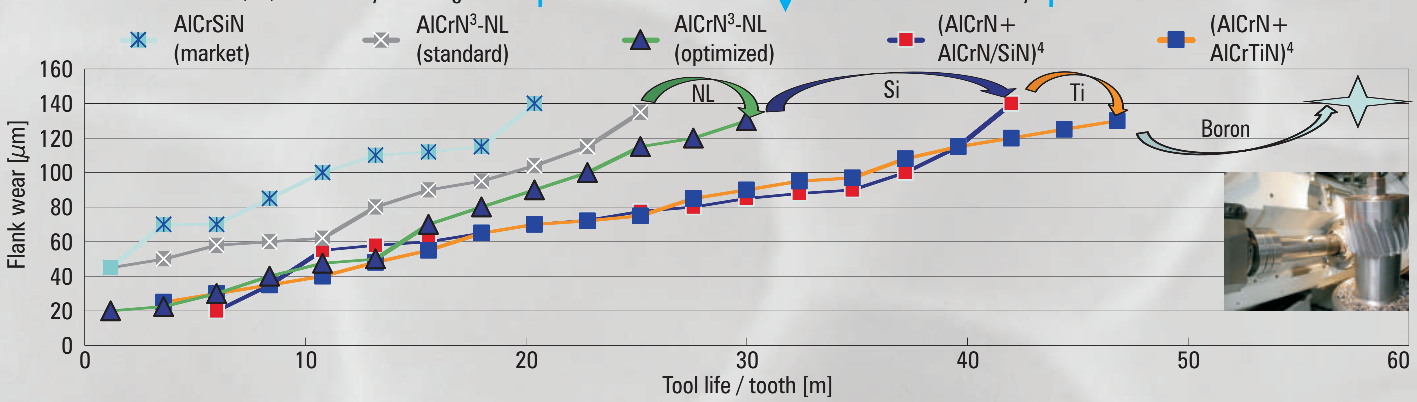
Material: 4140, H13, S7, D2, A2, Steel plates Tools: Saw blades, Carbide tipped 22" x 70"
RPM=42; SFPM=242 coolant emulsion; Source: Tru-Cut, Cleveland, USA

nACo4® & nACRo4®

Using Coating Material Components to Increase Performance

Al: Heat resistance: ↑ Cr: Thoughness + abrasive wear resistance: ↑

Al/Cr/Ti: Nanolayer: thoughness: ↑ Ti: risk for break out: ↓ Boron: chemical stability: ↑

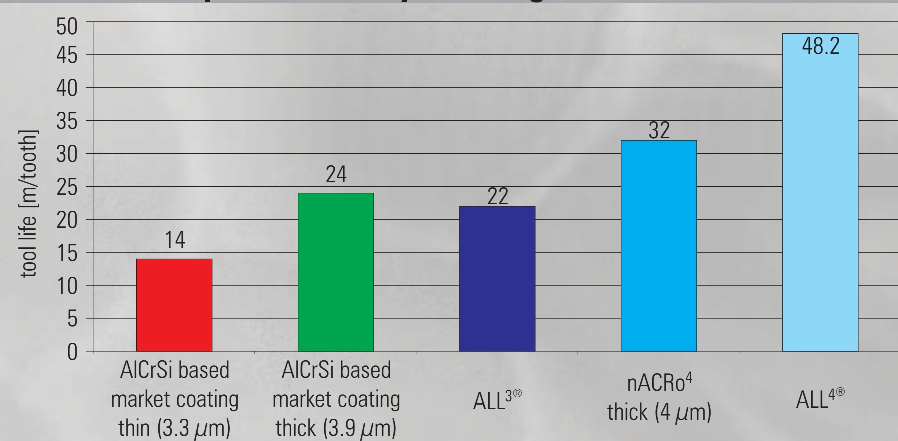


HSS hobbing - m_n = 2.31, v_c = 150 m/min, f_a = 1.69 mm/rev, z_o = 5, dry

Measured by the 1-tooth test at the University Magdeburg, IFQ, Germany

Hobbing

Tool Life Comparison at Dry Hobbing



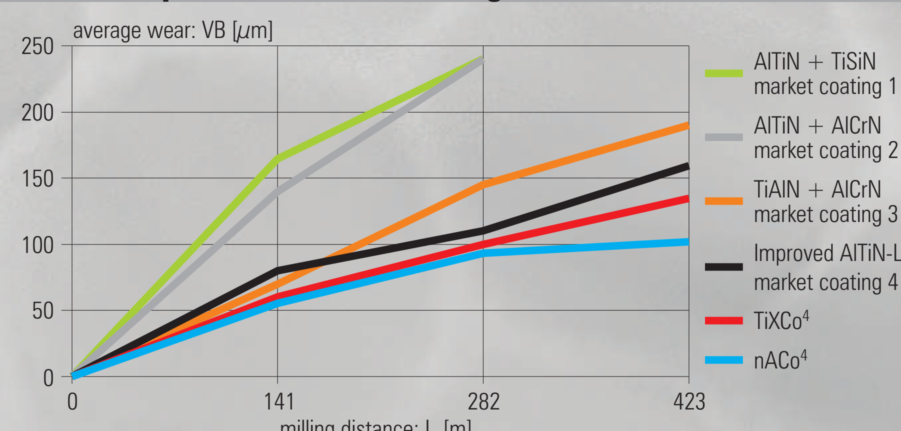
Mat. : 20 MnCrB5 - m=2.7

Tool: 2-teeth - PM-HSS - v_c=150 m/min - f_a=1.7/work piece revolution - with 5 gears

Measured at the University of Magdeburg, Germany

Milling

Wear Comparison at Hard Milling with Inserts



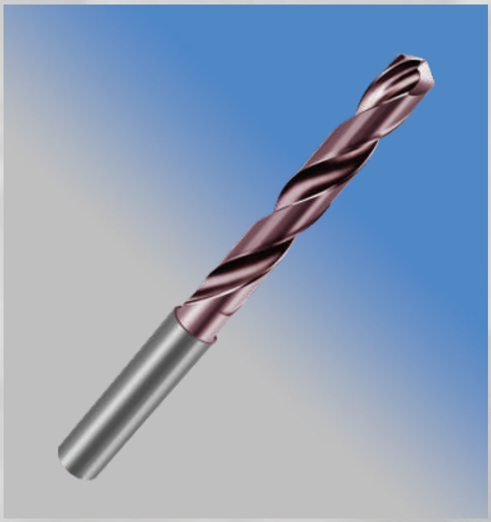
Workpiece: Wave profile - Material: X155CrVMo12 - 1.2379 - hardened to 55 HRC - coolant: IC-air

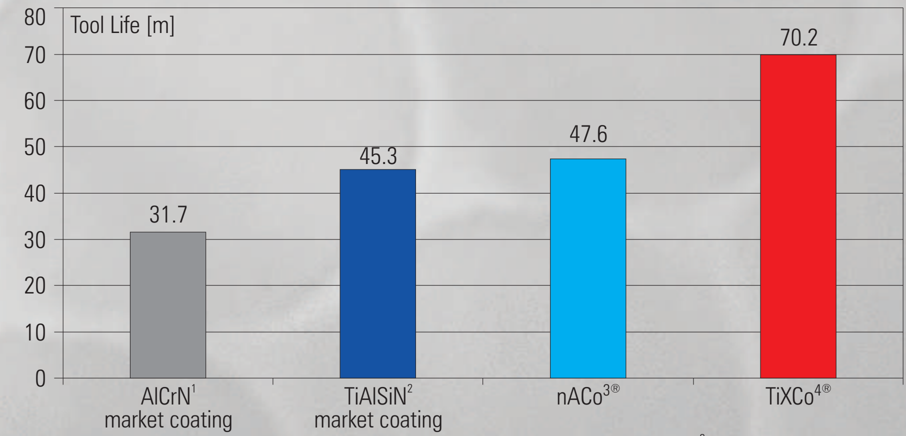
Tool: WPR 16-SF - v_c=240 m/min - f_z=0.2 mm - v_f=1910 mm/min - a_p=0.2 mm - a_e=0.3mm

Tested by LMT-Kieninger, Lahr, Germany

Applications

Drilling — Tool Life Comparison in High Strength Steel



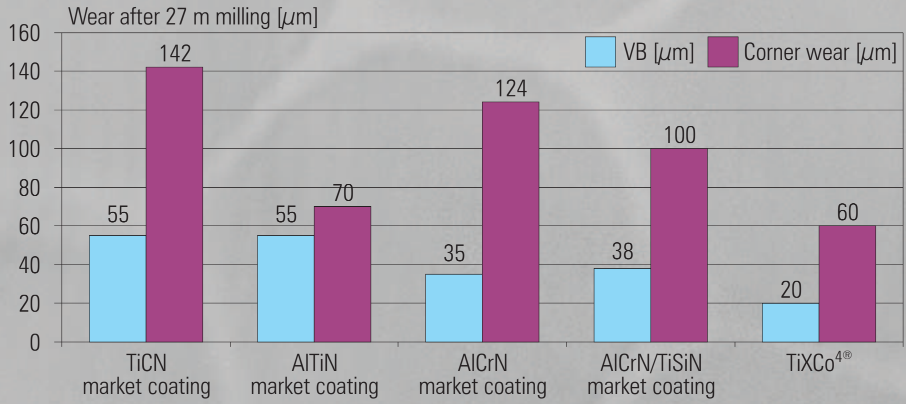


Work piece material: X155CrVMo12 - 1.2379 - R_m=1150 N/mm² - Coolant emulsion 7%

Tool: solid carbide drill: ø6.8 mm; Edge preparation: 50 µm - Coating thickness: 3 µm

v_c=70 m/min - f=0.16mm/rev - a_p=15 mm - Tested at GFE, Schmalkalden, Germany

Milling — Wear Comparison in Hot Working Steel, 54HRC



Tool: Solid carbide endmill - d=8mm - v_c=100m/min - a_p=4mm - a_e=0.03mm

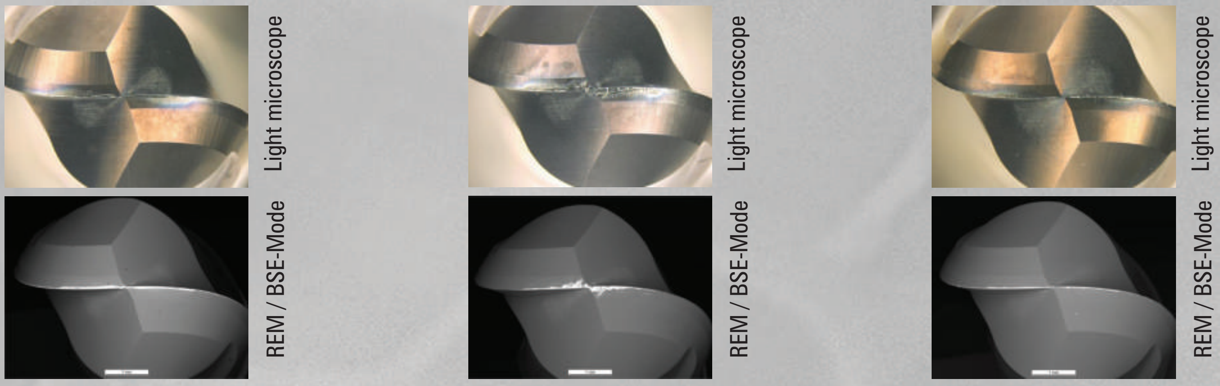
Coolant: Emulsion - Coating thickness: 2 µm - Edge radius: 7 µm - Cutting length: 27m

Work piece material: Hot working steel - 1.2344 / SKD61 - 54 HRC

Source: Tool manufacturer, China

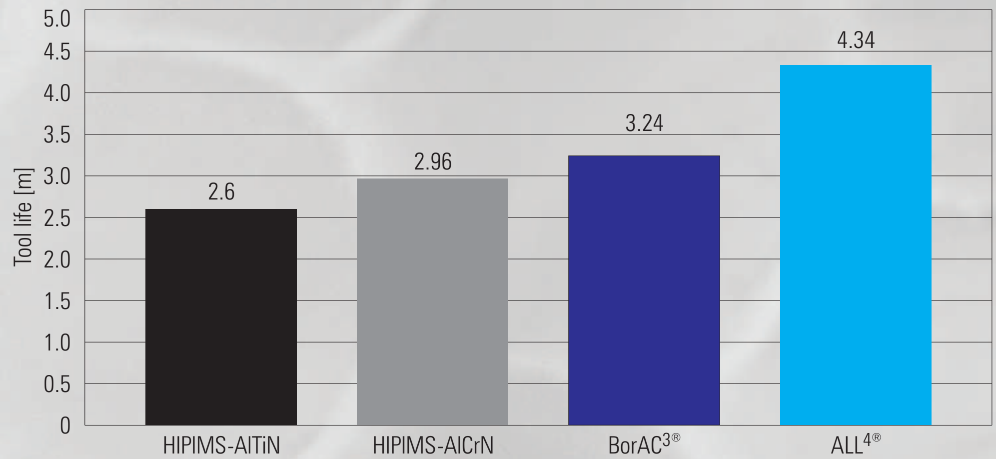
Wear Behaviour Comparison at Hard Milling after t_c=140 min

Coater B	Coater C	TiXCo[3]®-AlTi
140 min milling duration	140 min milling duration	140 min milling duration



Work piece: 1.2379 (60 HRC) – Tool: d=10 mm – ball nose – Roughing: v_c=87 m/min – f_z=0.065 – a_p=0.4 mm – a_e=0.4 mm – Finishing: v_c=167 m/min – f_z=0.07 mm – a_p=0.12 mm – a_e=0.12 mm – Source: Fraisa, Bellach, Switzerland

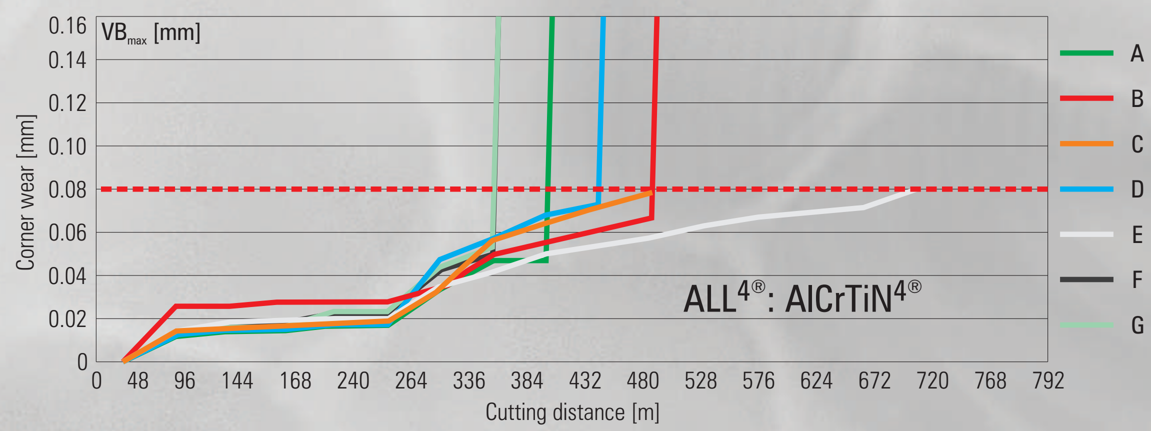
ALL4® — Tool Life Comparison in Heat Treated Steel



Material: Tool steel, 1.2312, HRC 28.4, a_p=14 mm, a_e=0.6 mm, v_c=177 m/min
Tools: d=8 mm, Fraisa NB-NVDS, z=4, f_z=0.18 mm/tooth – dry

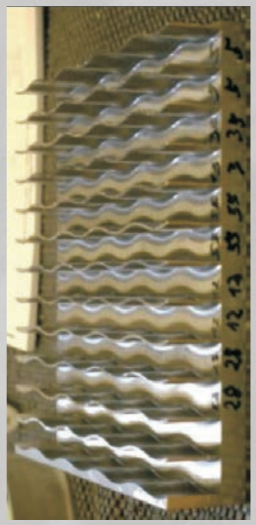
ALL4®: AlCrTiN4® — Wear Comparison at Milling

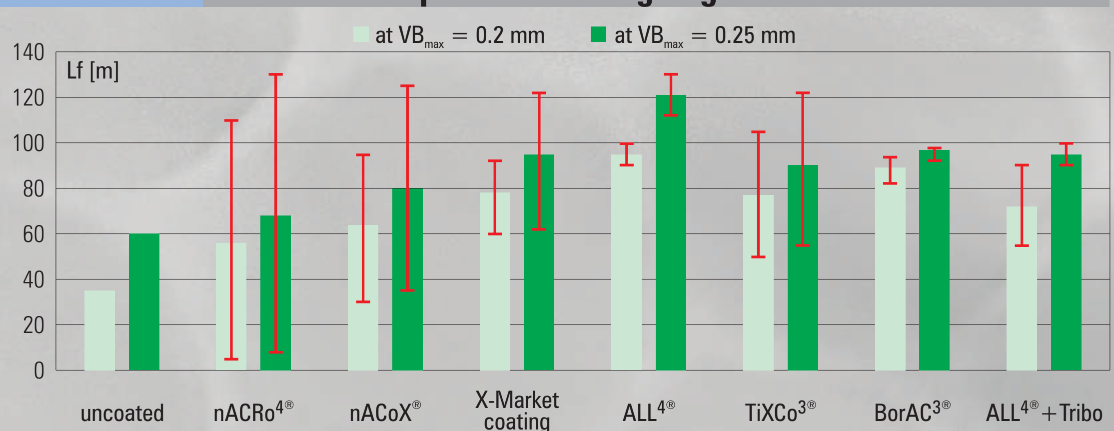
A, B, C, D, F, G
Market coatings



Machine: DMC80 linear – Material: 42CrMo4 160x50x300 – Roughing – 6% FU60 external emulsion – Tool: H4038217-3-0.2 D3 R0,2 z4 – D_c=3mm

Trochoidal Milling — Tool Life Comparison at Roughing in Nickel Based Material

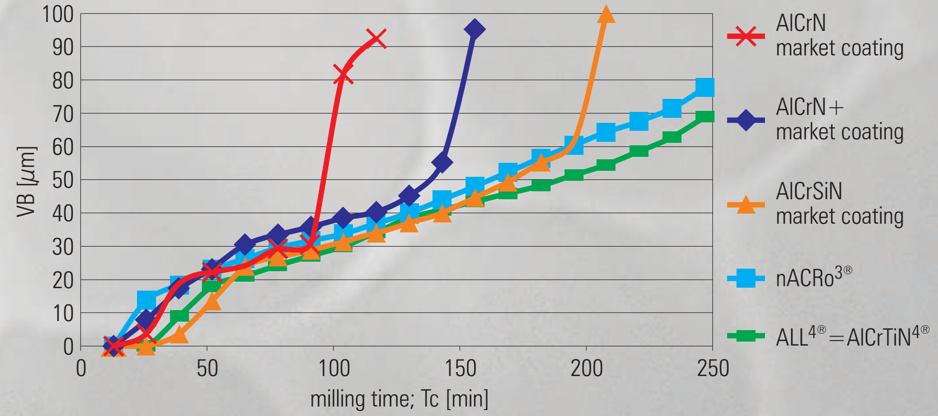




Work piece: thin-walles bars from Inconel 718 – Tool: Solid carbide torus end mill d=10 mm – z=4
v_c= 90 m/min – a_e=0.1 mm – a_p=12 mm – f_z=0.21 mm/t
Coolant: Blaser Swisslube B-Cool 9665 – Measured at GFE Schmalkalden, Germany

Applications

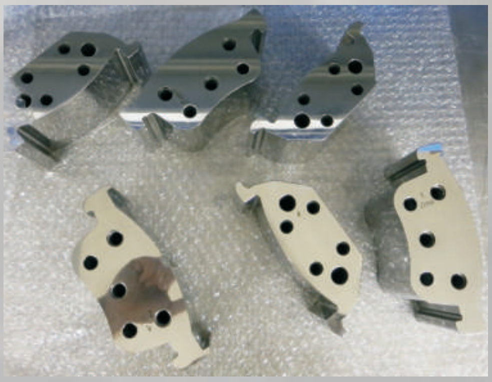
Wear Comparison at Milling with QuadCoatings4®

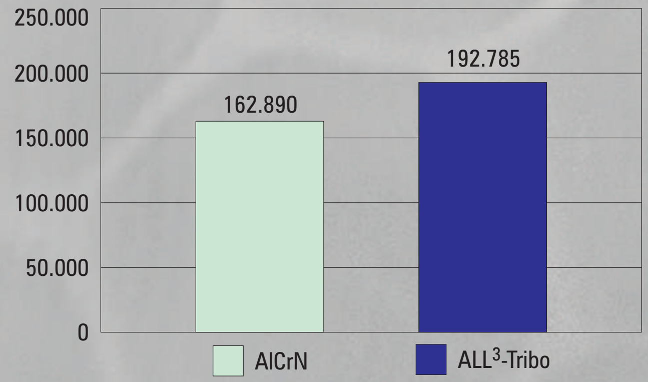


Tools: Solid carbide end mills – d=8 mm – z=4 - ap=5 mm – a=3.5 mm – vc=110 m/min – f=0.24 mm/rev – Work piece material: DIN 1.2085 – X33CrS16 – 31 HRC – External minimum lubrication

Tool Life Comparison

Applications with ALL4® + Tribo at Fine Blanking

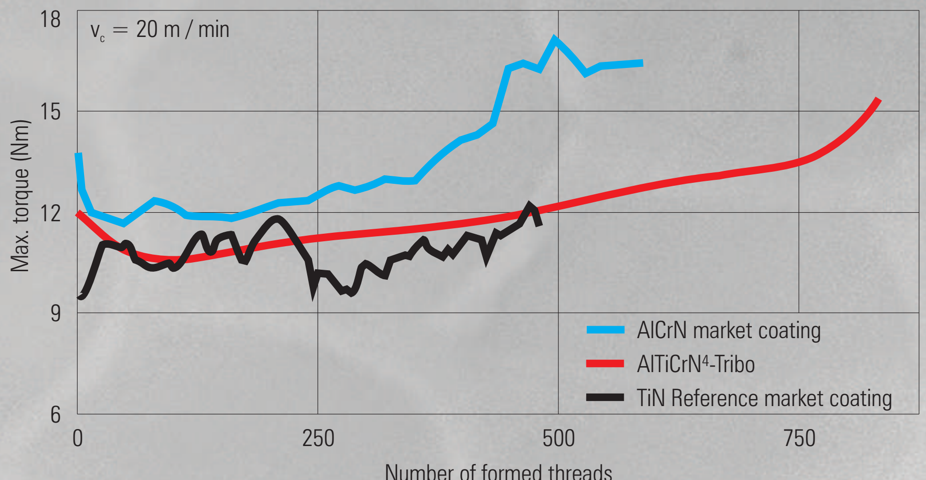




Material of punches BÖEHLER S600 (58-60 Hrc) & K890 (60-62 HRc)
Cutting punches with oil for cooling agent – Strokes / min: 25 to 40
Work piece material: S420-MC (EN-10149-2) & S275JR (EN-10125) - Thickness of material 4.5 to 7 mm
Source: HNCF, Italy

Thread Forming

Spindle Torque Measured in High Strength Steel



Work piece material: 40CrMnMo7 - Rm= 945 N/mm2
Tool: M8-InnoForm1-Z - HSSE 23/1 – Ø7.4 – ap=1.5xd - Minimum quantity lubrication (MQL)

Oxide and Oxynitride as QUAD Coatings4®

Goal of the Oxide and Oxynitride Coatings

Separator to decrease chemical affinity
between tool and workpiece in dry cutting processes at high temperature

Wear protection
- against adhesive wear
- against abrasive wear
- stable against further oxidation, avoiding oxygen diffusion
- chemical and thermal insulation

Decreasing friction
- At temperatures over 1000°C
- Reducing build-up edges and
- Reducing material interdiffusion in the tribological contact zone
- chemical indifference

Layer-architecture
- "Sandwich" like at CVD
- Metal nitride basis necessary, to avoid cracks and plastic deformation

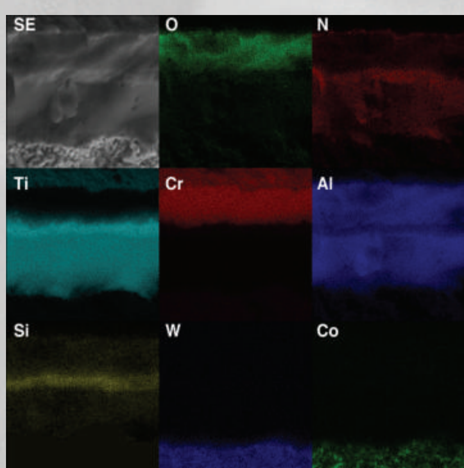
Layer Architecture

covering nitride; AlCrN, TiAlN, optional
oxide or oxynitride; $(Al,Cr)_2O_3$ - (Al,Cr)(O,N)
Nanocomposite; nACo, nACRo
Nitride; AlCrN, TiAlN
adhesion layer
tungsten carbide

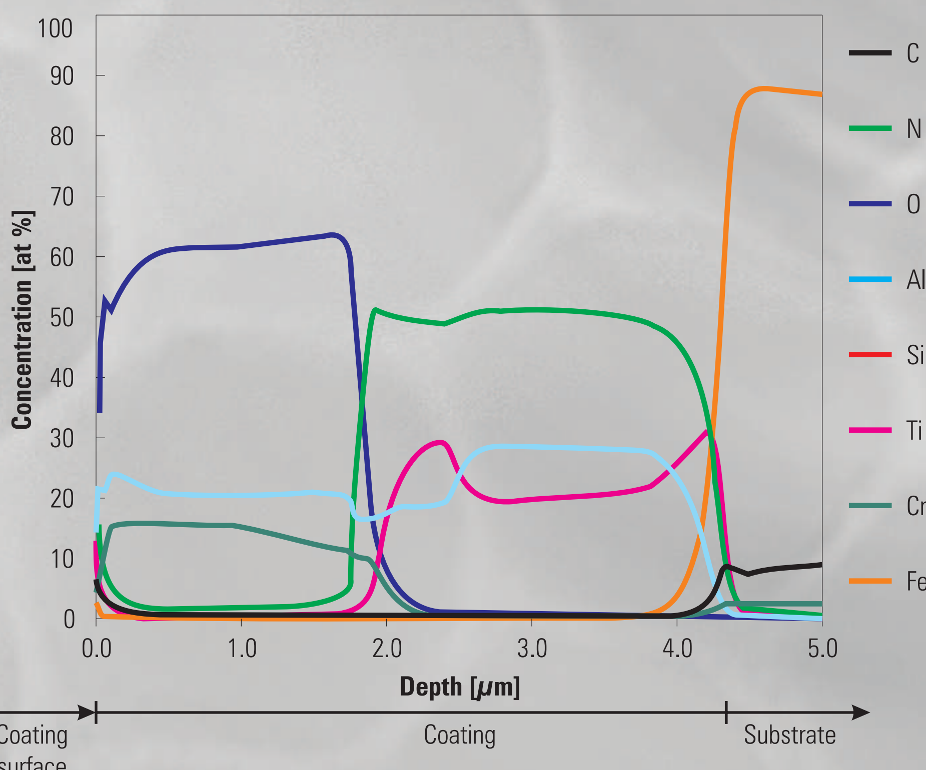
Features of nACoX4®

- Nitrogen to oxygen ratio: N/O: 50/50% – 80/20%
- Typical coating thickness on turning inserts: 4 - 18 μm
- Typical total hardness: 30 GPa
- Typical Young's modulus: ~400 GPa

Depth Profiles of nACoX4®



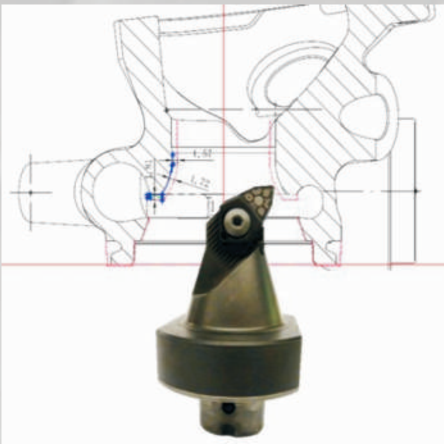
EDX (Energy-dispersive X-Ray spectroscopy) Element Map shows the distribution of the elements in the depth of the coating



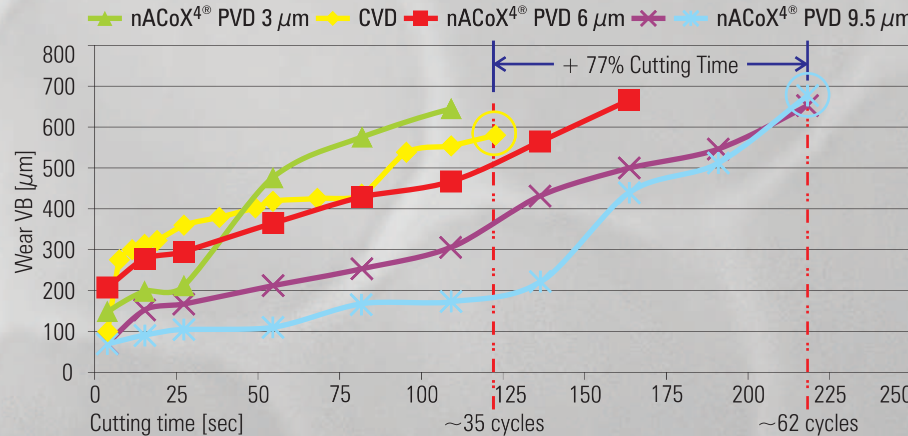
Measured by Fraunhofer Institute, Braunschweig. Germany

Applications

OXI-Option: Oxide Quad-Coatings versus CVD at Turning of High Alloyed Steel



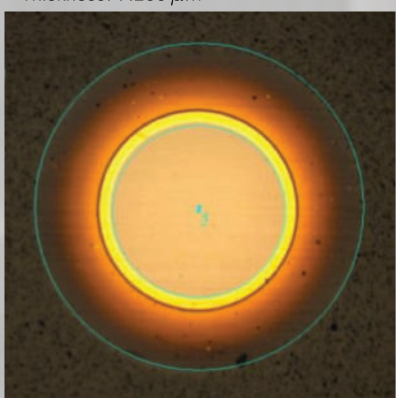
SME can more than compete with CVD using their own, thick PVD-OXI-coatings!

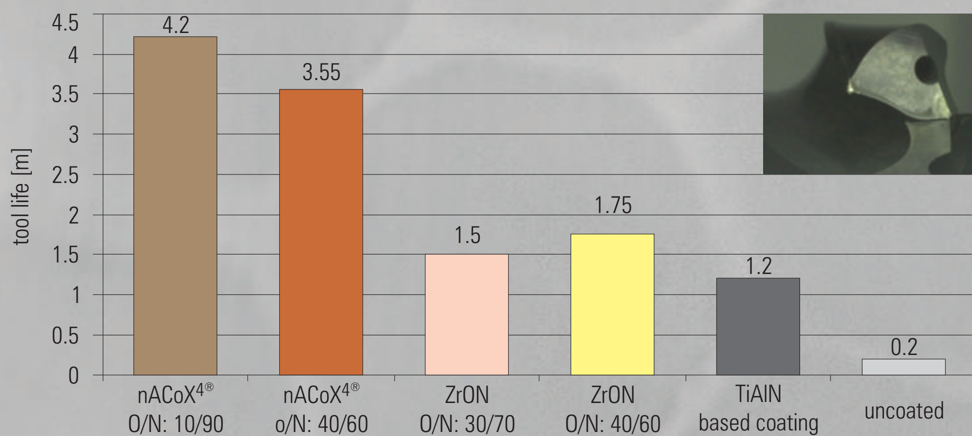


Inserts: WNMG – vc=110 m/min – f=0.4mm – Cutting length/cycle: 6.42m
Material Ni-steel – Rm=620 N/mm2 – Coolant: MQS
Source: Daimler AG, Stuttgart, Germany

Drilling in Difficult to Cut Austempered Ductile Cast Iron with Oxynitride Coatings

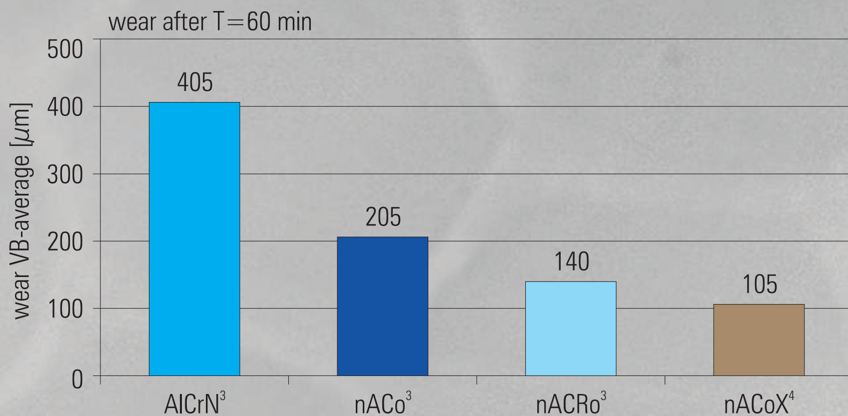
Zr-O-N with Gradient Triple-Structure
Grindball Diameter [mm]: 30
300 U/min 120s
Thickness: 7.260 µm





Mat.: ADI 900 – Tool: Solid carbide drill d=6.8mm
vc=120 m/min – f=0.3 mm/rev – ap=15mm - Internal MQL
Source: GFE, Schmalkalden, Germany

Profile Milling with Inserts - Roughing



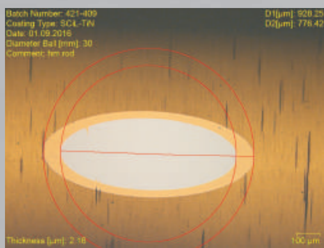
Material 1.2379 – Rm =1000 N/mm2
vc=240 m/min – fz=0.4mm ap=1.5 mm - ae=1 mm
Coolant: internal air

SCIL® Coatings and Their Applications

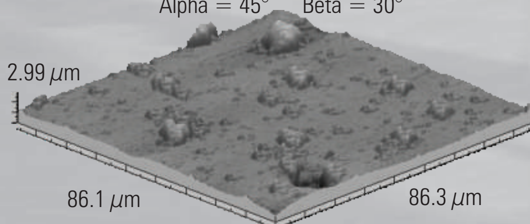
π411PLUS

Gun Drilling

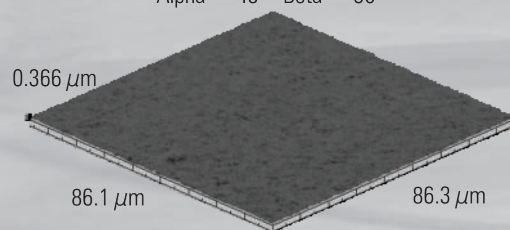
TiN-ARC <-> TiN-SCIL®



Coating Thickness for Both Cases: 2 μm



ARC surface
S_a= 0.1627 μm – S_z=2.087 μm

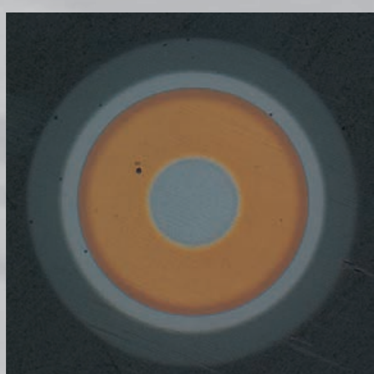


SCIL® surface
S_a= 0.0162 μm – S_z=0.311 μm

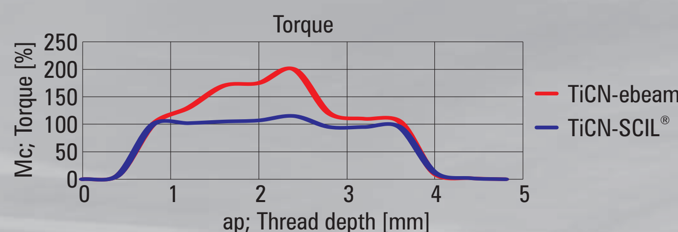
Sputtering power: Up to 30kW - No columnar structure - Reactive and non-reactive processes
Growth rate in reactive process: ≈ 2 μm/h in 3-fold rotation
Application fields: gun drilling, tapping, decorative coatings

Thread Forming

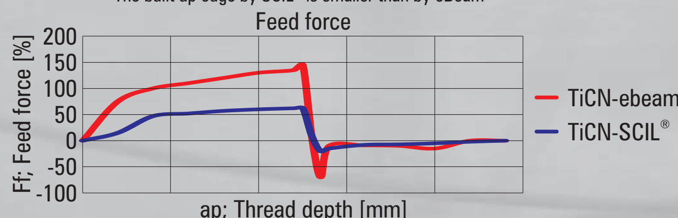
TiCN-SCIL® Torque and Force Comparison



	Adhesion layer Ti - TiN	Core Layer TiCN	Top layer TiCC
Total thickness [μm]	1. Thickness [μm]	2. Thickness [μm]	3. Thickness [μm]
2.59	1.16	0.41	1.02

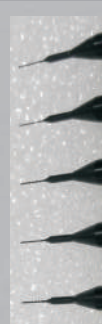


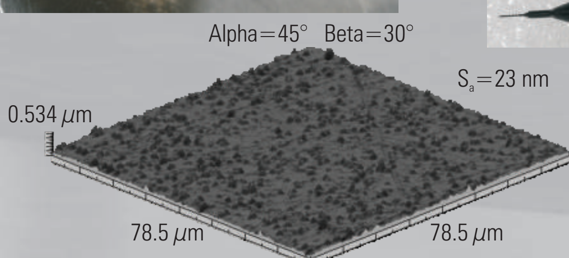
Tools: M3 - v_c=10mm/min - MQL
Material: stainless steel; SUS 304 - X2CrNi19-11
The built up edge by SCIL® is smaller than by eBeam



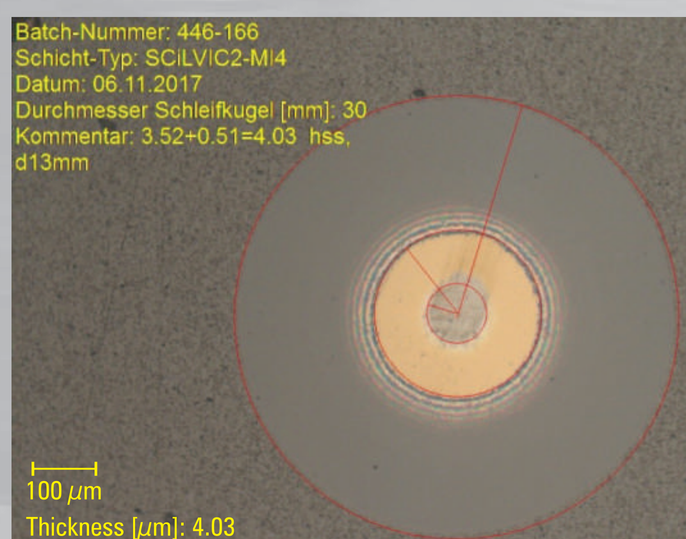
Micro Tooling

SCILVIc2®: Structure and Roughness





S_a=23 nm

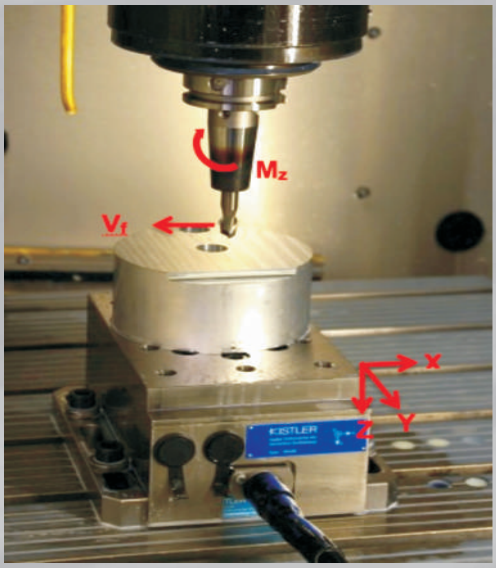


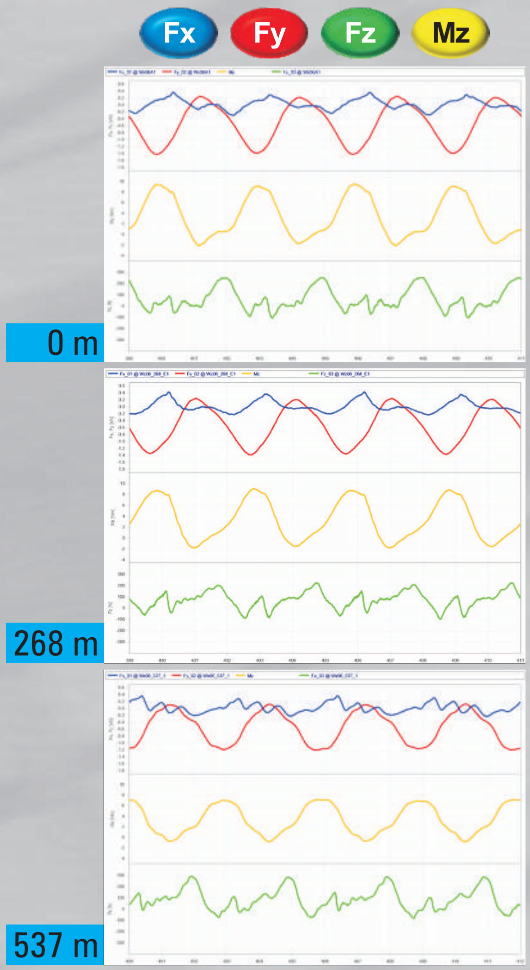
Applications

TiB$_2$-SCIL® and Its Characteristical Features

- Tailored for aluminum machining
- Preferable for softer, forgeable alloys with lower Si contents (~6%)
- For machine components with
  - high hardness
  - low friction coefficient

TiB$_2$ characteristics:
- Thickness = 1.3 μm
- H = 32.8 GPa
- E = 515 GPa
- Lc$_2$ HM > 100 N
- Lc$_2$ HSS > 51.8 N





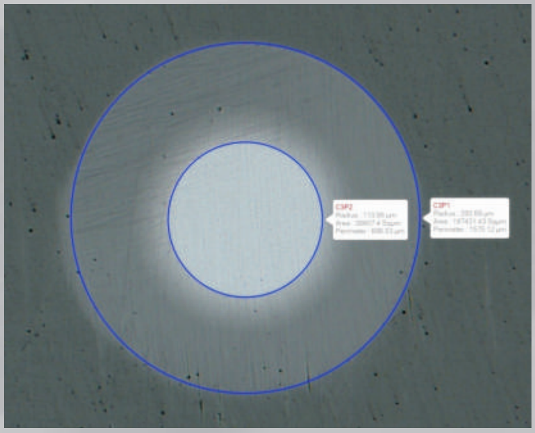
- Homogeneous surface remains after coating
- Ideal cutting edge coverage
- No set-free of cutting edges even post treatment applied

FRAISA AX-RV2 Torus end mill; ø12 mm; r = 2.5 mm; Z=2; emulsion 5-6%
Q = 120 cm^3/min; milling distance/cycle = 2.63 m; Machining Center DMC 64 V linear
Al alloy AlZnMgCu1.5 (Alloy 7075); State = hard; 156 HB;
a_p = 6 mm; a_e = 5 mm; v_c = 377 m/min; n = 10'000 min-1
f_z = 0.20 mm/Z; f = 0.40 mm/rev; v_f = 4'000 mm/min

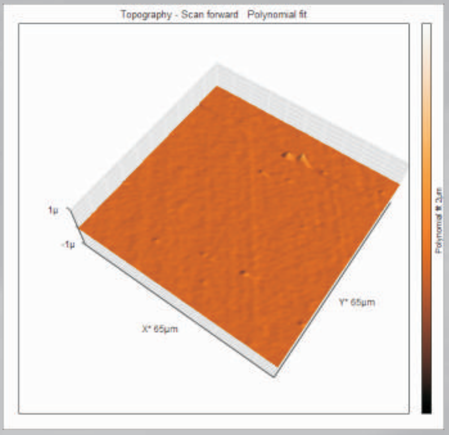
SCIL & LACS

WC/C-SCIL® and its Characteristical Features

Machine components coated by WC/C-SCIL®



Coating thickness: 1.44 μm

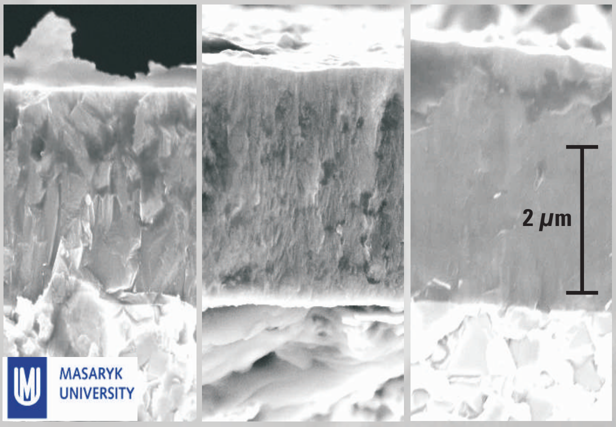


S_a= 3.5 ± 0.9 nm - S_q= 9.3 +-5.6 nm

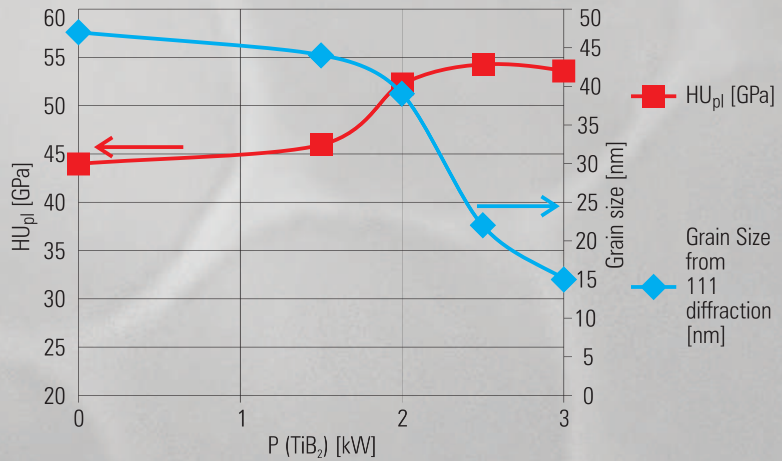
H~ up to 20 GPa – Y=240 GPa

Hybrid LACS® Coatings

Decreasing Grain Size and Increasing Hardness with LACS®-Technology for BorAC3®-Coating (AlCrTiN/BN)



Cross section SEM: Armorphous-like structure when adding Boron

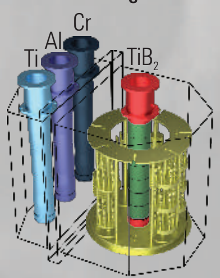


XRD: 111 Grain size changes 57 nm → 16 nm with increasing Boron content
Source: C. Tritremmel et al. Surface & Coatings 213 p.1-7

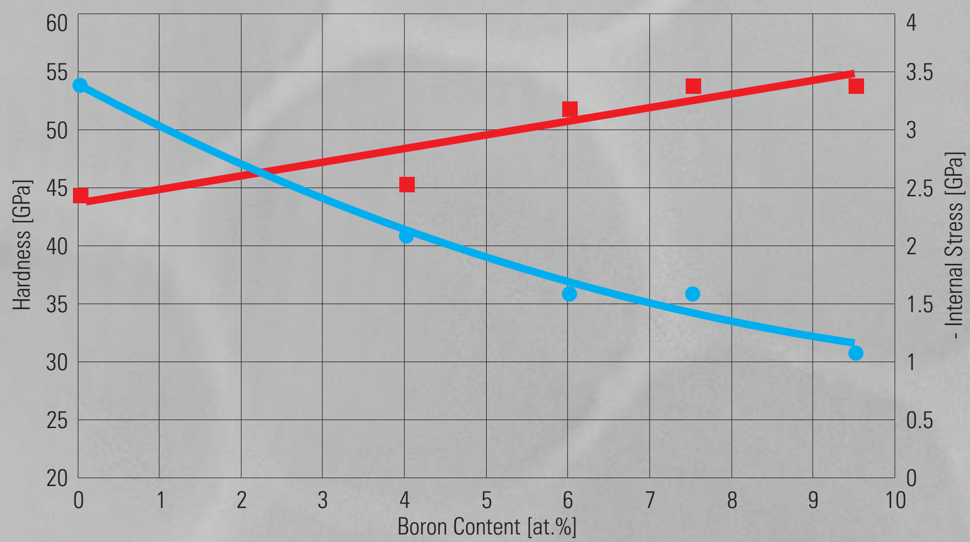
Interrelation between Hardness, Internal Stress and Boron Content

The internal stress can be reduced with higher boron content, in spite of higher hardness

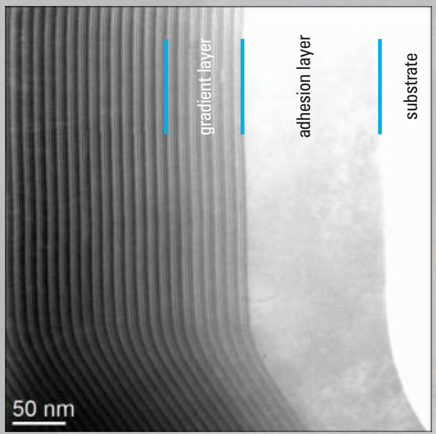
Cathode configuration



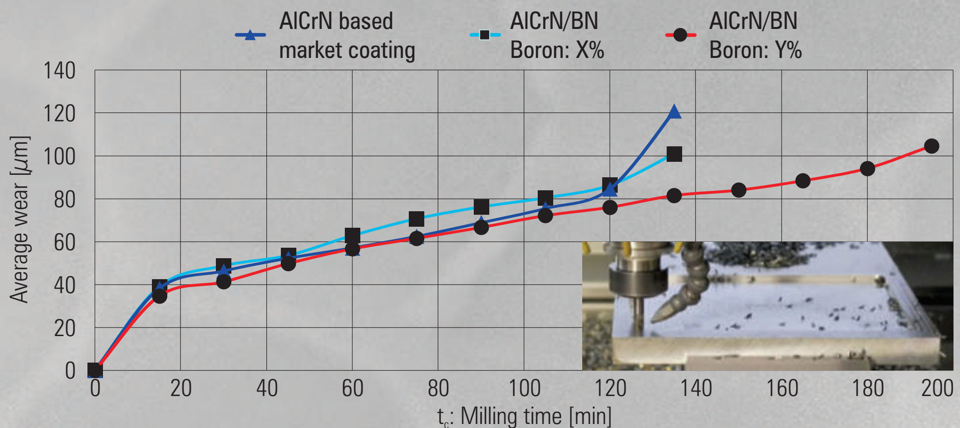
Coating: AlCrTiN/BN
Thickness: 2 µm



Using Boron as a Material Component for Optimizing the Coatings' Internal Stress



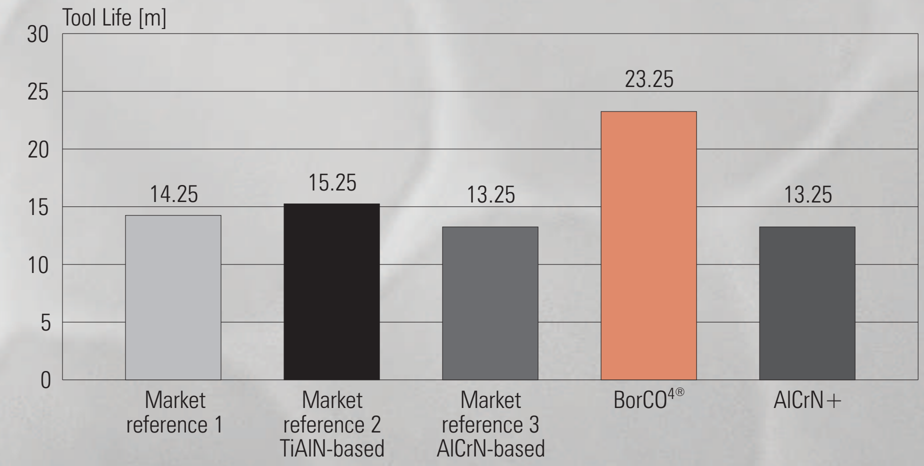
AlCrN/BN coating with triple structure measured by energy dispersed by X-Ray spectroscopy
Source: University Freiberg, Germany



Mat.: Tool steel - 1.2085 – X33CrS16 – HRC 29.2 – a_p=5 mm – a_e=02.5 mm – v_c=120 m/min
Tools: d=8mm - Fraisa NX-V Torus – d=2.2 mm – z=4 – f_z=0.06 mm/tooth – MQL
Average wear = (Max. margin wear + VBmax (clearence wear) + Top edge wear + corner wear) / 4

Applications for Milling and Drilling

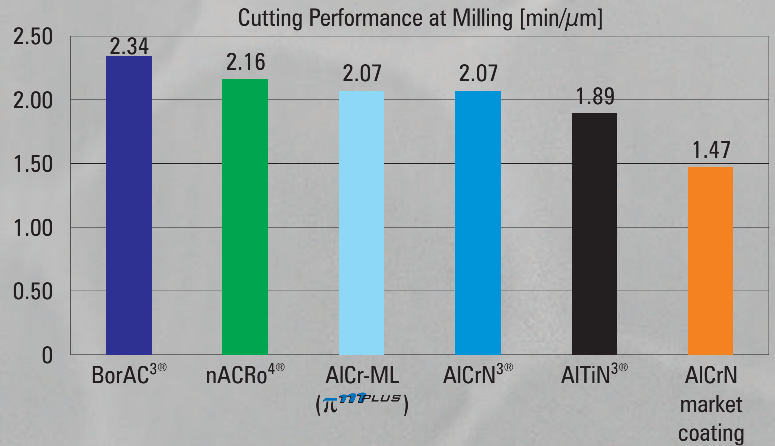
Using LACS®-Technology with Boron and Silicon at Milling Cold Working Steel



Mat.: Cold working steel, 1.2379 (X155CrMoV 5-1), a_p = 10 mm, a_e = 8 mm, v_c = 160 m/min
z = 4, f_z = 0.06 mm/rev – dry

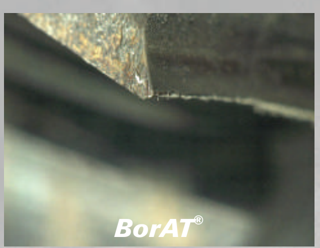
Using LACS-Technology: BorAC® - AlCrN/BN: Cutting Performance at Milling

Cutting Performance Measured and Calculated as Cutting Time [min] / Average Wear [µm]

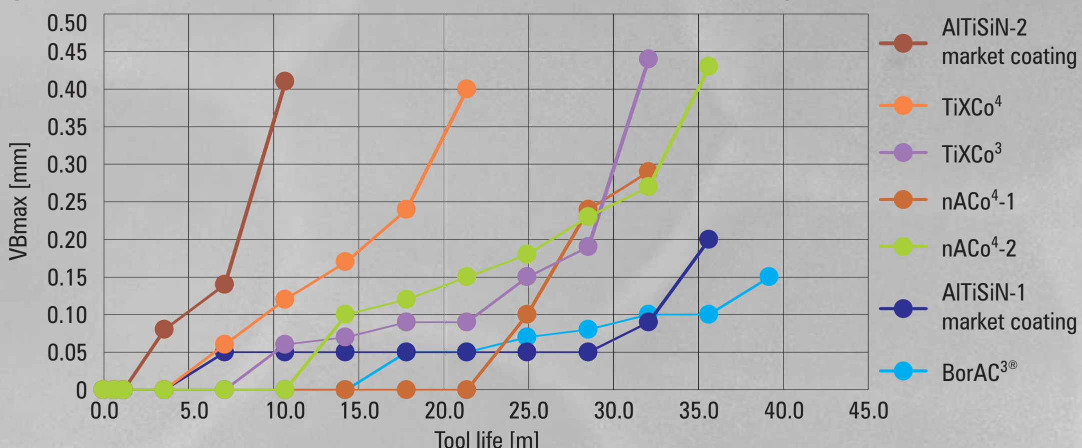


Mat.: Tool steel – 1.2085 – X33CrS16 – HRC 29.2 – a_p=5 mm – a_e=02.5 mm – v_c=120 m/min
Tools: d=8 mm – Fraisa NX-V Torus – d=2.2 mm – z=4 – f_z=0.06 mm/tooth – MQL
Average wear = (Max. margin wear + VBmax (clearence wear) + Top edge wear + corner wear) / 4

Using LACS-Technology: BorAC3® - AlTiCrN/BN: Wear Behavior at Drilling



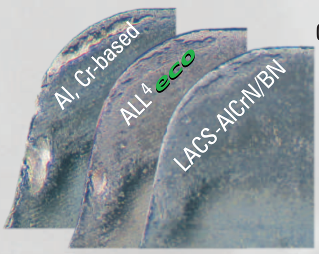
Drill's Corner Wear after 2178 Holes

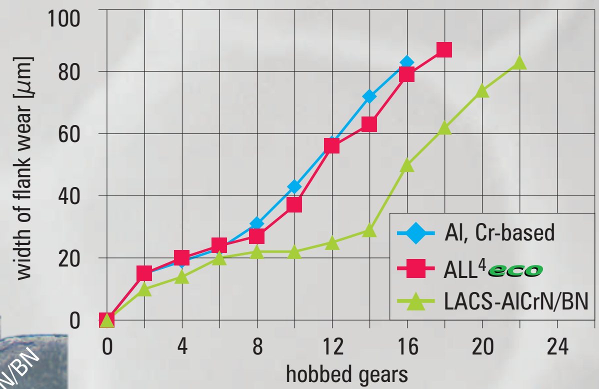


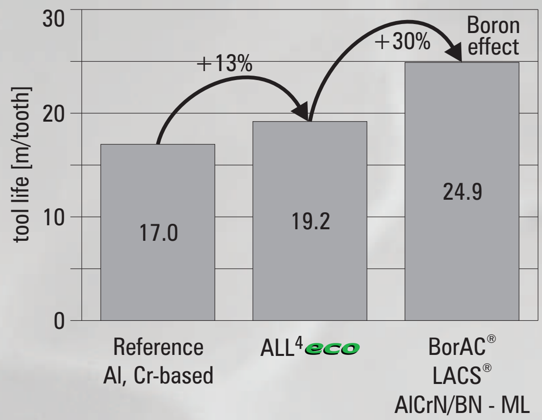
Mat.: Heat treated steel – 1.7225 – 42CrMo4 – HRC 30 – a_p=18 mm – v_c=120 m/min
Tools: Solid carbide drill – d=6.8 mm – Schlenker GmbH – z=2 – f=0.15 mm/rev – MQL
Measured at GFE, Schmalkalden, Germany

Hybrid LACS® Coatings for Hobbing

BorAC® - Hobbing with Boron Doped AlCrN-ML







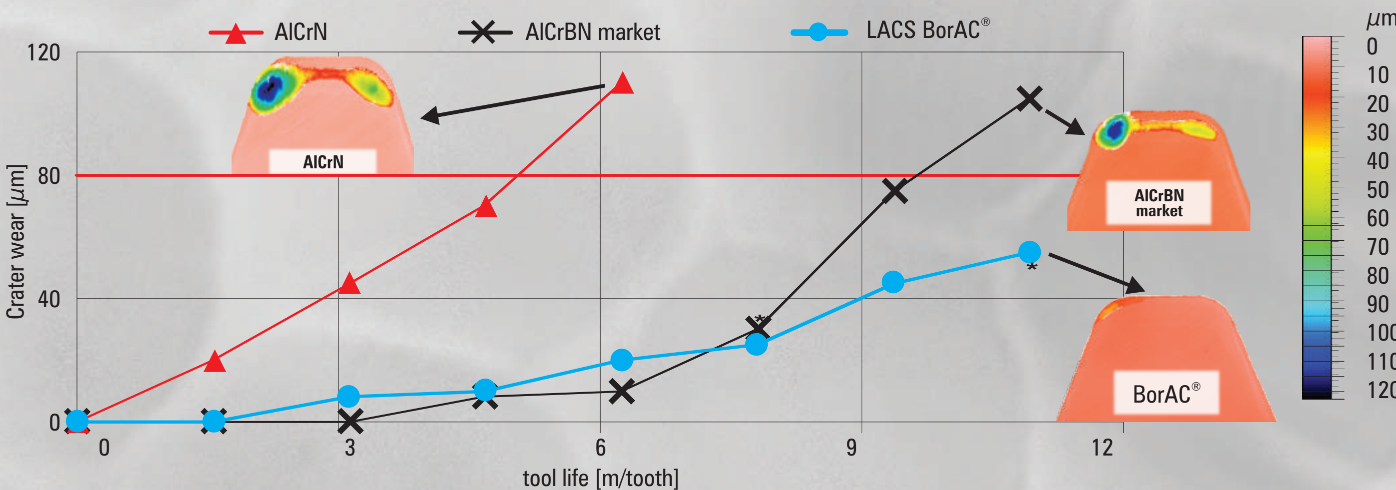
Fly-Hobbing test using PM-HSS - All teeth rounded by wet blasting, R = 15 - 18 μm

Coating thickness for all three variations by calo test = 4 μm

LACS-AlCrN/BN protects crater wear best

v_c=180 m/min - f_a=3.6 mm/rev, max. chip thickness = 0.20 mm

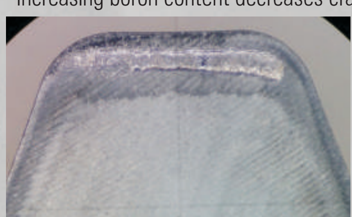
Hobbing Benchmark — BorAC®: Maximum Protection Against Crater Wear



v_c = 220 m/min f_a = -6,4 mm/rev, hcu, max = 0,24 mm, *VB_{max} reached

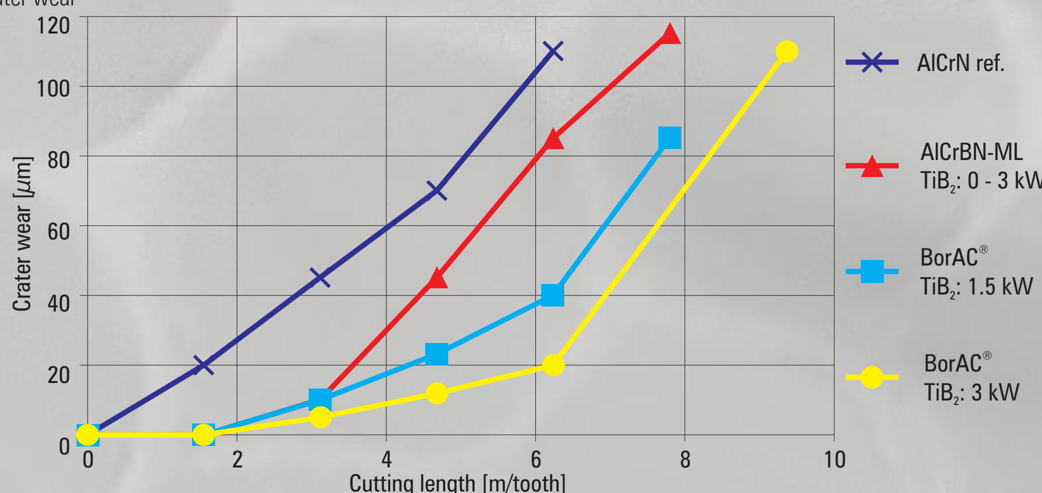
Hobbing Benchmark — The Influence of Boron Content

Increasing boron content decreases crater wear



AlCrN-ref. at 3.12 m

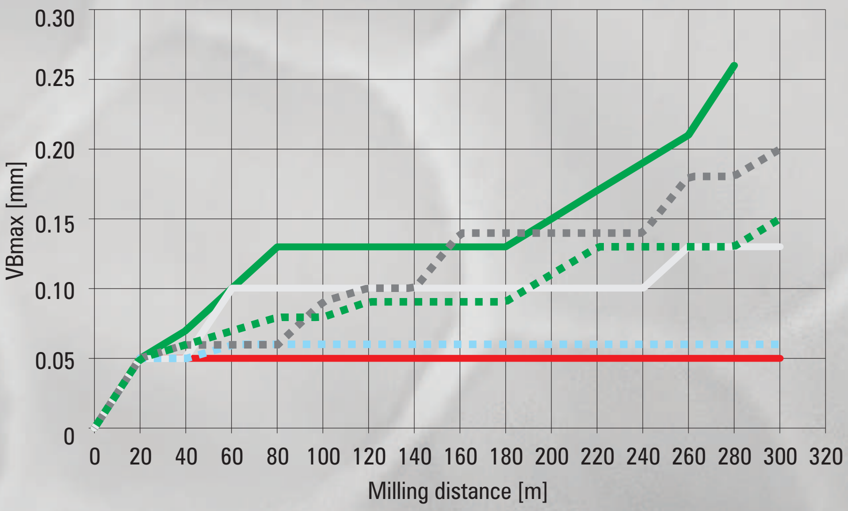
BorAC® at 3.12 m

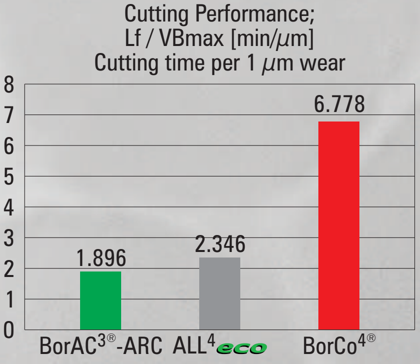


v_c = 220 m/min f_a = -6,4 mm/rev, hcu, max = 0,24 mm, *VB_{max} reached

Applications for Hard Milling and Reaming

Using LACS®-Technology with Boron and Silicon At Hard Milling (63 HRC)

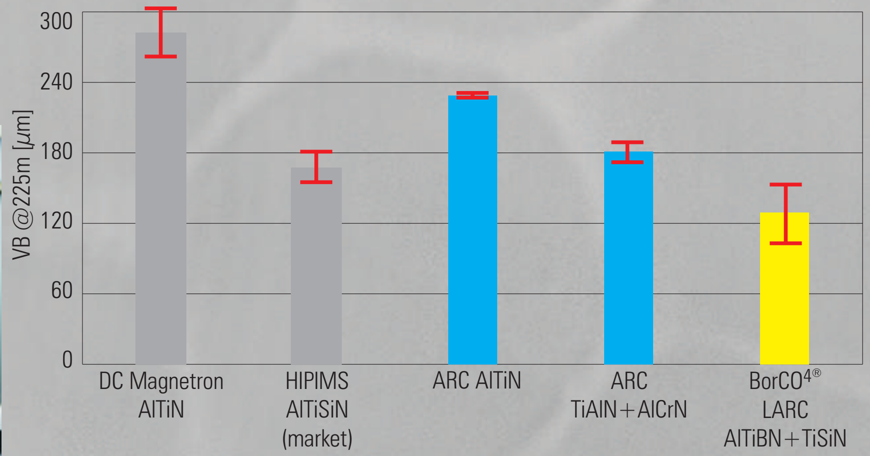




vc	182	m/min
n=vc*1000/d/Pi	5796	1 / min
f	0.14	mm/rev
vf=f*n	811	mm/min
Ball nose end mill d=10 mm		

Using LACS®-Technology with Boron and Silicon at Hard Milling (63 HRC)

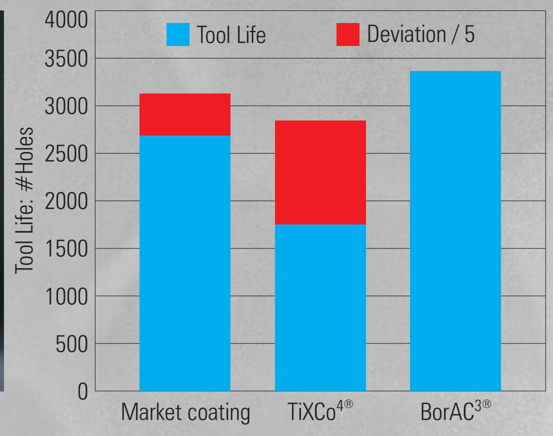
- Comparing: ARC and LACS® with sputtering references
- HIPIMS and ARC on a similar performance level in this test
- Lowest wear for the LACS® coating: BorCO4®



Material: Cold working steel, 1.2379 (SKD11), HRC 55, a_p =0.2mm, a_e =0.3mm, v_c =200m/min
Tools: LMT-Kieninger milling inserts, z =2, f_z =0.2mm/teeth – dry

Using LACS®-Technology — BorAC3® - AlCrN/BN: Wear Behavior at Reaming

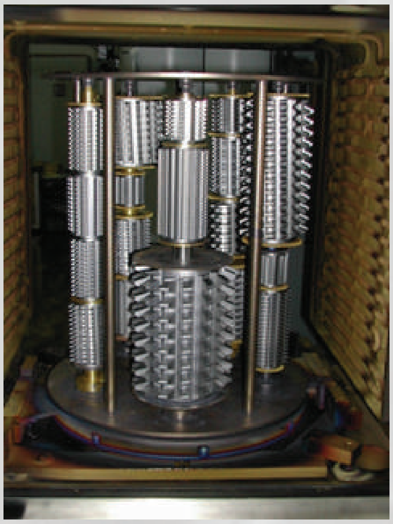
Picture source: Mauth GmbH, Oberndorf, Germany



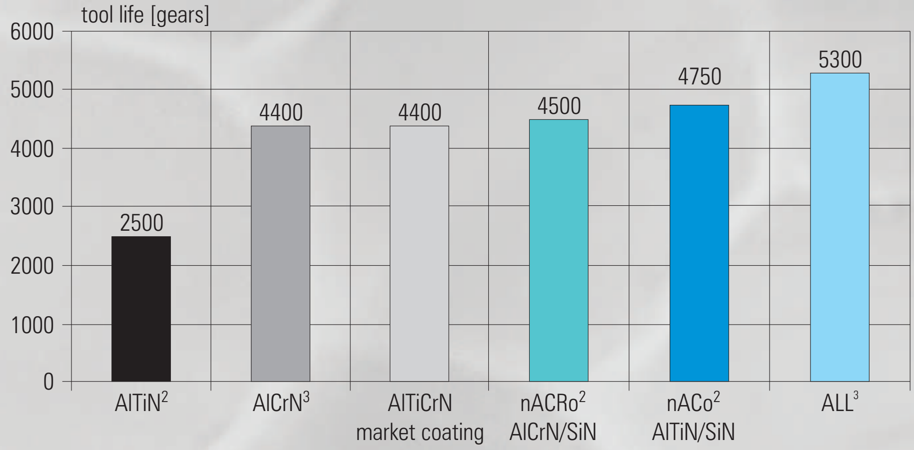
Cold working steel – R_m=500 N/mm² — Tolerance: H7
d=14mm - v_c=150 m/min - a_e=0.125 – f_z=0.06 mm – MQL

Dedicated Coatings
Developed by/with PLATIT's Users

Hobbing

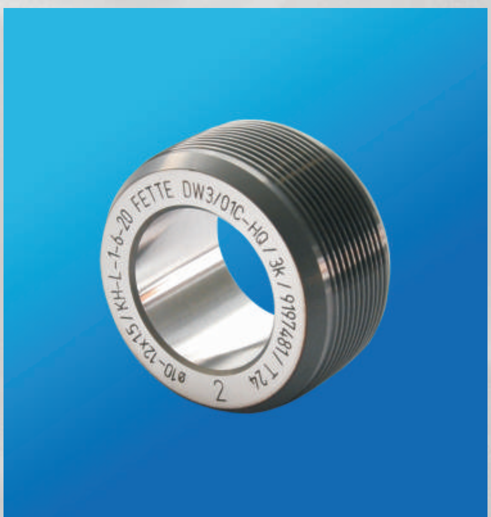


Tool Life Comparison

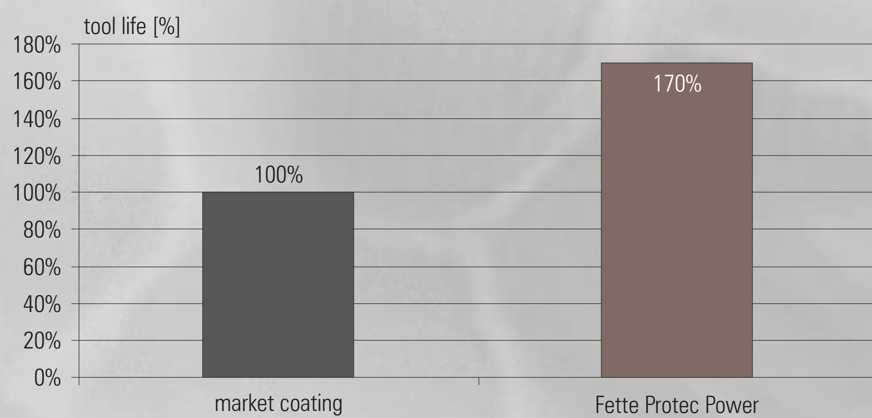


Material: 100Cr6 800-900 N/mm2 - Tools: HSS-PM4 - Modul=2.5 - vc=150 m/min
Developed by Liss, Roznov, Czech Republic

Thread forming



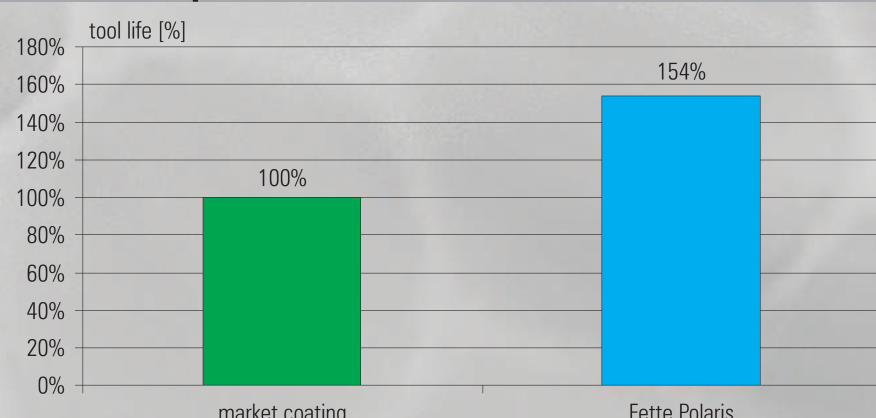
Tool Life Comparison



Work piece materials: Materials with high strength
Developed with LMT Fette, Schwarzenbek, Germany
Source: Werkzeugtechnik: 117 – Nov/2010 – p.71

Tapping

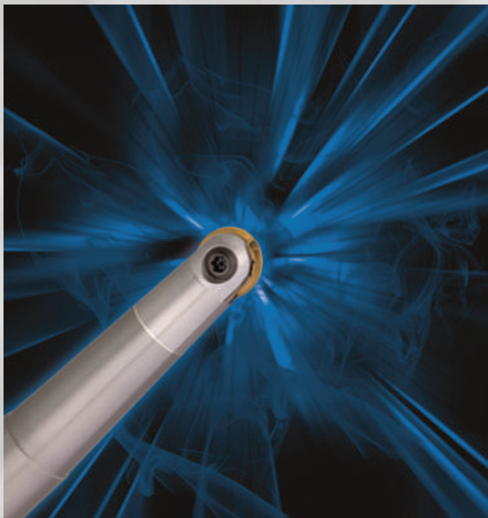
Tool Life Comparison



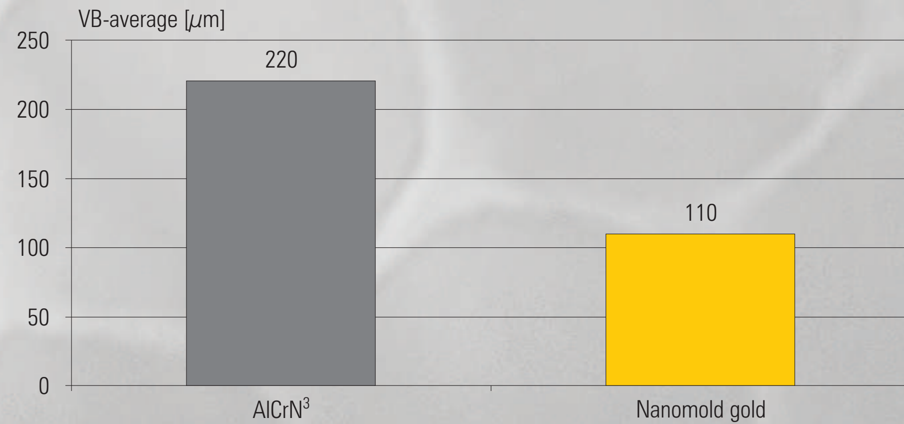
Work piece materials: cast iron and non steel materials
Developed by LMT Fette, Schwarzenbek, Germany
Source: Werkzeugtechnik: 117 – Nov/2010 – p.71

Applications

Mold and Die Milling

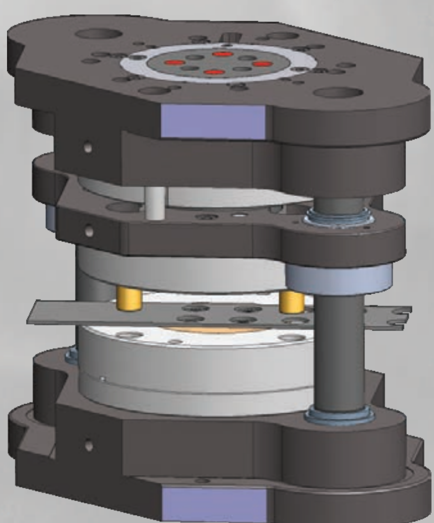


Wear Comparison after 1.0 h of Roughing

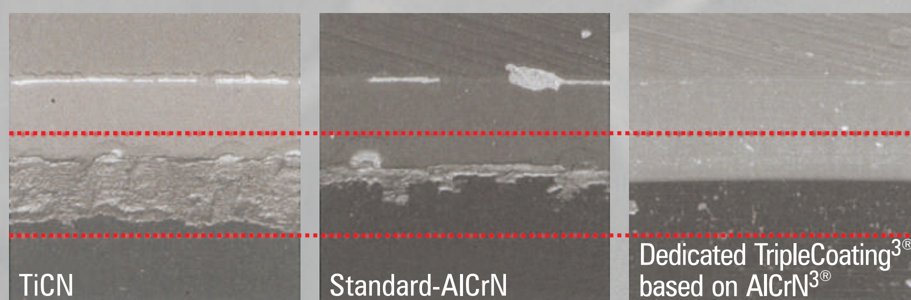


Work piece material: cold working steel - Rm=1000 N/mm^2 - Insert: WPR 16 AR - vc=240 m/min
n=4775 1/min - fz=0.4 mm - vf=3820 mm/min - ap=1.5 mm - ae= 1.0 mm
Developed with LMT Kieninger, Lahr, Germany

Fine Blanking



Comparative Analysis (SEM) after 30'000 Strokes



Coating detached, maintenance urgently needed.

Element requires preventive maintenance.

Element can continue in service.

Source: Feintool, Lyss, Switzerland

Injection Molding

Wear Comparison

Molds for aluminum alloys for automotive industry after the fabrication of 15 000 parts

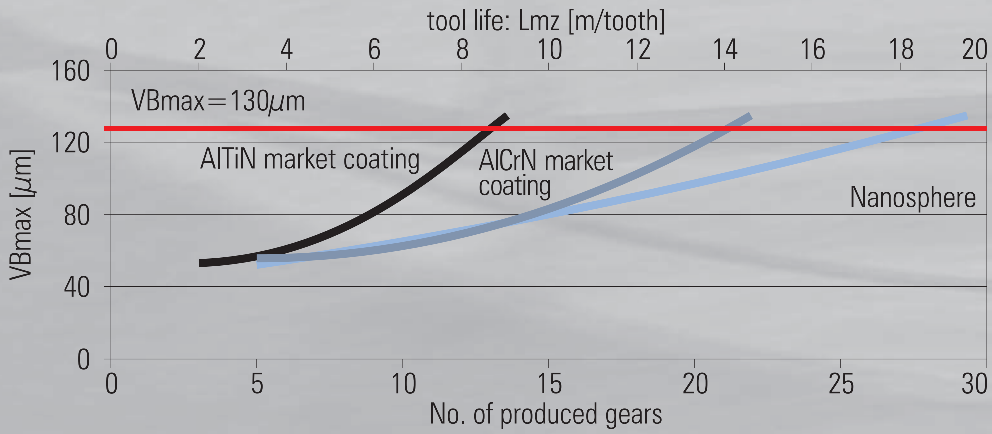
Plasma nitrided tool

Coated tool by ALLWIN, Cr-Al-Si based coating
Thickness: 2 to 3 μm

The lengths of the tools 180-200 mm - Diameters of tools: 15-25 mm
Developed by SHM, Sumperk, Czech Republic

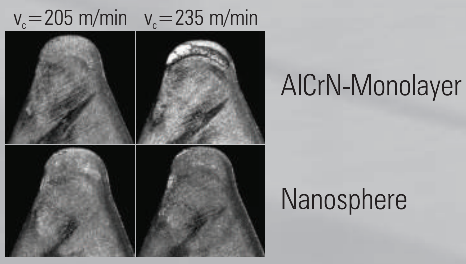
Dedicated Coatings
Developed by/with PLATIT's Users

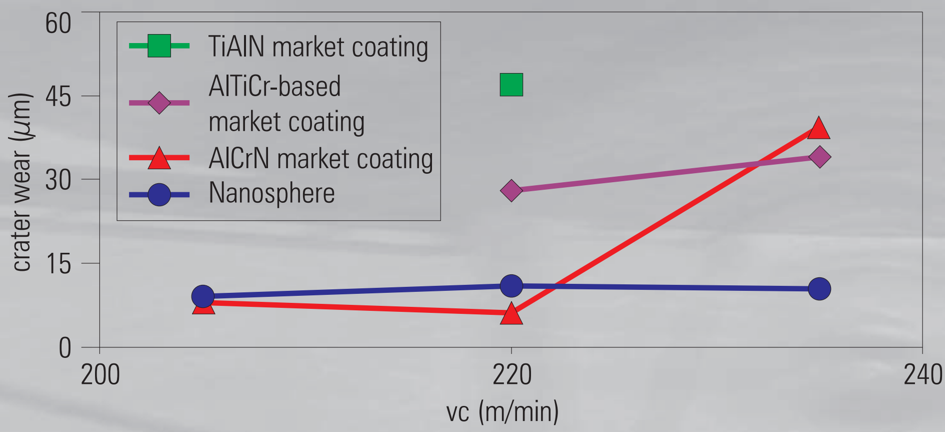
Wear Comparison at Hobbing with PM-HSS Tools



Mat.: 20MnCrB5 - Tool: PM-HSS - m=2.7 - Down hill milling - vc=220 m/min - fa=3.6 mm – dry
Source: IFQ Magdeburg in the development project LMT-Fette - PLATIT
The patented Nanosphere coating is a result of a common development project, exclusively for LMT-Fette

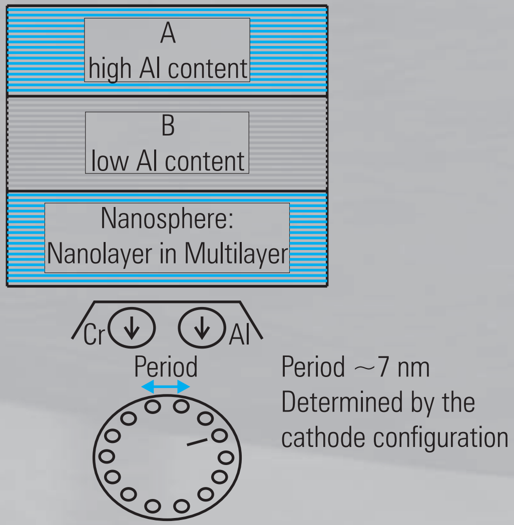
Crater Wear Comparison at Hobbing with PM-HSS Tools

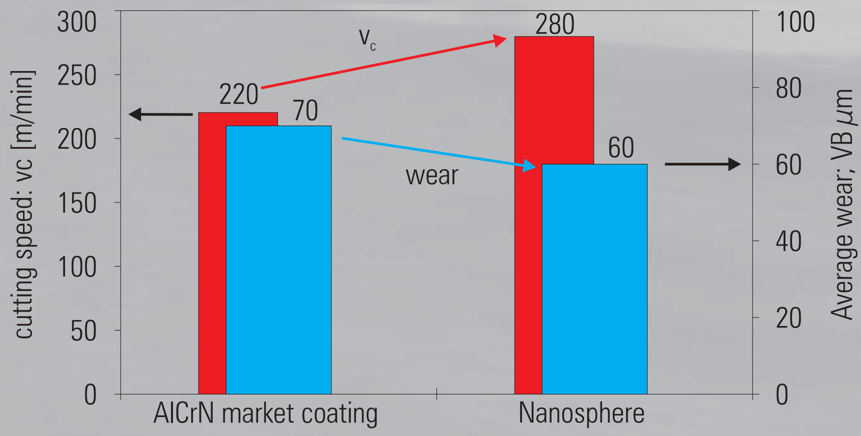




Mat.: 20MnCrB5 - Tool: PM-HSS - m=2.7
Down hill milling - vc=220 m/min - fa=3.6 mm - dry
Source: IFQ Magdeburg in the development project LMT-Fette - PLATIT

Technological Comparison at Hobbing with Solid Carbide Tools



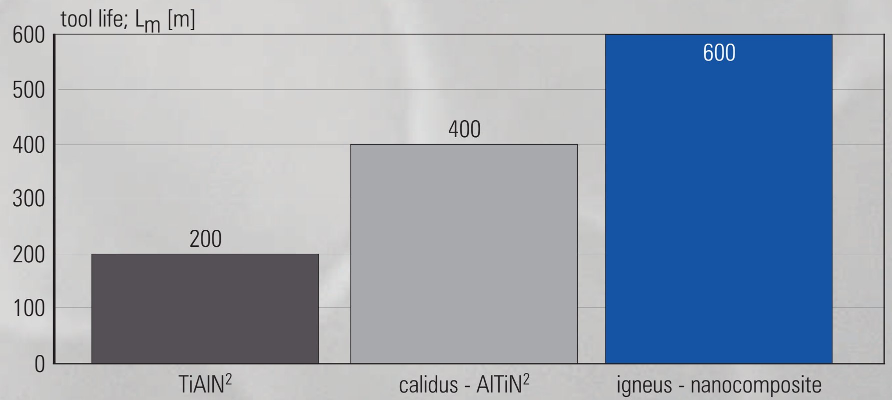


Mat.: 16MnCr5 - Tool: Solid carbide K30 - m=3 - b=40.5 mm - z=27
f=2.0 - 2.1 mm - wet cooling with emulsion
Source: Fette-LMT - Industry test at German car manufacturer

Applications

Milling

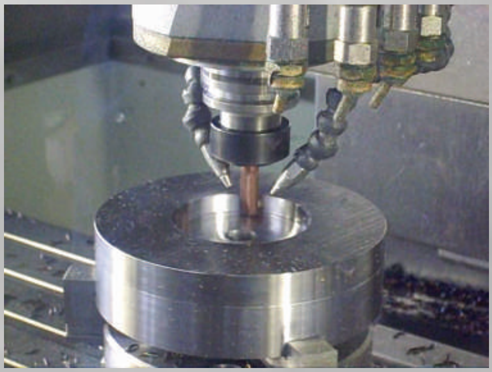
Tool Life in Hot Working Steel

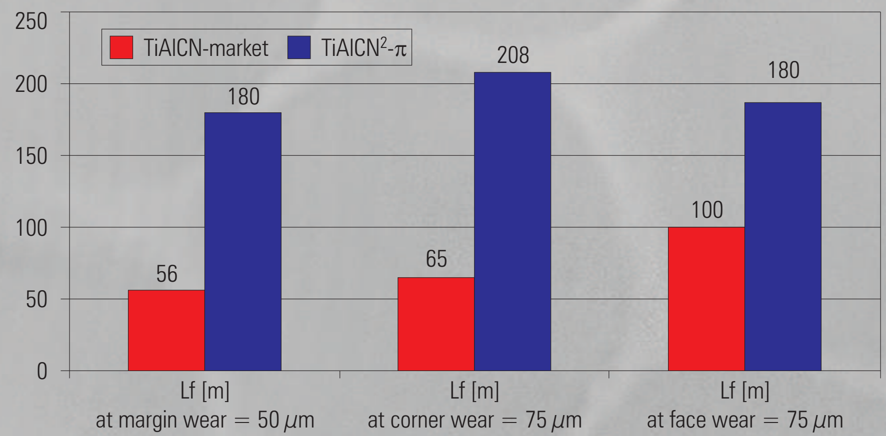


Work piece material: X40CrMoV5 – 1.2344 – R_m=1100 N/mm²
Tools: d=12mm - solid carbide end mill with corner radius r=2mm
v_c= 218 m/min – f=0.26mm - a_p=0.5mm – a_e=8mm – emulsion 7%
Source: Schlenker, Böbingen, Germany

Form Milling

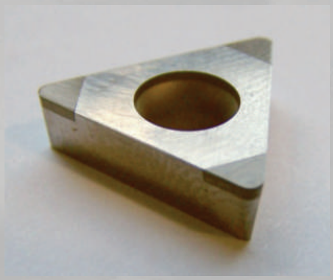
Tool Life Comparison

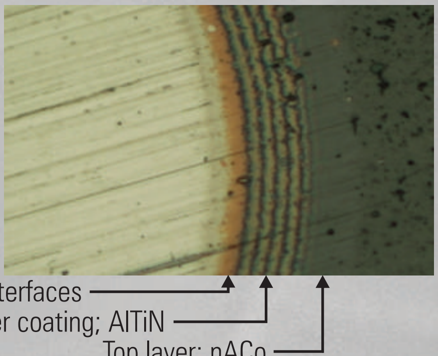


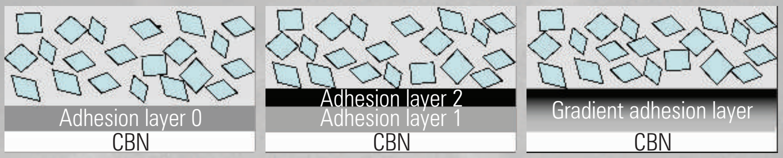


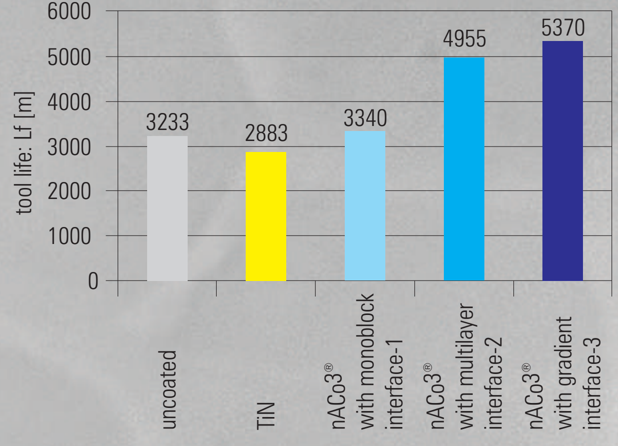
Carbide End Mills Ø10mm, z=4, steel 34CrNiMo6 (30 HRC), Coolant: MQL; Minimum lubrication - Tested tools: 2x4
Source: Carmex, Maalot, IL

Hard Turning using Coated CBN-Inserts with Special Adhesion Structure for nACo3®







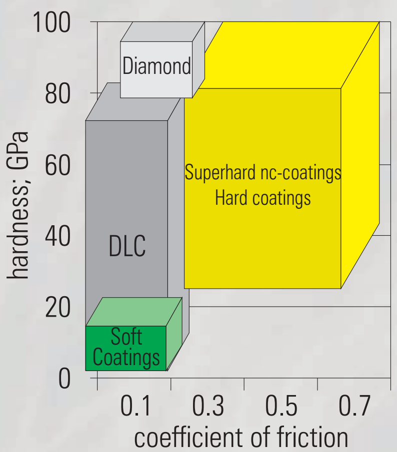


Mat: 100Cr6 - 63 HRC - vc=140 m/min - f=0.12mm - ap=0.2mm dry
Source: GFE, Schmalkalden, Germany

PLATIT 's DLC-Coatings

Diamond-Like Carbon (DLC) is a metastable form of amorphous carbon containing a significant fraction of sp^3 bonds. It can have high mechanical hardness, chemical inertness, optical transparency, smooth surface and low friction behavior.

Since their initial discovery in the early 1950s, DLC films have emerged as one of the most valuable engineering materials for various industrial applications, including microelectronics, optics, manufacturing, transportation, and biomedical fields. In fact, during the last two decades or so, DLC films have found uses in everyday devices ranging from razor blades to magnetic storage media.



Instead of using the term DLC, the term amorphous carbon is favored, to avoid the mix-up with diamond coatings, which are by definition crystalline.
These amorphous carbon coatings are classified into seven categories:

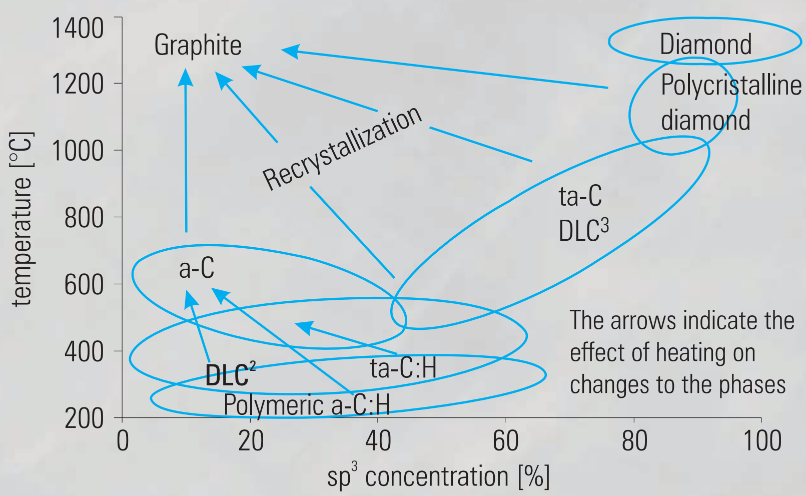
a-C	hydrogen-free amorphous carbon
ta-C	tetrahedral-bonded hydrogen-free amorphous carbon
a-C:Me	metal-doped hydrogen-free amorphous carbon (Me= W, Ti)
a-C:H	hydrogen-containing amorphous carbon
ta-C:H	tetrahedral-bonded hydrogen-containing amorphous carbon
a-C:H:Me	metal-doped hydrogen-containing amorphous carbon (Me=W, Ti)
a-C:H:X	modified hydrogen-containing amorphous carbon (X=Si,O,N,F,B)

		DLC^3				**CBC = DLC^1**	**DLC^2**
	a-C(:X)	**ta-C**	**a-C:Me**	**a-C:H (polymer)**	**ta-C:H**	**a-C:H:Me**	**a-C:H:X**
Process	PVD	PLD/ FCVA	PVD / MS	RS / PECVD	HPD- PECVD	PVD/PEPVD/CVD	PECVD
Interlayer	None or Ti	Ti / Cr	Ti / Cr	Si/Ti	-	Ti or Cr	Ti or Cr
Doping	None or Ti, Al, Si	None	Si/Ti/Cr/W	None	-	Ti or Cr	Si
H content [%]	0	0	0	40-60	25-30	~15	~20
Thickness (μm)	0.2-1	1	3	1/2	/	<5	<5
Young's Modulus (GPa)	200	>500	350	110/260	300	200	250
Hardness (GPa)	8 to 28	>50	30	8/28	50	<20	<25

PLD: Pulsed Laser Deposition – FCVA: Filtered Cathodic Vacuum Arc – MS: Magnetron Sputtering – RS: Reactive Sputtering – PECVD: Plasma Enhanced Chemical Vapor Deposition – HPD: High Plasma Density

Simplified Overview of Thermal Stability Limits of Different Categories of Hard Carbon Materials

Coating of punches with DLC^2 in the π111

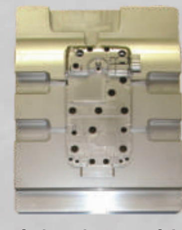


Source: K. Holmberg, A. Matthews, Coatings Tribology, Elsevier, 2007

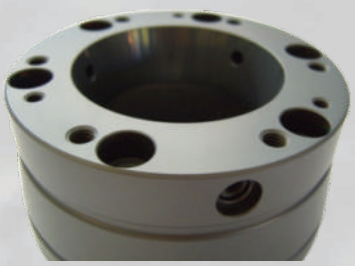
Applications with DLC-Coatings

Punches with nACVIc^{2}®

Fluteless thread former with CROMTIVIc^{2}®



Injection mold
coated with nACVIc®



Tool holder chuck
coated with nACVIc^{2}®

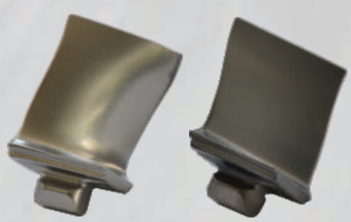
Camshaft with CROMVIc^{2}®

Control lever for cylinder head of
a racing car with Fi-VIc®

Thread former for TETRA Pak®,
made from copper, coated with cVIc^{2}®

Valves of a racing car
coated with Fi-VIc®

PET-Core with ALLVIc^{2}®



Uncoated and coated
turbine blade with Fi-VIc^{2}®

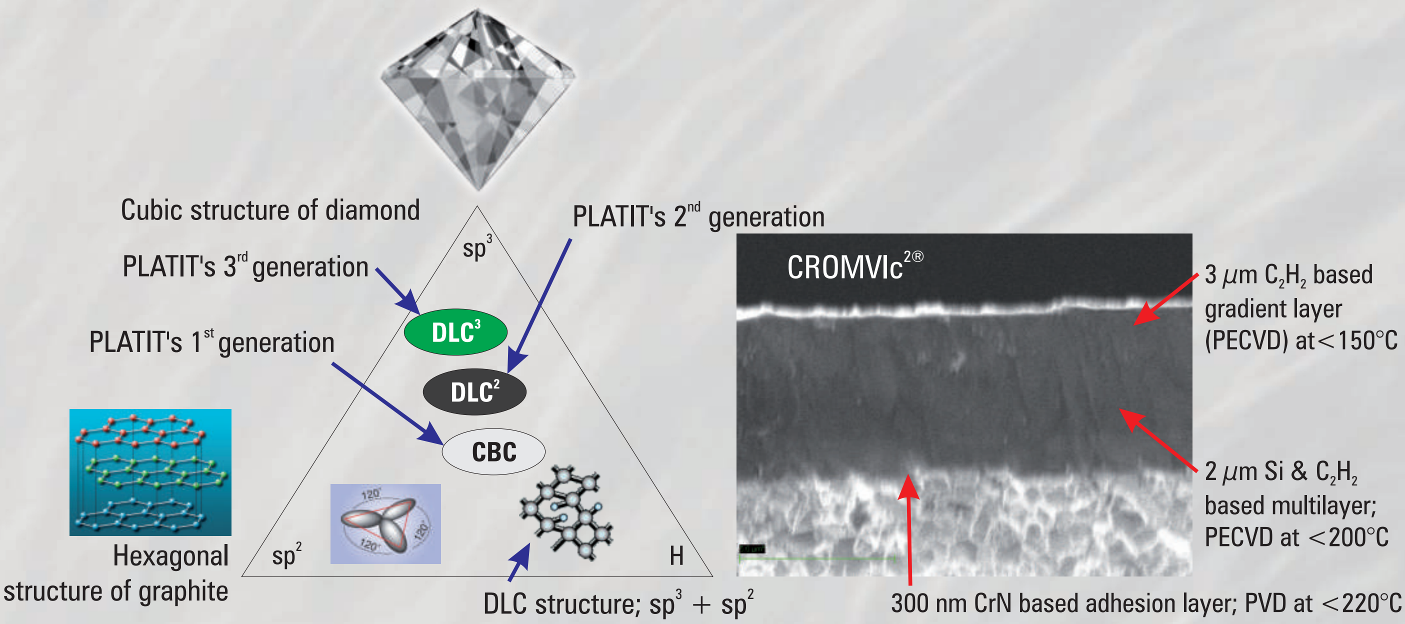
Medical Parts from titanium with cVIc®

Water pump shaft
coated with CROMVIc^{2}®

Machine parts
coated with CROMVIc^{2}®

Sewing machine part
coated with CROMTIVIc^{2}®

PLATIT 's DLC-Coatings



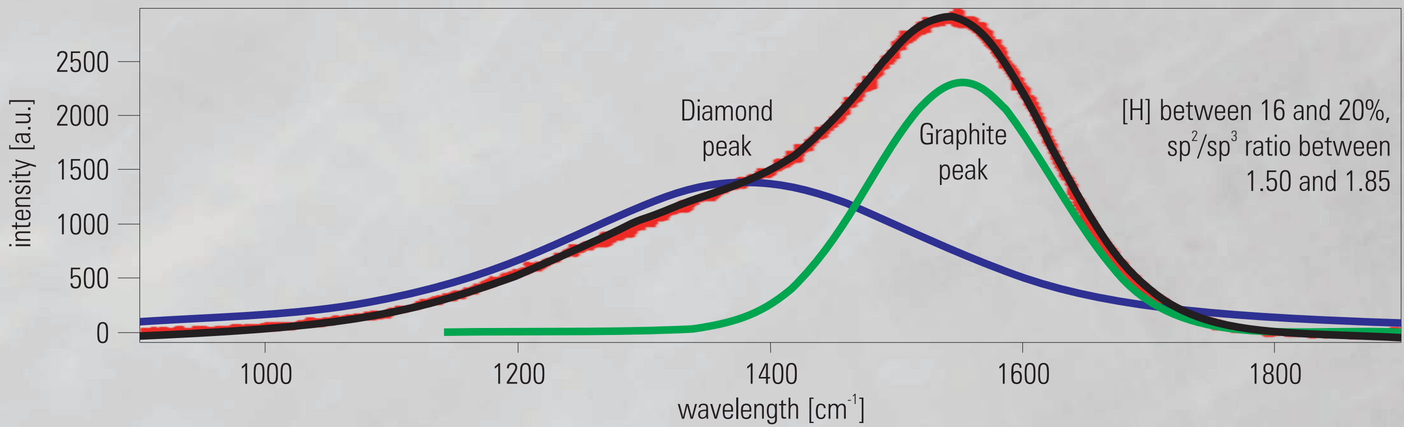
The goals of PLATIT's development of DLC-coatings

- The combination of the extremely good features of PLATIT's conventional and Nanocomposite coatings (especially of the outstanding adhesion) with the advantages of the DLC-coatings (like smoothest surface and low coefficient of friction).
- Deposition of double coatings, (PVD and DLC-coatings) in one chamber in one batch
- Profitable coating production with DLC even in small series, for:
  - high quality machine components - medical devices - aerospace components
  - cutting tools for composite materials with affinity for sticking - molds and dies and punches

Comparison of the most important features of PLATIT's DLC-coatings

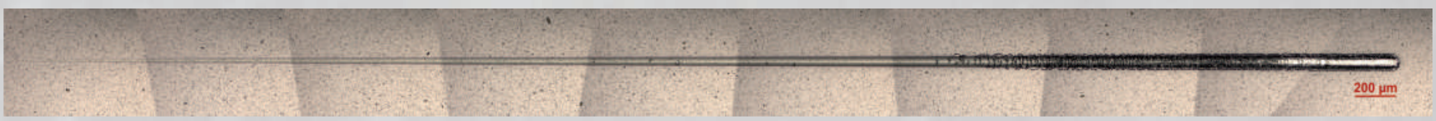
	1st generation	2nd generation	3rd generation
Name	**DLC¹ (CBC) - X-VIc®**	**DLC² - X-VIc²®**	**DLC³ - X-VIc³®**
Availability	Basis coating + DLC¹	Recommended as top coating Basis coating + DLC²	Basis coating + DLC³ for non-carbide Also without basis coating for carbide
Most common coatings	cVIc¹®	VIc²®, cVIc²®, CROMVIc²®, CROMTIVIc²®, nACVIc²®	VIc³®, cVIc³®, CROMVIc³®
Coating process	PVD	PVD+PECVD	PVD, filtered ARC
Deposition temperature	200 - 500°C	200 - 500°C	< 200°C
Composition	a-C:H:Me - Metal doped DLC	a-C:H:Si - Silicon doped metal free DLC	ta-C - Hydrogen-free DLC
Heat resistance	< 400°C	< 450°C	< 450°C
Internal stress	medium	lower due to Si	high
Typical thickness	up to 3 µm	up to 3 µm	up to 1 µm
Electrical conductivity	good	none	none
Hardness	< 20 GPa	< 25 GPa	> 50 GPa
Roughness	Ra~0.1µm - Rz~coating thickness	Ra~0.03µm - Rz~coating thickness	Ra~0.02µm - Rz~coating thickness
Friction coefficient to steel	µ~0.15	µ~0.1	µ~0.1
Wear resistance	Wear through after a short time	Wear through after a long time	Wear through after an extra long time
Main application goal	Improvement of tool's run-in behavior Lubrication by forming transfer films	Reducing friction for machine components, molds and dies	Cutting light metals, composites and graphite

Chemical Properties of DLC² of PLATIT



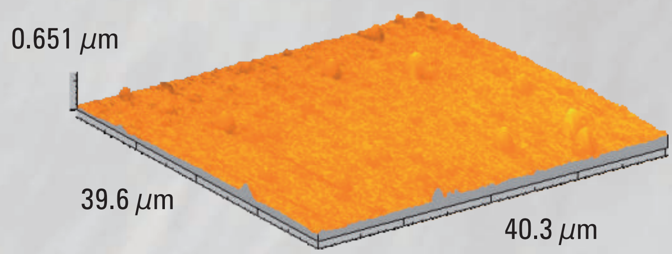
RAMAN Spectroscopy of CROMVIC2® with l=514.5 nm, Si calibrated, Labspec Software
G-band position: 1552.9 cm^{-1} - D-band position: 1382.8 cm^{-1} - Ratio IG/ID=0.85
Measured at Physics Department, Fribourg University, Switzerland

Adhesion measured by scratch-test: CROMVIc²® on carbide; L_{c2} = 74.3 N



Surface roughness measured by AFM: CROMVIc²® on carbide: S_a=0.0374 µm

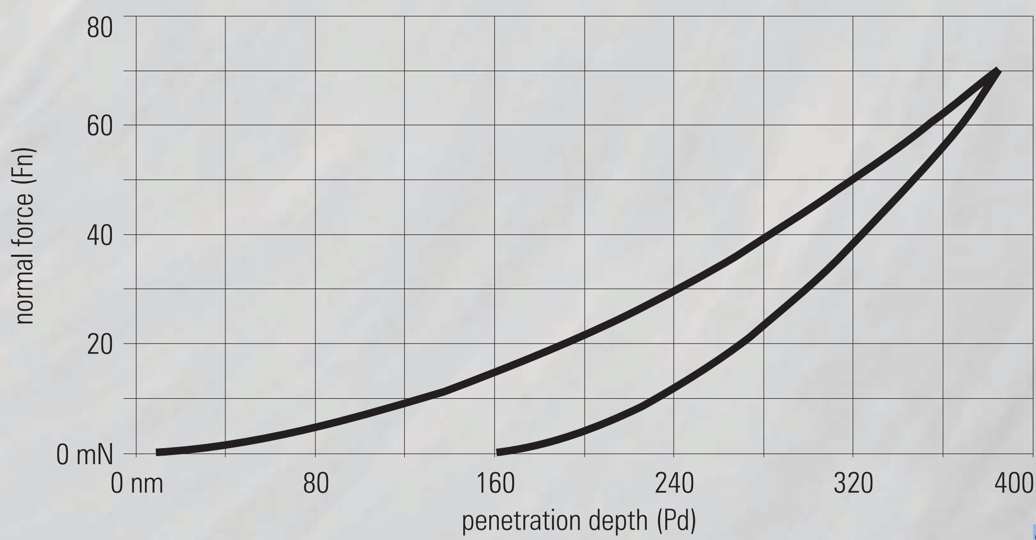
Sa	= 0.0374 µm
Sq	= 0.0501 µm
Sp	= 0.447 µm
Sv	= 0.136 µm
St	= 0.583 µm
Ssk	= 1
Sku	= 9.34
Sz	= 0.282 µm



Nanoindentation for Measuring Hardness of DLC² Coatings

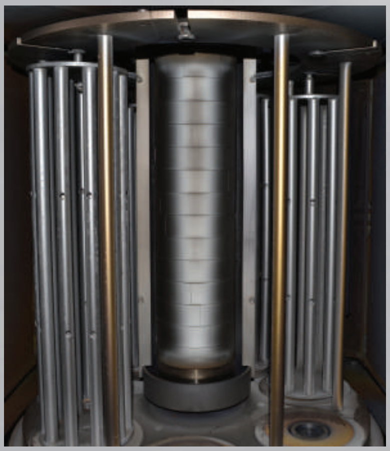
Berkovich Indenter
Method: Oliver & Pharr
Approach speed: 2000 nm/min
Acquisition rate: 10 Hz
Linear loading
Max. load: 70 mN
Loading rate: 70 mN/min

Main results:
HIT=25444 Mpa
EIT=331.99 Gpa
Hv=2356.4 Vickers



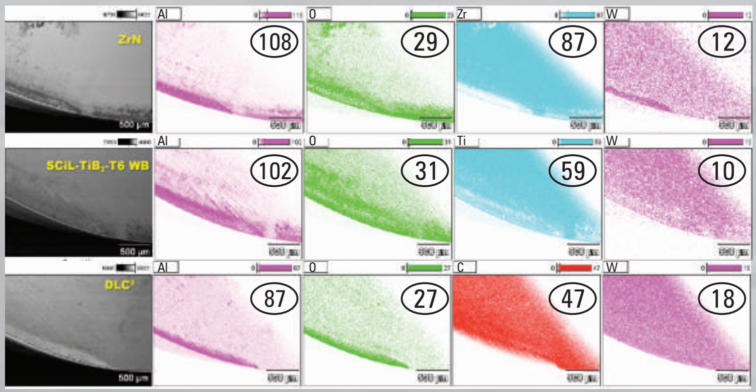
Friction Behavior of DLC² Coatings

Milling



Segmented TiB_2-cathode
for SCIL®-Technology

Comparison of the built up edges at aluminum cutting



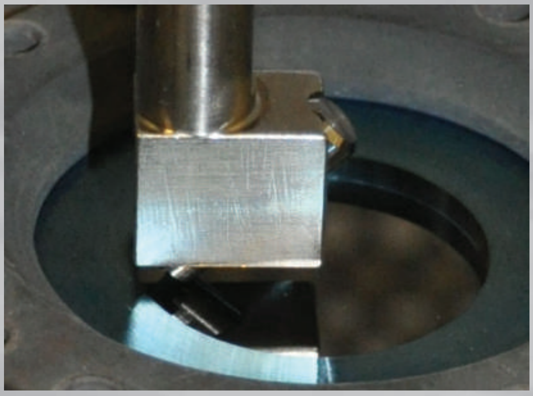
X EDX- detection frequency of the respective element: DLC³® deposited by π211

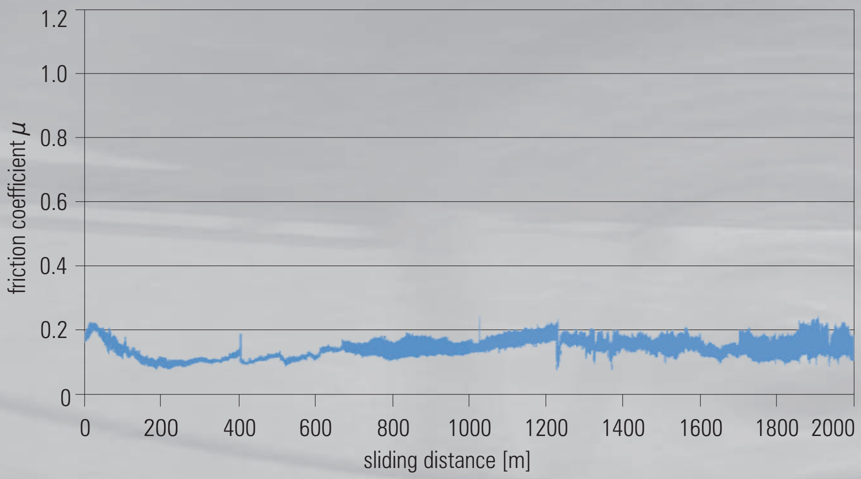
SEM and EDX after 283 m tool life

Material: 3.4365 AlZnMgCu1,5 - Tool: Torus end mill Ø12mm – r=2.5mm – z=2

vc=377 m/min – ae=5mm – ap=6mm – fz=0.2 mm/rev

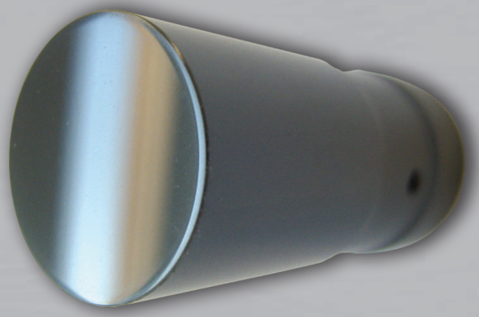
Measuring of the Coefficient of Friction by Pin on Disc Test at 400°C: nACVIc²® : μ=0.12 ±0.02

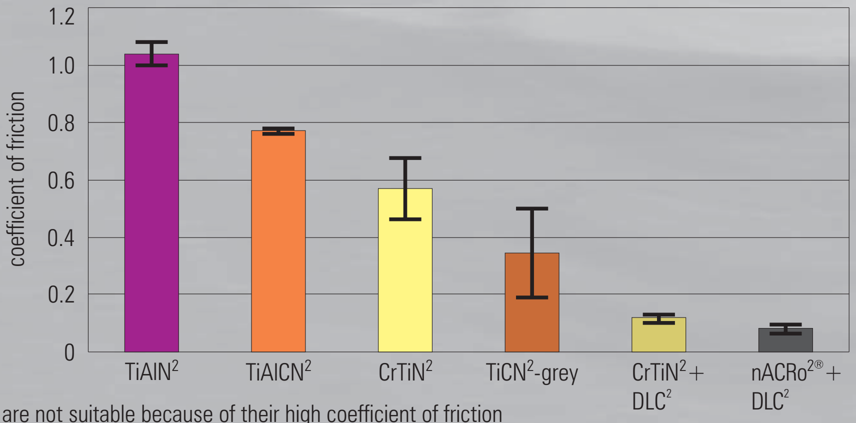




Pin on disc wear test with Ti pin grade 5 - r= 10 [mm] - Normal load : 2 [N] - Lin. Speed : 6.67 [cm/s] - Acquisition rate : 2 [Hz] - Rel. humidity: 0%

Coefficient of Friction Measurement by Pin-on-Disc Wear Test at 400°C





- (Ti, Al)-based layers are not suitable because of their high coefficient of friction
- Clear influence of the carbon gradient in the TiCN coating (high scatter)
- Excellent friction coefficients with DLC films and very low scatter
- Si-doped DLC survives more than 8-hour tests at 400°C !

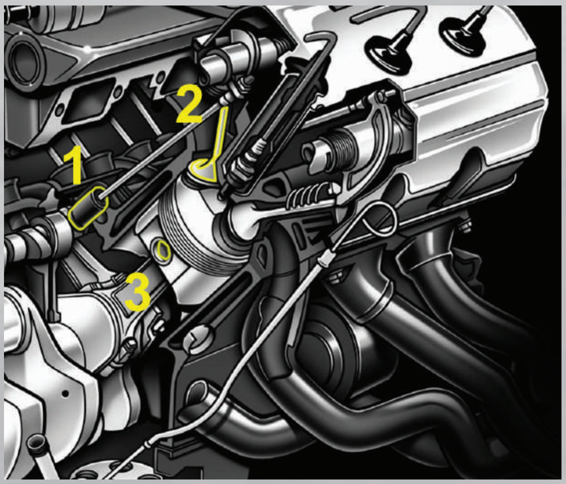
DLC² Coating in High Performance Racing Engines

Demanding Engine Applications for Racing Cars

1 → Mechanical lifter (M2 steel, 63-64 HRC)
Contact partner: tool steel camshaft with case hardened lobes
- No material transfer to the foot
- Low friction and high wear resistance

2 → Intake valve (Ti alloy)
Contact partner: AMCO45, Ni-Al Bronze alloy
- No material transfer to the seat
- Low friction on the stem

3 → Wrist pin (PM-HSS)
Contact partner: tool steel
- No material transfer
- Very low friction and low wear

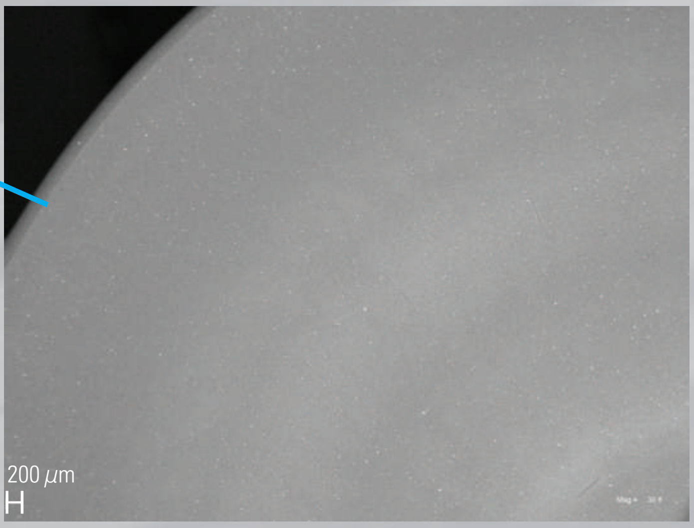


V8 engine, up to 9'000 RPMs, 750 HP

Coating Evaluation After Bench Test

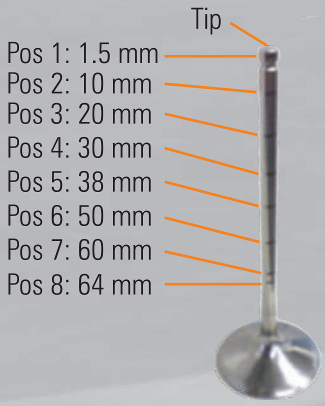
SEM micrograph of a lifter foot after a run with over 1000 miles

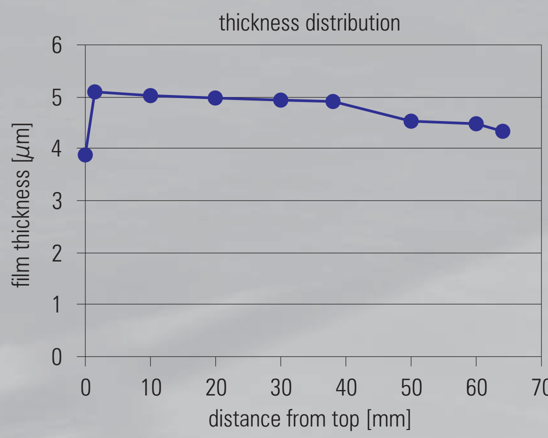
Result: Outstanding DLC² coating for reliability and performance

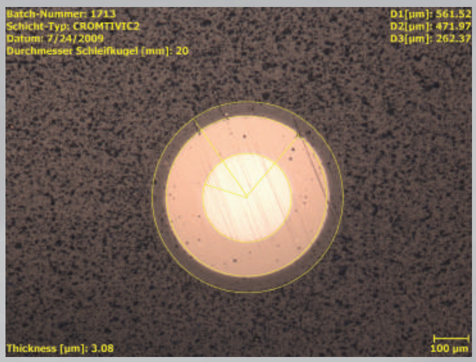


DLC² Thickness Distribution on Valve Shanks for Racing Cars, Deposited in π80+DLC Unit

One of the most important applications is the DLC-coating of valves for the racing and normal road cars, trucks and bikes.



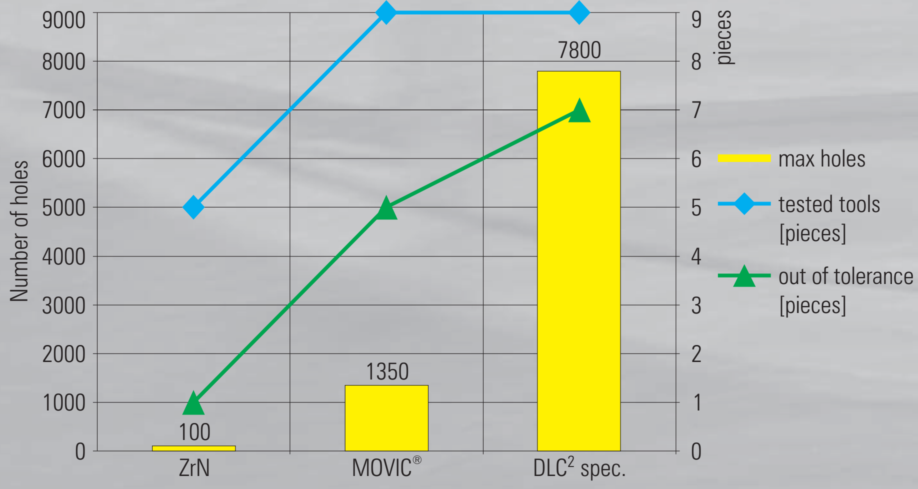




Using DLC Coatings in Small and Medium Size Industries

Micro Drilling in Titanium

Tool Life Comparison

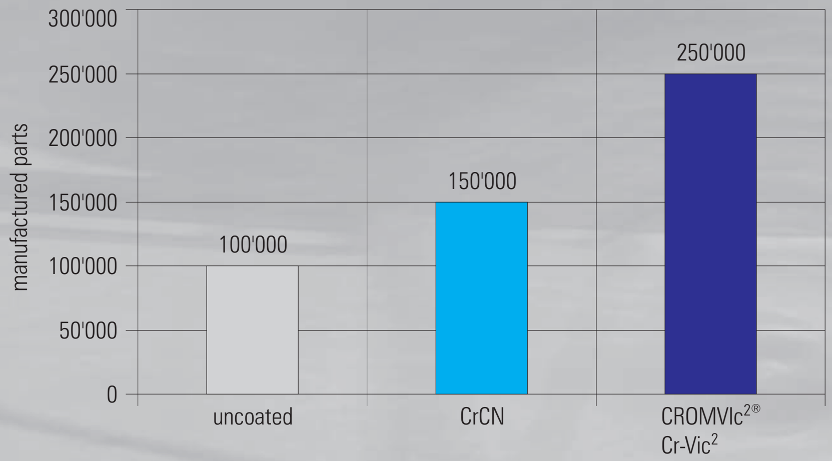


Source: Diamond SA, Losone, Switzerland

Minimizing of Wear and Friction at Extrusion

Manufacturing of case-parts from aluminum through extrusion

Coated tools for extrusion of aluminum-parts



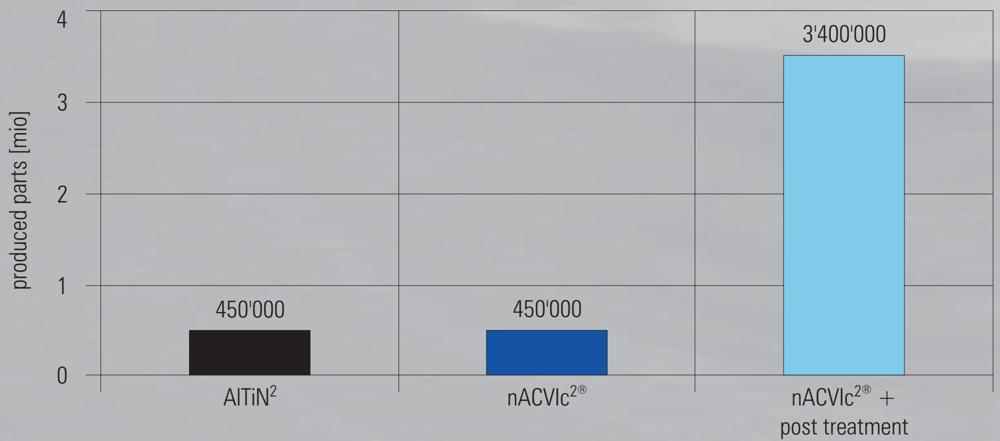
Result:
- DLC containing Si show very good tool life behavior

Source: Coexal Werkzeugbau, Gotha
GFE, Schmalkalden, Germany

Minimizing of Wear and Friction at Deep Drawing

Produced caps

Tool for deep drawing of aluminum parts

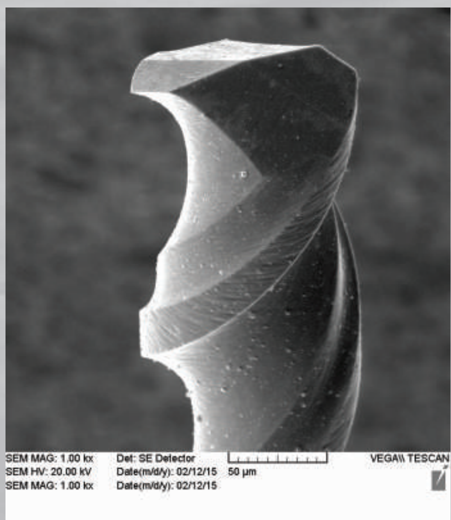


Result:
- Post-treatment absolutely necessary

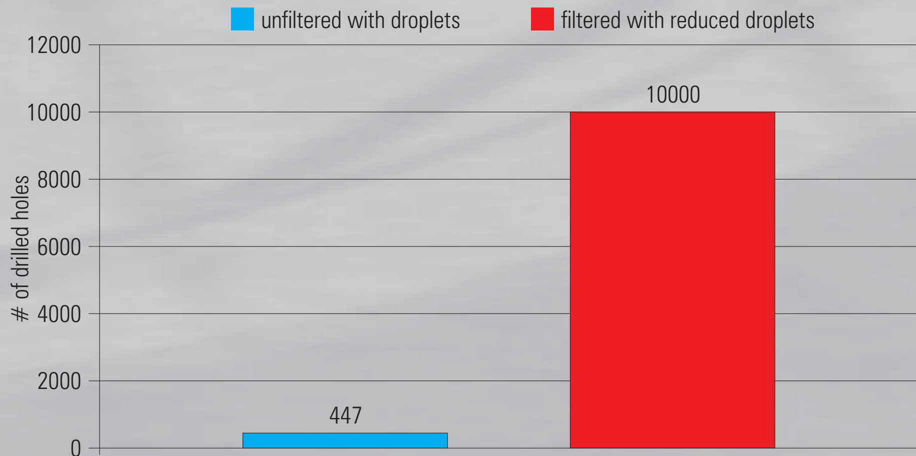
Source: Mala Verschlusssysteme, Schweina
GFE, Schmalkalden, Germany

Cutting Sticky Materials with DLC^2 and DLC^3

PCB Micro Drilling

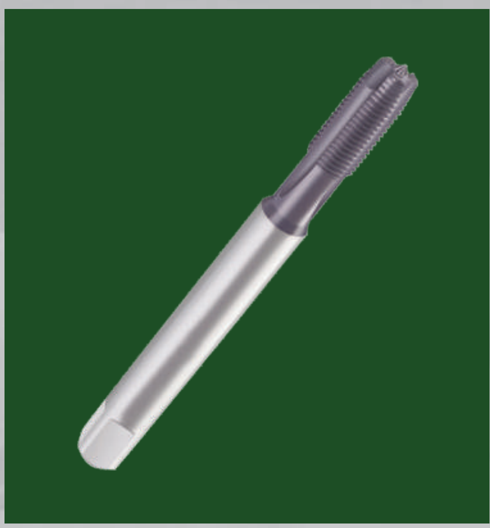


Tool Life Comparison

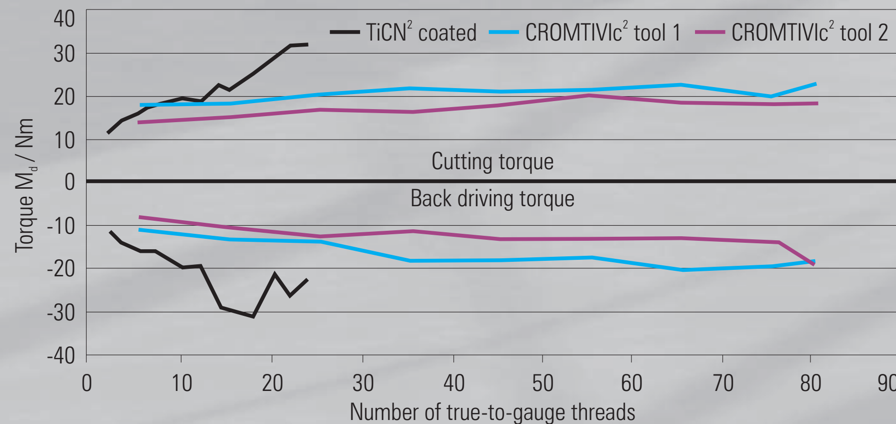


Coating: DLC^3=Cr-based ta-C - Workpiece material: printed circuit board - n=140'000 RPM
Source: Topoint, Taipei, Taiwan

Tapping in Titanium



Comparison of Cutting Torque with $TiCN^2$ and $CROMTIVIc^2$

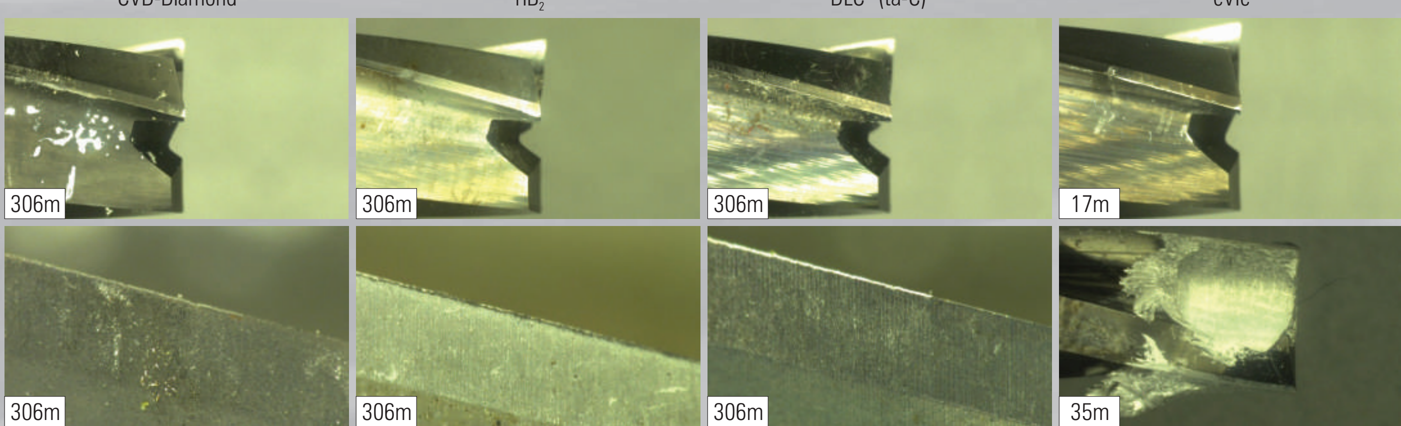


Material: TiAl6V4 - Tap: HSS - M10 - Thread depth a_p=24 mm
v_c = 8 m/min - Core hole diameter: d_c=8.5 mm - Coolant: Emulsion 10 % - external - p=50 bar
Source: IGF project - RWTH Aachen, Germany

Built-Up Edges at Dry Milling of Soft Aluminum Alloys With Different Coatings

The main target of the DLC^3 coating is to offer an economical alternative for expensive PCD-tools and CVD-diamond coatings.

CVD-Diamond | TiB_2 | DLC^3 (ta-C) | $cVIc^1$



Work piece material: AlMg4.5Mn - Tool: Solid carbide end mill d=8mm - v_c=250 m/min - f_z=0,16 mm - a_p=5 mm - dry - Source: GFE Schmalkalden, Germany

Why Integrate Coating in Small & Medium Sized Enterprises?

What is Important for the Users of Coatings?
or
The Most Important Reasons for In-House Coating

Importance for the Users

Independence
Full Production in one's own hand

With the own coating unit the tool maker is independent and can influence and warranty the performance of his product in full.
"Thanks to my flexible, complete tool production with integrated coating, I can more than a match for big companies!" M. Mauth, Oberndorf, Germany

Delivery Time

The short delivery time is extremly important, the A and O nowadays.
With the own coating unit, tool maker can produce special tools in one day, included grinding and coating.

Minimal Packaging and Transport

8 - 15 % of the tools will be damaged by the double transport to and from the job coaters.

Quality

The best job coater can not deposit the optimum coating for every tool.
Among other things basically not because he can not prduce the optimum coating thickness for the different mixed tools in his usually big chamber, see page 93.

Price / Business

The return of investment is around 1.5 - 2.5 years, see page 131.

Innovative, Dedicated own Coatings, Brands, Colors

The tool maker can adapt the coating to his tool geometry, see pages 118-125.

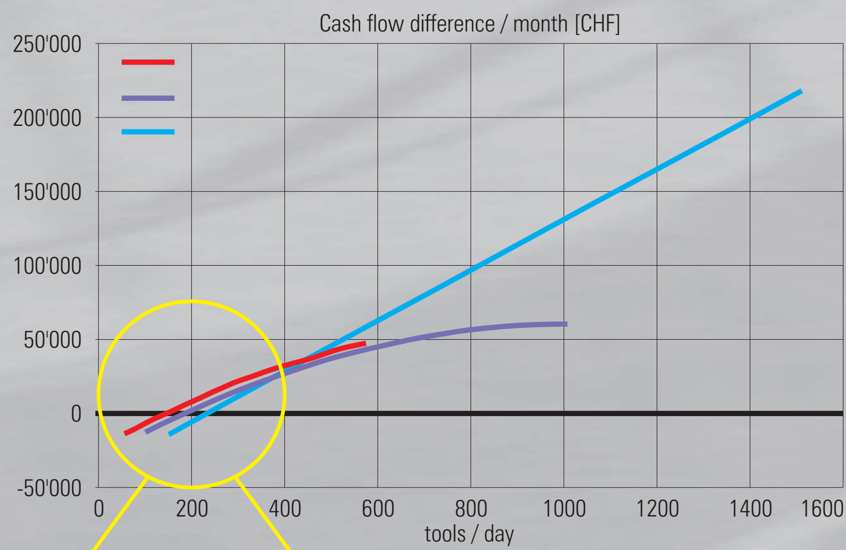
Wide, Flexible Coating Spectrum

SME should be able to coat very different coatings every day, see page 78-93.

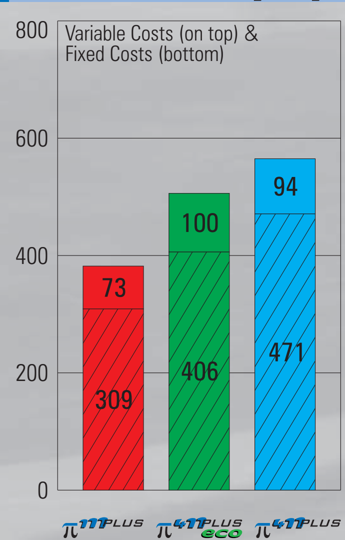
Economics - When should an SME change to integration?

Cash Flow Difference at Leasing of Small and Medium Size Coating Machines

- Investment calculated with coating unit, recipes, cathodes, basic holders, PVD accessories, cleaning system, quality control system
- Shifts per day: 1
- Leasing rate / month calculated with 4%
- Variable costs: energy, target, gas, water, detergents
- Fix costs: loan (credit), labour, social. rental costs and depreciation
- The costs which arise in case of job coating within a tooling company from transportation, repeated packaging, handling, rejected deliveries and damages are NOT considered.

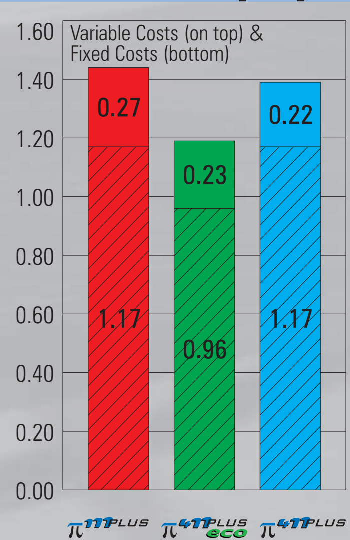


Total Costs / Batch [CHF]



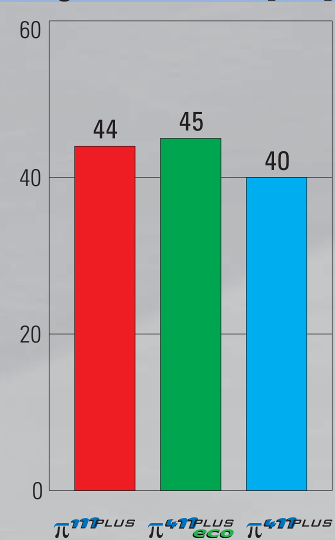
Valid for mixed tool spectrum, see page 40

Total Costs / Tool [CHF]



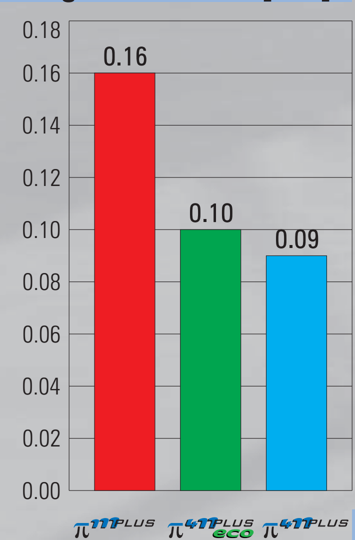
Valid for ø10 mm end mills

Target Costs / Batch [CHF]



Valid for mixed tool spectrum, see page 40

Target Costs / Tool [CHF]

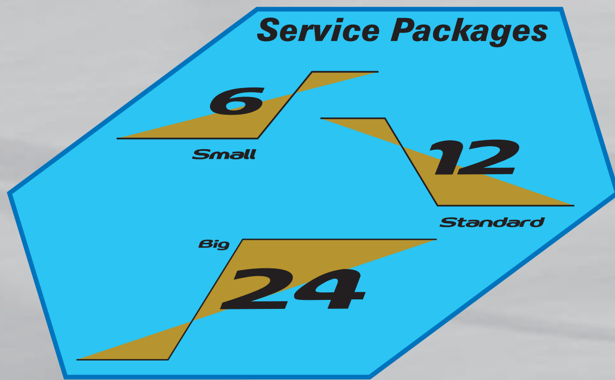


Valid for ø10 mm end mills

World Wide Service
Service Concept

Remote Diagnostics and Online Control

- Fast and secure online connection between PLATIT and customers worldwide
- Firewall protection should be installed by user's IT
- Remote and on-site diagnostics of all components and processes with graphical trace files
- Most recommended software for remote control and diagnostics: Teamviewer
- Remote diagnostics only possible with user's assistance



Standardized scopes of supply and services. PLATIT® recommends frequent services every 6 months.

π111
π211
π311
π411
π1511

based on 2 shifts/day and 5 days/week

Small	Standard	Small	Big
Small Service After 6 months: • Machine diagnostic • Maintenance on vacuum pump system 6 Official Service Label	**Standard Service** After 12 months: • Machine diagnostic • Maintenance on vacuum pump system • Complete chamber cleaning • Replacement of all sealings in vacuum system 12 Official Service Label	**Small Service** After 18 months: • Machine diagnostic • Maintenance on vacuum pump system 18 Official Service Label	**Big Service** After 24 months: • Machine diagnostic • Maintenance on vacuum pump system • Complete chamber cleaning • Replacement of all sealings in vacuum system • Replacement of heater elements 24 Official Service Label

Premium Plus status is awarded to customers upon regular completion of all four packages

Premium Plus

Premium Plus advantages based on 6/12/18/24 service concept:

- **Constant coating quality**
- **Reduced maintenance cost**
- **Maximized machine uptime**
- **Support via phone and internet included**

Options

Customized Service

Coating Units

π111
π211
π311
π411
π1511

- PLATIT Service packages
+ Specific end user needs

Maintenance Option 1

Rotary Pump

π111
π211
π311
π411
π1511

- Blade exchange of rotary pump at customer site
- Optional service of turbo molecular pump is provided in cooperation with Pfeiffer Vacuum

Maintenance Option 2

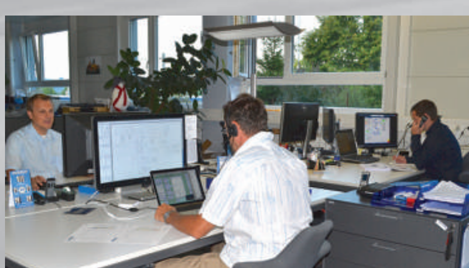
Cleaning Units

V80
V300
V311
V1511

- Annual service of the V-series cleaning units

Production Optimization

- Substrate Quality Analysis
- Production Flow Analysis
- Improvement Study



Official PLATIT Service Label

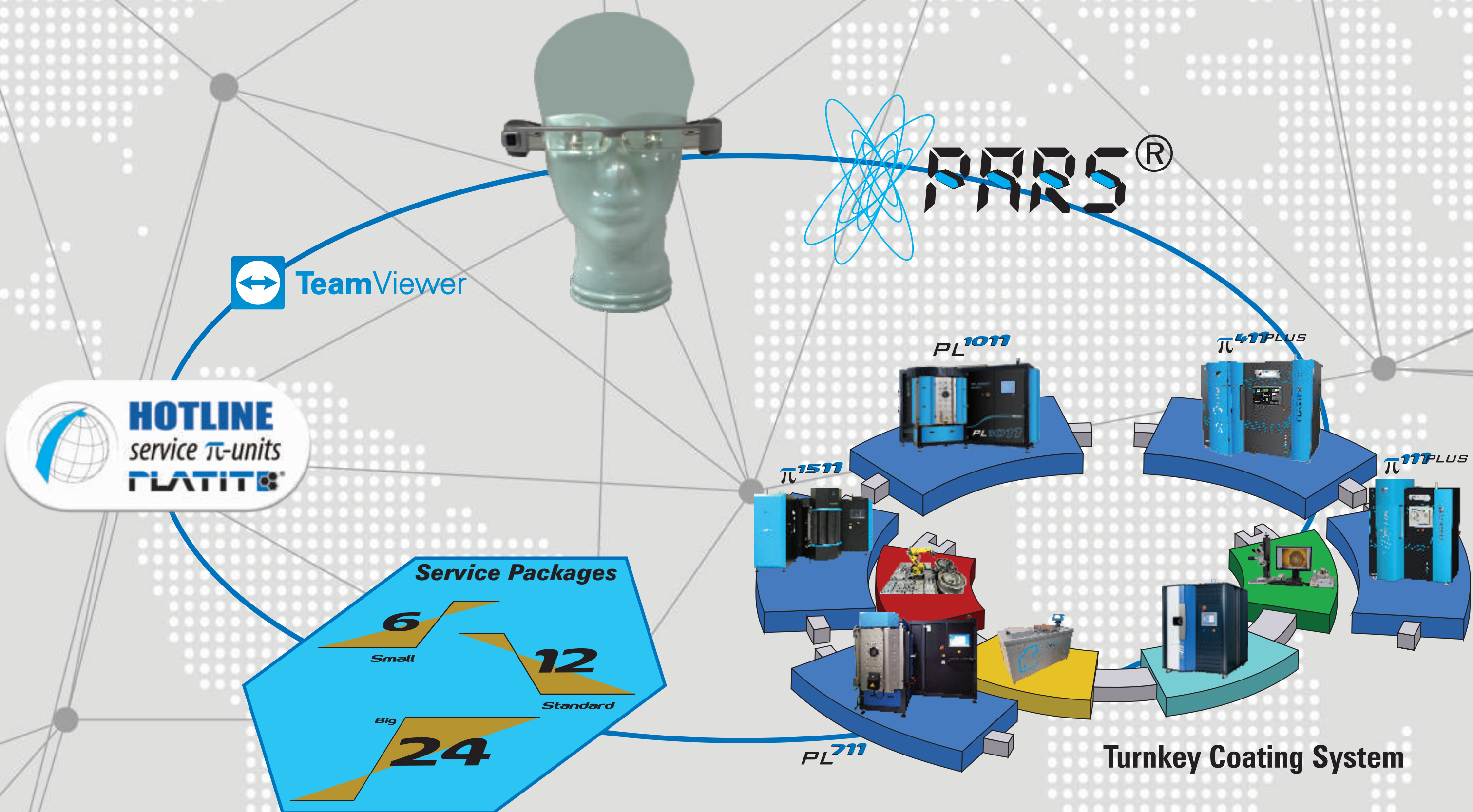
Each serviced unit is identified by a service label, which includes a link that leads the user to the PLATIT service database.

This database describes all carried out services and indicates upcoming recommended maintenance work.

PLATIT Augmented Reality Support
The New Service

PARS®-Service Process:

- The PLATIT machine user signs a service agreement with PARS®-option.
- The coating unit needs to have a fast internet connection (> 5 Mbit/s).
- In a service incident the operator connects the unit and PARS®-glasses to the internet.
- The operator puts on the PARS®-glasses and looks at the problem with the service-technician online.
- The service-technician marks the critical area on his computer screen, which also appears in the operator's glasses. He guides the operator with audible and visual suggestions on how to solve the problem.



Advantages of the PARS®-Service

- Worldwide presence without travel
- Shortest reaction time from 7:00 AM to 3:30 PM (CET)
- Saving of travel expenses
- Saving of labour costs
- Increase of service availability
- Reduction of production downtime

TeamViewer is a remote maintenance program of TeamViewer GmbH, Göppingen Germany

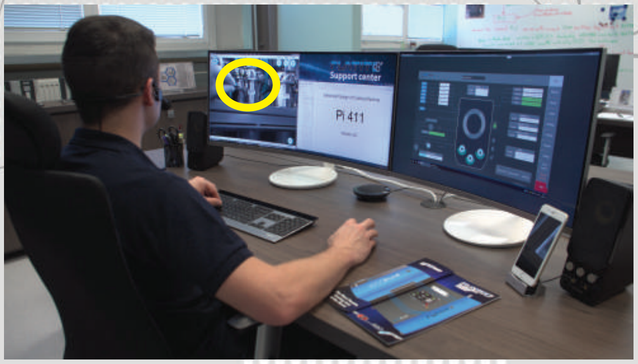
The Virtual Service-Technician in Action

Example case

10:00 AM
Alarm at the customer site

10:05 AM
The operator contacts the PLATIT hotline, establishes internet connection, and a support session:

- Using the PARS®-glasses for his view and
- TeamViewer for the coating unit.



10:10 AM
The service-technician on duty reviews the problem and trendfiles of the interupted process through TeamViewer.

10.15 Uhr
The operator and service-technician look at the machine through the operators PARS®-glasses.
The service-technician recognizes, that a cathode's striker is stuck. He marks the problem on his screen, which also appears in the PARS®-glasses.

10.25 AM
The operator resolves the problem, the production can continue. The virtual technician has avoided:

- travel,
- production downtime, and therefore
- thousands of € in cost.

Cathode Exchange Centers

Customer with PLATIT equipment
π80, π111, π111PLUS, π211, π300, π311 eco, π311, π411 eco, π411, π411PLUS & π1511

1. Customer requests for a refurbished cathode to CEC by email or fax

PLATIT's Cathode Exchange Centers (CEC):

- Sumperk, Czech Republic (EU)
- Libertyville, IL, USA
- Seoul, South Korea
- Curitiba, Brazil
- Shanghai, China
- Moscow, Russia

2. CEC dispatches cathode within 24 hours from stock

3. Customer ships used cathode back to CEC within 8 days

CEC-System = Lifetime Warranty for Cathodes

Stock of cathodes:

LARC®:

- Ti
- Al
- $AlSi_{06}$
- $AlSi_{12}$
- $AlSi_{18}$
- Cr
- Zr
- $TiAl_{50}$
- $AlTi_{33}$
- $AlCr_{30}$
- $AlCr_{45}$
- $TiSi_{20}$
- $CrTi_{15}$

CERC®:

- $AlTi_{33}$
- $AlCr_{30}$

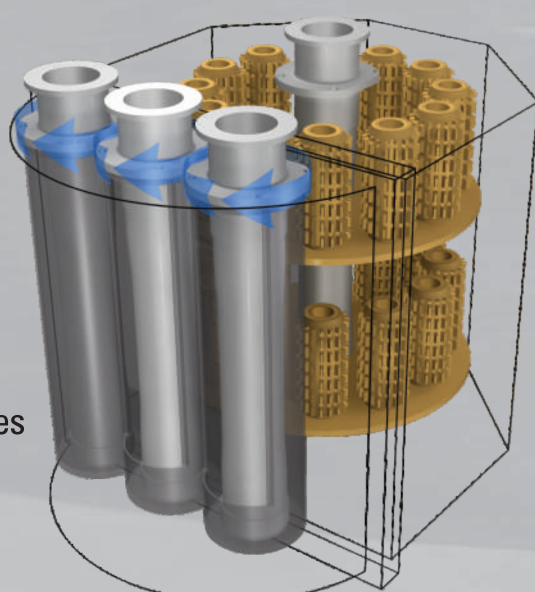
Type of cathodes depending on the machines types:

π80 / π300 / π311 :	short	e.g. Ti-short
π111 / π411 :	long	e.g. Ti-long
π111PLUS / π411PLUS :	plus	e.g. Ti-plus

SCIL®-Cathodes:

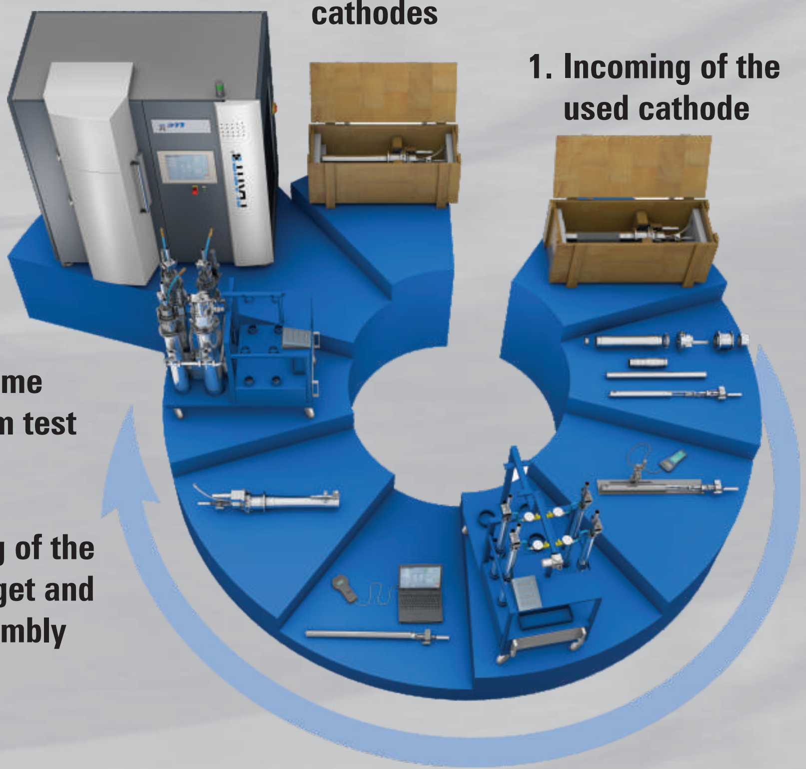
- Ti-SCIL®
- B_x-SCIL®
- $TiAl_{50}$-SCIL®
- TiB_2-SCIL®
- $AlCr_{30}$-SCIL®
- W-SCIL®

CERC® Cathode



LARC® Cathodes

Technical Process of Target Exchange in CEC



8. Burning in under production conditions

9. Stock of refurbished cathodes

1. Incoming of the used cathode

2. Disassembly, recycling of the used target

3. Replacing wear parts, setting of mechanical elements and the magnetic field

4. Long time test of the mechanical functions

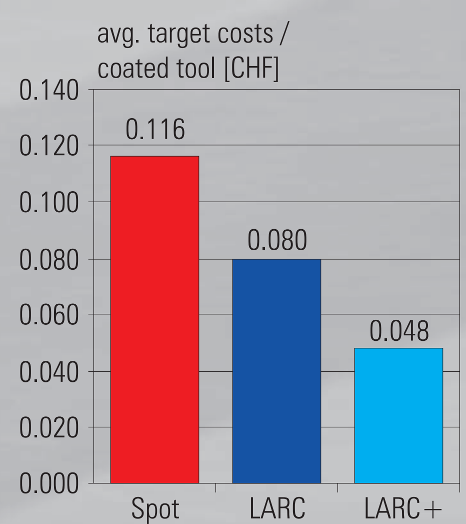
5. Writing of the cathode's identification chip

6. Inserting of the new target and full assembly

7. Long-time vacuum test

Advantages for the Users by PLATIT's Cathode Exchange Principle and Centers

- PLATIT's warranty for exchange quality
- No stocking costs for the users
- Cathodes are renewed by CEC at every change to state of the art
  - All wear parts are new after every change by CEC
  - Cathodes are long-time vacuum tested at CEC after every change
  - Optimum setting and burn in by CEC
  - User just quickly changes the cathodes
    - no setting, no weighing, no burn in by user
- Minimum transport costs and duties around the world
- Always high quality target material
- Environment friendly recycling of used target material by CEC
- Low target costs (see figure)
- The CEC system has been working at high satisfaction of users for many years



Calculated for the coatings AlTiN, AlCrN, AlTiCrN, nACo, nACRo
Machine: π411 - Tools: ø10mm end mills
LARC cathodes: Ti, Al, Cr, $AlSi_{18}$ - ø96x 510 mm - CERC cathodes: $AlTi_{33}$, $AlCr_{30}$ - ø110x510 mm
Machine with spot targets: 6 cathodes with Ti, Cr, AlCr, TiAl, AlTi targets - ø150 mm

World Wide Service

Training Programs

Training Certificate

PLATIT
Advanced Coating Systems
SWISS QUALITY

Operator Certificate

π111 Operator Basic Certificate

The Employee of

Compendium Ltd.
Road 20,
12345 City
Country

Mr. Marc Johnson

has successfully finished π111 Basis Operator Training.

Content

- Basics in Vacuum Technology
- Operating of Pi 111
- Service and Maintenance of Pi 111
- Surface Cleaning
- Edge Preparation
- Decoating
- Quality Control

Issued 2015 July 9

Approved by Dr. Tibor Cselle
CEO of Platit AG

Platit Advanced Coating Systems
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Installation Training

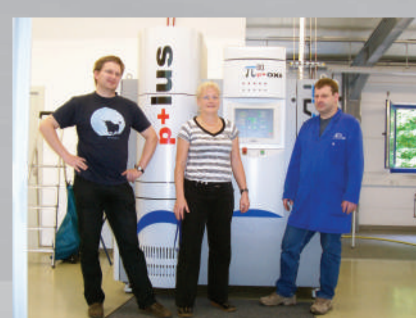
The installation trainings are carried out by our service team on location of our users.

Training on Demand

Our project engineers give dedicated trainings on a wide range of subjects from the basics to special fields.

Advanced Training

The advanced trainings take place on location of the user, or in our headquarters by our project engineers or our R&D people, typically for the installation of dedicated coatings.



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