A new generation of PVD coatings
PVD coatings (Physical Vapour Deposition)

PVD is applied to many tools, including drills, end mills, rotating tool inserts, and inserts for difficult-to-cut materials.

As the coating temperature of PVD is lower (around 700°) than that of other coatings applied to the cutting tools, damage to a substrate during coating is reduced. This maintains the toughness of even sharp edges and a coated layer with superior wear resistance and heat resistance is formed using the latest coating technologies.

PVD is applied to tools that require sharp cutting edges and shape maintainability.
In the past, almost all coating materials have been either TiN or TiCN for improved wear resistance. However, with the rapid development of PVD coating technology, (Al, Ti) N coating with thermal stability has become the most popular coating material in recent years and achieves high quality and performance for the machining of hardened steel and stainless steel, which have been difficult-to-cut materials. Through the use of Al-Cr-Ti based components and optimized layer coatings, Mitsubishi Materials continues to take a fresh approach to enable a wide range of different machining applications.

Next-generation PVD

It has already been 30 years since the PVD coating was developed. To satisfy our customers’ demand for achieving highly efficient machining, Mitsubishi Materials has developed “MIRACLE SIGMA,” which can be used together with products utilizing Mitsubishi’s new PVD coating technology by combining our latest coating technologies with our geometry designing technologies.
New PVD Coated Grades

**MP6100/MP7100/MP9100**

Wide range of grades for specific materials
MIRACLE SIGMA accumulated Al-Ti-Cr-N based PVD coating

![Image showing PVD accumulated coating and substrate]

- Excellent welding resistance due to low coefficient of friction
- PVD accumulated coating (Each damage measures)
- Special cemented carbide substrate

<table>
<thead>
<tr>
<th>Tool wear and Damage</th>
<th>P Steel</th>
<th>M Stainless Steel</th>
<th>S Heat Resistant Alloy • Ti Alloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Cracks</td>
<td>![Image of thermal cracks]</td>
<td>![Image of notching]</td>
<td>![Image of welding by chipping]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Features</th>
<th><strong>MP6120/MP6130</strong></th>
<th><strong>MP7130/MP7140</strong></th>
<th><strong>MP9120/MP9130</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Improved thermal conductivity</td>
<td>Improved layer toughness</td>
<td>Low affinity at high temperature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Images of various tool shapes]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ISO</th>
<th>Coated Carbide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PVD</td>
</tr>
<tr>
<td>P</td>
<td>P10, P20, P30, P40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ISO</th>
<th>Coated Carbide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PVD</td>
</tr>
<tr>
<td>M</td>
<td>M10, M20, M30, M40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ISO</th>
<th>Coated Carbide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PVD</td>
</tr>
<tr>
<td>S</td>
<td>S10, S20, S30, S40</td>
</tr>
</tbody>
</table>

Features:
- Improved thermal conductivity
- Improved layer toughness
- Low affinity at high temperature

Thermal Cracks, Notching, Welding by Chipping
TOUGH-Σ Technology

A fusion of the separate coating technologies; PVD and multi-layering realises extra toughness.

PVD accumulated coating

Base layer
High Al-(Al, Ti)N

The new technology Al-(Al, Ti)N coating provides stabilisation of the high hardness phase and succeeds in dramatically improving wear, crater and welding resistance.

Best layer of each workpiece

P (Al,Cr)N
Tough! Thermal Cracks

M TiN
Tough! Notching

S CrN
Tough! Resistant Chipping

Dramatically improving the heat and wear resistance!

Excelfent welding resistance due to low coefficient friction!
Low cutting resistance, double sided insert face mill for general machining

**WSX445**

New face milling cutter with innovative double sided insert. Perfect balance between high efficiency and ease of use.

**Designed to control abnormal insert breakage and body damage**

The unique conical insert seat and Anti Fly mechanism (AFI) hold the insert securely. The outer edge of the insert is not in contact with the body, thereby preventing damage if sudden fracturing occurs. The thick insert negates the need for a shim.

**Through Coolant Holes**

Through coolant holes are standard for cutters under 160mm diameter. Improves chip discharge and prevents chip welding.
Unique insert minimizes chatter and vibration
Z Insert Geometry provides low cutting resistance

Mitsubishi Materials’ proprietary “Double sided, Z Geometry” insert features a sharp cutting edge with low cutting resistance by utilizing features of both conventional positive and negative rake inserts.

Double sided Z Geometry

Conventional positive insert

Conventional negative insert

For a sharper cutting edge

Single sided insert

For higher edge strength

Double sided insert

*Rake angle mounted an insert.
The iMX series is a revolutionary end mill system that enables efficiency, high accuracy and rigidity by combining the advantages of both solid carbide and indexable end mills. Security and rigidity close to that of a solid type end mill because the clamping faces are all carbide. Excellent for reduced inventory over a variety of applications due to the exchangeable head.
Tool life comparison when machining flat surfaces in Inconel 718

EP7020 is a new grade that enables extended tool life when machining difficult-to-cut materials.

**Comparison of tool rigidity**

The double face contact of the carbide head and carbide holder gives an increase in rigidity of 30%.

**Strength comparison when slot machining titanium alloy**

The reliability of the screw fastening is significantly improved when compared to competitors that employ only steel fastenings. It is also able to cope with high cutting loads.
Vibration Control End Mills for Machining Difficult-to-Cut Materials

SMART MIRACLE® Coating

Smart Miracle end mills have been treated with a newly developed (Al, Cr)N group coating which delivers substantially better wear resistance. The surface of the coating has been given a smoothening treatment resulting in better machined surfaces, reduced cutting resistance and improved chip discharge. This is the next generation of coated end mills that delivers long tool life when machining stainless steels and other difficult-to-cut materials.

ZERO-μ Surface

With the unique ZERO-μ Surface, the cutting edge retains its sharpness. While previous technologies often resulted in diminished sharpness, the ZERO-μ Surface achieves both smoothness and sharpness, as well as longer tool life.

Comparison of cutting resistance

<table>
<thead>
<tr>
<th>Work material</th>
<th>SUS304</th>
</tr>
</thead>
<tbody>
<tr>
<td>End mill</td>
<td>VQMHV0600(ø6)</td>
</tr>
<tr>
<td>Spindle revolution</td>
<td>n=2,650/min^-1</td>
</tr>
<tr>
<td>Cutting speed</td>
<td>v=50m/min</td>
</tr>
<tr>
<td>Feed rate</td>
<td>vf=320mm/min(0.03mm/tooth)</td>
</tr>
<tr>
<td>Depth of cut</td>
<td>ap=8mm</td>
</tr>
<tr>
<td>Protrusion length</td>
<td>20mm</td>
</tr>
<tr>
<td>Cutting mode</td>
<td>Down cut</td>
</tr>
<tr>
<td>Coolant</td>
<td>Emulsion</td>
</tr>
<tr>
<td>Machine</td>
<td>Vertical M/C (BT50)</td>
</tr>
</tbody>
</table>

Cutting resistance reduced by more than 20%
Carbide end mills

MS plus

(Al, Ti, Cr)N Multilayer coating

Excellent wear resistance allows a wide range of applications.

<table>
<thead>
<tr>
<th></th>
<th>MS plus</th>
<th>(Al,Ti)N</th>
<th>(Al,Cr)N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (HV)</td>
<td>3,200</td>
<td>2,800</td>
<td>3,100</td>
</tr>
<tr>
<td>Oxidation Temperature (°C)</td>
<td>1,100</td>
<td>800</td>
<td>1,100</td>
</tr>
<tr>
<td>Adhesion (N)</td>
<td>100</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

The improved end geometry provides increased sharpness and wear resistance when compared to conventional products.

Micro-grain cemented carbide substrate

Higher wear resistance than conventional products

Seamless cutting edge

Radius tolerance R±0.005mm

End cutting edge geometry

Suitable for finishing

Conventional

MS plus

Sharp but strong cutting edge enables good surface finishes.

Conventional

Good surface finishes possible even when simultaneously cutting with end and side edges; for example on drafts of dies and moulds.

<Cutting Condition>

Work material: SKD61 (HRC38 heat treated steel)
Machine: Tapping center (BT20)
Cutting Fluid: External emulsion

Application Examples

Sharp edges leave a uniform finish.

A dull edge leaves an undefined finish.
New coated grade **DP1020**

The newly developed DP1020 grade offers excellent wear resistance and reduced friction for longer tool life and a versatile range of applications.

**Reduced margin wear**

DP1020 has excellent wear resistance properties and therefore reduces the amount of material that needs to be removed when re-grinding.

**Margin wear after 57m machining**

**<Cutting conditions>**

- Work material: S50C
- Cutting speed: 100m/min
- Feed: 0.2mm/rev
- W.S.O (External coolant)
New wavy cutting edge

The unique wavy cutting edge provides excellent sharpness and rigidity and helps to control wear at the periphery.

Comparison of wear at the cutting edge periphery (After 57m machining)

<Cutting conditions>
Work material : S50C
Cutting speed : 100m/min
Feed : 0.2mm/rev
W.S.O (External coolant)

ZERO-μ Surface

Our unique smooth surface technology reduces cutting resistance and offers excellent chip evacuation.

TRI-cooling Technology®

The unique coolant hole geometry (on drills over ø6) increases the rate of coolant flow for improved cooling effect and chip removal.
Coated CBN Grade for High Hardened Steel Turning

**BC8110**

Longer tool life with a coated CBN grade when turning hardened steels.

Newly developed special ceramic coating

Prevention of welding
Peeling of the coating is prevented by improving welding resistance.

*NEW*

TiAlSiN Coating
Improved wear and chipping resistance.

*NEW*

TiAlN Coating
Improved adhesion to the CBN surface provides increased peeling resistance.

The newly developed “Ultra Micro-particle Binder” prevents sudden fracture

Dispersal of the new Ultra Micro-particle Binder in BC8110 prevents linear crack development that can cause sudden fracturing.

Cutting resistance

- Forces dispersed in a linear direction can cause sudden fracturing.
- Forces dispersed radially help to prevent sudden fracturing.

Conventional

“Ultra Micro-particle Binder”

BC8110
ISO Turning Inserts for Difficult to Cut Materials

MP9005
MP9015
PVD coated grade

High Al and conventional coating comparison

The new technology high Al-rich (Al,Ti)N single layer coating provides stabilisation of the high hardness phase and succeeds in dramatically improving wear, crater and welding resistance.

<table>
<thead>
<tr>
<th>ISO Grade</th>
<th>Grade</th>
<th>Concept</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>S05</td>
<td>MP9005</td>
<td>Top-quality grade focusing on wear resistance</td>
<td>Heat Resistant Alloy Finish-Medium Cutting</td>
</tr>
<tr>
<td>S15</td>
<td>MP9015</td>
<td>First recommendation for general applications</td>
<td>Heat Resistant Alloy Medium-Rough Cutting</td>
</tr>
</tbody>
</table>
Low cutting resistance, double sided insert face mill for general machining

WSX445

Screw-on Insert type Face Milling Cutter

ASX445
Screw-on Insert type Shoulder Milling Cutter

ASX400

Multi-functional Indexable Cutter

APX3000
APX4000

High Feed Radius Milling Cutter

AJX

For Machining of Aluminium and Titanium Alloys

AXD4000

For Titanium Alloy Milling

VFX

New Generation Solid Carbide Drills

MVE/MVS

Coated CBN Grade for High Hardened Steel Turning

BC8110

ISO Turning Inserts for Difficult to Cut Materials

MP9005
MP9015

SMART MIRACLE®

SMART MIRACLE®

For Your Safety

- Don't handle inserts and chips without gloves.
- Please machine within the recommended application range and exchange expired tools with new ones in advance of breakage.
- Please use safety covers and wear safety glasses.
- When using compounded cutting oils, please take fire precautions.
- When attaching inserts or spare parts, please use only the correct wrench or driver.
- When using rotating tools, please make a trial run to check run-out, vibration and abnormal sounds etc.

MITSUBISHI MATERIALS CORPORATION

Overseas Sales Dept, Asian Region
KFC bldg., 8F, 1-6-1 Yokoami, Sumida-ku, Tokyo 130-0015, Japan
TEL +81-3-5819-8771 FAX +81-3-5819-8774

Overseas Sales Dept, European & American Region
KFC bldg., 8F, 1-6-1 Yokoami, Sumida-ku, Tokyo 130-0015, Japan
TEL +81-3-5819-8772 FAX +81-3-5819-8774

URL: http://www.mitsubishicarbide.com
(Tools specifications subject to change without notice.)