# Diamond Cutting Tools

**A.L.M.T.**

<table>
<thead>
<tr>
<th>AL1 to AL14</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AL1</strong></td>
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<tr>
<td><strong>AL2</strong></td>
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<td><strong>AL3</strong></td>
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<td><strong>AL7</strong></td>
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<td><strong>AL8</strong></td>
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<tr>
<td><strong>AL9</strong></td>
</tr>
<tr>
<td><strong>AL10</strong></td>
</tr>
</tbody>
</table>

**A.L.M.T. Diamond Cutting Tools**

- Ultra-Precision Cutting Tool UPC
- UPC-Nano groove / UPC-Nano endmill
- UPC-Nano ballendmill / UPC-Nano Profile
- UPC-R
- UPC-F / UPC-T
- BL-UPC
- New D Tools
- New D / New D e-EDGE
- PCD Rotating Tools
A.L.M.T. Corp., as a leading manufacturer of ultra-precision diamond cutting tools, offers a broad range of nano- and micro-forming cutting tools to meet market needs. Our many years of experience and extensive knowledge give us a comprehensive understanding of the optimal physical properties of single-crystal diamond. Our state-of-the-art development process yields the highest precision in tool edge measurement. As a result, our diamond cutting tools achieve high-precision microscopic cutting of workpieces in the order of nanometers.

Identification and Measurement Technology

Identify the anisotropy of atoms in single-crystal diamond and pursue the best crystal orientation

Creation of tools pursuing cutting edge sharpness in the order of nanometers starts with the screening and selection of single-crystal diamond. The lattice constant of diamond is always 3.5667 Å, but the distance between crystal faces varies, causing differences in the ease of cleavage and intrusion of impurities. Therefore, sorting of rough diamonds is important in addition to the identification of crystal orientation according to the machining conditions.

Polishing and Measurement Technologies

Cutting edge polishing technology that produces nanometer-controlled movement

In order to accurately produce nanometer-controlled movement on a workpiece, a cutting tool requires a sharp cutting edge capable of producing nanometer-sized chips and high profile precision. We have achieved this using our unique polishing and measurement technologies.

Nano/Micro Processing Technology

Straightness and surface roughness unattainable with photolithography or ion-beam method

With its cutting edge sharpness in the order of nanometers, A.L.M.T.'s UPC-Nano series achieves a surface roughness and straightness that cannot be obtained by the photolithography or ion-beam method. This technology is also effective for micrometer-order processing of high aspect ratio.
Characteristics
1. The world’s smallest grooving tool with a cutting edge width of 0.9 μm
2. Provides the world’s highest dimensional accuracy of ±0.5 μm
3. High-precision-polished durable cutting edge
4. Enables high-precision fine grooving that cannot be achieved using the photolithography or ion-beam method

Application
1. Hologram diffraction grating molds
2. Fine linear grooving
3. Molds with fine grooves
4. Optical sheet molds

Characteristics
1. Enables the world’s thinnest-in-its-class 30-μm wide flexible grooving
2. Enables machining with a high aspect ratio of 2.5 times the rotation diameter
3. High-precision-polished durable cutting edge
4. Enables high-precision fine grooving that cannot be achieved using the photolithography or ion-beam method

Application
1. Hologram grating
2. Fine free curve grooving
3. LCD light guide plate molds
4. Micro machine parts grooving
**Characteristics**
1. The world’s smallest-in-its-class ball endmill with R=30 μm
2. Provides the world’s highest profile of 50 nm
3. Enables high-precision 3-D machining with its extremely sharp cutting edge

**Application**
1. Micro lens array
2. Free-form submillimeter lens
3. LCD light guide plate molds
4. Micro machine parts grooving

**Characteristics**
1. Enables flexible one-pass machining of free-form surfaces including elliptical and paraboloidal surfaces with a form accuracy of 1 μm or less
2. Ensures high form accuracy in machining of paraboloidal and other free-form surfaces

**Application**
1. Optical sheet molds for LCD panels
2. Micro lens array molds
3. Various optical element molds

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**Example of Grooving Using a Nano Ball Endmill**

**Elliptical Cutting Edge**

**Parabolic Cutting Edge**
**UPC®-R**

**Description:**
- High precision for ultra-precision spherical and aspherical cutting.
- Uniform Negative Rake Face of Cutting Edge (Patented).

**Characteristics:**
1. Achieves an edge arc profile of 50 nm (0.05 µm) over a wide working angle range of 90°.
2. The cutting edge is uniformly finished in high quality, achieving a surface roughness in the order of nanometers.
3. A record of the edge arc profile measured with our originally-developed measuring instrument (with a resolution of 5 nm) is attached to the product for thorough quality control.

**Application:**
1. Camera lens molds for CD, DVD, and BD players
2. Lens molds for digital cameras
3. Camera lens molds for smartphones, PCs, and tablets
4. Infrared lens
5. Spherical and aspherical mirrors for lasers and X-rays
6. Various spherical and aspherical lenses
7. Profile processing using a ultra-precision processing machine

**Dimension and Highest Accuracy:**

<table>
<thead>
<tr>
<th>Cat. No.</th>
<th>Profile (R)</th>
<th>Corner Radius R</th>
<th>Cutting Edge Angle β</th>
<th>Geometric Tilt W (°)</th>
<th>Relief Angle γ</th>
<th>Rake Angle β</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPC-R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Precision SS</td>
<td>0.05µm</td>
<td>0.1µm</td>
<td>-0.20µm</td>
<td>0.002 to 200</td>
<td>15° min.</td>
<td>0.5 to 20°</td>
</tr>
<tr>
<td>High Precision S</td>
<td>0.25µm</td>
<td>0.5µm</td>
<td>1µm</td>
<td></td>
<td></td>
<td>-30° to 10°</td>
</tr>
</tbody>
</table>
## UPC®-F

**Exhibits its potential in high-efficiency ultra-precision cutting into plane and cylindrical shapes**

### Characteristics
1. Drastically reduces or dispenses with running-in processing time.
2. You can obtain uniform, high-quality worked surfaces by setting the roundness (sharpness) of the cutting edge according to the work material and processing conditions.

### Application
1. Laser reflective mirrors
2. Polygon mirrors
3. Photosensitive drums of copying machines
4. Plane and cylindrical mirror finishing

### Dimension and Highest Accuracy

<table>
<thead>
<tr>
<th>Cat. No.</th>
<th>Cutting Edge Angle</th>
<th>Grooving Width</th>
<th>Rake Angle</th>
<th>Relief Angle</th>
<th>Lateral Rake Angle</th>
<th>Relief Face R</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPC-FC</td>
<td>45° to 80°</td>
<td>1.0 to 4.0</td>
<td>-5° to 0°</td>
<td>0° to 15°</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>UPC-FR</td>
<td>10° to 45°</td>
<td>2.0 to 4.0</td>
<td>2° to 5°</td>
<td>0°</td>
<td>0°</td>
<td>30 to 40mm</td>
</tr>
</tbody>
</table>

## UPC®-T

**Ideal for fine grooving such as that for Fresnel lenses**

### Characteristics
1. The cutting edge is uniform and extremely sharp, free from chipping and undulation.
2. Guarantees the cutting edge shape in the order of submicrons.

### Application
1. LCD light guide plate molds
2. Fresnel lens molds
3. Optical sheet molds
4. Various diffraction grating molds
5. Other fine grooving

### Dimension and Highest Accuracy

<table>
<thead>
<tr>
<th>Cat. No.</th>
<th>Cutting Edge Angle</th>
<th>Angular Tolerance</th>
<th>Tip Width W</th>
<th>Relief Angle</th>
<th>Rake Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPC-T</td>
<td>High Precision SS</td>
<td>±6°</td>
<td>0.2 μm min.</td>
<td>0° to 15°</td>
<td>-5° to 10°</td>
</tr>
<tr>
<td></td>
<td>High Precision S</td>
<td>±15°</td>
<td></td>
<td>Pin Angle</td>
<td></td>
</tr>
</tbody>
</table>
SUMIDIA® Binderless (Nano-polycrystalline Diamond)

**Ultra-Precision Cutting Tool BL-UPC®**

Employs SUMIDIA® Binderless on the edge of UPC®

Achieves long tool life in mirror finish and fine machining of carbides

- **Features of SUMIDIA® Binderless**
  - Fine grains of several tens of nanometers are firmly and directly bonded together without the use of binder.
  - Harder than single-crystal diamond.
  - No anisotropy and specific cleavage.

- **Features of BL-UPC®**
  - Superior chipping and wear resistance compared to single-/polycrystalline diamond.
  - Sharp and precise cutting edge equivalent to UPC® (single-crystal diamond).
  - Free from uneven wear caused by crystal orientation due to no anisotropy.

- **Application**
  - Molds for carbide glass lenses
  - Large molds for prism sheets and light guide plates
  - Glass lenses
  - Machining of other high-hardness and brittle materials

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Ultra Precision Cutting Tools

BL-UPC®

Binderless Ultra Precision Cutting Tools

- Sharp Cutting Edge Equivalent to Single-Crystal Diamond
- Flank Wear Comparison of Machined Carbide
- Comparison of Required Characteristics for Cutting Tool Materials

### Comparison of Required Characteristics for Cutting Tool Materials

<table>
<thead>
<tr>
<th>Required Characteristics</th>
<th>Diamond</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Crystal</td>
</tr>
<tr>
<td>(1) High Hardness</td>
<td>✔</td>
</tr>
<tr>
<td>(2) High Temperature Hardness</td>
<td>✔</td>
</tr>
<tr>
<td>(3) Suitable Toughness</td>
<td>✗</td>
</tr>
<tr>
<td>(4) High Thermal Diffusibility</td>
<td>✔</td>
</tr>
<tr>
<td>(5) Sharpness of Cutting Edge</td>
<td>✔</td>
</tr>
</tbody>
</table>

“SUMIDIA®” is a registered trademark of Sumitomo Electric Industries, Ltd.
New D Tools® New D

Achieves stability and long tool life by measuring and optimizing the crystal orientation.

Characteristics
(1) Less variation in tool life, which is a weakness of single-crystal diamond tools, and 1.5 to 2 times longer tool life than conventional tools on average.
(2) The combination of our originally-designed inserts and holders enables easy and precise tool setting like indexable inserts.
(3) There are inserts for straight cutting and those for curved-surface copying. The form accuracy of the latter is 5 μm.
(4) The rake face is free from adhesions and accumulation of chips and maintains the high quality of worked surfaces even during continuous use.
(5) The diamond is firmly attached by a unique brazing method.
(6) Exhibits high durability even during interrupted cutting.
(7) Unlike the conventional type with a retaining cap, there is no retaining cap to hold the diamond, enabling chips to move smoothly on the rake face, improving the machining accuracy.

Application
- Automotive components (pistons, aluminum wheels, compressors, commutators, etc.)
- Plastic lenses, resin parts
- HDD parts
- Aluminum die cast alloys, other non-ferrous metals
Environmental protection by dry cutting etc. is an important issue in manufacturing sites as well as the reduction of tool costs.

New D e-EDGE is a cutting tool used for machining of general parts, which is cost-saving and environmentally-friendly and utilizes the features of single-crystal diamond.

### Characteristics

1. **Significantly lower price.**
2. **Insert holders for HDD (hard disk drive) aluminum die castings and boring (minimum boring dia.: 5.5 mm) are included in the standard specification.**
3. **Inserts can be replaced according to the holder you are currently using.**
4. **Sharp cutting and extremely high cutting heat diffusivity (compared with polycrystalline diamond).**

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**New D e-EDGE**

Patent Registered
Characteristics
- Multiple parts can be machined in a single pass by using an integrated formed step tool.
- Adoption of diamond offers significantly-improved tool life (10 times or longer than that of carbide ones).
- Surfaces can be machined without burn at a cutting speed of 300 m/min or higher.
- Stable cutting is possible even when using emulsion-type water-soluble coolant. (Semi-dry cutting is also possible according to your environment.)

PCD Reamer Application Example Reaming of automotive fuel pump regulator valve

<table>
<thead>
<tr>
<th>Items</th>
<th>PCD Reamer</th>
<th>Carbide Reamer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting Speed (m/min)</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Feed Rate (mm/rev)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Stock Removal (mm/dia.)</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Coolant</td>
<td>Water soluble</td>
<td>Oil based</td>
</tr>
<tr>
<td>Roughness(µmRz)</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Circularity</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Economic Efficiency Ratio</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

Data 1 Improvement of Productivity by Breaking Chips

The breaker function is enhanced to prevent a reduction in productivity due to problems caused by chips. Solutions are proposed according to the type of chip problem.

Data 2 Good Balance between High-Efficiency Cutting and High Machining Accuracy

The coaxiality and cylindricity of the cutting edge is dramatically improved by the high rigidity of the shank (made of carbide) and excellent cutting edge polishing technology. The high run-out precision leads to stable machining, and consequently, reduction of the cycle time.

Difference in Performance by Shank Material

<table>
<thead>
<tr>
<th>Results</th>
<th>1 Flute</th>
<th>4 Flutes (Steel)</th>
<th>4 Flutes (Carbide)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting Time (s)</td>
<td>52</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Circularity (mm)</td>
<td>0.01</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Coaxiality (mm)</td>
<td>0.01</td>
<td>0.07</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Cutting Conditions

Workpiece | Finishing of cylinder heads and guide-and-sheet fitting holes
Work Material | Aluminum alloy castings AC4B
Machine | Horizontal machining center
Tool Size (mm) | ø11 - ø36 - L150
S/Speed (min⁻¹) | 3,500
Cutting Speed (m/min) | 395
Feed Rate (mm/rev) | 0.3
Stock Removal (mm/dia.) | 0.5
Coolant | Emulsion-type water-soluble oil
### Machining Process

**Process 1**  
**Finishing of Valve-and-Sheet Fitting Holes**  
Achieves a good balance between coaxiality and cylindricity from the high rigidity of the shank and the high accuracy of the cutting edge.

**Specifications for Finishing of Valve-and-Sheet Fitting Holes**

- **Processing machine**: Horizontal machining center
- **Spindle Speed** (min⁻¹) 6,000
- **Feed Rate** (mm/rev) 0.48
- **Feed Rate** (mm/min) 2,880
- **Stock Removal (mm/dia.)** 0.6
- **Coolant**: Emulsion-type water-soluble oil

**Process 2**  
**Finishing of Hydraulic Lash Adjuster (HLA) Holes**  
Improves chip evacuation and achieves a high cylindricity using a design ideal for machining thin-wall parts and stop holes.

**Specifications for Finishing of Hydraulic Lash Adjuster (HLA) Holes**

- **Processing machine**: Horizontal machining center
- **Spindle Speed** (min⁻¹) 5,000
- **Feed Rate** (mm/rev) 0.34
- **Feed Rate** (mm/min) 1,540
- **Stock Removal (mm/dia.)** 0.5
- **Coolant**: Emulsion-type water-soluble oil

**Process 3**  
**Finishing of Intake and Exhaust Valve Guide Holes**  
Since the overhang (L) is long and the diameter (D) is small, consequently L/D is large, the coaxiality and cylindricity of tools are controlled with high accuracy to improve the self-guide effect during reaming. Additionally, chip evacuation is improved by the guide shape and coolant design. As a result, the tool life is elongated to 10 times that of carbide, improving productivity.

**Specifications for Finishing of Intake and Exhaust Valve Guide Holes**

- **Processing machine**: Horizontal machining center
- **Spindle Speed** (min⁻¹) 3,250
- **Feed Rate** (mm/rev) 0.1
- **Feed Rate** (mm/min) 325
- **Stock Removal (mm/dia.)** 0.1
- **Coolant**: Emulsion-type water-soluble oil

### Results

<table>
<thead>
<tr>
<th></th>
<th>Material</th>
<th>Tool Life (No. of Holes)</th>
<th>Price Ratio</th>
<th>Cost Ratio</th>
<th>Coaxiality</th>
<th>Inner Diameter Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carbide</td>
<td>1,200</td>
<td>1</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>A.L.M.T. PCD Tool</td>
<td>12,000</td>
<td>3</td>
<td>0.8</td>
<td>10μm</td>
<td>3 μm/10,000 holes</td>
</tr>
</tbody>
</table>
Tools for Cylinder Head Machining

**Characteristics**
- Design and balance treatment intended for high-feed machining and rigidity.
- Solves problems caused by chips by effectively directing coolant.

**Advantages**
- Improvement of the machining efficiency and quality
- Reduction of tool costs per machine

Achieves high-efficiency machining with formed multi-edge shapes.

- For Solenoid Hole Machining
- For Spark Plug Hole Machining
- For Guide-and-Sheet Hole Machining
- For Spring Sheet Hole Machining

Enables high-efficiency machining using the high rigidity of the shank and the high accuracy of the cutting edge.

- For Valve Guide Hole Machining
- For Lash Adjuster Hole Machining

An endmill that enables high-efficiency machining using the high rigidity of the shank

- For Camshaft Bearing (Half R) Machining

An endmill that enables high-efficiency machining using the multi-edge structure

- For Cam Oil Hole Grooving
Special Tools for Cylinder Head Machining

**Characteristics**
- Design and balance treatment ideal for high rotation speed
- You can reduce the machining time and the tool management cost by using composite tools that integrate machining processes.

**Advantages**
- Integration of processes
- Preventing damage to tools
- Elimination of variance in quality due to tool sets

With a run-out adjustment function
- Mechanical Clamp Monoblock

Enables high-efficiency high-precision machining using the high rigidity of the shank
- Monoblock

Enables high-efficiency machining using the structure
- Face Milling Cutter

Achieves high-efficiency machining by a structure that integrates several processes
- Special Process Integrating Tools
  - Reamer + Cutter
  - Reamer + Tap