Baikowski®

Solution partner for FINE MINERALS

TAILORED ALUMINA-BASED SOLUTIONS FOR ADVANCED CERAMIC CUTTING TOOLS

3N & 4N Baikalox® Powders

Undoped & Doped solutions

Alumina Based Composites

> The advancement of mechanical processing technologies has led to an increased demand for cutting tools that can deliver high-quality results, improve processing efficiency, and reduce costs.

> Traditional cutting tools, such as carbide tools, high-speed steel and hard alloy tools, often fall short in meeting the requirements for high-speed, high-strength, and high-hardness materials.

> Ceramic cutting tools, with their high melting points, hardness, chemical stability, and wear resistance, have emerged as a superior alternative. They allow manufacturers to achieve **longer tool life, faster cutting speeds, and superior surface finishes, reducing overall machining costs and downtime.**

> Baikowski® specializes in customized fine **high-purity alumina** powders offer precise **particle size control, high sintering reactivity, and fine microstructures solutions** to enhance ceramic cutting tool performance.

Among our customization possibilities, magnesium oxide (MgO) refine grain structure and improve toughness, ensuring greater wear resistance and reliability.

Additionally, we provide tailored Zirconia-Toughened Alumina. Its exceptional thermal shock resistance makes it ideal for high-speed machining, where tools endure extreme temperatures and stress.

1. Performance Advantages of Ceramic Cutting Tools

> Cutting tool materials must endure harsh machining conditions, including elevated temperatures, intense friction, and high mechanical loads. To meet these challenges, they require a precise balance of mechanical, thermal, and tribological properties.

In this context, alumina-based cutting tools offer several advantages over conventional tool materials such as:

> Exceptional Hardness & Wear Resistance

With a hardness exceeding 15-20 GPa, ceramic cutting tools offer superior abrasive and adhesive wear resistance, enabling the machining of hard materials that are challenging for traditional cutting tools.

> Outstanding Thermal & Oxidation Resistance

Ceramic cutting tools maintain their hardness and strength at temperatures up to 1350°C, allowing higher cutting speeds than hard alloy tools. This enables dry machining, reducing the need for coolants and minimizing contamination risks, crucial for aerospace and medical applications for instance.

> High Chemical Stability & Low Friction with Metals

Alumina-based ceramic tools are chemically stable, reducing adhesion, minimizing the formation of built-up edges, and ensuring consistent performance in harsh conditions.

Their low friction coefficient with metals reduces bonding during cutting, leading to lower cutting forces, smaller deformations, and improved efficiency.

> Excellent Impact & Thermal Shock Resistance

Ceramic cutting tools are highly resistant to impact, making them suitable for high-speed machining, interrupted cutting, and milling operations.

Their thermal shock resistance ensures durability under rapid temperature fluctuations, preventing tool failure and improving reliability.

> Higher Cutting Speeds & Productivity

They allow cutting speeds 2-3 times faster than carbide tools. By increasing industrial throughput and reducing overall machining cycle times, they lead to cost savings and efficiency gains in large-scale manufacturing.

2. Main Applications

> Alumina-based cutting tools, including alumina-coated inserts, are suited for:

3. Material classes of Ceramic Cutting Tools

> Advanced ceramics cutting tools form the backbone of cutting tools and they are often **enhanced with dopants and secondary phases** to improve performance and longevity.

> By carefully selecting additives and optimizing synthesis techniques, it is possible to develop alumina composites that meet very demanding requirements like in machining applications.

> Depending on application needs, the main types of alumina-based ceramic cutting tools are:

Type of tools	Definition	Purpose	Advantages	Drawbacks	Applications
Alumina Ceramic Cutting Tools	Made from advanced ceramic materials like alumina (Al_2O_3) and silicon nitride (Si_3N_4).	Suitable for cutting hard and brittle materials.	High-temperature resistance, excellent for hard materials.	Not ideal for aluminum and its alloys.	Used for machining chilled cast iron, hardened steel, and engineering plastics.
Cemented Oxide Tools	Alumina-based tools with titanium, magnesium, chromium, zirconium oxides, or silicon-carbide grains.	Enhancing toughness and thermal conductivity for demanding machining.	Suitable for high-speed machining.	Less fracture resistance than whisker-reinforced ceramics.	Rough and finish turning, grooving of cast iron, continuous cutting at high speeds without coolant.
Functionally Graded Ceramic Cutting Tools (FGCTs)	Tools with graded material composition to optimize performance.	Increasing damage resistance and tool longevity in high-speed cutting.	Service life 1-2 times longer than cemented carbide tools, better at high speeds.	Complex manufacturing process.	Used in high-speed machining requiring durability and precision.
Self-Lubricating Ceramic Tools	FGCTs with embedded solid lubricants to reduce wear.	Enhancing tool performance by lowering friction and cutting forces.	Reduces tool wear, extends tool life, decreases cutting force.	Requires precise control over material distribution.	Applied in various high-performance cutting operations.
Coated Ceramic Tools	Ceramic tools with protective coatings.	Improving toughness and abrasion resistance.	Suitable for high-speed and dry cutting, enhanced wear resistance.	Coating wear over time can affect performance.	Used in high-speed machining and dry cutting applications.
Whisker Reinforced Ceramic Cutting Tools	Ceramic tools reinforced with whiskers for added toughness.	High-speed machining of hardened and medium-hardness steels.	Enhanced fracture toughness and impact resistance.	More expensive than standard ceramics.	Suitable for conditions requiring toughness and impact resistance, including hardened steel machining.

4. Key & custom Properties of Baikowski High-Purity Alumina

> Baikowski® leverages its deep expertise in high-purity alumina to develop cutting-edge solutions that enhance tool durability, precision, and performance. Their keys characteristics include:

> Purity & Composition

• **High-Purity Alumina:** Our 3N and 4N grades minimize impurities that weaken grain boundaries and cause porosity, ensuring longer tool life.

> Particle Size, PSD and Morphology

• **Fine Grain Structure:** Improves mechanical strength, surface finish, and precision, making it particularly beneficial for applications requiring tight tolerances and smooth surface quality, such as high-precision machining in aerospace, automotive, and medical industries.

• **Optimized Particle Size:** Baikowski® submicronic particles (d_{50} as low as 0.12 – 0.4 microns) enable high density and uniform sintered microstructure, resulting in stronger, sharper cutting edges and smoother workpiece finishes.

• **Uniformity & Consistency:** The narrow particle size distribution of our powders prevents pores and microcracks, ensuring structural integrity during high-speed machining.

• **Controlled Morphology:** Spherical or near-spherical particles improve packing density, optimizing mechanical performance.

> Densification and Structural Stability

• **Crystal Structure and Specific Surface Area:** Our alpha-alumina structure (hexagonal close-packed) is engineered to increase reactivity during sintering, leading to better densification, hardness, wear resistance and thermal stability at extreme temperatures.

> MGO Doping for Performance Optimization

Baikowski® is renowned for custom oxide design solutions. Sintering Aids like MgO can be added, resulting in:

• **Improved Hardness and Wear Resistance:** MgO inhibits grain growth, leading to a finer microstructure and increased hardness.

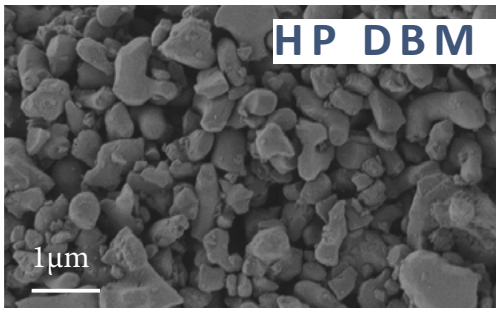
• **Enhanced Sintering Efficiency:** faster densification and reduce porosity.

• **Increased Toughness:** The modified microstructure improves the fracture resistance, extending tool life under high-speed machining conditions for instance.

• **Superior Thermal Stability:** The high melting point and low thermal expansion of alumina, combined with MgO's effect, enable thermal conductivity reduction.

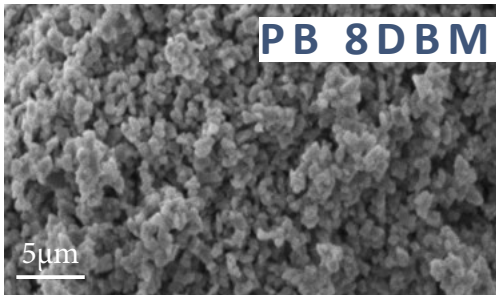
5. Baikowski Optimized Alumina Offering for Cutting Tools

> **HP DBM** is a ball-milled powder that offers excellent sintering reactivity and fine grain microstructure, ensuring high mechanical strength and wear resistance. Typical values are:



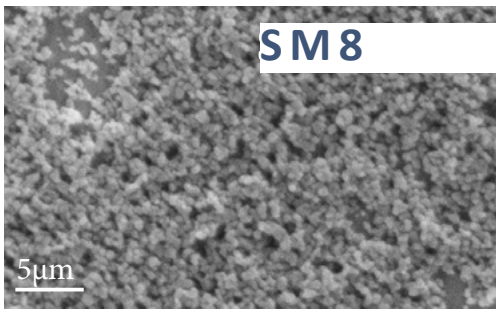
- 100% alpha
- High chemical purity (3N)
- Controlled particle size distribution d50 ≈ 0.4µm (Laser diffraction)
- High SSA ≈ 8 m^2/g
- Green Density (g/cm^3), uniaxial pressing at 350 bar: 2.22
- Fired Density (g/cm^3), sintered at 1510°C for 2 hours: 3.96 with MGO addition (500ppm)

> **PB 8DBM** is a ball-milled powder that offers controlled particle size distribution and good sintering. Typical values are:



- 100% alpha
- High chemical purity (3N)
- Controlled particle size distribution d50 ≈ 0.3µm (Laser diffraction)
- High SSA ≈ 8 m^2/g
- Green Density (g/cm^3), uniaxial pressing at 350 bar: 2.20
- Fired Density (g/cm^3), sintered at 1510°C for 2 hours: 3.95

> **SM8** features a monodisperse particle size distribution with high SSA and good green density, ensuring ultra-fine microstructure and superior tool performance.



- 100% alpha
- High chemical purity (3N)
- Controlled particle size distribution d50 ≈ 0.12µm (Laser diffraction)
- High SSA ≈ 10 m^2/g
- Bulk Density (g/cm^3): 0.8
- Taped Density (g/cm^3): 1.1

> **ZTA** (Zirconia Toughened Alumina) solutions include ready-to-use slurries, spray-dried and Ready To Press powders with a precisely custom engineered blend of high-purity Al_2O_3 and stabilized ZrO_2.

Our advanced formulations ensure a homogeneous particle distribution, ultra-fine microstructure, and high sintering reactivity, enabling a low firing temperature for enhanced tool durability.

We also provide zirconia stabilization with various stabilizers, as well as third-phase additions to optimize mechanical properties.

> Click to learn more about our cutting tools offering

PRODUCT DESIGN

> **Contact us** and we will develop together the product that meets your specific needs and requirements.

> Ceramic cutting tools, particularly those based on high-purity alumina, are crucial for high-performance machining. Their ability to withstand high temperatures, resist wear, and maintain precision makes them an essential component in various industries such as in the aerospace, automotive, energy or medical sectors.

> By further optimizing material composition and machining parameters, tool performance, productivity and cost efficiency could still be enhanced in the future. Current material science research focuses on **nano-structured ceramics and hybrid composites** for improved toughness and wear resistance, as well as additive manufacturing for complex geometries and customized tool designs.

Your solution partner for fine minerals

Baikowski®

Baikowski® SA
France | Poisy | +33 4 50 22 69 02

Mathym® SAS
France | Lyon | +33 4 78 83 72 93

Baikowski® Malakoff Inc.
USA | Malakoff (TX) | +1 903-489-1910

Baikowski® International Corp.
USA | Charlotte (NC) | +1 704-587-7100

www.baikowski.com
sales@baikowski.com

Follow us:

Sales Representative in China
China | Shanghai | +86 21.6289.2883

Baikowski® Korea Co, Ltd.
Korea | Seoul | +82 255.281.97

Baikowski® Japan Co, Ltd.
Japan | Chiba | +81 474.73.8150