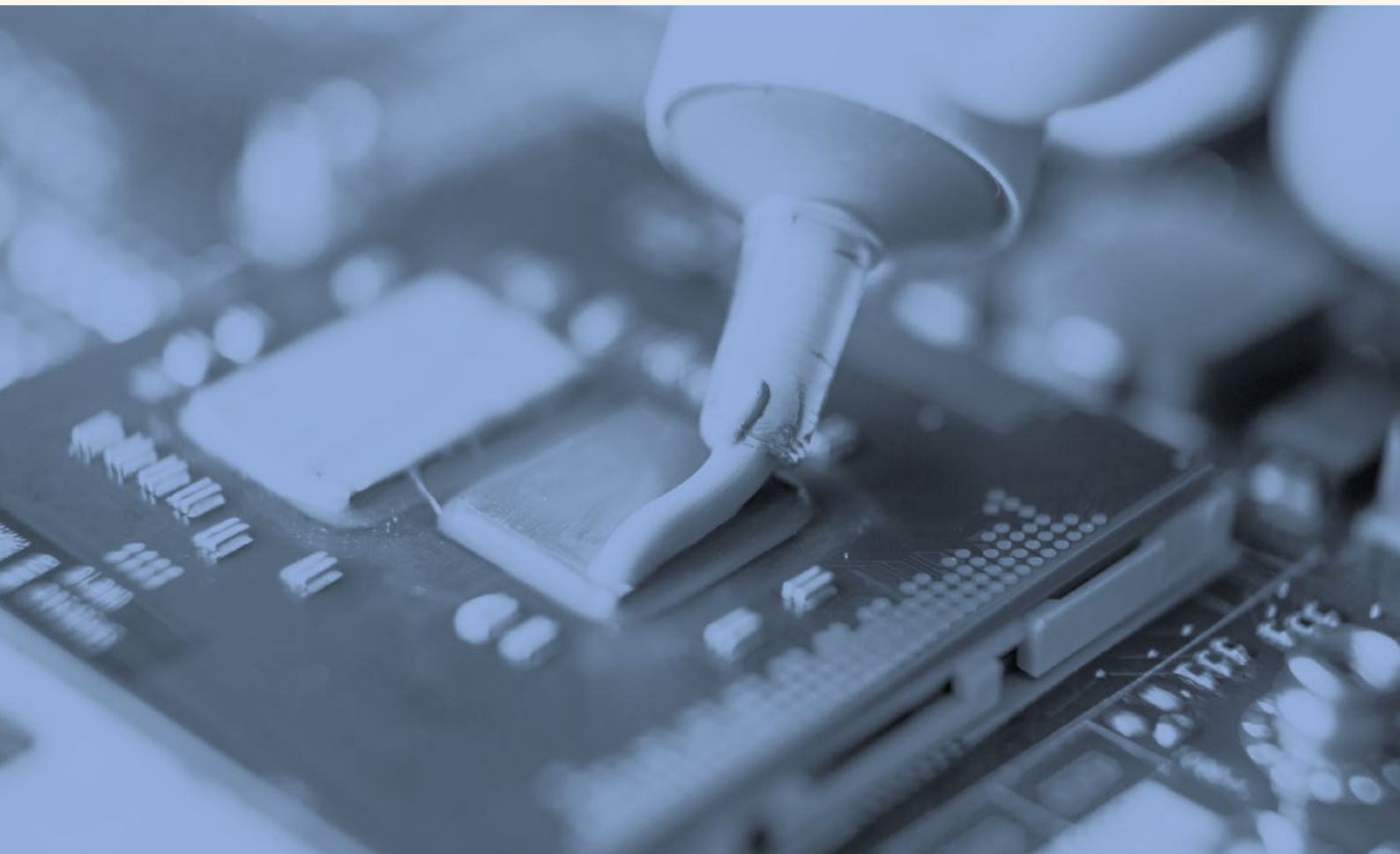


# Thermally Conductive Filler Materials

## APPLICATIONS

Thermal interface products (Sheets, Greases, Adhesives) | Integrated circuits, etc. |  
Additive to various thermosetting resins, thermoplastic resins, rubbers, etc.



# INTRODUCTION

Showa Denko manufactures several kinds of Alumina and Hexagonal Boron Nitride. These have excellent characteristics for rubber and resin-based thermally conductive fillers.

Showa Denko offers a wide variety of thermally conductive fillers and is continually working to develop new, more effective grades. These include blends of various particle sizes and fillers and surface treated material.

We can offer several blends of different alumina types. Please don't hesitate to contact our local sales offices for further details.

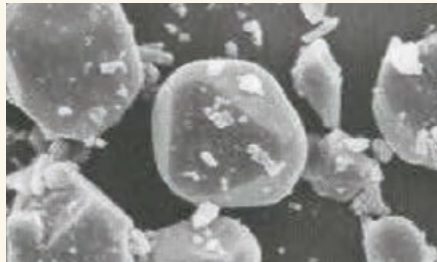
## THERMALLY CONDUCTIVE FILLER LINEUP

### Aluminum Oxide (Al<sub>2</sub>O<sub>3</sub>)

Aluminum Oxide (Alumina) filler has been manufactured at Showa Denko K.K. for over 80 years and strides continue to be made in this market. Commonly referred to as alumina, Showa Denko K.K. supplies a wide variety of grades with unique and distinguishing features.

#### Roundish Alumina (AS, AS-C Series)

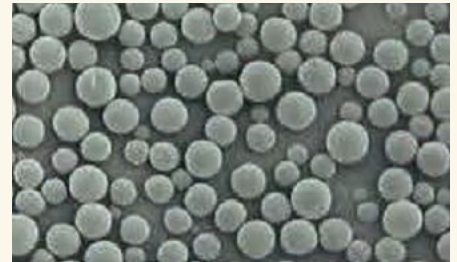
The AS and AS-C series are single-grain corundums with fewer crystal edges. Since the AS series has a large particle diameter and broad particle size distribution, it excels at filling resin and producing compounds with low viscosity and good fluidity.



Roundish (AS series)

#### Spherical Alumina (Alunabeads™ CB Series)

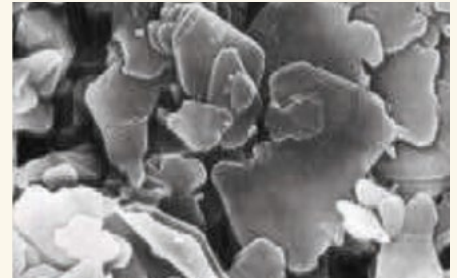
Alunabeads™, also known as our CB series, is a spherical single-grained alumina. CB series is featuring more than 10 grades and in addition we can propose customized products to meet your requirements. CB produces compounds with high filling rates and good viscosity.



Spherical CB Series (Alunabeads™)

#### Hexagonal Boron Nitride (SHOBN™ UHP Series)

Our SHOBN™ UHP series is a high purity crystalized Hexagonal Boron Nitride. SHOBN™ has excellent thermal conductivity, high thermal stability, corrosion resistance, and good electrical characteristics (high electrical insulation, low dielectric constant). SHOBN™ is offered as both platelet and agglomerate types. By utilizing Showa Denko's proprietary technology, our agglomerate grade of hBN is particularly unique by providing exceptionally high particle hardness while maintaining a low level of impurities. The UHP series is used for high heat radiation applications which require electrical insulation.



Hexagonal Boron Nitride (UHP series)

### Comparison of Showa Denko Thermally Conductive Filler properties

Filler	Shape	Mean particle size	Features (filler or compound property)
Roundish Alumina (AS, AS-C series)	Roundish	9 - 44 μm	High filling, High purity, Low abrasion, High fluidity
Spherical Alumina (Alunabeads™ CB )	Spherical	2 - 100 μm	High filling, High purity, Low abrasion, High fluidity
Hexagonal Boron Nitride (UHP series)	Platelets	0.2 - 12 μm	Low specific gravity, Low abrasion, Electrical insulation, Low dielectric constant, Thermal and Chemical stability
	Agglomerates		Platelets properties + High loading and High density

# AS SERIES

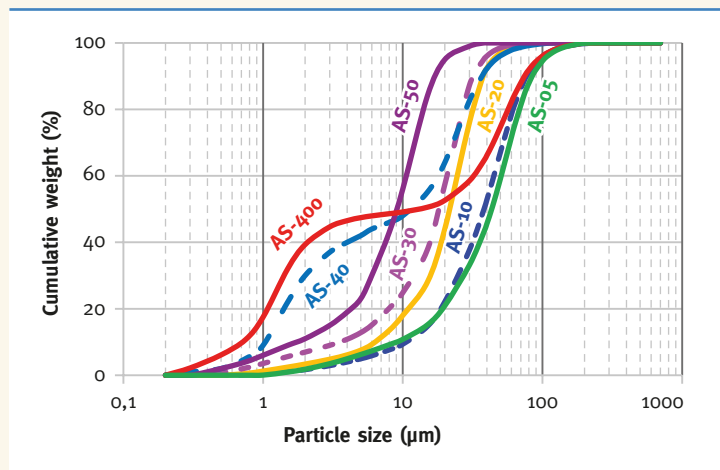
## Typical properties of common grades

			AS-10	AS-20	AS-30	AS-40	AS-50	AS-400
Chemical Composition	L.O.I <sup>※1</sup>	%	0.05	0.07	0.09	0.13	0.18	0.09
	Fe <sub>2</sub> O <sub>3</sub>	%	0.04	0.06	0.07	0.06	0.05	0.02
	SiO <sub>2</sub>	%	0.05	0.06	0.06	0.06	0.06	0.03
	Na <sub>2</sub> O	%	0.03	0.03	0.03	0.04	0.03	0.03
	Na <sup>+</sup> ※2	ppm	3	3	3	50	7	32
	Cl <sup>-</sup> ※2	ppm	1	1	1	2	1	1
	Al <sub>2</sub> O <sub>3</sub>	%	99.83	99.78	99.75	99.71	99.68	99.87
Mean Particle Size (d <sub>50</sub> )※3	μm	39	22	18	12	9	13	
Top cut size	μm	105	75	75 (or 45)	-	75 (or 45)	-	
BET Specific Surface area	m <sup>2</sup> /g	0.5	0.8	1.0	1.2	1.9	1.2	
Bulk Density	Loose	g/cm <sup>3</sup>	1.8	1.8	1.6	1.5	1.5	1.4
	Tap	g/cm <sup>3</sup>	2.4	2.4	2.2	2.1	2.0	2.0
Electric Conductivity※4	μS/cm	3	4	5	31	11	29	
Viscosity (Pas)	Epoxy resin (250PHR)		95	110	135	102	130	-
	Silicone resin (600PHR)		124	114	128	106	150	83

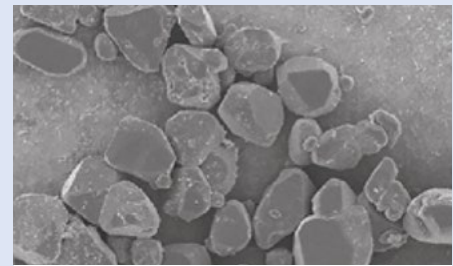
※1 Loss On Ignition, ※2 Warm water extraction (100°C, 2Hr), ※3 LASER DIFFRACTION AND SCATTERING METHOD ANALYZER

※4 20g/100ml purified water, ※The data shown above are representative figures. They are not guaranteed values.

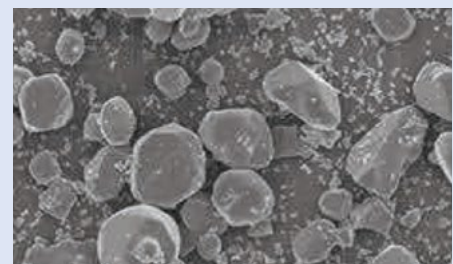
### Particle Size Distribution



### SEM images



AS-10



AS-40

### Features and Advantages

- Large particle sizes and broad particle size distributions allow for a high filling density in various resins.
- Roundish shape makes AS Series suitable as a thermal filler with lower viscosity.
- Roundish shape also means a large contact area between particles, increasing thermal conductivity of the compound.
- Bimodal AS-400 is a grade specifically designed for achieving higher filling rates in resins.

# AS-C SERIES

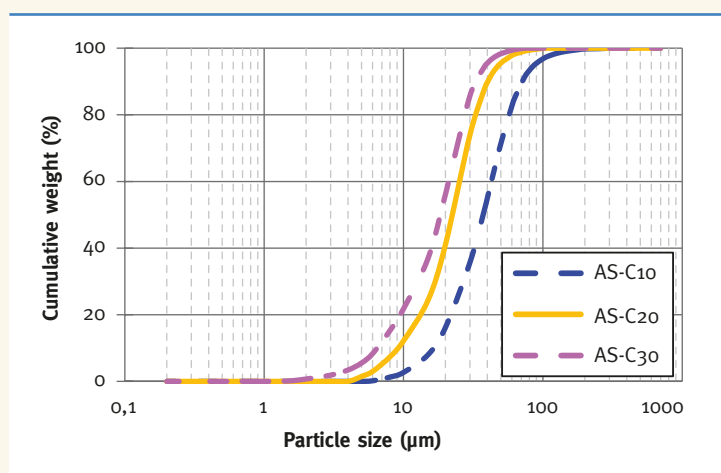
## Typical properties of common grades

			AS-C10	AS-C20	AS-C30
Chemical Composition	L.O.I <sup>※1</sup>	%	0.05	0.08	0.13
	Fe <sub>2</sub> O <sub>3</sub>	%	0.03	0.03	0.03
	SiO <sub>2</sub>	%	0.05	0.08	0.08
	Na <sub>2</sub> O	%	0.12	0.14	0.13
	Cl <sup>※2</sup>	ppm	1	1	2
	B	ppm	1,110	1,190	1,380
	F	ppm	350	210	230
	Al <sub>2</sub> O <sub>3</sub>	%	99.75	99.67	99.63
Mean Particle Size (d <sub>50</sub> ) <sup>※3</sup>		μm	37	22	19
Top cut size		μm	105	75	75 (or 45)
BET Specific Surface area		m <sup>2</sup> /g	0.2	0.3	0.4
Bulk Density	Loose	g/cm <sup>3</sup>	2.4	2.3	2.1
	Tap	g/cm <sup>3</sup>	3.1	3.0	2.9
Electric Conductivity <sup>※4</sup>		μS/cm	105	155	240

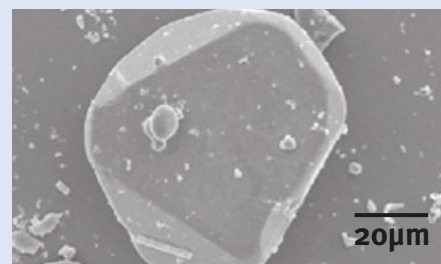
※1 Loss On Ignition, ※2 Warm water extraction (100°C, 2Hr), ※3 LASER DIFFRACTION AND SCATTERING METHOD ANALYZER

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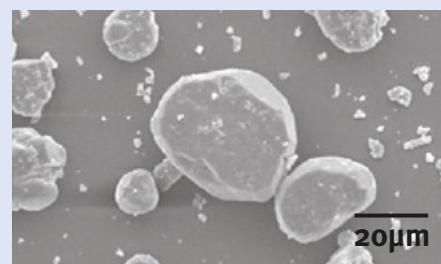
### Particle Size Distribution



### SEM images



AS-C10



AS-C30

### Features and Advantages

- Large particle sizes and broad particle size distributions allow for a high filling density in various resins.
- Roundish shape makes AS-C Series suitable as a thermal filler with lower viscosity.
- AS-C Series is a highly cost efficient series directed especially at Automotive EV related applications.

# ALUNABEADS™ CB SERIES

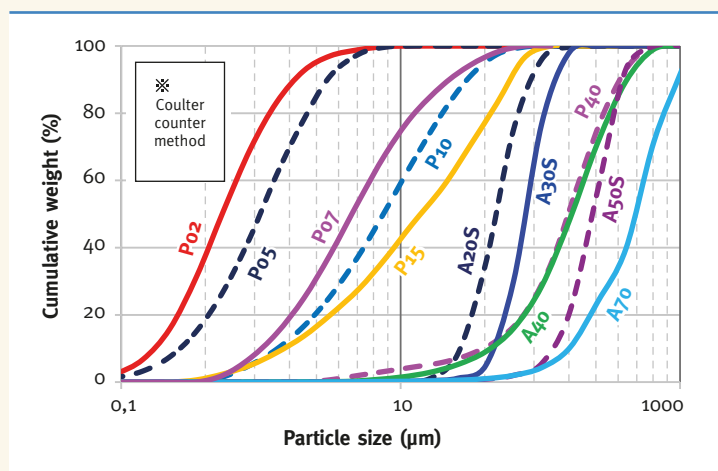
## Typical properties of common grades

			CB -P02	CB -P05	CB -P07	CB -P10	CB -P15	CB -A20S	CB -A30S	CB -A40	CB -P40	CB -A50S	CB -A70	CB -A100S
Chemical Composition	L.O.I** <sup>1</sup>	%	0.06	0.05	0.07	0.05	0.04	0.03	0.03	0.02	0.05	0.02	0.02	0.02
	Fe <sub>2</sub> O <sub>3</sub>	%	0.04	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01
	SiO <sub>2</sub>	%	0.06	0.03	0.02	0.02	0.06	0.02	0.01	0.01	0.05	0.01	0.01	0.04
	Na <sub>2</sub> O	%	0.02	0.01	0.19	0.07	0.06	0.03	0.01	0.01	0.01	0.07	0.01	0.06
	Na <sup>+</sup> ** <sup>2</sup>	ppm	5	4	17	5	6	10	8	7	20	6	30	5
	Al <sub>2</sub> O <sub>3</sub>	%	99.82	99.89	99.71	99.85	99.82	99.91	99.94	99.91	99.86	99.92	99.89	99.94
Mean Particle Size (d <sub>50</sub> )** <sup>3</sup>	µm	2	4	7	8	16	21	28	40	44	50	71	94	
Top cut size	µm	24	24	45	24	45	45	45	88	88	88	149	149	
BET Specific Surface area	m <sup>2</sup> /g	1.1	0.7	0.6	0.6	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Bulk Density	Loose	g/cm <sup>3</sup>	1.1	1.3	1.5	1.7	1.7	2.1	2.1	2.2	2.2	2.1	2.1	2.2
	Tap	g/cm <sup>3</sup>	1.9	2.2	2.4	2.5	2.5	2.3	2.3	2.3	2.5	2.3	2.4	2.5
Electric Conductivity** <sup>4</sup>	µS/cm	8	9	11	6	8	7	6	7	74	4	24	5	
Viscosity (Pas)	Epoxy resin (250PHR)		142	130	-	85	76	116	117	138	88	99	105	-
	Silicone resin (600PHR)		305	274	-	123	73	104	90	100	70	77	57	-

\*\*1 Loss On Ignition, \*\*2 Warm water extraction (100°C, 2Hr), \*\*3 LASER DIFFRACTION AND SCATTERING METHOD ANALYZER

\*\*4 20g/100ml purified water, \*\*The data shown above are representative figures. They are not guaranteed values.

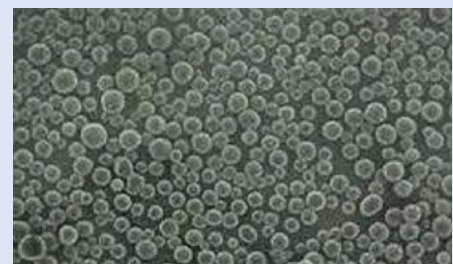
### Particle Size Distribution



### SEM images



CB-P40



CB-A20S

### Features and Advantages

- Spherical shape allows for especially high filling into resin. It is especially suitable for applications which require high fluidity.
- CB-A20S and CB-A50S grades have a sharp particle size distribution, while CB-A40, CB-A70, CB-P02, and CB-P40 grades have a broad particle size distribution.
- Alunabeads™ CB Series has good properties for special abrasives in addition to insulation and thermal filler applications.

# ALUNABEADS™ CB SERIES BLENDED

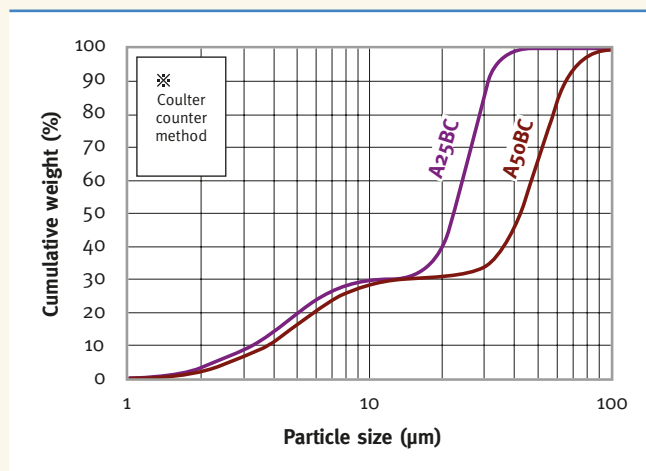
## Typical properties of common grades

			CB-A25BC	CB-A50BC
Chemical Composition	L.O.I**1	%	0.04	0.03
	Fe <sub>2</sub> O <sub>3</sub>	%	0.01	0.01
	SiO <sub>2</sub>	%	0.08	0.04
	Na <sub>2</sub> O	%	0.06	0.01
	Na+**2	ppm	15	8
	Al <sub>2</sub> O <sub>3</sub>	%	99.81	99.90
Mean Particle Size (d <sub>50</sub> )**3		µm	24	48
BET Specific Surface Area		m <sup>2</sup> /g	0.3	0.3
Bulk Density	Loose	g/cm <sup>3</sup>	-	-
	Tap	g/cm <sup>3</sup>	-	-
Electric Conductivity**4		µS/cm	17	12
Viscosity (Pas)	Epoxy resin (250PHR)	Pas	63	59
	Silicone resin (600PHR)	Pas	55	42

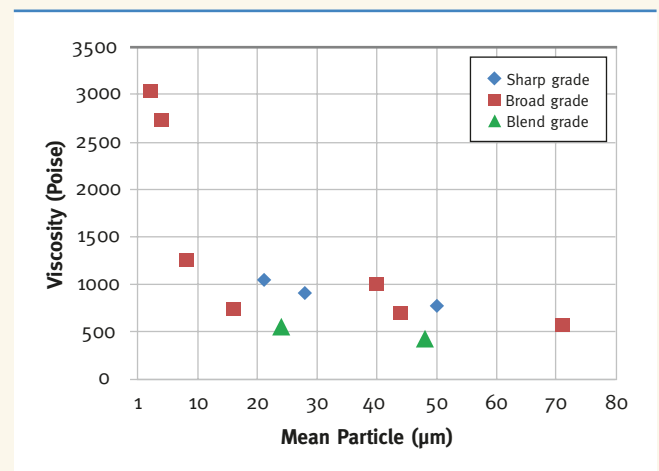
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\*\*4 20g/100ml purified water, \*\*The data shown above are representative figures. They are not guaranteed values.

### Particle Size Distribution



### Viscosity with Silicone resin



### Features and Advantages

- Alunabeads™ CB Blend Series (“BC”) is a series of bimodal grades for achieving even higher filler rates in various resins.
- In addition, we can offer several blends of different alumina types. We are open to work on customized blends, as well. Please don’t hesitate to contact your sales office for further details.

### SEM images



# SHOBN™ UHP SERIES

## Typical properties of common grades

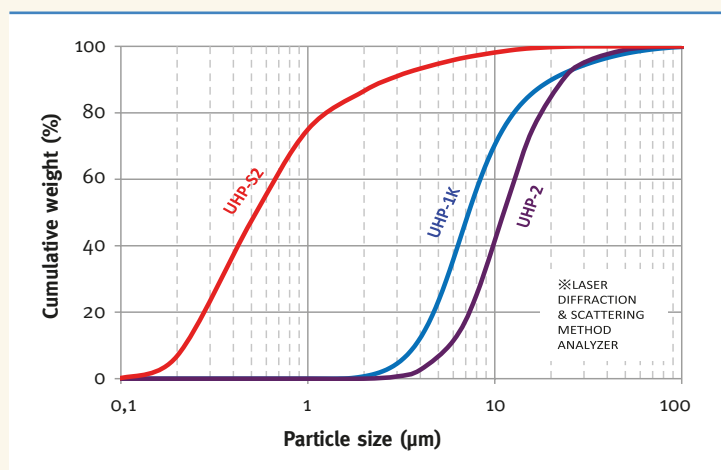
Shape	Platelet			Agglomerate		
	UHP-S2	UHP-1K	UHP-2	UHP-G1H		
Chemical Composition	B <sub>2</sub> O <sub>3</sub>	%	0.04	0.03	0.04	0.04
	CaO	%	0.01	0.01	0.02	0.01
	C	%	0.02	0.02	0.02	0.01
	BN	%	99.9	99.9	99.9	99.9
Mean Particle Size (d <sub>50</sub> ) <sup>※1</sup>	μm	0.7	8	11	33	
BET Specific Surface Area	m <sup>2</sup> /g	8-12	3-5	3-5	3-5	
Bulk Density (Vibration)	g/cm <sup>3</sup>	0.25	0.22	0.30	0.6	

※1 Loss On Ignition,

※The data shown above are representative figures.

They are not guaranteed values.

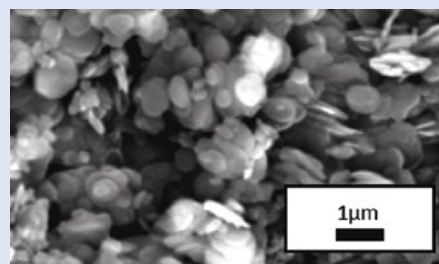
### Particle size distribution: Platelet Type



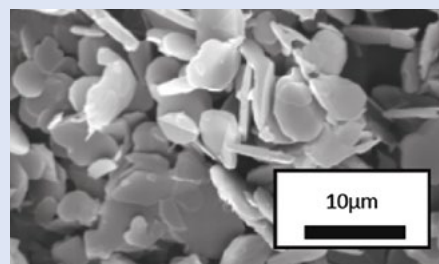
### Features and Advantages

- SHOBN™, our UHP Series, offers superior thermal conductivity, high thermal stability, corrosion resistance, and strong electrical characteristics (i. e. high electrical insulation, low dielectric constant ).
- SHOBN™ has two different particle types, Platelet type and Agglomerated type.
- UHP-G1H, our newest product, has high hardness and high purity agglomerates.
- SHOBN™ UHP is suitable for applications which require lubricity and mold-release efficiency.

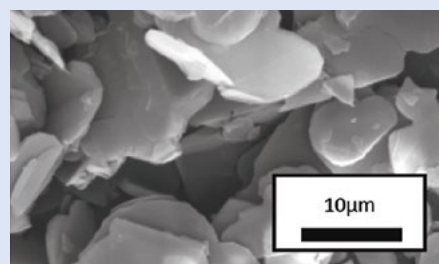
### SEM images



UHP-S2



UHP-1K



UHP-2

# GENERAL OVERVIEW OF THERMALLY CONDUCTIVE FILLER MATERIALS

## Basic properties

Material		Al <sub>2</sub> O <sub>3</sub>	h-BN	AlN	BeO	MgO	SiO <sub>2</sub> Crystalline	SiO <sub>2</sub> Fused
Crystal shape		Hexagonal	Hexagonal	Hexagonal	Hexagonal	Cubic	Trigonal	Amorphous
Density	g/cm <sup>3</sup>	3.98	2.27	3.27	3.02	3.58	2.65	2.21
Specific heat (Room temp.)	J/kg · °C	750	810	700	1090	960	740	770
CTE	×10 <sup>-6</sup> / °C	6	1	4.5	6.4	13	15	0.5
Volume Resistivity	Ω/cm	10 <sup>15</sup>	10 <sup>14</sup>	>10 <sup>14</sup>	>10 <sup>14</sup>	10 <sup>17</sup>	10 <sup>15</sup>	>10 <sup>17</sup>
Dielectric constant	-	8.5	3.6~4.2	8.5	-	-	-	-
Hardness	Mohs	9	2	8	9	5.5	7	7
Notes				hydrophilic	toxicity			

Source: TECHNICAL INFORMATION INSTITUTE.CO.LTD

## Thermal conductivity

Material	Diamond (C)	Silicon Carbide (SiC)	Beryllia (BeO)	Aluminum Nitride (AlN)	Hexagonal Boron Nitride (h-BN)	Silicon Nitride (Si <sub>3</sub> N <sub>4</sub> )	Magnesium Oxide (MgO)	Aluminum Oxide (Al <sub>2</sub> O <sub>3</sub> )	Silica (SiO <sub>2</sub> ) Crystalline	Silica (SiO <sub>2</sub> ) Fused
Thermal conductivity (W/m*k)	2000	270	270	70~270	1) >200 2) several 3) 60	30~80	40	20~36	10	1.3
Notes		Semi-conduction	Toxicity		1) X direction 2) Z direction 3) Compact					

Source: TECHNICAL INFORMATION INSTITUTE.CO.LTD

## Showa Denko Group Overview

(as of December 31, 2018)

**Company Name:** Showa Denko K.K.  
**Head Office Location:** 13-9, Shiba Daimon 1-chome, Minato-ku, Tokyo 105-8518, Japan

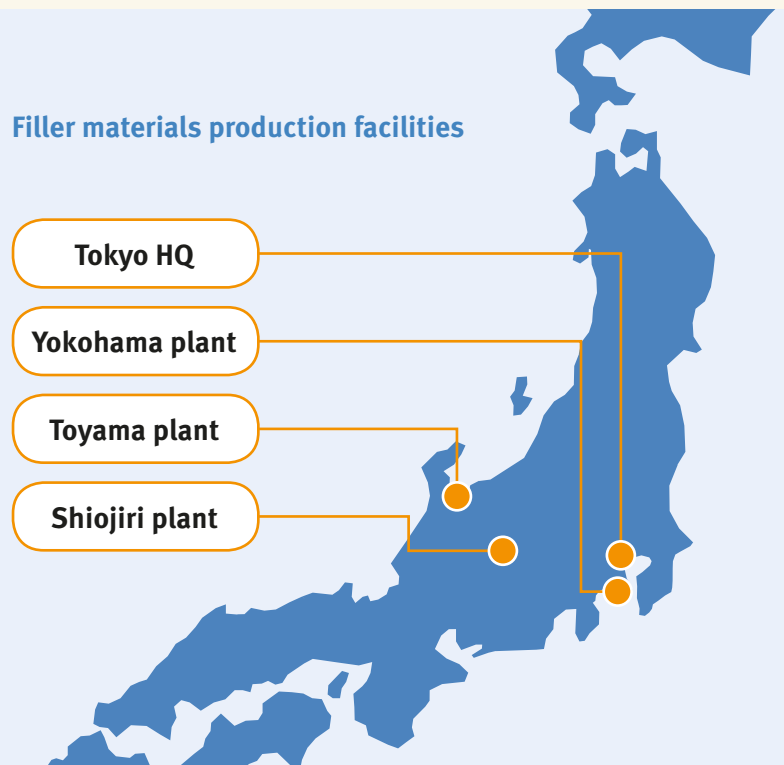
**Number of Consolidated Subsidiaries:** 58

**Number of Employees:** 10,634 Total

### Consolidated Business Results:

**Sales** 992 billion yen  
**Operating Income** 180 billion yen  
**Net Income** 117 billion yen

## Filler materials production facilities







**SHOWA DENKO K.K.**

Marketing Department 2,  
Ceramics Division  
13-9 Shiba Daimon 1-chome,  
Minato-ku,  
Tokyo, 105-8518  
Japan  
Tel: +81 3 6402 5080  
Fax: +81 3 5403 5730  
URL: [www.sdk.co.jp/english](http://www.sdk.co.jp/english)

**SHOWA DENKO EUROPE GmbH**

Konrad-Zuse-Platz 3  
81829 Munich  
Germany  
Tel: +49 89 93 99 62 0  
Fax: +49 89 93 99 62 50  
URL: [www.showa-denko.com](http://www.showa-denko.com)

**SHOWA DENKO AMERICA, INC.**

420 Lexington Avenue,  
Suite 2850,  
New York, NY 10170  
U.S.A.  
Tel: +1 21 23 70 00 33  
Fax: +1 21 23 70 45 66  
URL: [www.showadenko.us](http://www.showadenko.us)

**SHOWA DENKO SINGAPORE  
(Pte.) Ltd.**

2 Shenton way, #15-03/04  
SGX Centre  
1, Singapore 068804  
Singapore  
Tel: +65 62 23 18 89  
URL: [www.sds.com.sg](http://www.sds.com.sg)



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