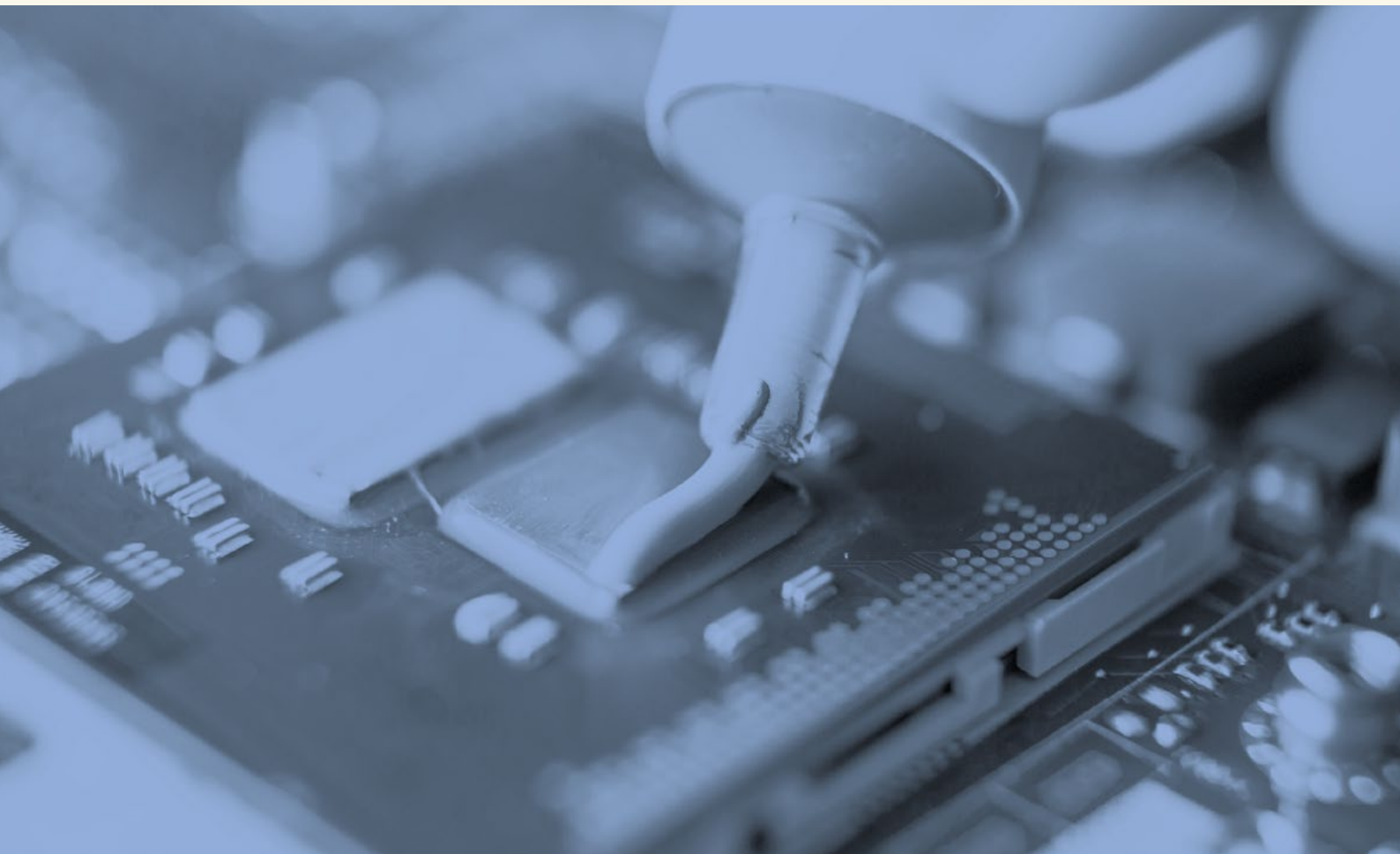


# Thermally Conductive Filler Materials

## APPLICATIONS

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



# INTRODUCTION

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

Resonac 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.

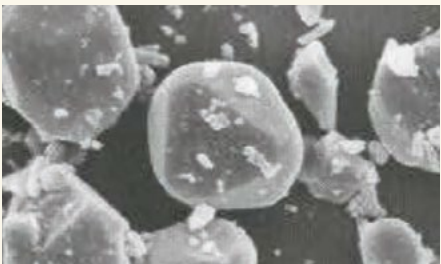
## THERMALLY CONDUCTIVE FILLER LINEUP

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

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

#### Roundish Alumina (AS Series)

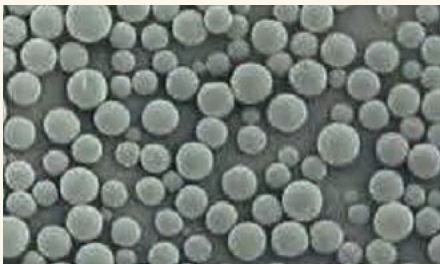
The AS series are single-grain corundums with fewer crystal edges. Since the AS series has a large particle diameter and broad particle size distribution, it excels at filling resin and producing compounds with low viscosity and good fluidity.



Roundish (AS series)

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

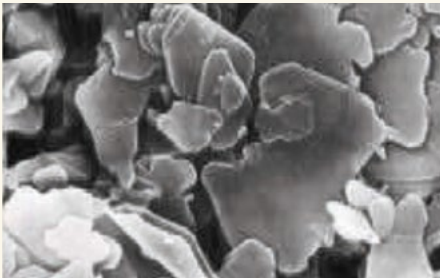
Alunabeads™, also known as our CB series, is a spherical single-grained alumina. CB series is featuring more than 10 grades and in addition we can propose customized products to meet your requirements. CB produces compounds with high filling rates and good viscosity.



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 Resonac'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 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

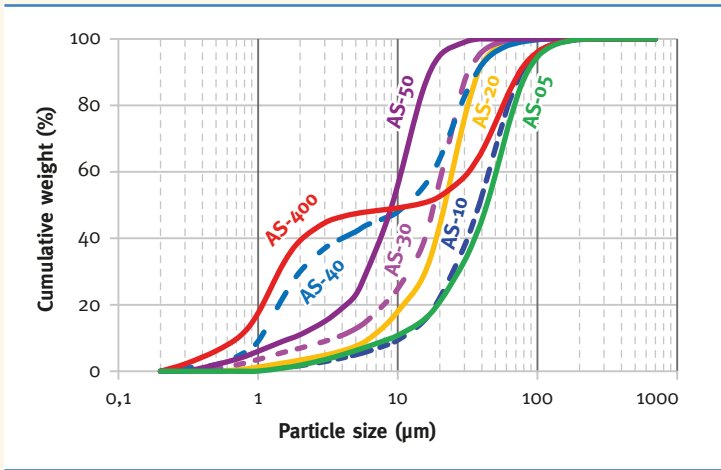
## Typical properties of common grades

|   |                                |                   | 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>※2</sup>               | ppm               | 3     | 3     | 3          | 50    | 7          | 32     |
|   | Cl <sup>※2</sup>               | 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> ) <sup>※3</sup> |                                | 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 <sup>※4</sup>                 |                                | 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.

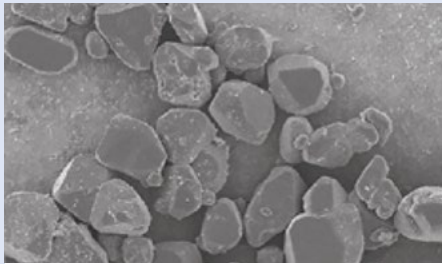
## Particle Size Distribution



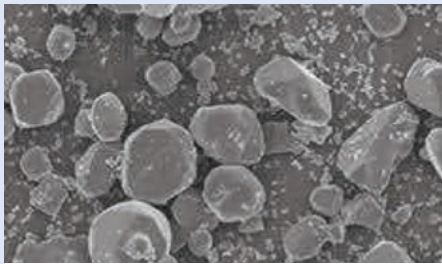
## Features and Advantages

- 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.

## SEM images



AS-10



AS-40

## ALUNABEADS™ CB SERIES

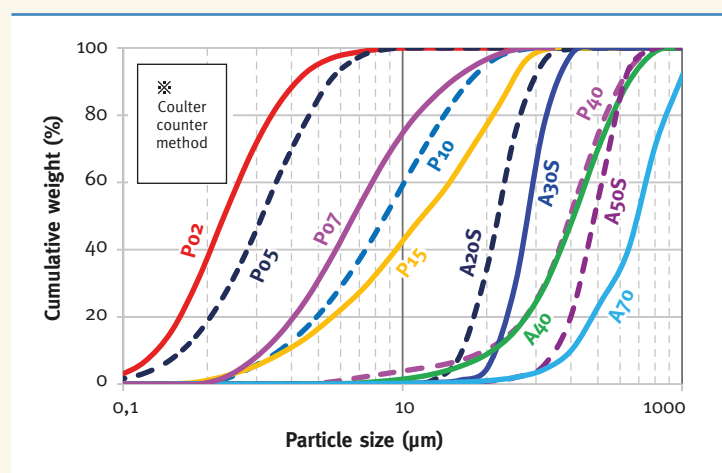
## Typical properties of common grades

|   |                                |                   | CB<br>-P02 | CB<br>-P05 | CB<br>-P07 | CB<br>-P10 | CB<br>-P15 | CB<br>-A20S | CB<br>-A30S | CB<br>-A40 | CB<br>-P40 | CB<br>-A50S | CB<br>-A70 | CB<br>-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        | 0.05       | 0.01       | 0.01        | 0.04       | 0.01         |
|   | Na <sub>2</sub> O              | %                 | 0.02       | 0.01       | 0.19       | 0.07       | 0.06       | 0.03        | 0.01        | 0.01       | 0.07       | 0.01        | 0.06       | 0.02         |
|   | 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        | 0.1         | 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         | -            |

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

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

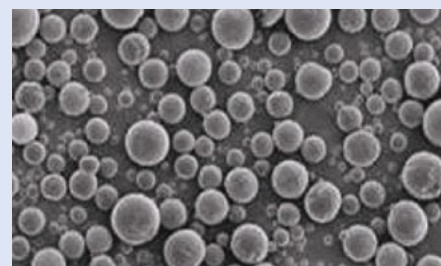
## Particle Size Distribution



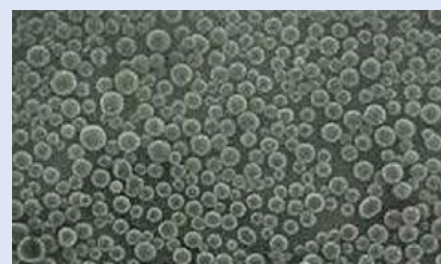
## Features and Advantages

- 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.

## SEM images



CB-P40



CB-A20S

# ALUNABEADS™ CB SERIES BLENDED

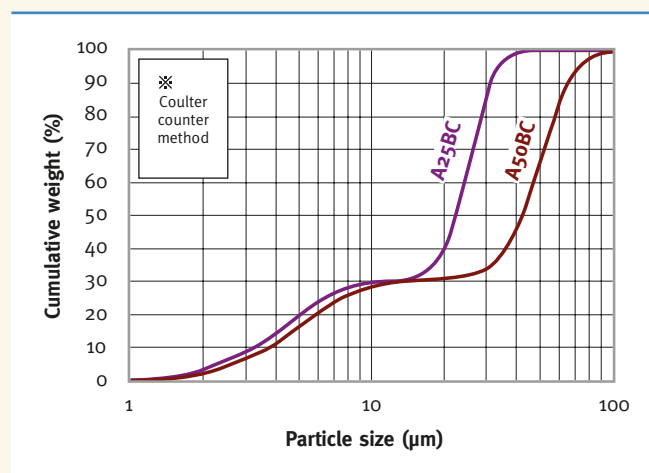
## Typical properties of common grades

|   |                                |                   | CB-A25BC | CB-A50BC |
|---|--------------------------------|-------------------|----------|----------|
| Chemical Composition                    | L.O.I <sup>※1</sup>            | %                 | 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 <sup>+</sup> ※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       |

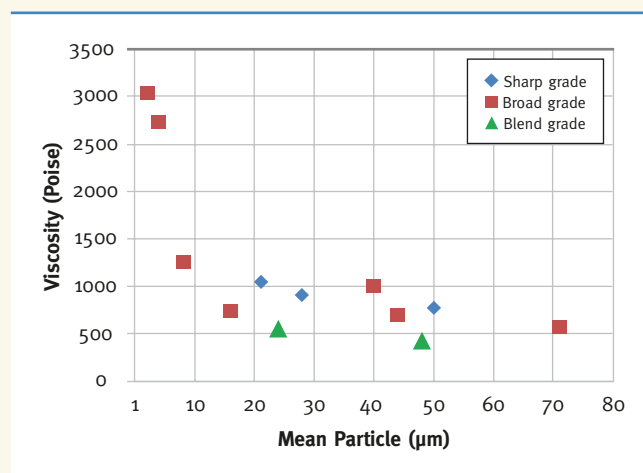
※1 Loss On Ignition, ※2 Warm water extraction (100°C, 2Hr), ※3 LASER DIFFRACTION AND SCATTERING METHOD ANALYZER

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

## Particle Size Distribution



## 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



CB-A50BC



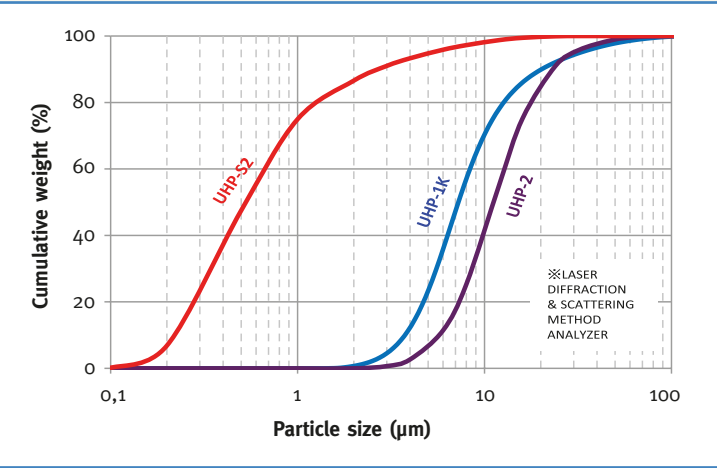
# SHOBN™ UHP SERIES

## Typical properties of common grades

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

※<sup>1</sup> Loss On Ignition,  
※The data shown above are representative figures.  
They are not guaranteed values.

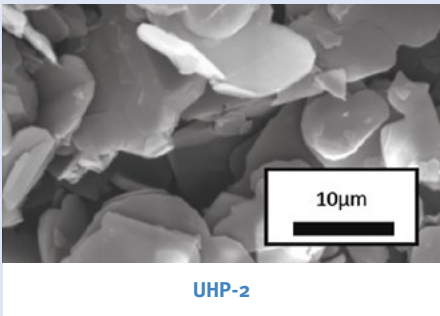
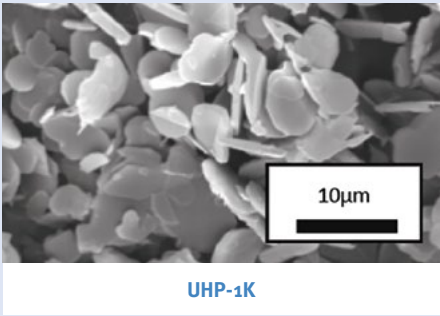
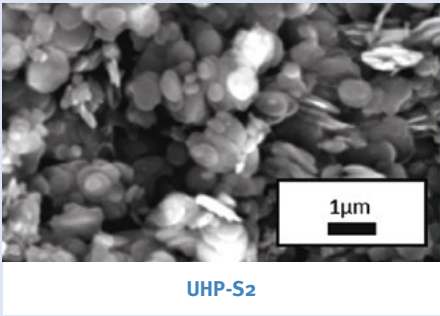
### Particle size distribution: Platelet Type



### 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



GENERAL OVERVIEW OF THERMALLY CONDUCTIVE FILLER MATERIALS

Basic properties

| Material                      |                        | Al2O3            | h-BN             | AlN               | BeO               | MgO              | SiO2<br>Crystalline | SiO2<br>Fused     |
|-------------------------------|------------------------|------------------|------------------|-------------------|-------------------|------------------|---------------------|-------------------|
| Crystal shape                 |                        | Hexagonal        | Hexagonal        | Hexagonal         | Hexagonal         | Cubic            | Trigonal            | Amorphous         |
| Density                       | g/cm³                  | 3.98             | 2.27             | 3.27              | 3.02              | 3.58             | 2.65                | 2.21              |
| Specific heat<br>(Room temp.) | J/kg ·°C               | 750              | 810              | 700               | 1090              | 960              | 740                 | 770               |
| CTE                           | x10 <sup>-6</sup> / °C | 6                | 1                | 4.5               | 6.4               | 13               | 15                  | 0.5               |
| Volume<br>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<br>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<br>(C) | Silicon<br>Carbide<br>(SiC) | Beryllia<br>(BeO) | Aluminum<br>Nitride<br>(AlN) | Hexagonal<br>Boron Nitride<br>(h-BN)           | Silicon<br>Nitride<br>(Si3N4) | Magnesi-<br>um Oxide<br>(MgO) | Aluminum<br>Oxide<br>(Al2O3) | Silica<br>(SiO2)<br>Crystalline | Silica<br>(SiO2)<br>Fused |
|------------------------------------|----------------|-----------------------------|-------------------|------------------------------|--|-------------------------------|-------------------------------|------------------------------|---------------------------------|---------------------------|
| Thermal<br>conductivity<br>(W/m*k) | 2000           | 270                         | 270               | 70~270                       | 1) >200<br>2) several<br>3) 60                 | 30~80                         | 40                            | 20~36                        | 10                              | 1.3                       |
| Notes                              |                | Semi-<br>conduc-<br>tion    | Toxicity          |                              | 1) X direction<br>2) Z direction<br>3) Compact |                               |                               |                              |                                 |                           |

Source: TECHNICAL INFORMATION INSTITUTE.CO.LTD



Resonac Corporation Overview

Company Name: Resonac Corporation  
Head Office Location: 13-9, Shiba Daimon  
1-chome, Minato-ku,  
Tokyo 105-8518,  
Japan

Filler Materials Production Facilities

