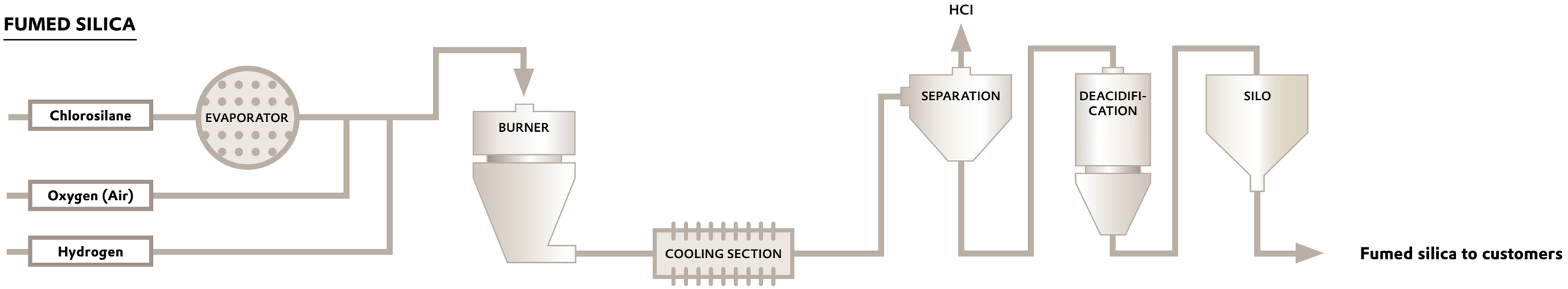
TECHNICAL INFORMATION 1433

# **SILICA** TECHNICAL INFORMATION FOR **3D PRINTING ADDITIVES**

EVONIK
Leading Beyond Chemistry

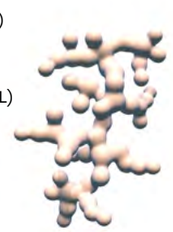
# TWO MAIN TECHNICAL ROUTES

## FUMED SILICA




### AGGREGATE

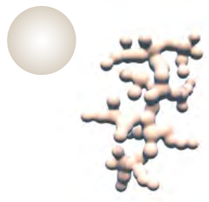
- High purity (>99.8%)
- Chain like aggregate structure
- Low density (~50 g/L)



### METAL OXIDE VARIATION

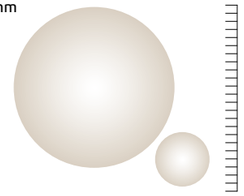

### AGGREGATE STRUCTURE

- Low structure
- High structure
- PSD control



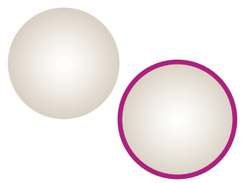
### PARTICLE SIZE

Primary particle size:
6~100 nm



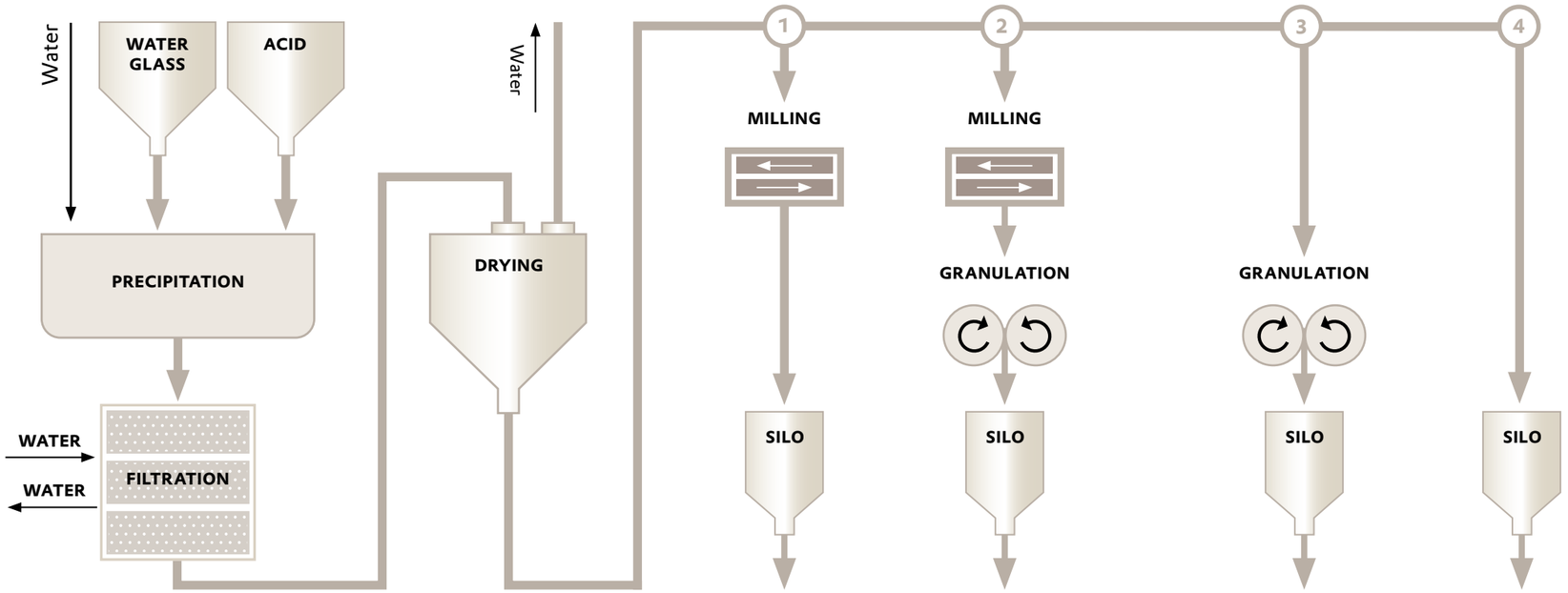
### SURFACE MODIFICATION

- Hydrophilic
- DDS*
- HMDS*
- PDMS*
- MS*
- …

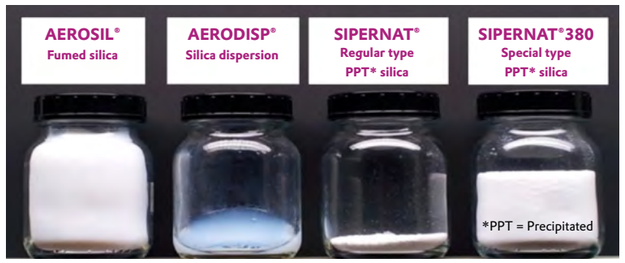


*Abbreviations:
DDS=Dichlorodimethylsilane,
PDMS=Polydimethylsiloxane,
HMDS=Hexamethyldisilazane,
MS=Methacryloxypropyltrimethoxysilane

## PRECIPITATED SILICA

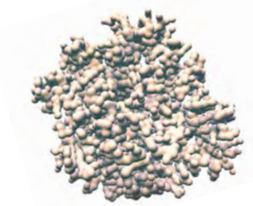



**5g silica (dry weight) made by different process**




Medium diameter (D50) of SIPERNAT® 380 is controlled at 0.3 µm via Evonik special process technology, that makes it more like fumed silica in morphology. Characteristics: good dispersibility, good anti-setting performance and smooth matting effect.

- 'Sponge'like loose porous structure
- Aggregates in micron scale
- Good at absorption and matting

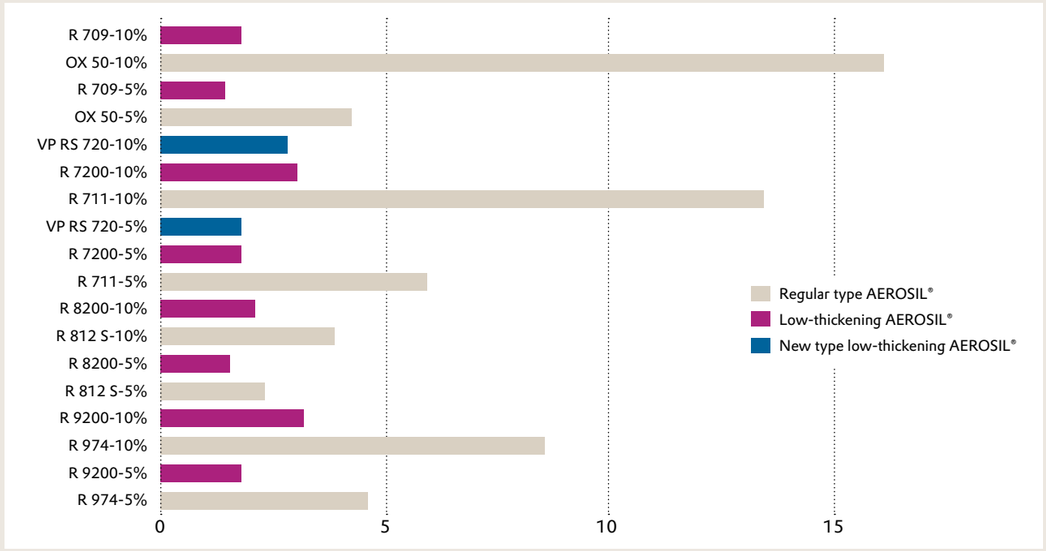


# APPLICATION DATA AND CASES SHARING

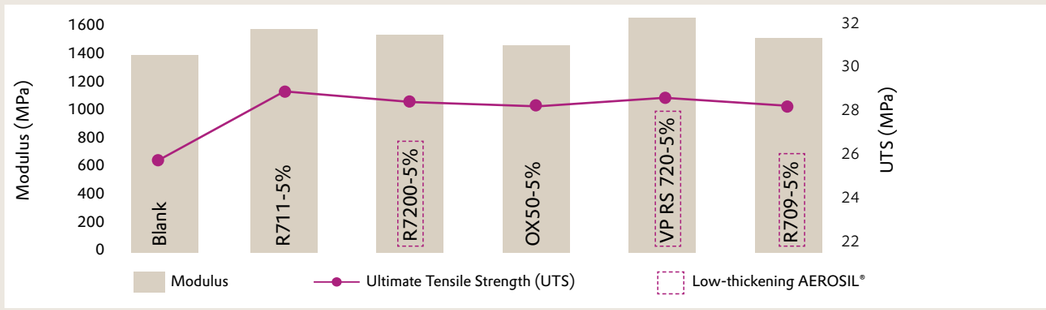
## LOW-THICKENING AEROSIL®
## AS REINFORCEMENT FILLER IN PHOTOPOLYMER

In stereolithography technology, UV light is used to cure photopolymer layer by layer. Low-viscosity of formulation is a crucial parameter of ensuring printing fluency and accuracy in this photopolymerization process. Hence, as reinforcement filler, low-thickening AEROSIL® fumed silicas are best choices undoubtedly.

**FOR EXAMPLE:** Below are the viscosity and mechanical performance of our AEROSIL® fumed silicas in one common SLA resin (acrylates formula). It shows that photopolymers still maintain low viscosity even with high dosage of fumed silica added, meanwhile, mechanical performance is obviously improved.




Relative viscosity of different fumed silica in photopolymer

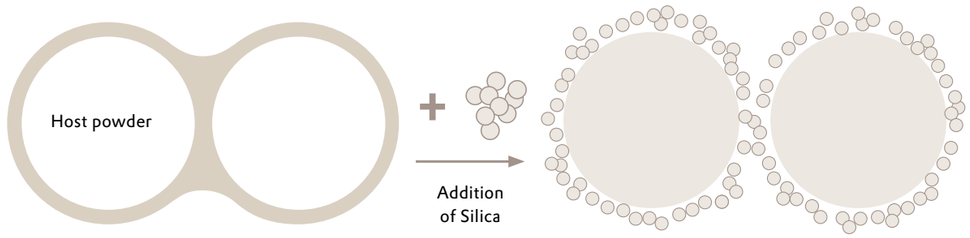


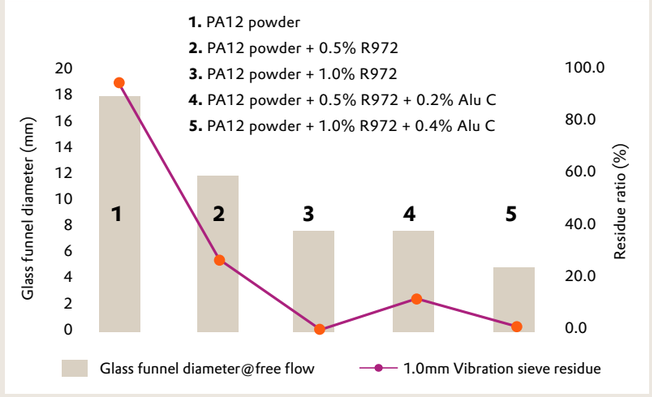

Mechanical performance of printed objects with different fumed silica

## FREE-FLOW AND REINFORCEMENT AGENT
## FOR POWDER MATERIALS

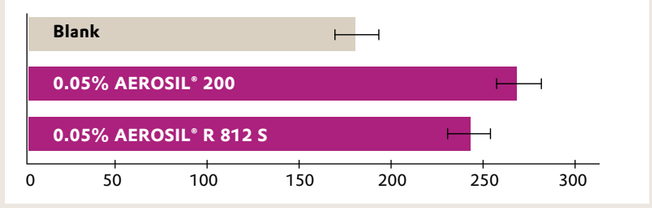
**In Selective Laser Sintering (SLS) technology, polymer and metal powder materials are sintered with laser layer by layer. Poor flowability or caking problems will cause surface craters and inner voids, leading to low yield rate. AEROSIL® and AEROXIDE® can improve their flowability, balance tribo-charge and reduce caking tendency to ensure printing process smooth and effective.**

**For example:** In SLS process of Nylon powder, AEROSIL® and AEROXIDE® are used for improving its flowability and anti-caking performance. In SLS process^ of 316 L stainless steel powder, it is proved that AEROSIL® can improve the microhardness and reduce the inner voids of printed subjects.



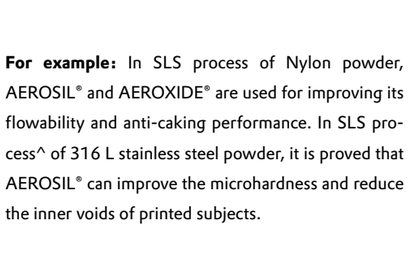



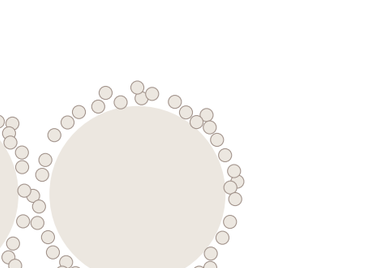

Flowability and anti-caking effect of Nylon powder with fumed oxides inside




Microhardness and metallograph observation of 316L stainless steel powder printed objekts

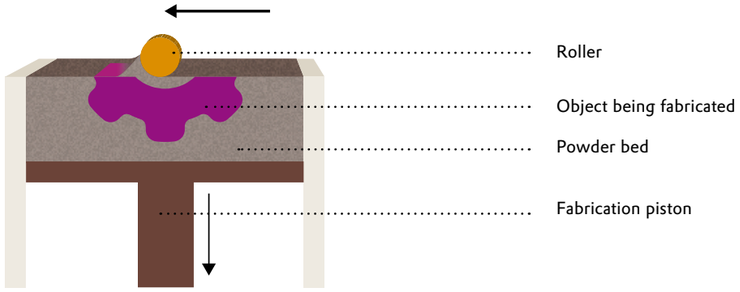


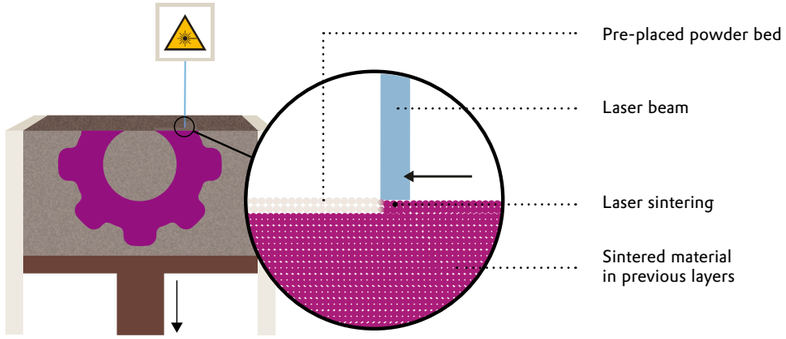



## POWDER BED FUSION (EBS/ EBM/ SLS/ SLM/ BJ...)

**Step 1**
Powder bed distribution




**Step 2**
Fusion process

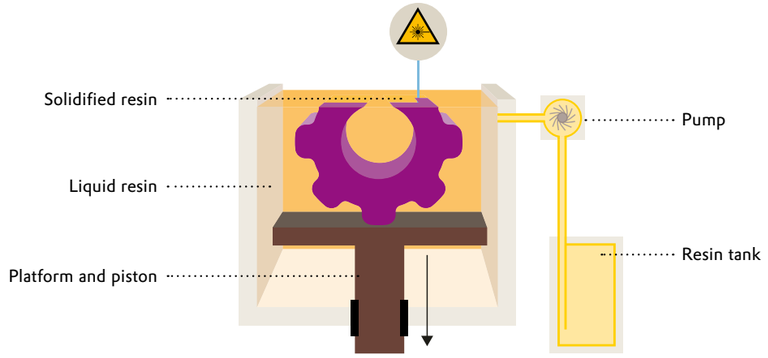



*Powder bed fusion printing process*

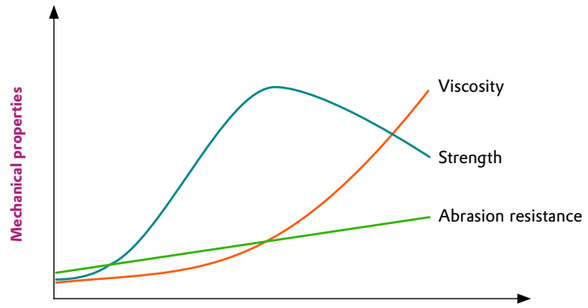
| | Functionality | Proposal amount | Product code | Material type | Surface treatment | BET ($m^2/g$) | Primary particle size/nm | Characteristics |
|---|---|---|---|---|---|---|---|---|
| Polymer materials (PA12/ PP/ TPU...) | Free-flow | 0.1~2% | **AEROSIL® R 812 S** | $SiO_2$ | HMDS | 300 | 7 | High hydrophobicity & flowability |
| | | | **AEROSIL® R 972** | $SiO_2$ | DDS | 130 | 16 | Medium hydrophobicity & flowability |
| | | | **AEROSIL® R 974** | $SiO_2$ | DDS | 200 | 12 | Medium hydrophobicity & flowability |
| | | | **AEROSIL® R 976 S** | $SiO_2$ | DDS | 300 | 7 | High hydrophobicity & flowability |
| | Tribo-charge balancing | 0.1~2% | **AEROSIL® R 504** | $SiO_2$ | Amino silane | 200 | 12 | Good flowability, positive charge |
| | | | **AEROXIDE® Alu C** | $Al_2O_3$ | / | 100 | 13 | Hydrophilic, weak positive charge |
| | | | **AEROXIDE® Alu C 805** | $Al_2O_3$ | Alkyl silane | 100 | 13 | Hydrophobic, weak negative charge |
| | Long-term durability | 0.5~2% | **AEROXIDE® $TiO_2$ T 805** | $TiO_2$ | Alkyl silane | 50 | 21 | High hydrophobicity, avoid tribo-charge accumulation |
| | | | **AEROXIDE® $TiO_2$ NKT 90** | $TiO_2$ | Alkyl silane | 90 | 14 | Strong hydrophobicity, avoid charge accumulation |
| | Anti-caking | 1~10% | **AEROSIL® OX 50** | SiO2 | / | 50 | 40 | Hydrophilic silica, big particle |
| | | | **AEROSIL® RY 50** | SiO2 | PDMS | 50 | 40 | Hydrophobic silica, big particle |
| | | | **AEROSIL® RX 50** | SiO2 | HMDS | 50 | 40 | Hydrophobic silica, big particle |
| Metals (Fe/Ti...) | Free-flow | 0.05~1% | **AEROSIL® R 812 S** | $SiO_2$ | HMDS | 300 | 7 | High hydrophobicity& flowability |
| | | | **AEROSIL® 200** | $Al_2O_3$ | / | 200 | 12 | Hydrophilic silica, medium size |
| | | | **AEROXIDE® Alu C** | $Al_2O_3$ | / | 100 | 13 | Hydrophilic alumina, high hardness |
| | | | **AEROXIDE® Alu C 805** | $Al_2O_3$ | Alkyl silane | 100 | 13 | Hydrophobic alumina, high hardness |



## VAT POLYMERIZATION (SLA/ DLP/ CLP/ CLIP/ MJM...)




*Schematic drawing of the vat polymerization process*




*General correlation between filler content and polymer properties*

| Functionality | Proposal amount | Product code | Material type | Surface treatment | BET ($m^2/g$) | Primary particle size/nm | Characteristics |
|---|---|---|---|---|---|---|---|
| Reinforcement | 2~30% | **AEROSIL® R 709** | $SiO_2$ | MS | 50 | 40 | Good compatibility, low-thickening |
| | | **AEROSIL® R 711** | $SiO_2$ | MS | 200 | 12 | Good compatibility |
| | | **AEROSIL® R 7200** | $SiO_2$ | MS | 200 | 12 | Good compatibility, low-thickening |
| | | **VP RS 720** | $SiO_2$ | MS | 200 | 12 | Good compatibility, low-thickening |
| | | **VP RM 30** | $SiO_2$ | MS | 30 | ~100 | Good compatibility, low-thickening |
| Anti-setting | 1~3% | **AEROSIL® R 9200** | $SiO_2$ | DDS | 200 | 12 | Easy-dispersing, low-thickening |
| | | **AEROSIL® R 711** | $SiO_2$ | MS | 200 | 12 | Good compatibility |
| | | **AEROSIL® R 8200** | $SiO_2$ | HMDS | 200 | 12 | Easy-dispersing, low-thickening |
| | | **AEROSIL® R 972** | $SiO_2$ | DDS | 130 | 16 | Economical, obvious thickening |
| Matting | 1~3% | **SIPERNAT® 380** | $SiO_2$ | / | 165 | 300 | Smooth matting effect |
| Structure component | 50~80% | **AEROSIL® 50** | $SiO_2$ | / | 50 | 30 | Quartz glass printing, low-thickening, low shrinkage |
| | | **AEROSIL® OX 50** | $SiO_2$ | / | 50 | 40 | Quartz glass printing, low-thickening, low shrinkage |
| | | **VP OX 30** | $SiO_2$ | / | 30 | ~100 | Quartz glass printing, low-thickening, low shrinkage |
| Refractive index control | 1~10% | **AEROXIDE® $TiO_2$ T 805** | $TiO_2$ | Alkyl silane | 50 | 21 | High hydrophobicity, high refractive index ~ 2.70 |
| | | **VP Alu C 711** | $Al_2O_3$ | MS | 100 | 13 | Good compatibility, high hardness, medium refractive index ~1.70 |

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