

1- Zetamix General guidelines silicon carbide

Zetamix filaments are on a fine powder ($< 1.0 \mu\text{m}$) and a thermoplastic binder system for the FDM process. Green parts need a binder removal in a two-stage debinding process before being sintered. First debinding step is dissolving the binder in a solvent bath. In the second debinding step the remaining binder is thermally removed. These general guidelines are based on the processing of test parts with a wall thickness of 2 to 4 mm.

The recommendations are considered to work as a standard guideline and must be adapted to individual wall-thickness and part-design.

Filament characteristics

Typical material properties	
<i>Product</i>	Filament for FDM process
<i>Binder basis</i>	Polyolefinebased binder system
<i>Appearance</i>	grey filament

Typical processing properties	
<i>Printing temperature</i>	120°C
<i>Plate temperature</i>	50 °C
<i>Nozzle size</i>	From 0.4 mm to 1 mm (need to adjust the printing speed, the wider the nozzle the slower) 0.6mm recommended
<i>Layer thickness</i>	0.20mm (possibility to go from 0.1 to 1mm, need to adjust printing speed)
<i>Printing speed</i>	15mm/s - 30 mm/s
<i>Debinding process</i>	Two-stage debinding process
<i>1st step : chemical debinding</i>	24 hours in an acetone bath at 40°C (it depends on the geometry of the part) → Mass loss > 12% 2 hours drying in ambient atmosphere
<i>2nd step : thermal debinding</i>	Thermal debinding up to 700 °C with a 10°C/h ramp, 1 hour holding time, all achieved under primary vacuum
<i>Sintering</i>	20°C to 2200°C with a up to 300°C/hour ramp, 1 hour holding time, all achieved under argon (90 mb)
<i>Shrinkage rate</i>	x,y = 16.8% ±1% z = 22.6% ±1%

Printing instructions:

The filament is softer than plastic filaments. Therefore, it is preferable to use a driving gear which is not too much aggressive and will not crush the filament (ideally a grooved driving gear). The filament can be grinded by the extruder, that's why it should be cleaned before a long print. To make sure that the printer is ready we recommend preheating the system and start extruding some material. If nothing come out of the nozzle there might be a clog. Therefore, the nozzle must be replaced or cleaned.

In order to avoid filament grinding, we recommend to load the filament without any pressure at all and then delicately increase it until the filament just gets pushed through the PTFE tube.

We recommend printing the piece on flexible plate. The part can be detached by bending it.

The filament is advised to be used for one year.

Printing parameters: Refers to the IdeaMaker parameters guidelines

Scale: 120,2 % (x and y) / 129,2% (z)

Printing speed: from 15 to 30 mm/s depending on the shape of the part

Layer height: from 0.3mm down to 0.1mm

Retraction: 1mm at 5 mm/s

Fan speed: 100% (the higher the better the print quality)

Wall line count: at least two

Infill: any 2D pattern (triangles, grid, honeycomb, rectilinear)

Infill density: from 100% down to 5% (the top surfaces above the infill depends on the pattern infill density)

Top/bottom surface number:

- for a 0.1mm layer height: 10
- for a 0.2mm layer height: 5

Supports structure: Can be printed using the same material or a soluble material via a dual extrusion system. In order to have a great surface quality at least 3 dense top layers should be printed between the support structure and the part.

2- Debinding Recommendations

First step: solvent debinding (acetone bath)

Step 1: Solvent bath

- It is recommended to debind the printed parts in an acetone bath at 40 °C.
- At least 12% of the weight of the piece should be removed during the solvent debinding step (after drying)
- The duration is depending on wall thickness and part geometry but takes at least 2 hours.

Step 2: Drying

- Let the parts dry at the ambient air (the part can be placed on a tissue to absorb the water)
- The duration is depending on wall thickness and part geometry but takes at least 2 hours.
- This step is essential to measure the mass removed by the solvent debinding step

Second step: thermal debinding

Place the parts in a crucible on a refractory powder bed to accommodate shrinkage and support the part during debinding.

The most reliable process consists of a heating rate of 10°C per hour from 20°C to 700°C. It takes 3 and a half days to complete the debinding.

For small parts the process can be as described below:

segment	From (°C)	To (°C)	Heating rate (°C/h)	Dwell time (h)	Segment duration (min)	Duration in total (h)
0	RT	700	10	1	4200	70
1	700	RT	50		840	84

3- Sintering Recommendations

Sintering in a high temperature furnace

Thermal cycle: RT -> 150°C with 100°C/h ramp, under secondary vacuum, in 1 hours and 30 minutes

150°C -> 2200°C with up to 300°C/h ramp, 1 hour holding time, under partial vacuum (90 mb argon) in 8 hours and 20 minutes

2200°C -> RT at maximum 300 °C/h ramp, return to secondary vacuum under 1000°C, in 7 hours and 20 minutes.

Because of the shrinkage, there is a change of volume. Please modify the scale in the slicer before printing, as it is said in "Printing parameters".