Processing Guide

Tough 2100 VP

Robust and affordable functional material

Fast and easy-to-print functional material with a good balance of toughness, impact resistance and HDT. Due to its robust properties , additional post-treatment like drilling and grinding is easily possible.

Customizable coloring and high transparency available.

Materials can be used in

Tooling Machinery Toys

Performance Indicators

Processing	Very Easy
Flexural Strength	118 MPa
HDT B	76 °C
Izod notched	36 J/m

Preparation

Printing

LCD, DLP, mSLA

Washing

1-5 min Cleaner 400 or IPA

Post-Curing

Cure with UV

Preparation

Safety Guideline

Tough 2100 VP is a chemical formulation in the liquid state and has to be treated as such until it is fully cured. Please use personal lab protection equipment such as appropriate gloves, goggles and lab coat. Wash contaminated body parts and equipment directly after occurrence and change contaminated gloves immediately. Do not consume the resin.

Danger

The information given in this document do not constitute a legally binding SDS, which will be provided at purchase.

Storage and Preparation

Please make sure the resin is stored at minimum at 21 °C.

Please make sure the resin is not exposed to light.

Please stir resin prior to use.

Printing

Print Settings

Tough 2100 VP printed part properties may vary with printer, print settings, object orientation, part geometry and post-processing. The shown recommendations of printer and print settings are based on Cubic Ink's experiments and experience and do not include all possible processes and feasibility of the material (Table 1 - 3). The processor is welcome to explore the workflow regarding printer and print settings since Tough 2100 VP is compatible with a broad range of LCD, DLP and mSLA. Nevertheless, Cubic Ink supports and customizes the processing guidelines together with their partners. If not stated otherwise specimens and objects are printed vertically.

Printing

General Curing Parameters

In Table 1 different curing characteristics are presented. The necessary critical energy as well as the penetration of depth indicate the reactivity and curing in depth abilities of the liquid resin.

Table 1: Curing Parameters measured at Cubic Ink for Tough 2100 VP in uncolored and black.

Measurement	Uncolored		Black
405 nm, 8 mW/cm²:			
E_c [mJ/cm²]	3.52		3.46
D_p [mm]	0.30		0.17
Thickness after 1 s of exposure [mm]	0.24		0.15
Thickness after 4 s of exposure [mm]	0.67		0.38
385 nm, 11 mW/cm²:			
E_c [mJ/cm²]	4.46		3.95
D_p [mm]	0.22		0.13
Thickness after 1 s of exposure [mm]	0.20		0.14
Thickness after 4 s of exposure [mm]	0.50		0.30
x-y-Compensation [%]	1.9[1]	0.8[2]	1.4[3]
z-Compensation [mm]	0.20[1]	0.20[2]	0.20[3]
Printable overhangs [°]	up to 25[1]	up to 25[2]	up to 20[3]
Minimal wall thickness unsupported [mm]	0.4[1]	0.2[2]	0.4[3]
Minimal wall thickness supported [mm]	0.6[1]	0.4[2]	0.6[3]
Minimum pin thickness [mm]	0.5[1]	0.5[2]	1.0[3]
Minimum hole thickness vertical [mm]	0.5[1]	1.5[2]	1.0[3]
Minimum hole thickness horizontal [mm]	1.0[1]	-	0.5[3]

[1]Measured with samples printed and cured via Asiga Pro 4K (DLP 385 nm, 11 mW/cm², 100 µm) and 2x 30 min Formcure L 80 °C; [2]Measured with samples printed and cured via Form 4 (LCD 405 nm, 11 mW/cm², 50 µm) and 2x 30 min Formcure L 80 °C. ; [3]Measured with samples printed and cured via Asiga Pro 4K (DLP 385 nm, 11 mW/cm², 50 µm) and 2x 30 min Formcure L 80 °C. For more details, please contact us.

Printing

Print Settings

Table 2: Suggested curing times depending on wavelength, color, printing thickness and intensity of light source for Tough 2100 VP.

Wavelength	Color	Layer thickness [µm]	11 mW/cm²	8 mW/cm²	5 mW/cm²	2 mW/cm²
385 nm	Uncolored	50	0.6 s	0.8 s	1.3 s	3.3 s
	Uncolored	100	0.7 s	1.0 s	1.6 s	3.9 s
	Black	50	0.7 s	1.0 s	1.6 s	4.2 s
	Black	100	0.9 s	1.3 s	2.0 s	5.2 s
405 nm	Uncolored	50	-	0.6 s	1.0 s	2.4 s
	Uncolored	100	-	0.7 s	1.1 s	2.7 s
	Black	50	-	0.7 s	1.1 s	2.8 s
	Black	100	-	0.8 s	1.3 s	3.3 s

Tough 2100 VP was tested on several printers such as

Prusa SLS1s Speed (LCD, 405 nm, 2 mW/cm²), Phrozen 8K Mighty (LCD, 405 nm, 2 mW/cm²), Phrozen 8K Mega S (LCD, 405 nm, 3 – 5.6 mW/cm²), Asiga Pro 4K80 (DLP, 385 nm, 11 mW/cm²), Formlabs Form 4 (LCD, 405 nm, 2 - 11 mW/cm²), Genera G2 /DLP, 385 nm, 8 mW/cm²), Nexa XiP (LCD, 405 nm, 2.3 -5.5 mW/cm²) . For more information, please contact us.

Table 3: Examples of print settings at Cubic Ink for Tough 2100 VP in uncolored and black.

Printing system	Color	Layer thickness [µm]	Exposure time bottom layer [s]	Exposure time default layer [s]
Prusa SL1S Speed	Uncolored	50	10.0	2.50
(LCD, 405 nm, 2 mW/cm²)	Black	50	10.0	6.50
Formlabs Form 4	Uncolored	50	4.2	0.44
(LCD, 405 nm, 11 mW/cm²)	Black	50	18.2	0.50
Nexa XiP	Uncolored	100	6.2	2.50
(LCD, 405 nm, 2,3 mW/cm²)	Uncolored	200	13.0	6.10
	Black	50	20.0	2.50
	Black	100	36.0	3.00
Asiga Pro 4K80	Uncolored	100	11.1	0.71
(DLP, 385 nm, 11 mW/cm²)	Black	50	30.5	0.75

Washing

Removing & Washing

- Washing with Cubic Ink Cleaner 400 or isopropyl alcohol up to 5 min
- Ultrasonic bath or adequate mixing equipment is beneficial
- Rinse with IPA beneficial

Cleaning

- Treatment with compressed air optional

Drying

- Let dry at ambient conditions for at least 30 min
- To accelerate the process: Dry for 30 – 60 min at 50 °C

Post-Curing

Tough 2100 VP needs to be post-cured to reach its final material properties. The post-cure used on the TDS (Version 4) contained 2 x 30 min UV-treatment via Formlabs Formcure L at 80 °C (LED, 375 and 405 nm). Other examples of post-curing are shown in Table 4 and 5 to emphasize different effects of UV-curing chambers, wavelengths, intensities, time and additional thermal post-cure.

Tough 2100 VP is post-cured via

- UV-cure is necessary
- Temperature in UV-chamber as high as possible (≥80 °C)
- If possible, use vacuum or nitrogen atmosphere
- Thermal post-cure recommended if low intense light chambers were used to gain full potential of material properties (e.g. 2 h at 100 °C)

Table 4: UV post-processing carried out at Cubic Ink for Tough 2100 VP Uncolored (printed with 50 µm).

Post-Process	E-Modulus [GPa]	Tensile strength [MPa]	Elongation at break [%]	HDT B [°C]
Green	1.3	27	40	-
2 x 30 min Formcure L, 80 °C	**2.8**	**73**	**12**	**76**
2 x 2000 flashes Otoflash, N_2	2.7	65	15	64
2 x 6000 flashes Otoflash, N_2	2.7	65	16	68
2 x 30 min 3D Systems	2.7	65	31	62
2 x 30 min Hg-lamp	2.6	66	12	68
2 x 30 min Prusa	2.6	62	14	58
2 x 30 min Phrozen	2.6	60	32	55
2 x 90 min Phrozen	2.6	61	18	57
30 min RSCure, vac.	2.6	62	14	60

Formlabs Formcure L = LED 375, 405 nm; NK Optik Otoflash G171-6 = light-flashes, 350 – 550 nm, N_2; 3D Systems LC-3D post-process unit = 350-550 nm; Hg-lamp = Hönle UVAcube 100; Prusa CW1S = LED 405 nm; Phrozen = LED 405 nm; Rapidshape RSCure = upper + lower wavelength, 170%. Tensile testing Din EN ISO 527-1 5A-specimens, 5 mm/min, 23 °C; HDT B Din EN ISO 75, all specimens printed vertically.

Post-Curing

Table 5: UV post-processing carried out at Cubic Ink for Tough 2100 VP Black (printed with 50 µm).

Post-Process	E-Modulus [GPa]	Tensile strength [MPa]	Elongation at break [%]	HDT B [°C]
2 x 30 min Formcure L, 80 °C	2.9	73	10	80
2 x 5 min Formcure 2nd, 80 °C	2.7	67	16	68
2 x 30 min Formcure 2nd, 100 °C	2.8	71	13	76
2 x 2000 flashes Otoflash, N_2	2.7	63	12	63
2 x 9000 flashes Otoflash, N_2	3.2	81	6	83
2 x 30 min 3D Systems	2.7	66	12	66
2 x 30 min Prusa	2.6	61	13	57
2 x 30 min Prusa + 2 h 100 °C	3.1	78	7	74
2 x 30 min Phrozen	2.0	43	13	53
60 min Asiga Cure, 80 °C, vac.	2.6	62	13	70
60 min F2, N_2	2.7	64	23	68

Formlabs Formcure L = LED 375, 405 nm; Formlabs Formcure 2nd Gen= LED, 405 nm; NK Optik Otoflash G171-6 = light-flashes, 350 – 550 nm, N_2; 3D Systems LC-3D post-process unit = 350-550 nm; Prusa CW1S = LED 405 nm; Phrozen = LED 405 nm; Asiga Cure 1.5 L = LED, vacuum, UV and temperature simultaneously; Genera F2 (100%, LED, 405 nm); thermal post-cure with Memmert UF30 ventilated oven (place only one tray into oven, leave space between objects). Tensile testing Din EN ISO 527-1 5A-specimens, 5 mm/min, 23 °C; HDT B Din EN ISO 75, all specimens printed vertically.

Post-Curing

General Effects of Post-Curing

- Washing and drying:
  - The washing fluid and time of washing can influence the final material properties.
  - In some cases (e.g. using higher temperatures while post-curing) cracks can occur if not washed as recommended and not dried thoroughly.

- UV-Post-cure:
  - Higher wavelength (e.g. ≥405 nm) better for cure in depth, shorter wavelength (e.g. ≤365 nm) better for surface cure.
  - Broad spectra light sources or the combination of multiple wavelengths improve the overall curing process.
  - The higher the intensity of a light source, the shorter the time in the curing chamber.
  - Part orientation in the chosen UV-chamber is crucial. Most chambers focus the LED-spots in the middle of the volume. Placing flat objects on the bottom may cause nearly no or less irradiation by light. Curing time may need to be adjusted depending on the geometry of the part.

- UV Post-cure with vacuum or nitrogen atmosphere:
  - Better for surface cure. Decrease of time in UV-chamber.
  - Less stickiness.

- UV-Post-Cure with simultaneously temperatures above 60 °C:
  - Good for cure in depth and surface cure. Decrease of time in UV-chamber.
  - Not that much depending on the color and geometry of the part, the effect of temperature influences the homogeneity of curing.

- Additional thermal post-cure after finished UV-cure:
  - Good for final cure in depth and surface cure.
  - Recommended temperature varies between 80 - 130 °C for 1 – 5 hours for most materials, between 130 - 190 °C for 0,5 – 5 hours for very high temperature resistant materials.

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