



3D digitization and Rapid Prototyping

Jiří Šafka

13.11.2020

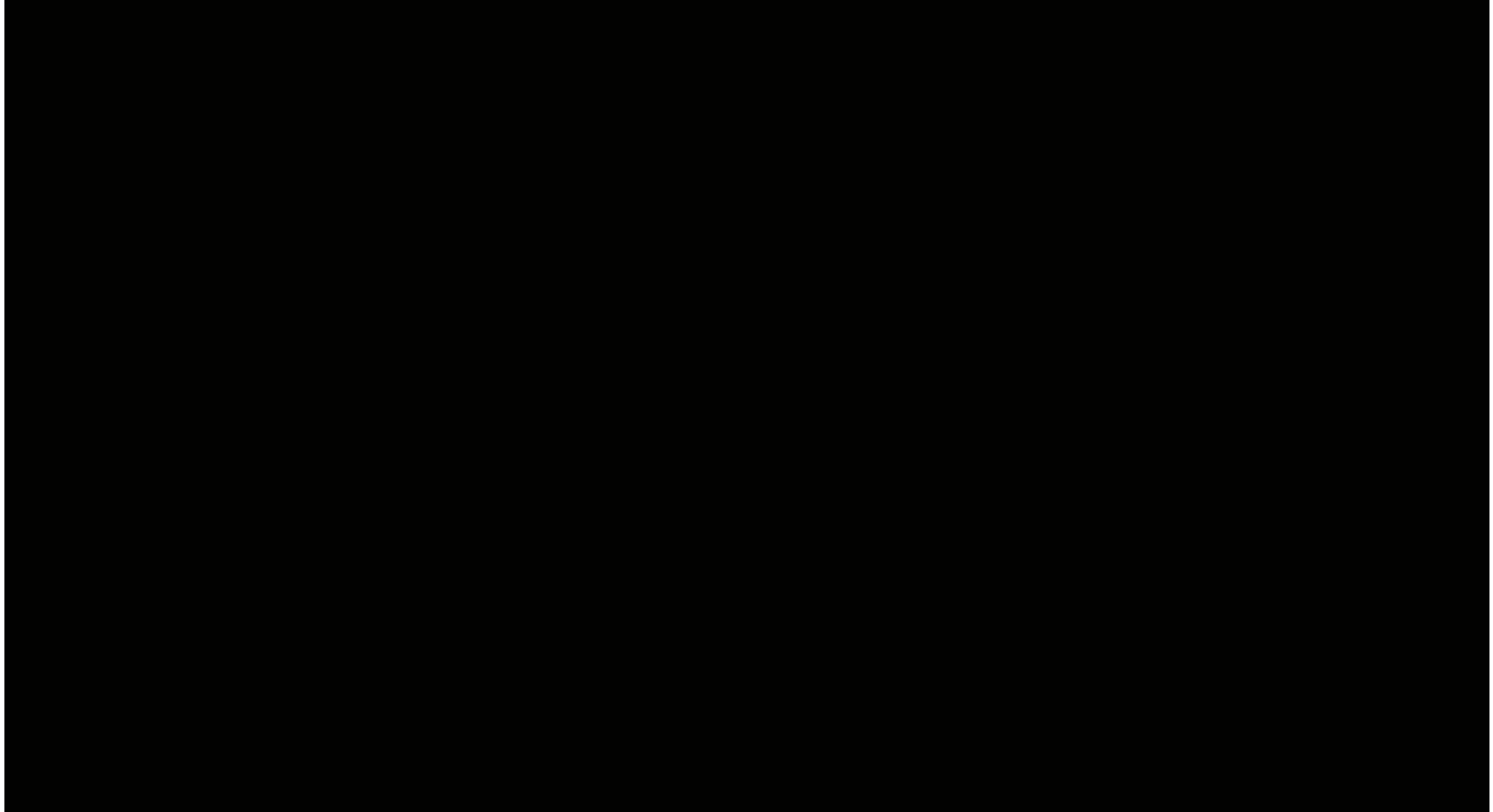


Index

- **Principle of PolyJet, PolyJet Matrix**
- **Objet Connex 500**
- **Objet J750**
- **Samples preparation of data for 3D printing**
- **Examples of practical examples**
- **Practical tests in the 3D print laboratory**

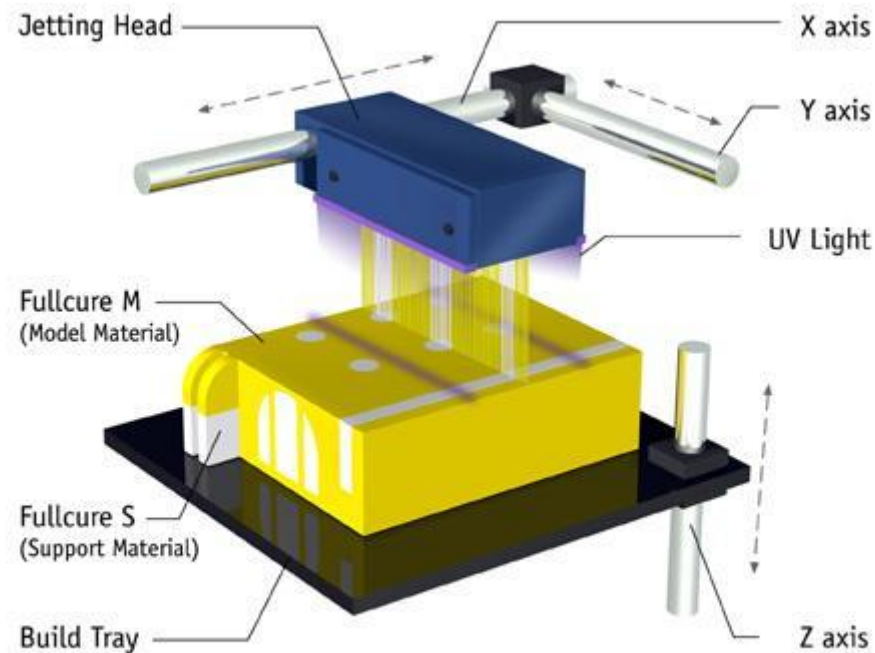


3D printing process



PolyJet - PolyJetMatrix

Technologie PolyJet



The Objet PolyJet Process



Technologie PolyJet



Technology PolyJet

One component 3d printing process

Layer thickness 28 micrometers

Objet 24

234 x 192 x 148,6 mm



Technology PolyJet

Two – component 3d printing process

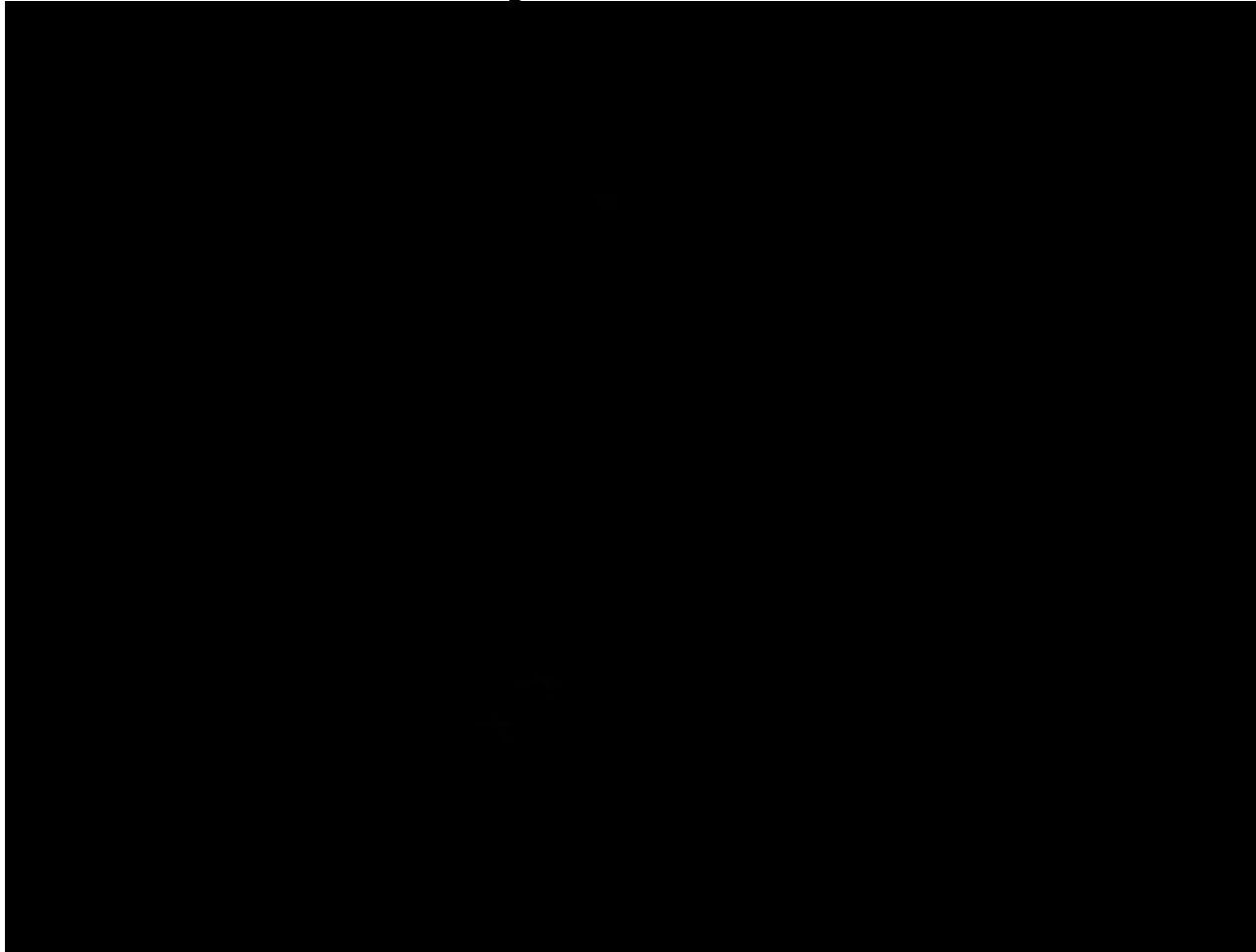
Layer thickness 28 micrometers

Objet 1000

1000 x 800 x 500 mm



PolyJetMatrix

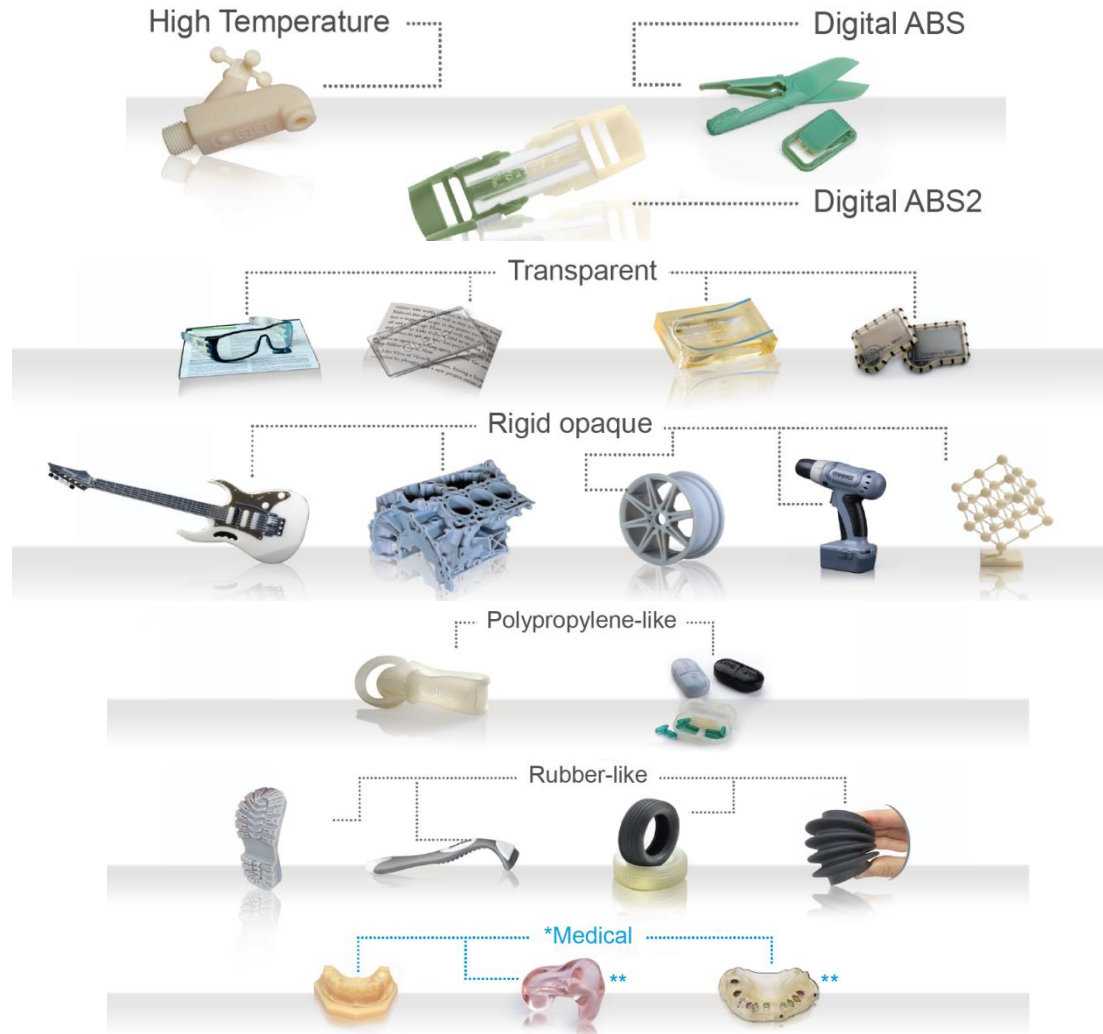


Objet Connex 500

- The first 3D printer with two-component printing
- Possibility of building two materials at the same time (PolyJet Matrix)
- Printing from 14 different materials
- Utilization of up to 104 combinations of digital materials
- Layer thickness 16 or 30 μm
- Print area 500 × 400 × 200 mm



Obiet Connex 500



Materials

- Fullcure®705 – Support material
- Fullcure®720 – base material
- VeroClear – rigid, clear
- VeroBlue – rigid, blue
- VeroWhite – rigid, white
- VeroBlack – rigid, black
- VeroGrey - rigid, grey
- TangoBlack – flexible, black
- TangoGrey – flexible, grey
- TangoPlus – flexible, clear
- TangoBlackPlus – flexible, black
- Durux White – pp like, white
- MED 610 – bio-compatible



FullCure®720



- Base material

	ASTM	Units	Metric	Units	Imperial
Tensile strength	D-638-03	MPa	50-65	psi	7250-9450
Elongation at break	D-638-05	%	15-25	%	15-25
Modulus of elasticity	D-638-04	MPa	2000-3000	psi	290,000-435,000
Flexural Strength	D-790-03	MPa	80-110	psi	12000-16000
Flexural Modulus	D-790-04	MPa	2700-3300	psi	390,000-480,000
HDT, °C @ 0.45MPa	D-648-06	°C	45-50	°F	113-122
HDT, °C @ 1.82MPa	D-648-07	°C	45-50	°F	113-122
Izod Notched Impact	D-256-06	J/m	20-30	ft lb/inch	0.375-0.562
Water Absorption	D-570-98 24hr	%	1.5-2.2	%	1.5-2.2
Tg	DMA, E _s	°C	48-50	°F	118-122
Shore Hardness (D)	Scale D	Scale D	83-86	Scale D	83-86
Rockwell Hardness	Scale M	Scale M	73-76	Scale M	73-76
Polymerized density	ASTM D792	g/cm ³	1.18-1.19		
Ash content	USP281	%	0.01-0.02	%	0.01-0.02



VeroClear



■ Clear material

	ASTM	Units	Metric	Units	Imperial
Tensile strength	D-638-03	MPa	50-65	psi	7250-9450
Elongation at break	D-638-05	%	15-25	%	15-25
Modulus of elasticity	D-638-04	MPa	2000-3000	psi	290,000-435,000
Flexural Strength	D-790-03	MPa	80-110	psi	12000-16000
Flexural Modulus	D-790-04	MPa	2700-3300	psi	390,000-480,000
HDT, °C @ 0.45MPa	D-648-06	°C	45-50	°F	113-122
HDT, °C @ 1.82MPa	D-648-07	°C	45-50	°F	113-122
Izod Notched Impact	D-256-06	J/m	20-30	ft lb/inch	0.375-0.562
Water Absorption	D-570-98 24hr	%	1.5-2.2	%	1.5-2.2
Tg	DMA, E _s	°C	48-50	°F	118-122
Shore Hardness (D)	Scale D	Scale D	83-86	Scale D	83-86
Rockwell Hardness	Scale M	Scale M	73-76	Scale M	73-76
Polymerized density	ASTM D792	g/cm ³	1.18-1.19		
Ash content	USP281	%	0.01-0.02	%	0.01-0.02



Group Vero



VeroWhite



VeroBlue



VeroGray



VeroBlack

- Rigid materials
- different colors

	ASTM	Units	Metric	Units	Imperial
Tensile strength	D-638-03	MPa	50-65	psi	7250-9450
Elongation at break	D-638-05	%	10-25	%	10-25
Modulus of elasticity	D-638-04	MPa	2000-3000	psi	290,000-435,000
Flexural Strength	D-790-03	MPa	75-110	psi	11000-16000
Flexural Modulus	D-790-04	MPa	2200-3200	psi	320,000-465,000
HDT, °C @ 0.45MPa	D-648-06	°C	45-50	°F	113-122
HDT, °C @ 1.82MPa	D-648-07	°C	45-50	°F	113-122
Izod Notched Impact	D-256-06	J/m	20-30	ft lb/inch	0.375-0.562
Water Absorption	D-570-98 24hr	%	1.1-1.5	%	1.1-1.5
Tg	DMA, E»	°C	52-54	°F	126-129
Shore Hardness (D)	Scale D	Scale D	83-86	Scale D	83-86
Rockwell Hardness	Scale M	Scale M	73-76	Scale M	73-76
Polymerized density	ASTM D792	g/cm ³	1.17-1.18		
Ash content VeroGray, VeroWhitePlus	USP281	%	0.23-0.26	%	0.23-0.26
Ash content VeroBlack	USP281	%	0.01-0.02	%	0.01-0.02



Group Tango



TangoBlack



TangoGray



TangoPlus



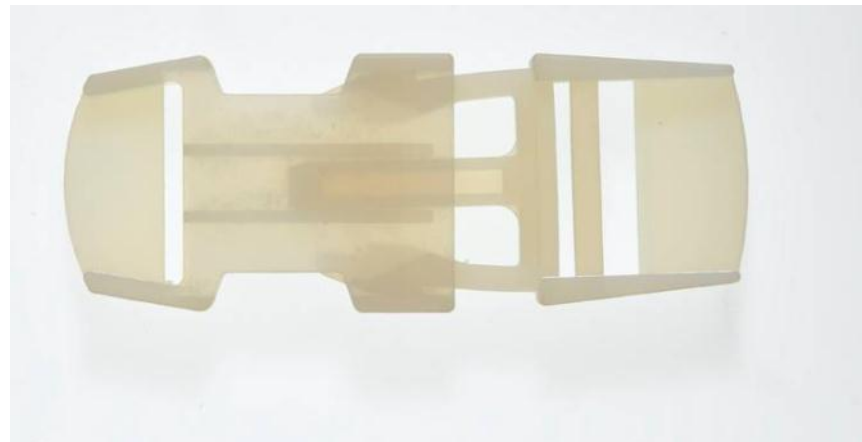
TangoPlusBlack

- Rubber like materials
- Different colors

	ASTM	Units	Metric	Units	Imperial
Tensile strength	D-412	MPa	0.8-1.5	psi	115-220
Elongation at break	D-412	%	170-220	%	170-220
Compressive set	D-395	%	4-5	%	4-5
Shore Hardness (A)	D-2240	Scale A	26-28	Scale A	26-28
Tensile Tear resistance	D-624	Kg/cm	2-4.	Lb/in	18-22
Polymerized density	ASTM D792	g/cm ³	1.12-1.13		



Durux White

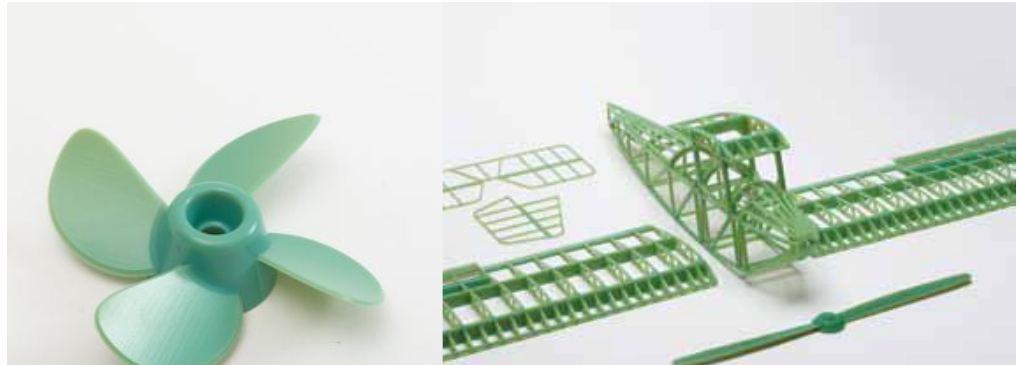


■ PP like material

	ASTM	Units	Metric	Units	Imperial
Tensile strength	D-638-03	MPa	20-30	psi	2900-4350
Elongation at break	D-638-05	%	40-50	%	40-50
Modulus of elasticity	D-638-04	MPa	1000-1200	psi	145,000-175,000
Flexural Strength	D-790-03	MPa	30-40	psi	4350-5800
Flexural Modulus	D-790-04	MPa	1200-1600	psi	175,000-230,000
HDT, °C @ 0.45MPa	D-648-06	°C	37-42	°F	99-108
HDT, °C @ 1.82MPa	D-648-07	°C	32-34	°F	90-93
Izod Notched Impact	D-256-06	J/m	40-50	ft lb/inch	0.749-0.937
Water Absorption	D-570-98 24hr	%	1.5-1.9	%	1.5-1.9
Tg	DMA, E»	°C	35-37	°F	95-99
Shore Hardness (D)	Scale D	Scale D	74-78	Scale D	74-78
Rockwell Hardness	Scale M	Scale M	no data	Scale M	no data
Polymerized density	ASTM D792	g/cm3	1.15-1.17		
Ash content	USP281	%	0.10-0.12	%	0.1-0.12



dABS like material (RGD515,535)

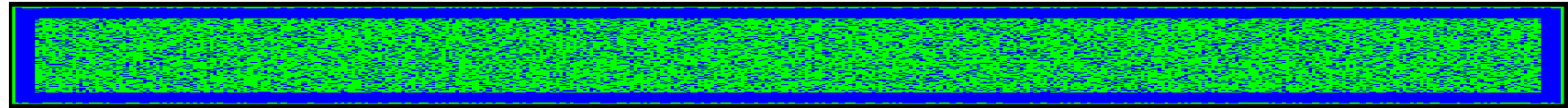
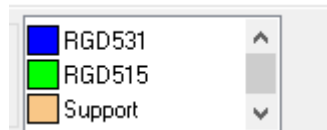


- ABS like
- Suitable for technical parts

	ASTM	Units	Metric	Units	Imperial
Tensile strength	D-638-03	MPa	55-60	psi	8000-8700
Elongation at break	D-638-05	MPa	25-40	psi	25-40
Modulus of elasticity	D-638-04	MPa	2600-3000	psi	375,000-435,000
Flexural Strength	D-790-03	MPa	65-75	psi	9,500-11,000
Flexural Modulus	D-790-04	MPa	1700-2200	psi	245,000-320,000
HDT, °C @ 0.45MPa	D-648-06	°C	58-68	°F	136-154
HDT, °C @ 0.45MPa after thermal post treatment procedure A	D-648-06	°C	82-90	°F	180-194
HDT, °C @ 0.45MPa after thermal post treatment procedure B	D-648-06	°C	92-95	°F	198-203
HDT, °C @ 1.82MPa	D-648-07	°C	51-55	°F	124-131
Izod Notched Impact	D-256-06	J/m	65-80	ft lb/inch	1.22-1.50
Tg	DMA, E ₂	°C	47-53	°F	117-127
Shore Hardness (D)	Scale D	Scale D	85-87	Scale D	85-87
Rockwell Hardness	Scale M	Scale M	67-69	Scale M	67-69



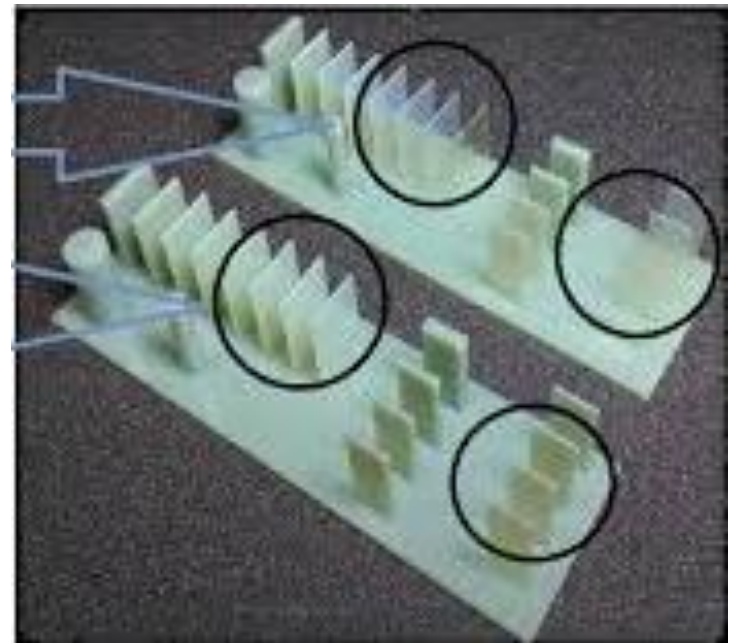
dABS like material (RGD515,535)



dABS like material (RGD515,535)

dABS – 1. generation

dABS2 – 2. generation



High Temperature material (RGD525)



- Suitable for high temperature application

	ASTM	Units	Metric	Units	Imperial
Tensile strength	D-638-03	MPa	70-80	psi	10,000-11,500
Elongation at break	D-638-05	%	10-15	%	10-15
Modulus of elasticity	D-638-04	MPa	3200-3500	psi	465,000-510,000
Flexural Strength	D-790-03	MPa	110-130	psi	16,000-19,000
Flexural Modulus	D-790-04	MPa	3100-3500	psi	450,000-510,000
HDT, °C @ 0.45MPa	D-648-06	°C	63-67	°F	145-163
HDT, °C @ 0.45MPa after thermal post treatment procedure A	D-648-06	°C	75-80	°F	167-176
HDT, °C @ 1.82MPa	D-648-07	°C	55-57	°F	131-135
Izod Notched Impact	D-256-06	J/m	14-16	ft lb/inch	0.262-0.300
Water Absorption, %	D-570-98 24hr	%	1.2-1.4	%	1.2-1.4
Tg	DMA, E _α	°C	62-65	°F	144-149
Shore D	Scale D	Scale D	87-88	Scale D	87-88
Rockwell Hardness	Scale M	Scale M	78-83	Scale M	78-83
Polymerized density	ASTM D792	g/cm ³	0.97-0.98		
Ash content	USP281	%	0.38-0.42	%	0.38-0.42



Bio – biocompatible material – (MED610)



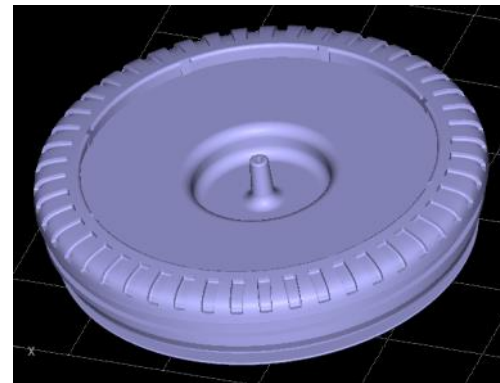
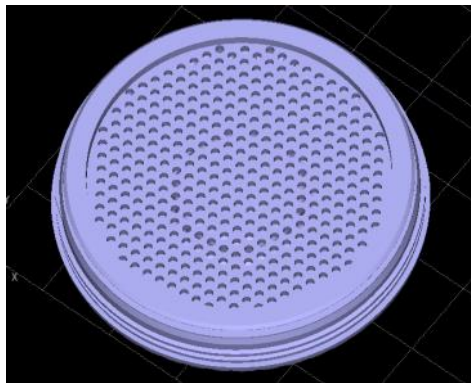
Property	ASTM	Metric		Imperial	
		MPa		psi	
Tensile Strength	D-638-03	MPa	50-65	psi	7,250-9,450
Modulus of Elasticity	D-638-04	MPa	2,000-3,000	psi	290,000-435,000
Elongation at Break	D-638-05	%	10-25	%	10-25
Flexural Strength	D-790-03	MPa	75-110	psi	11,000-16,000
Flexural Modulus	D-790-04	MPa	2,200-3,200	psi	320,000-465,000
Izod Notched Impact	D-256-06	J/m	20-30	ft lb/in	0.375-0.562
HDT at 0.45 MPa	D-648-06	°C	45-50	°F	113-122
Water Absorption	D570-98 24 Hr	%	1.1-1.5	%	1.1-1.5



Compare FDM and PolyJet 3D print technology

Technology FDM) – machine Stratasys Dimension,
Layer thickness 0,25 mm, material ABS

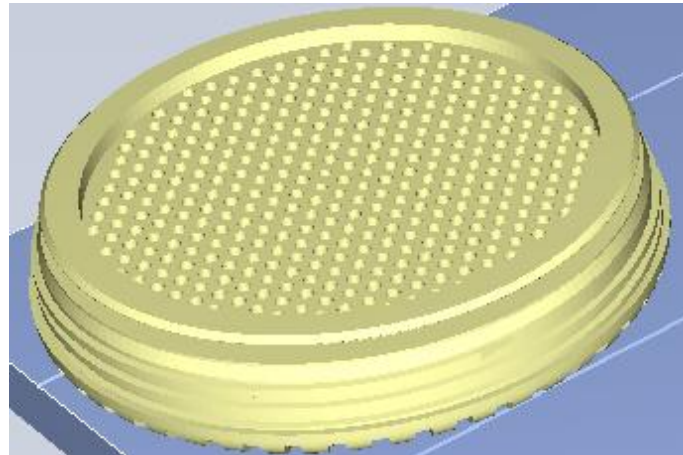
Dimension	Diameter [mm]	Height [mm]
	114	24,7



Model material [g]	Support material [g]	Build time [hod.]
66,87	41,71	10:53

Compare FDM and PolyJet 3D print technology

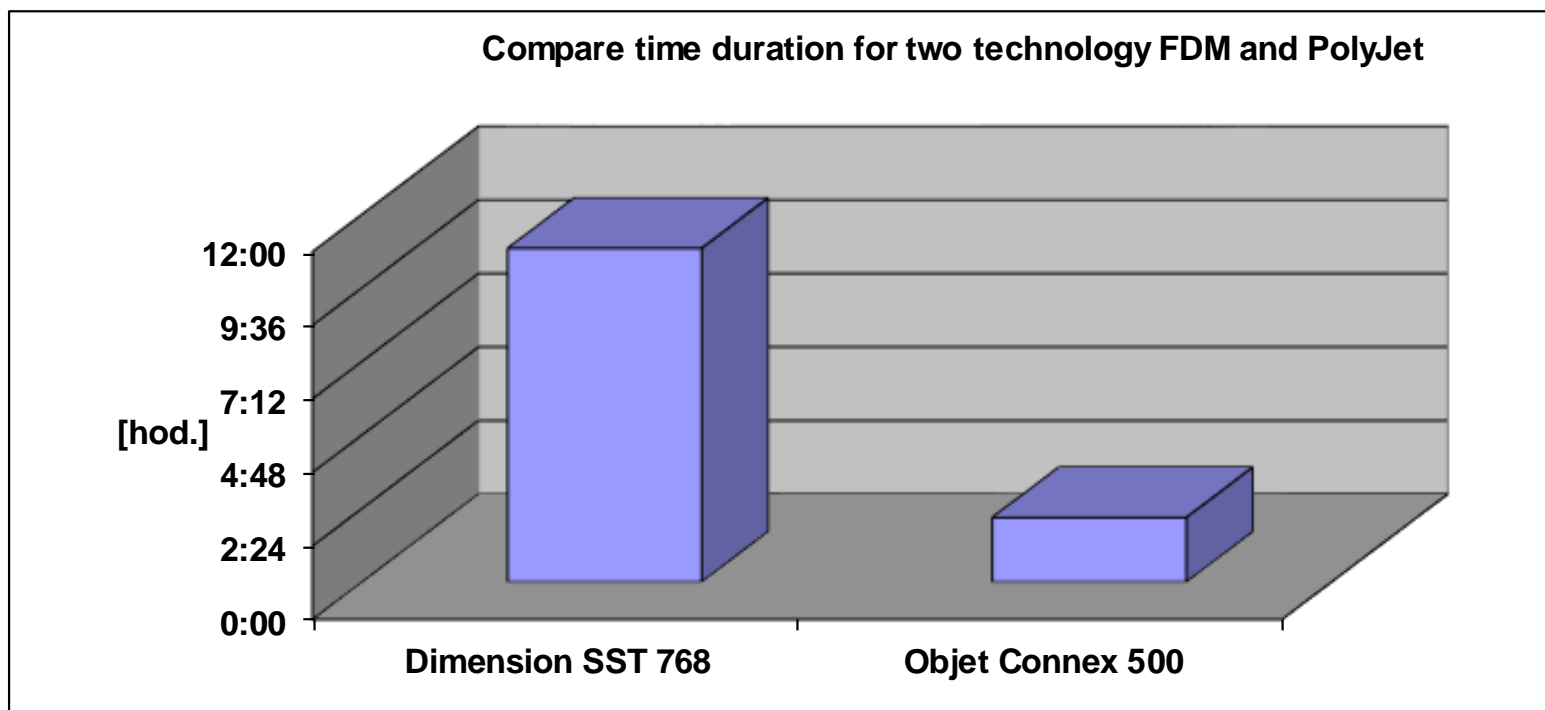
Technology PolyJetMatrix, Layer thicknes 0,03 mm, material Fullcure®720



Model material [g]	Support material [g]	Build time [hod.]
157	181	2:06



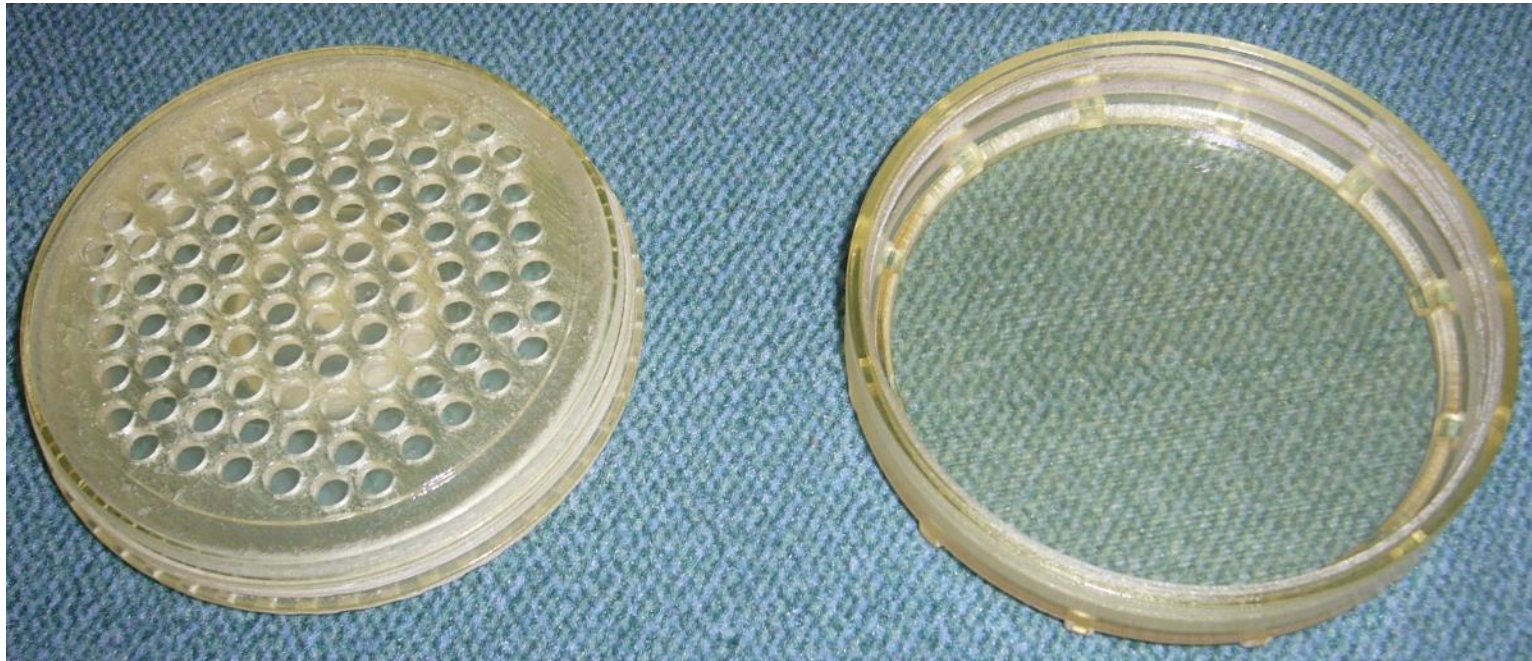
Compare FDM and PolyJet 3D print technology



Time difference more than 9 hours.



Results from PolyJet technology



Rigid Transparent & Rubber-Like DMs



TangoBlackPlus + VeroClear



TangoPlus + VeroClear

20 Digital material combinations

Rigid materials
Different transparent
shades of gray

Rigid materials
PP like DM

Rubber like materials
Shore 27, 40, 50, 60, 70, 85 and
95
(no need for material
replacement)

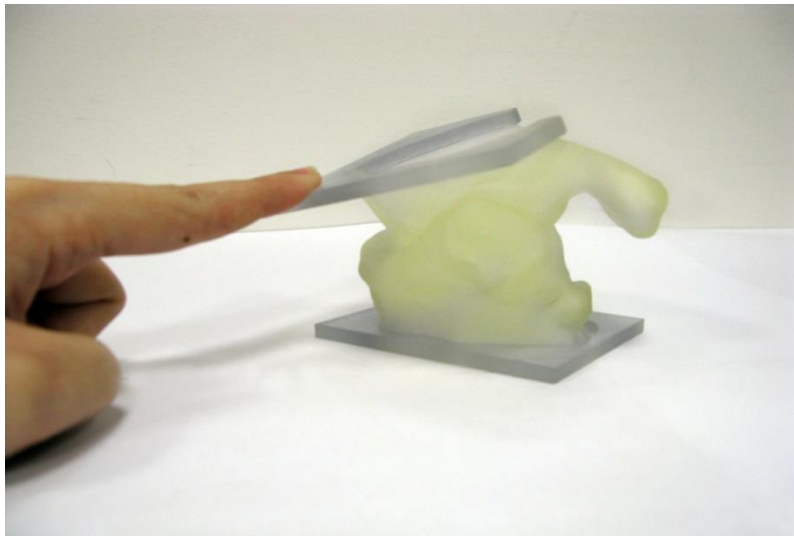


Rigid Transparent & Rubber-Like DMs



TangoPlus + VeroClear

Heart Valve made of TangoPlus & VeroClear



Functional testing of a heart valve



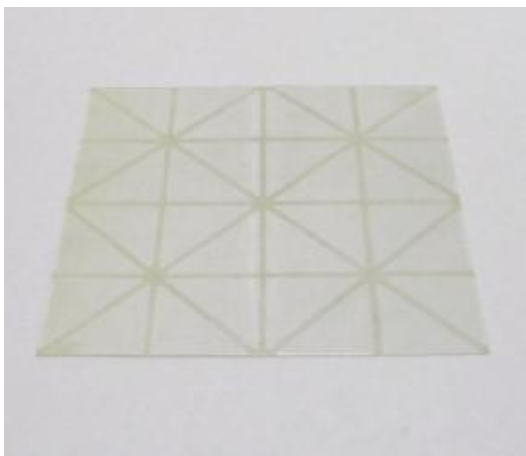
Rigid Transparent with Shore 60 DM

Rigid Transparent & Rubber-Like DMs

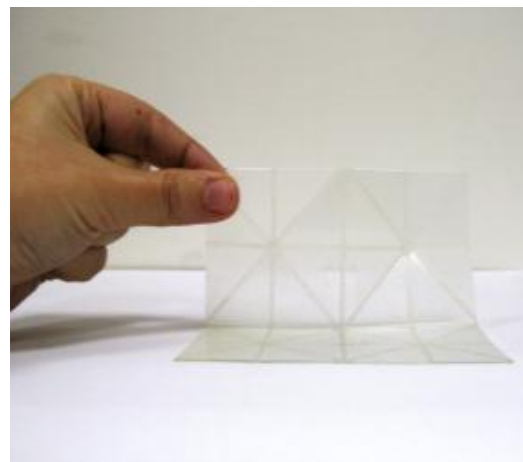


TangoPlus + VeroClear

Origami



VeroClear triangles connected
with TangoPlus DM Shore 40



Wall Thickness of 0.6mm



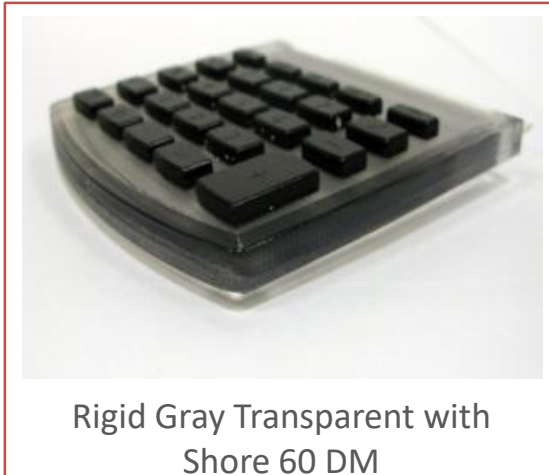
Exceptional demonstration
of living hinges



Origami



Rigid Transparent & Black Rubber- Like



Rigid Transparent & Black Rubber-Like



**Ideal Standard – CG,
Germany**

Pipe made of VeroClear and
inside Tango BlackPlus
Rubber-like DM Shore 40



- Nozzles made of rubber-like DM Shore 85
- Internal disk made of PP-like DM,
- External disk made of transparent light gray rigid DM



TangoBlackPlus + VeroClear

Rigid High Temp & Black Rubber-Like



TangoPlus + High Temp



TangoBlackPlus + High Temp

19 Digital material combinations

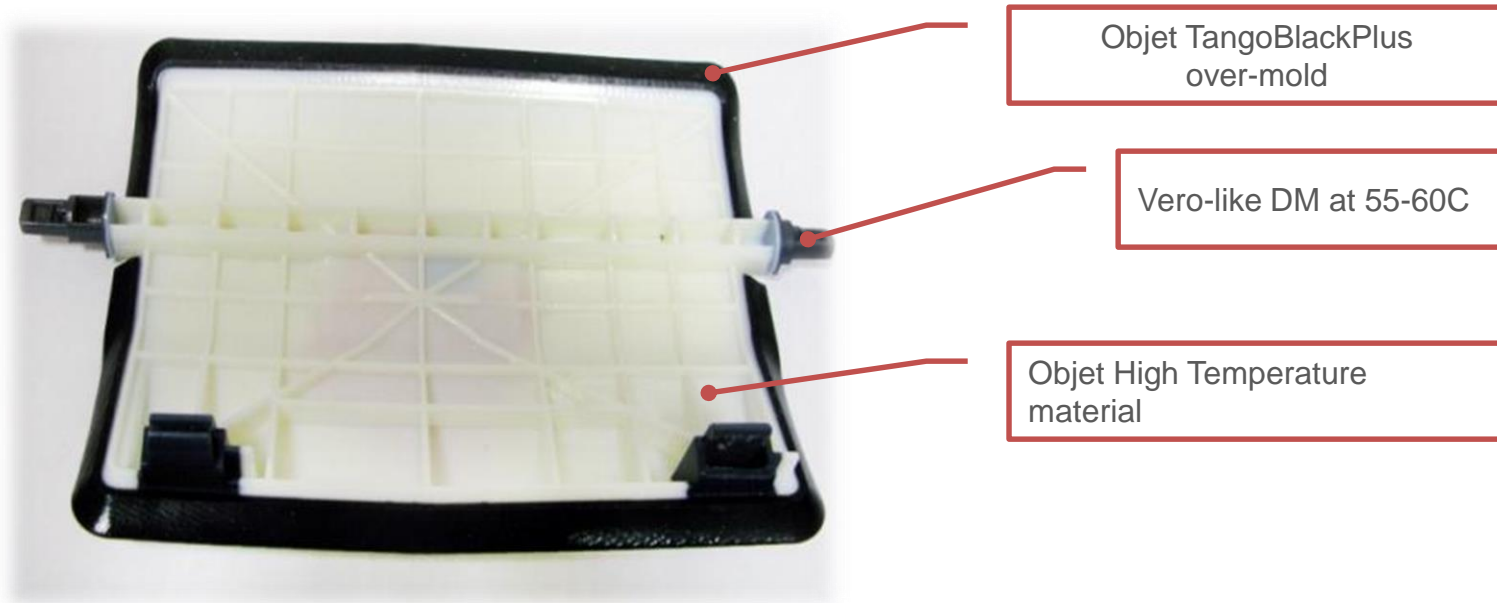
Rigid high temp materials
Different shades of gray

Tougher DM
Performs as Vero
at 56C (133F)

Rubber-like materials
Shore 27, 40, 50, 60, 70, 85 and
95
(no need for material
replacement)



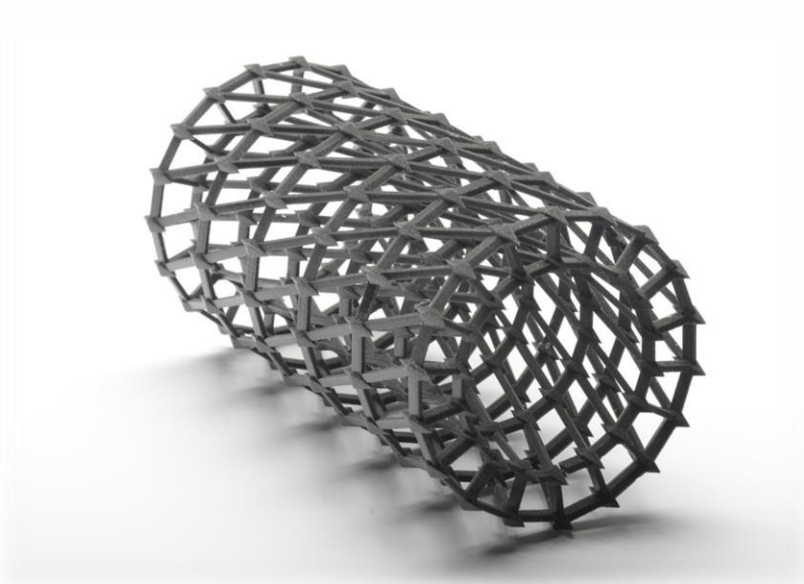
Rigid Transparent & Black Rubber-Like



- Car air inflow where air comes directly from the motor
- Part was assembled – no breakage
- Part was tested for 15 days at 60°C
- Full functionality, no deformation

VeroBlack

- VeroBlackPlus replaces VeroBlack in Desktop, Eden and Connex product lines
- Great dimensional stability and surface smoothness
- Based on VeroGray formulation, same properties



Rigid Black & Black Rubber-Like



TangoPlus + VeroBlackPlus



VeroBlackPlus + TangoBlackPlus

16 Digital material combinations

*Enabling black appearance at different properties –
from rigid to rubber*

Rigid materials

Balanced Rigidity and PP-like

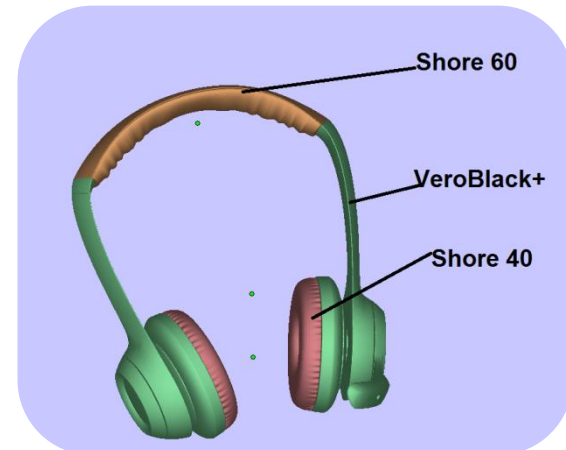
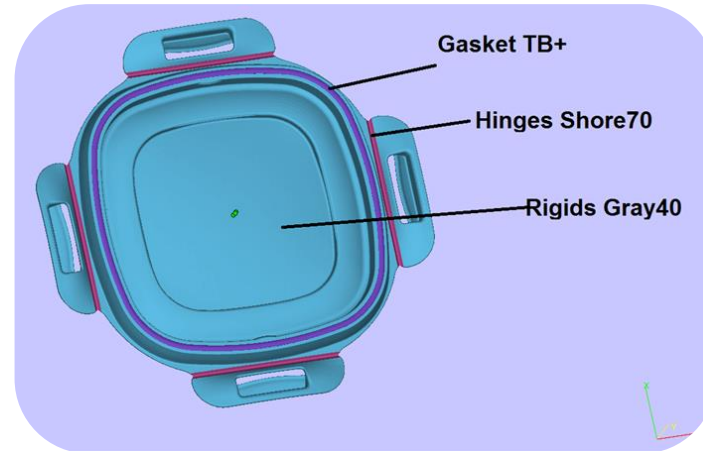
Rubber like materials

Shore 27, 40, 50, 60, 70, 85 and
95

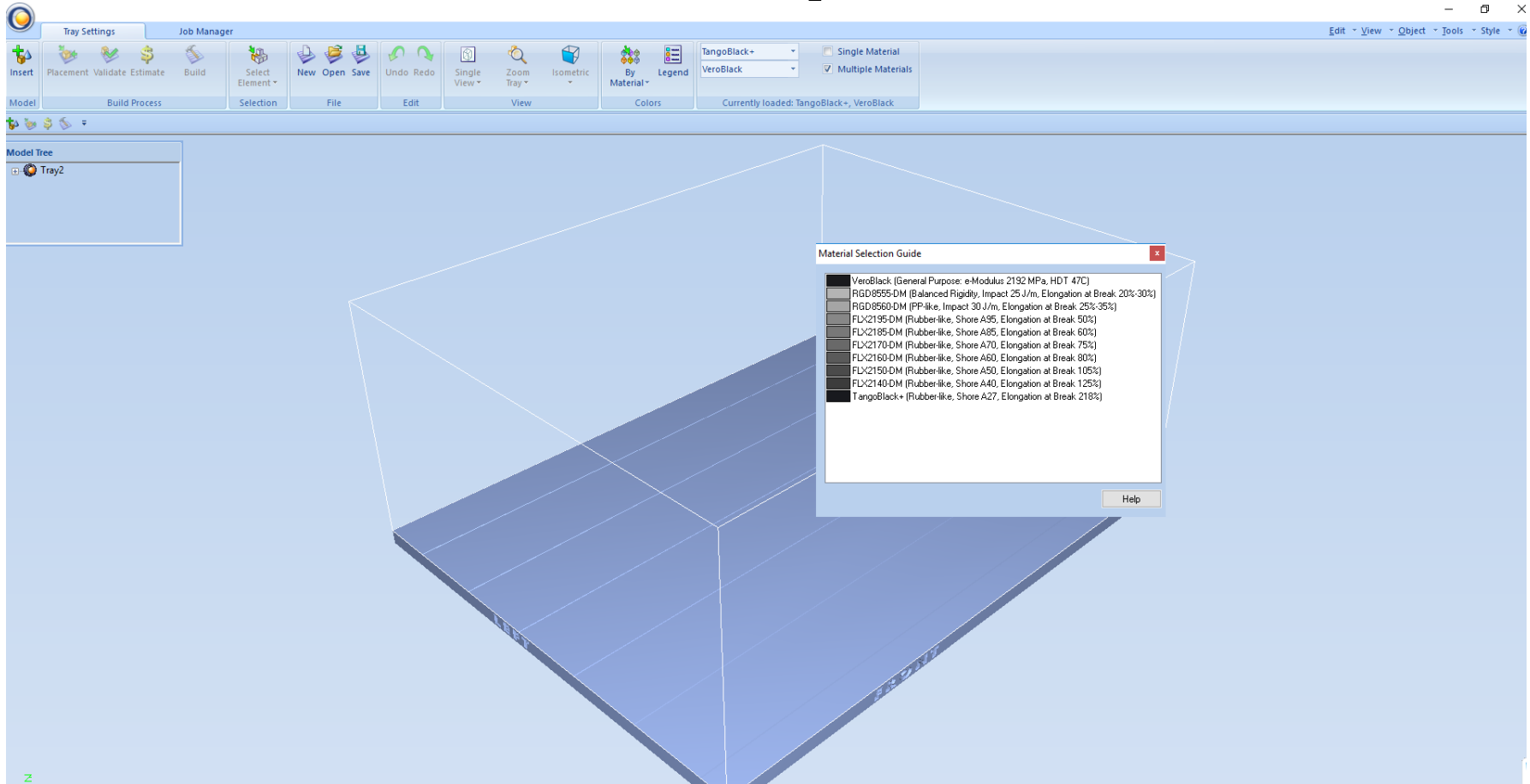
(no need for material
replacement)



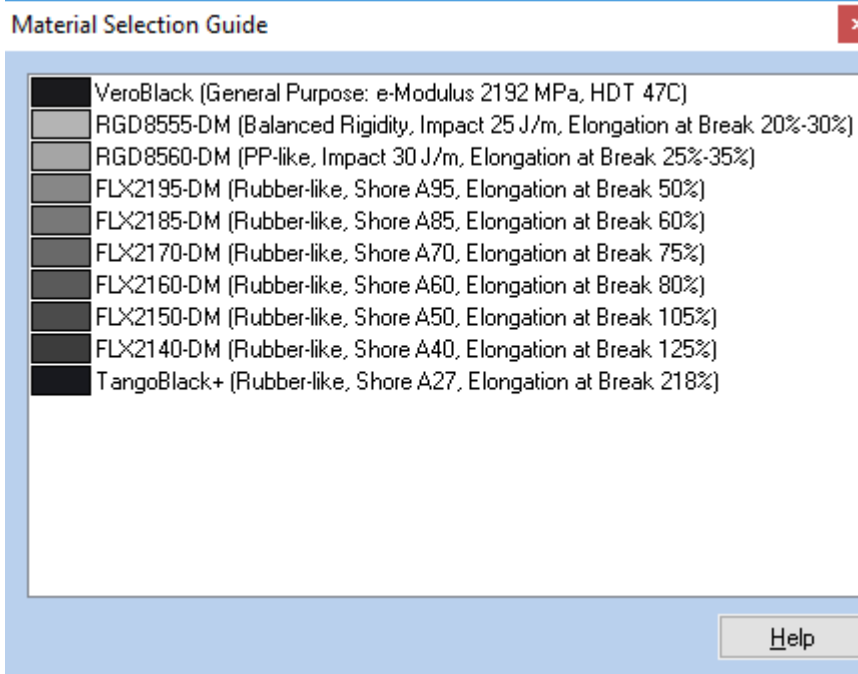
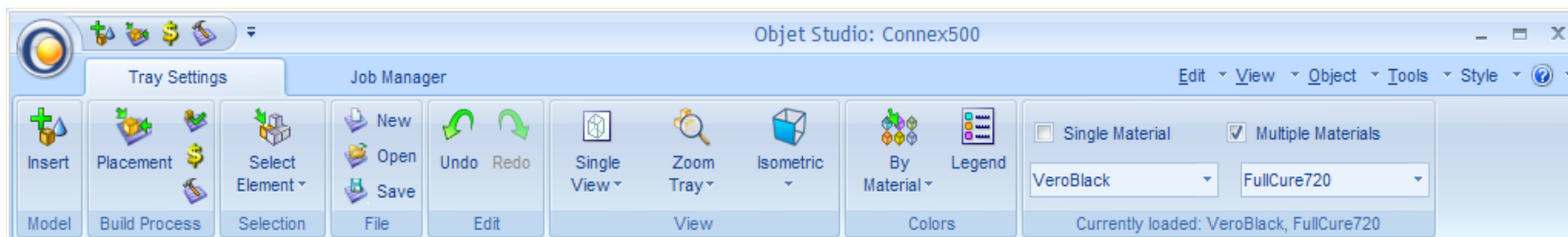
Rigid Black & Black Rubber-Like



Software Objet Studio

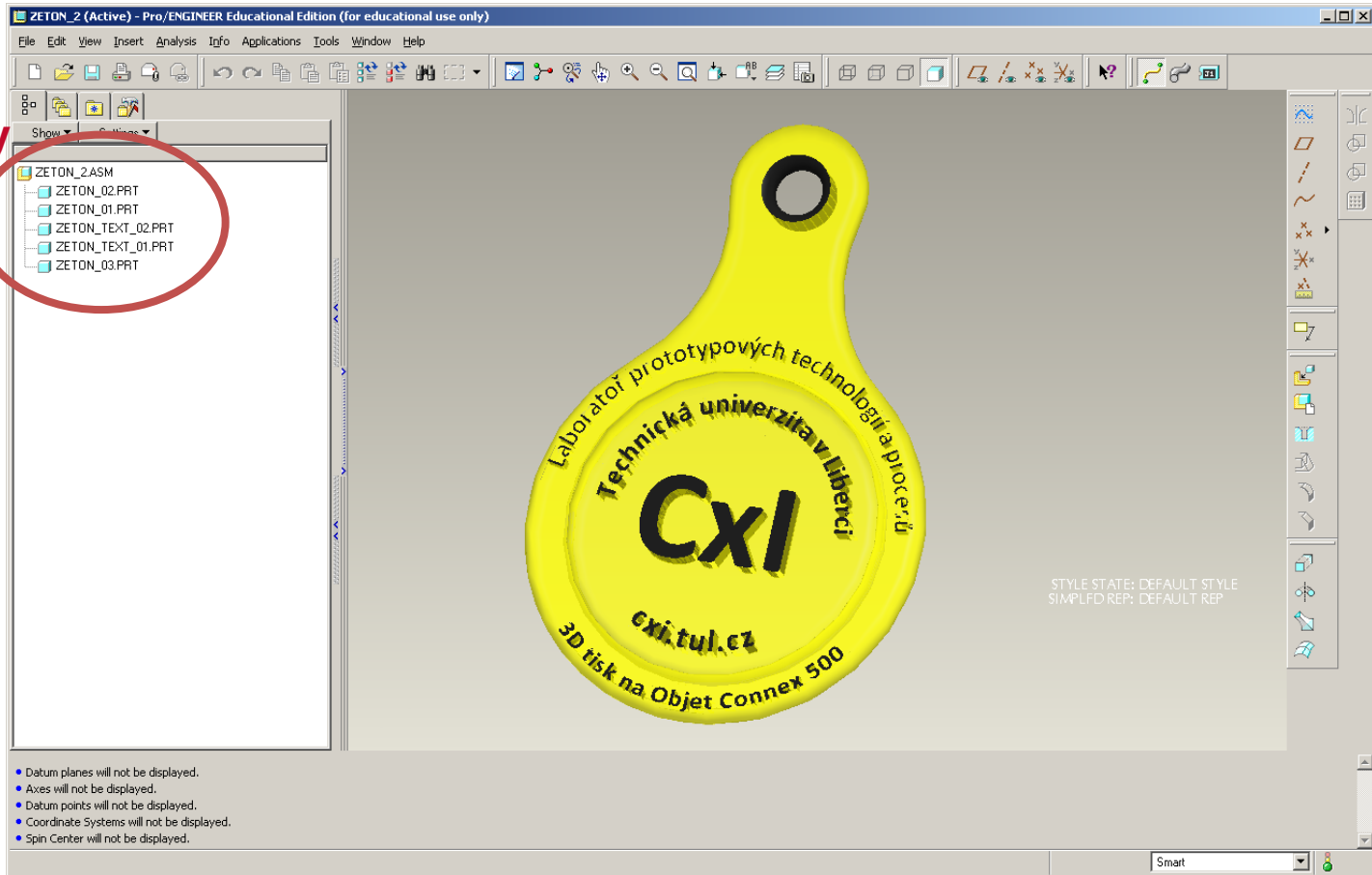


Software Objet Studio

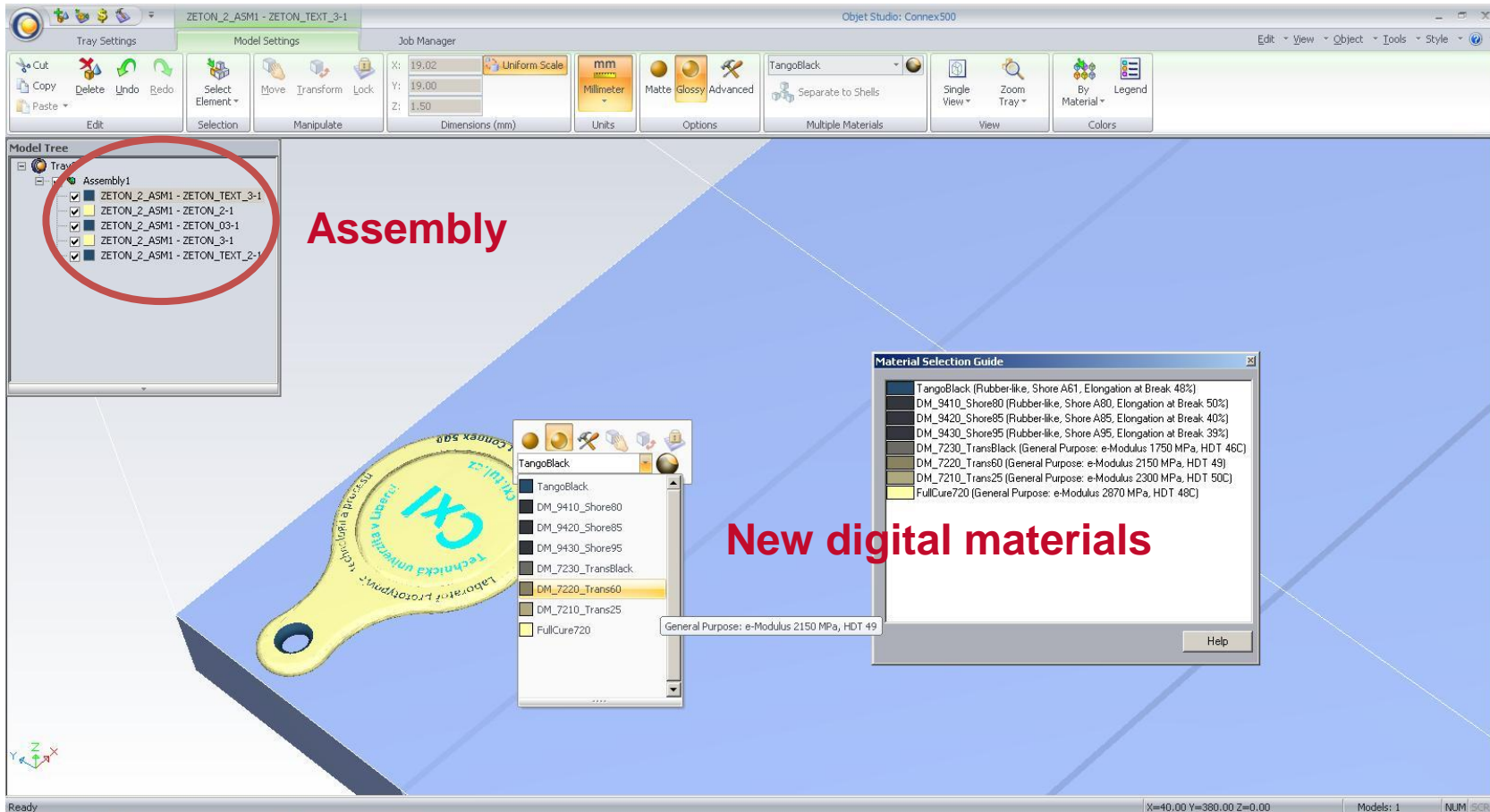


Preparing data for 3D printing

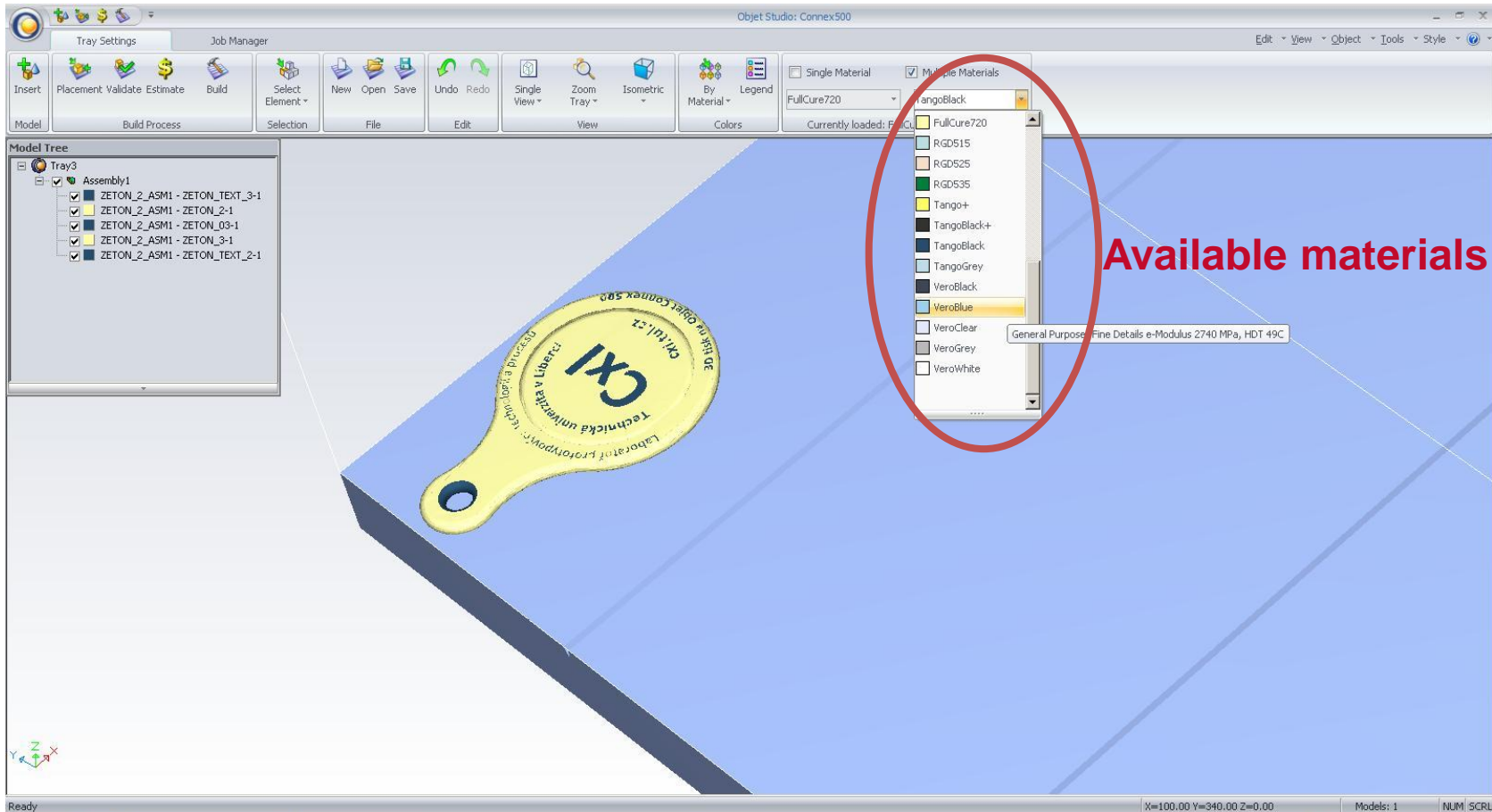
Assembly



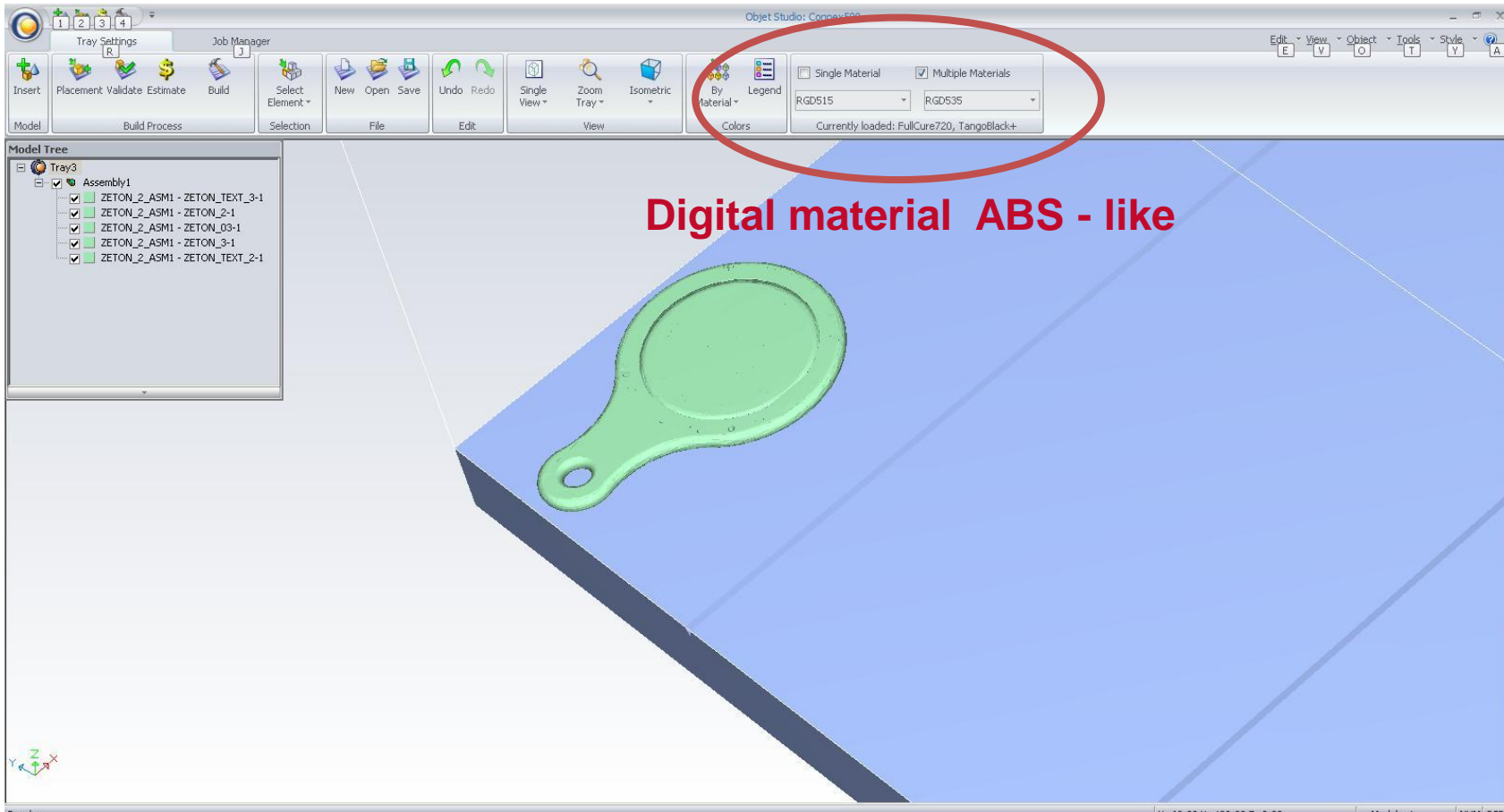
Preparing data for 3D printing



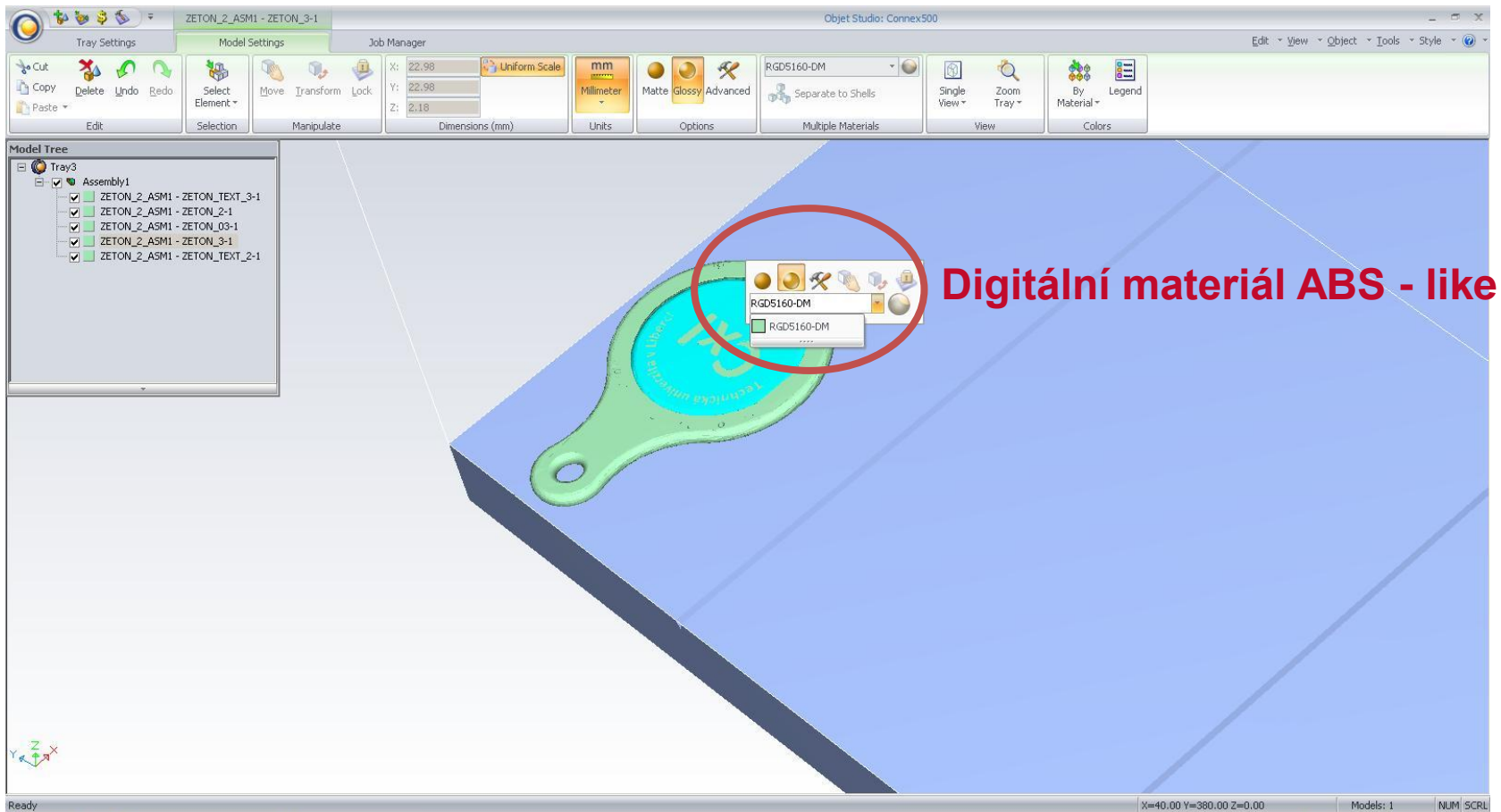
Preparing data for 3D printing



Preparing data for 3D printing



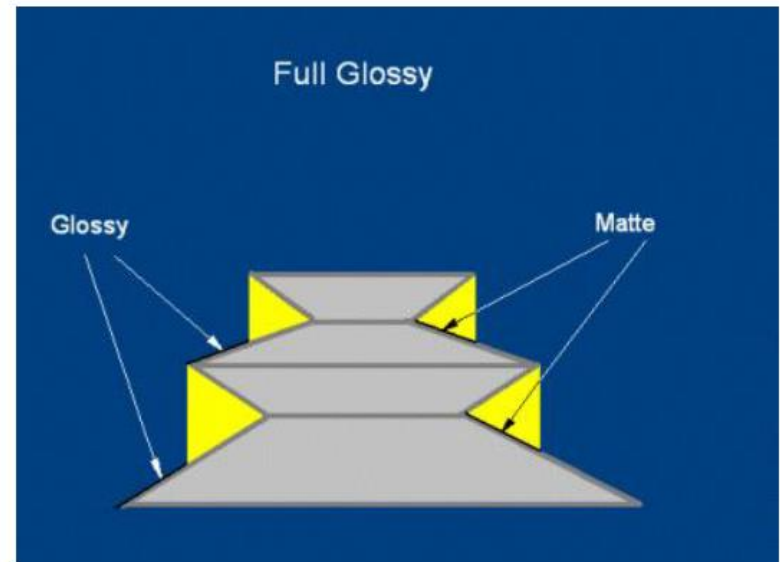
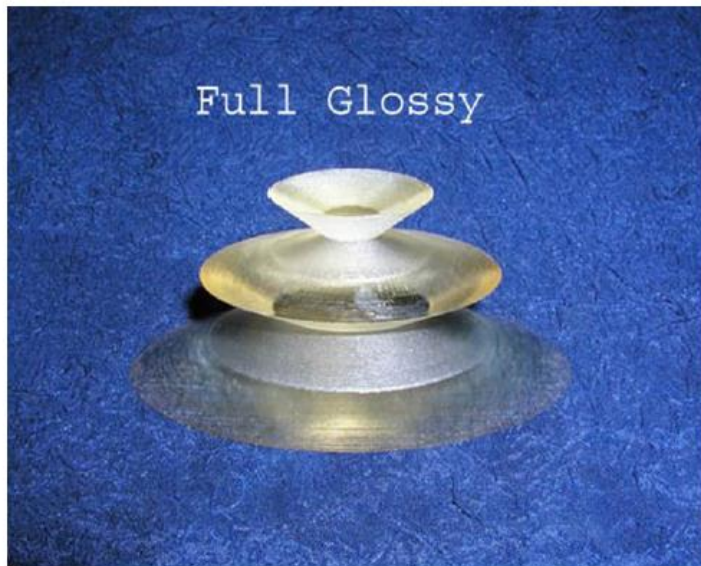
Preparing data for 3D printing



Glossy - Matte

Glossy

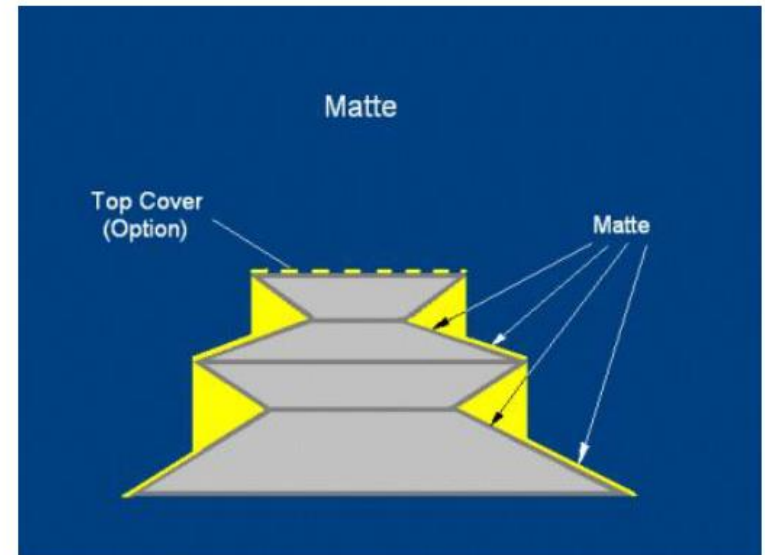
- Support only where necessary
- Matte bottom, glossy top surface(s)



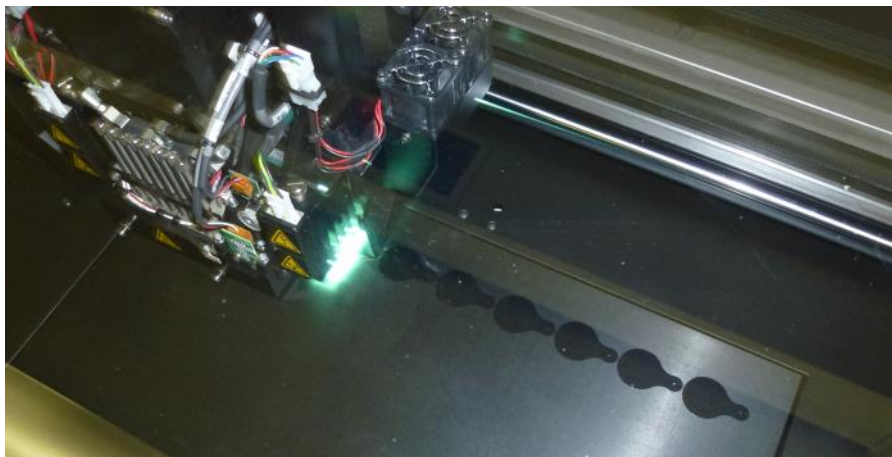
Glossy - Matte

Matte

- All surfaces interface support
- Uniform finish



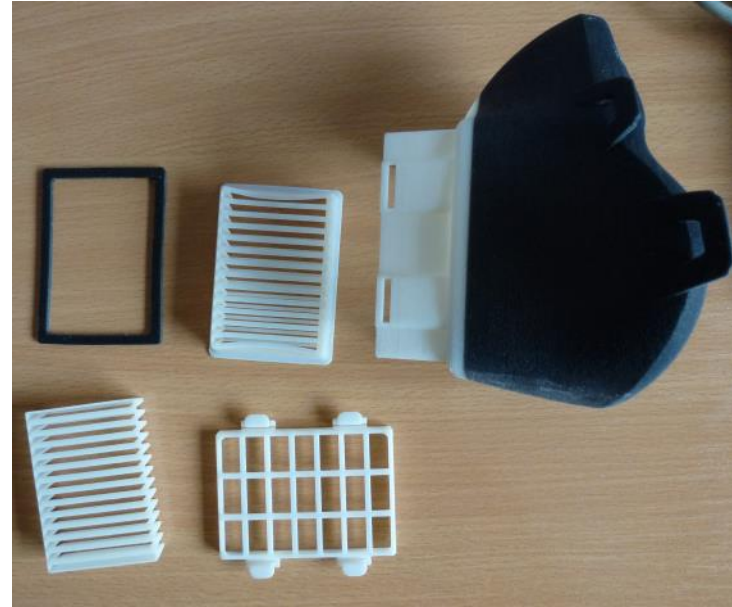
Products



Products



Products



Products

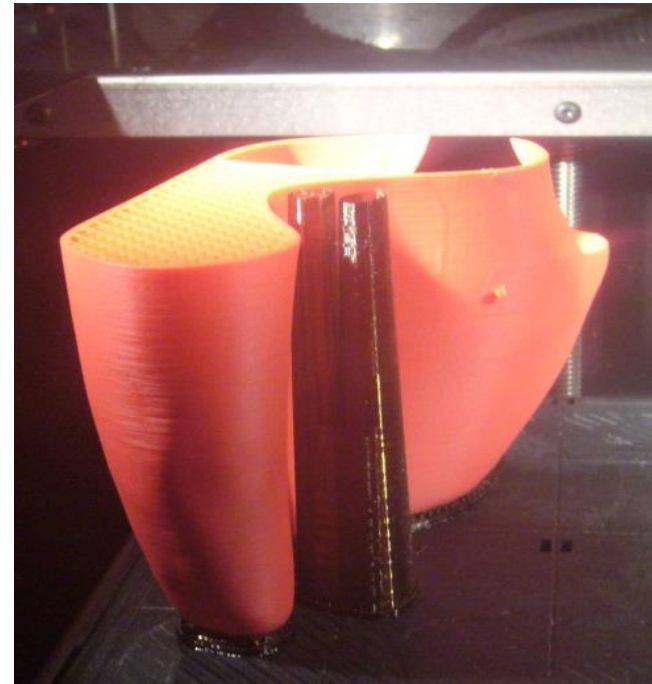
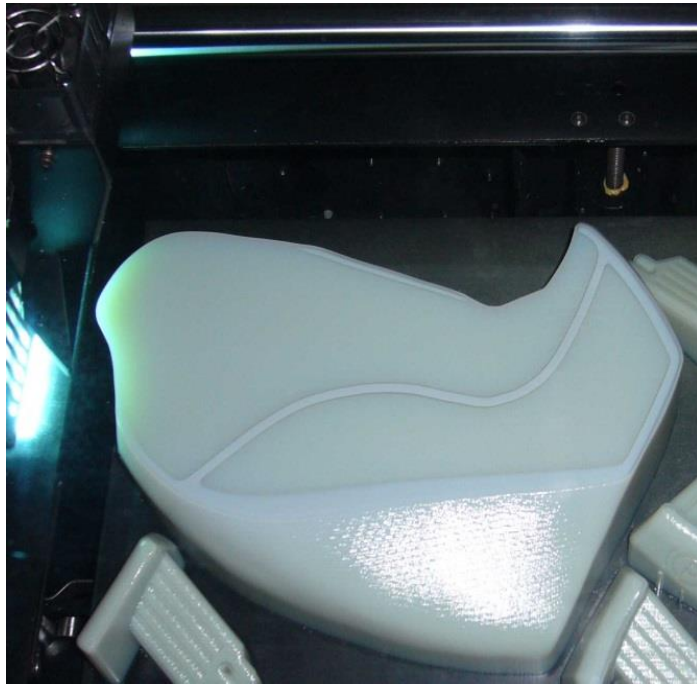


- Machining time more than 16hours.
- Only one material

- Printing time 4 hours
- Different color is available



Products



Products



Products



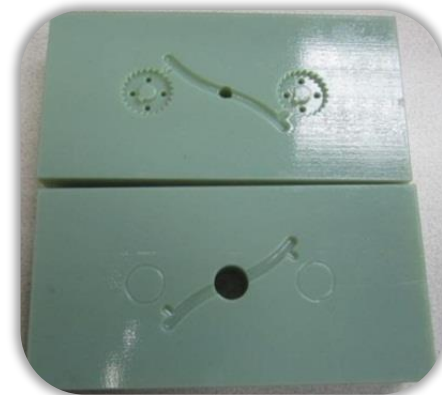
Injection Molding Application

Injection molding is the most commonly used manufacturing process for producing high precision, complex plastic parts.

Traditionally... tooling for injection molding is a slow and expensive process

Printing the mold with Inkjet technology using ABS-like material allows:

- Short series production
- Prototyping from the real plastic material
- Drastically reduced time and costs



*Material injected-
Acetal (POM) - 30 parts were injected*

Injection Molding Application

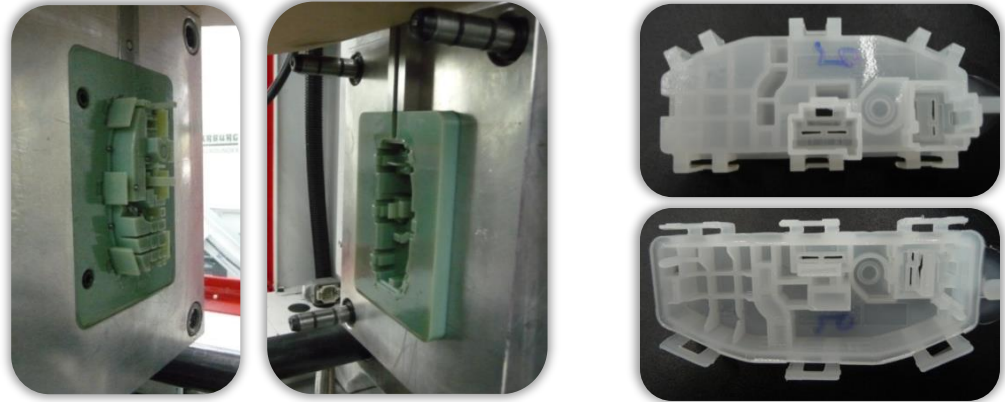
Case Study 1

Industry: Automotive

Material injected: PE (Polyethylene)

at 190°C

Number of parts*: 10



* Mold is available for additional use

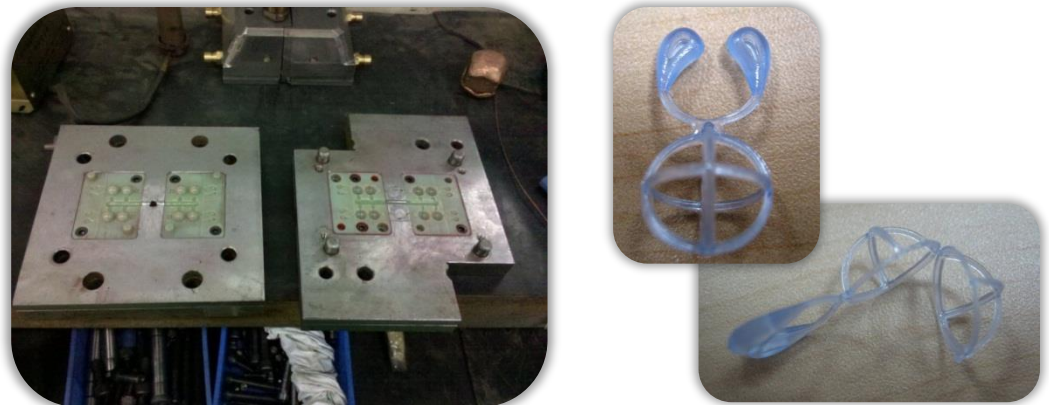
Case Study 2

Industry: Toys

Material injected: PP (Polypropylene)

at 220°C

Number of parts: 80



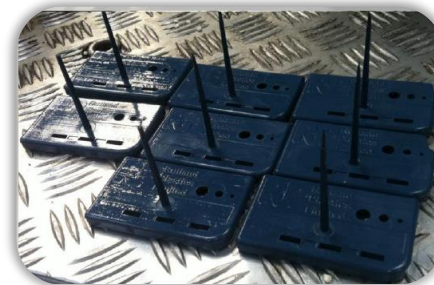
Injection Molding Application

Case Study 3

Industry: General

Material injected: PP (Polypropylene) & ABS
at 220-230°C

Number of parts: 20 PP, 16 ABS



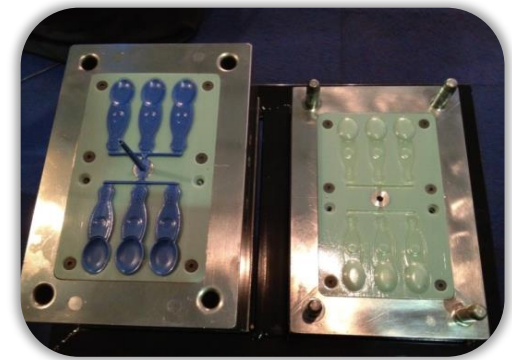
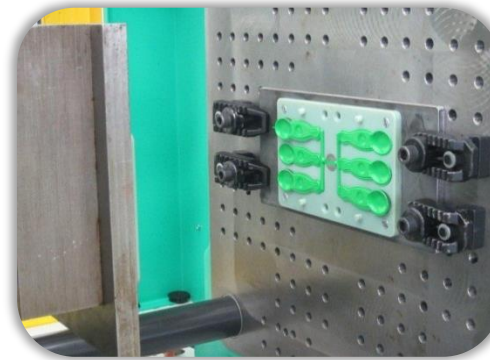
Injection Molding Application

Case Study 4

Industry: General

Material injected: PP (Polypropylene)

at 220-230°C



600 parts (100 injection cycles) were successfully injected

No degradation to the mold, still totally functional

Blow Molding Application

What is Blow Molding?

- Blow molding is a process that produces hollow plastic parts, mainly bottles and containers.
- It is based on inflating preheated plastic against a mold in the desired shape.
- Many of the products that we use in our day-to-day life are blow molded, such as drink bottles, containers, toys, even the fuel tanks in our cars.

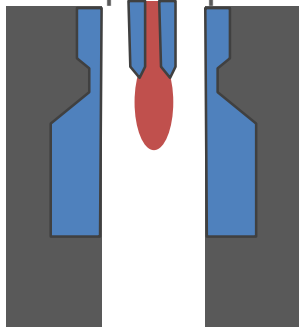


Blow Molding Application

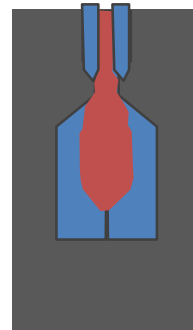
The Blow Molding Process

- There are three main types of blow molding:
Extrusion blow molding, Injection blow molding and stretch blow molding
- Each type has a slightly different process but they all have a common,

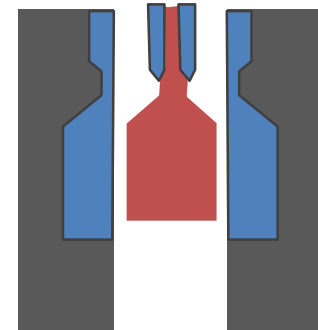
basic principal of operation:



Hot pipe or tube shaped plastic is placed in a steel mold



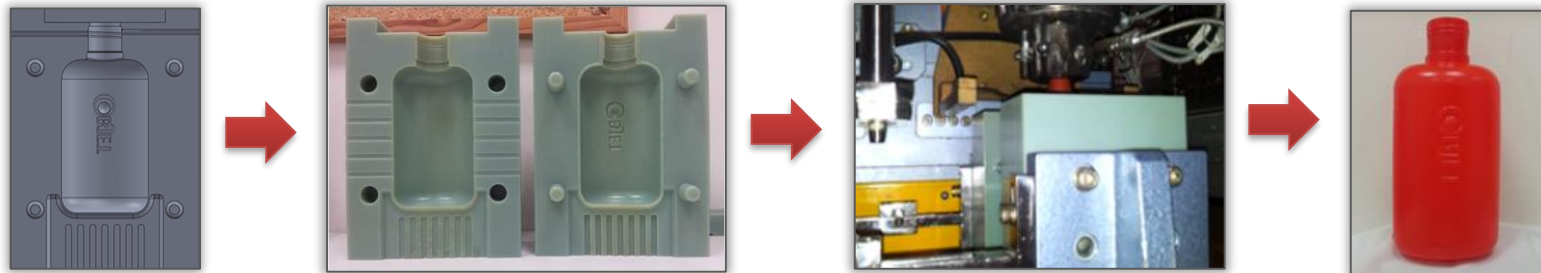
Mold closes and the plastic is inflated against the mold



The mold cools the plastic and ejects it once it is hard enough

Blow Molding Application

Objet Solution- **Print the mold using ABS-Like Material**

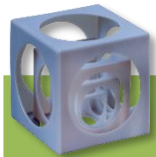


Blow Molding Application



Software Objet Studio

- 3rd Generation Multi-Material Technology



2004. Eden
1 Material

Highly accurate, finely detailed models with ultra-thin walls.



2007. Connex
2 materials

The world's first multi-material 3D printer.



2014. Connex 1/2/3
3 Materials

Stratasys introduces the first-ever color and multi-material 3D printer.

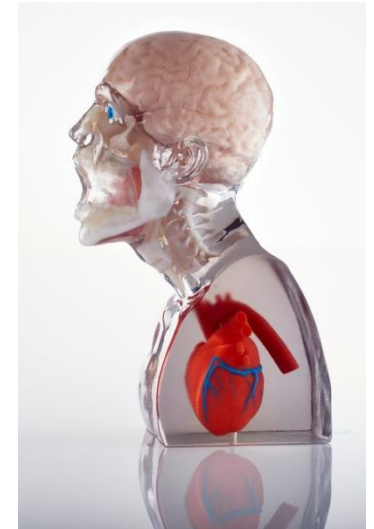


2016. J750
6 Materials

The world's only full color, multi-material, high resolution 3D printer.



Stratasys J750



Stratasys J750

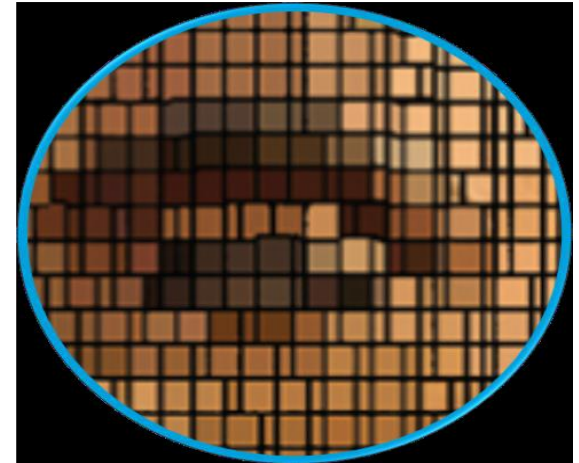
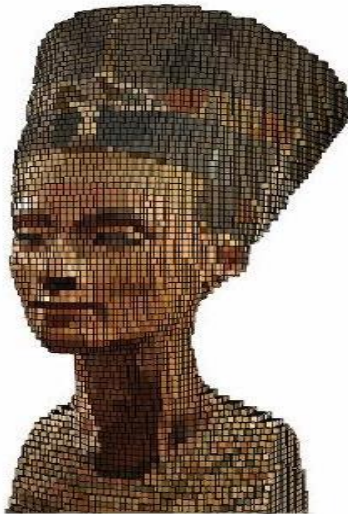
Build space: 490 x 390 x 200 mm

Layer thickness: 14 or 28 μm

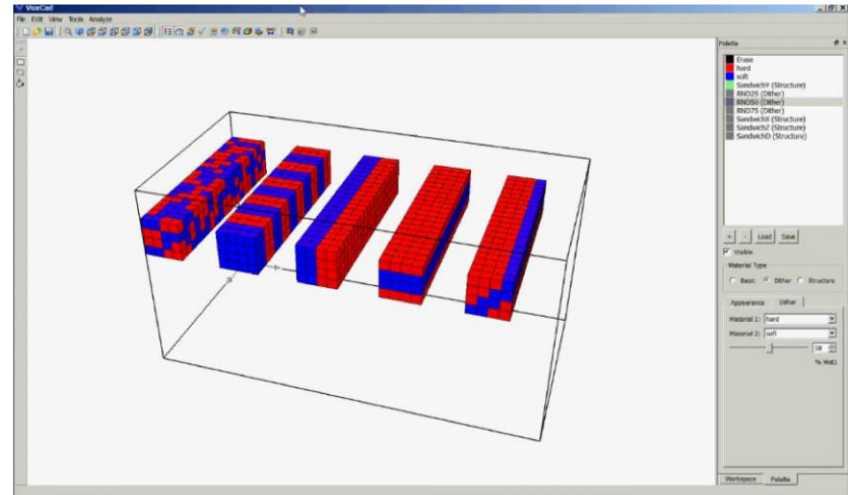
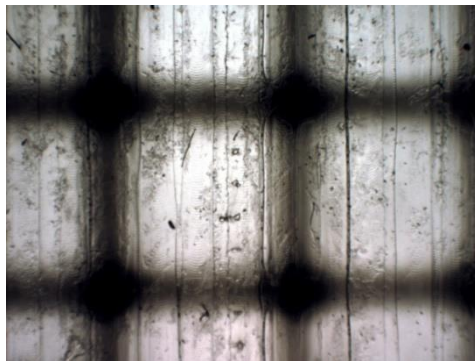
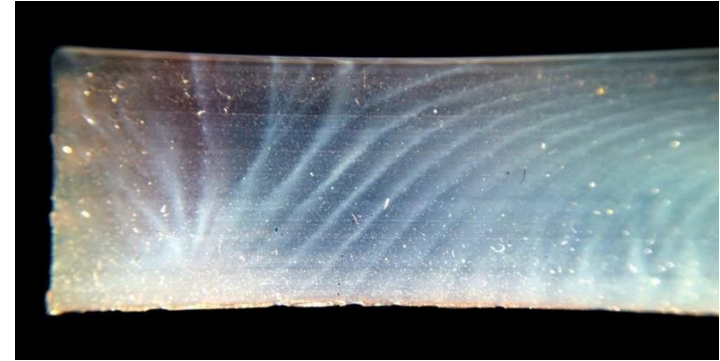
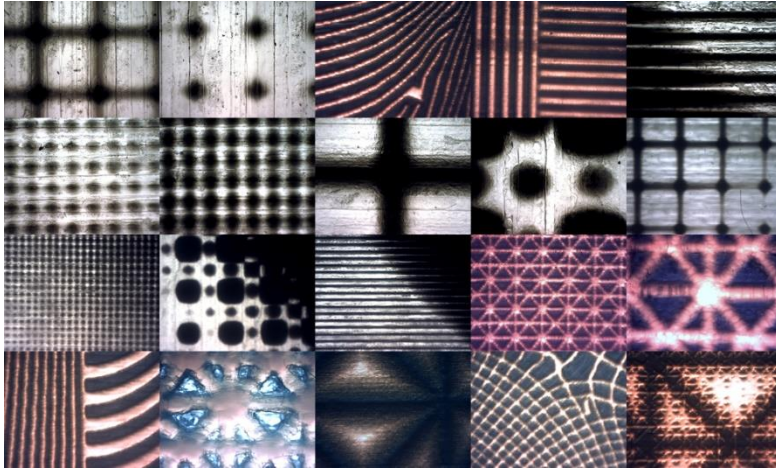
Materials: Full color printing process
Combination ABSlike + Rubber like material
(Tango or Agilus)
Transparent
Rigid materials
Rubber-like
Bio-Compatible
Dental



Stratasys J750 VoxelPrint

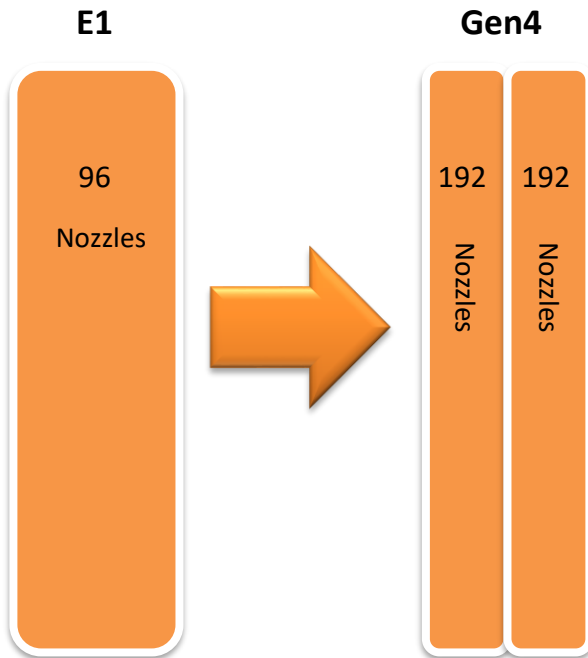


Stratasys J750 VoxelPrint



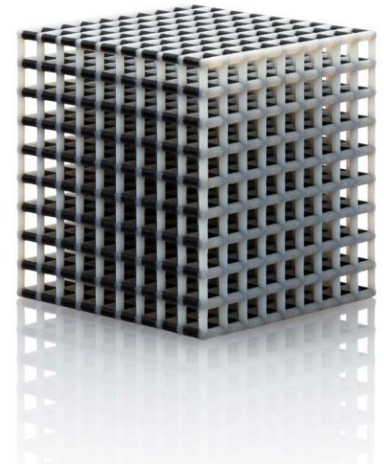
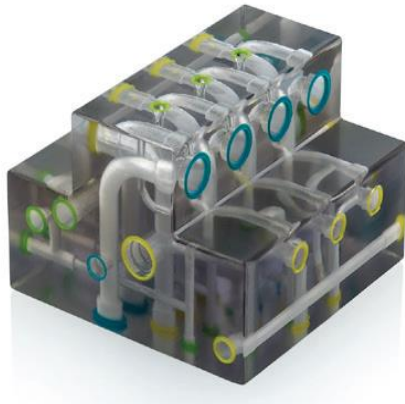
Stratasys J750

- New, improved print heads bring you greater speed, accuracy, and versatility:
- 2 material channels in 1 print head
- 4 times the number of nozzles.

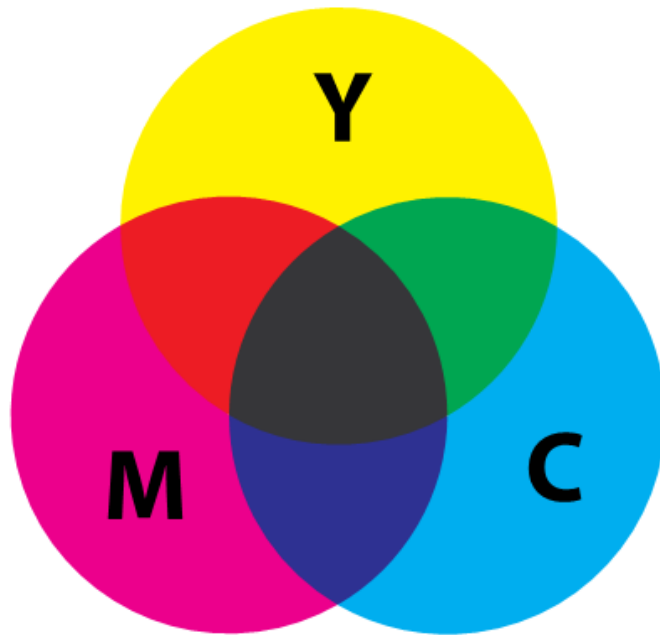


Stratasys J750 SUP706 Soluble Support

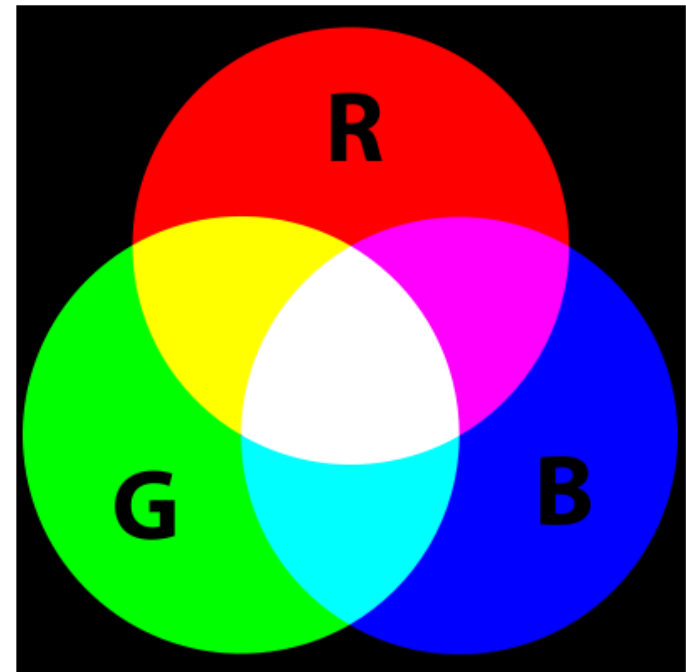
- Allows cleaning of **fine details**
- Allows cleaning of **complex interior cavities**
- **Hands-free support removal**
- **Quicker** support removal (with WaterJet and semi-manual)
- **Reduces time and labor** in the post-process of support removal



Stratasys J750 Color Print

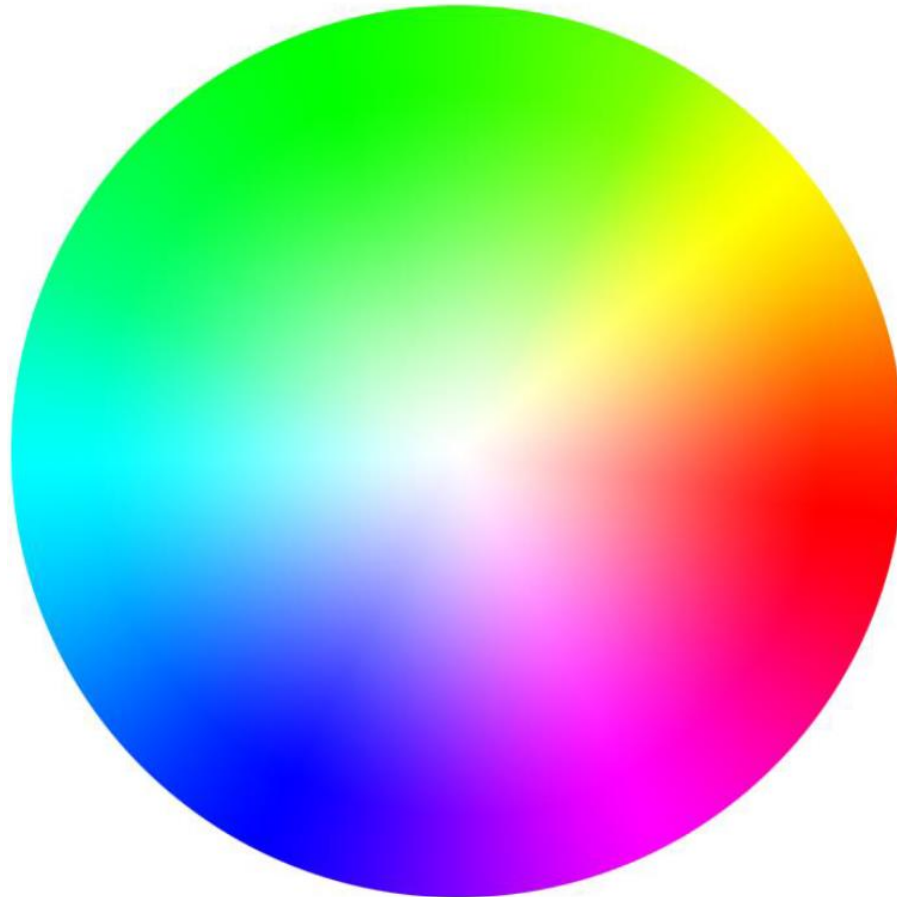


CMYK-CYAN, MAGENTA, YELLOW, BLACK

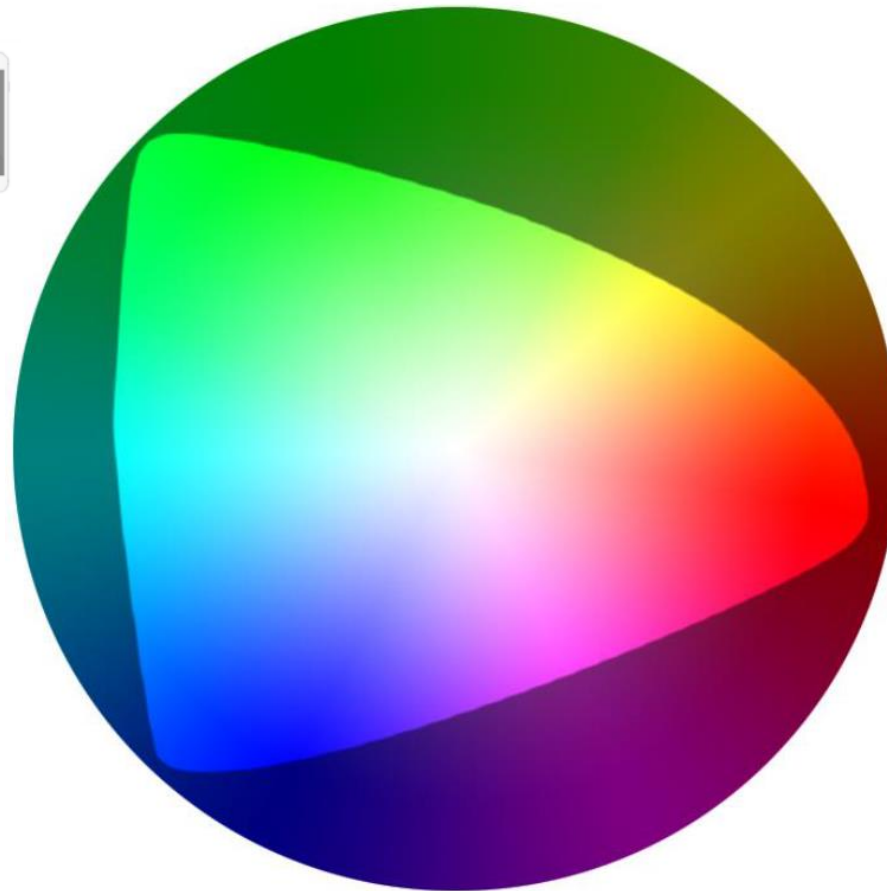


sRGB-RED, GREEN, BLUE

Stratasys J750 Color Print

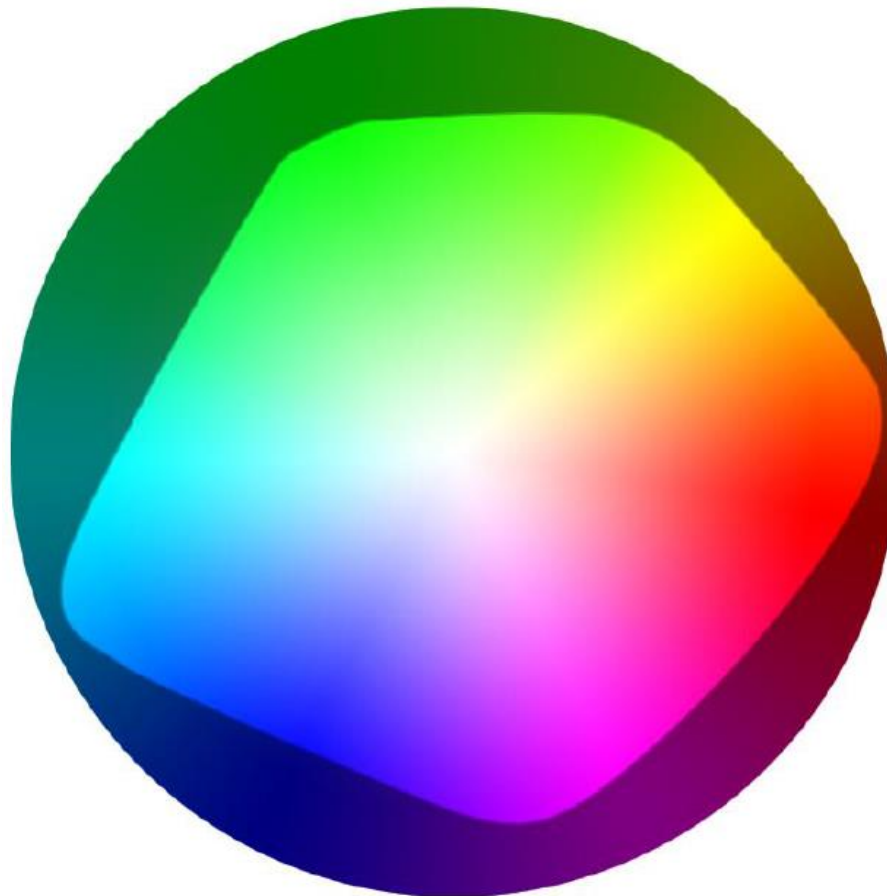
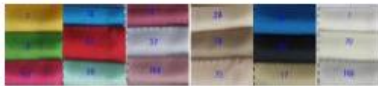


Stratasys J750 Color Print



Stratasys J750 Color Print

Pantone barvy



Stratasys J750 Color Print

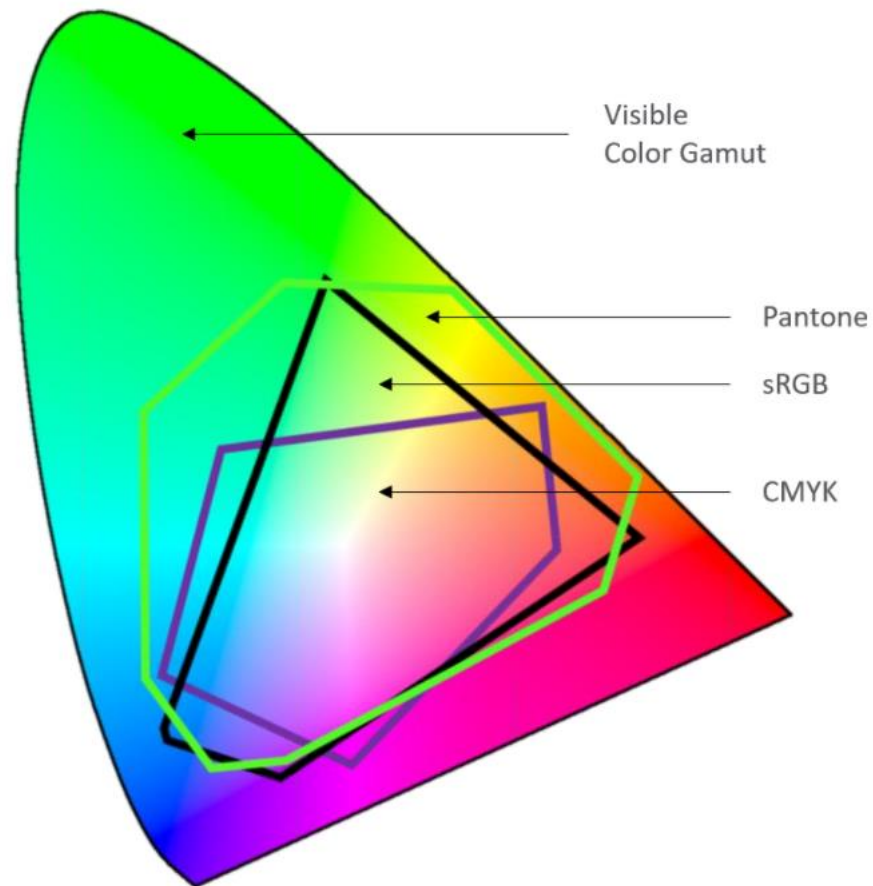


Stratasys J750 Color Print

J750 CMYK



Stratasys J750 Color Print



Stratasys J750 Color Print

CMYK

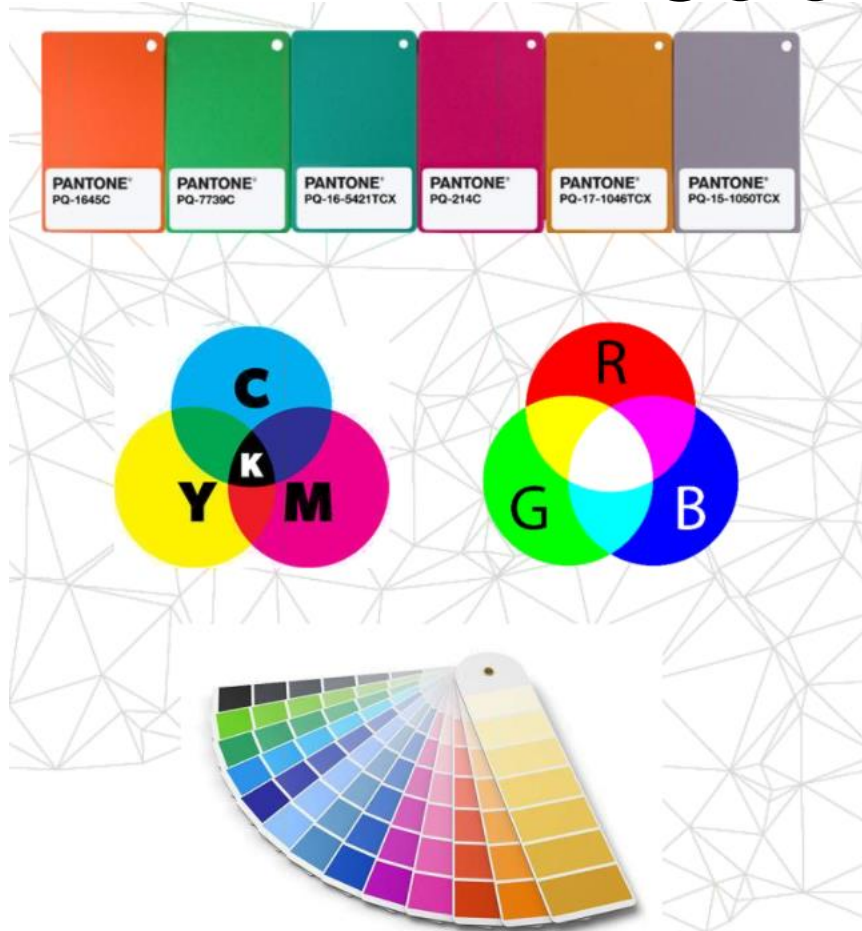


Stratasys J750 Color Print



What is CMYK and what RGB?

Stratasys J750 Color Print



< Find another color
PANTONE Orange 021 C

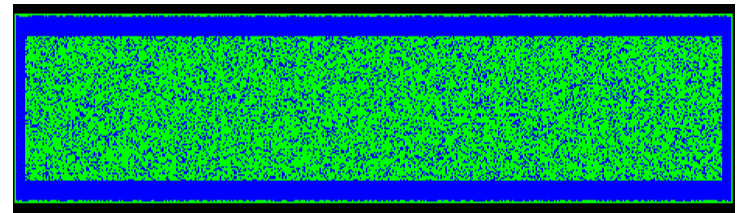


Color values:

RGB	254 80 0
HEX/HTML	FE5000
CMYK	0 65 100 0

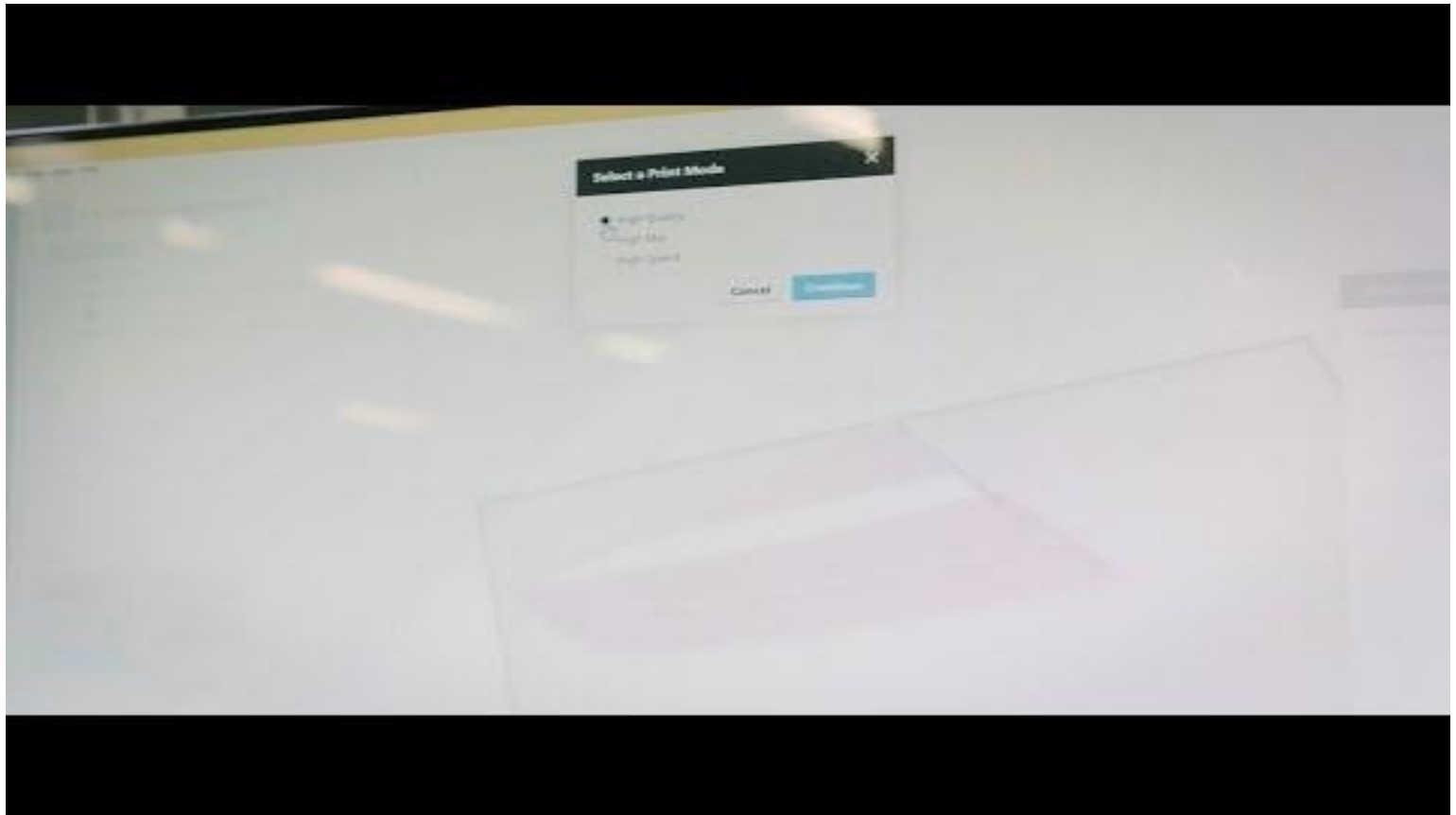


Stratasys J750 UltraClear



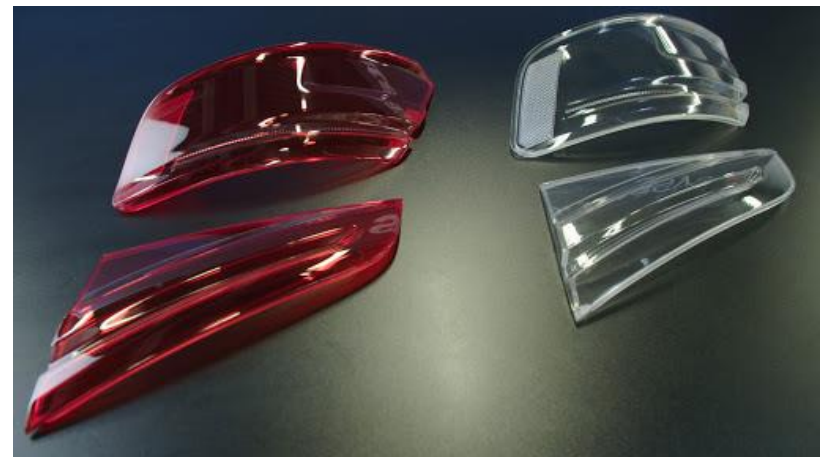
Stratasys J750

Vivid colors



Stratasys J750

Vivid colors



GrabCAD

