

Shape Memory Polymer

INOSELF[®]

Innovative materials for a smart world

The world's leading technology of TMD LAB

TMD LAB is an R&D-based company with a long history of developing polycaprolactone(PCL)-based shape memory polymer(SMP) technology. TMD LAB presents new solutions to various industries including biomedical, multi-dimensional printing, textile, and engineering part by upgrading pre-used materials to functional shape memory polymers.

The founder, professor Hak-Joon Sung, developed the fundamental technology of SMP since 2009 when he was a professor in Vanderbilt University in the U.S. He has been upgrading the material to establish a broad range of property spectrum.

Now, TMD LAB is ready to present our signature material PCL-based SMP to the world where there is unmet need.



TMD LAB Headquarters (in Seoul)

Production / R&D Facility



Mass Production Equipment



Mass Synthesis Equipment



Synthetic Lab



Drying Room



Processing Room



Washing Room



Bio Lab



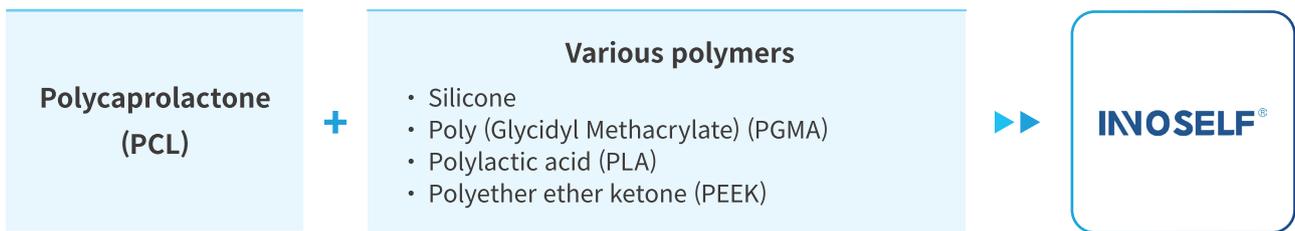
Physics and
Chemistry Lab

INNOSELF®

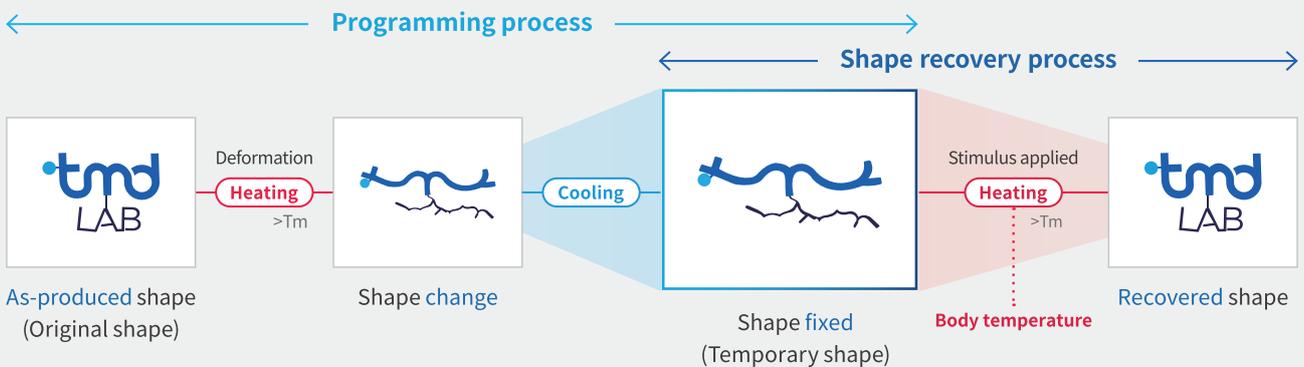
Shape Memory Polymer (SMP) is a polymeric materials that has an ability to be transformed to a pre-designed shape when a certain type of stimulus (temperature, light, etc.) is applied.

TMD LAB's SMP, called INNOSELF®, is the only SMP that has lowered the melting point to body temperature among commercialized SMP. As an implantable medical device, INNOSELF® is beneficial for minimal invasive insertion into a body due to its auto-transformation ability triggered by body temperature.

What is INNOSELF®?

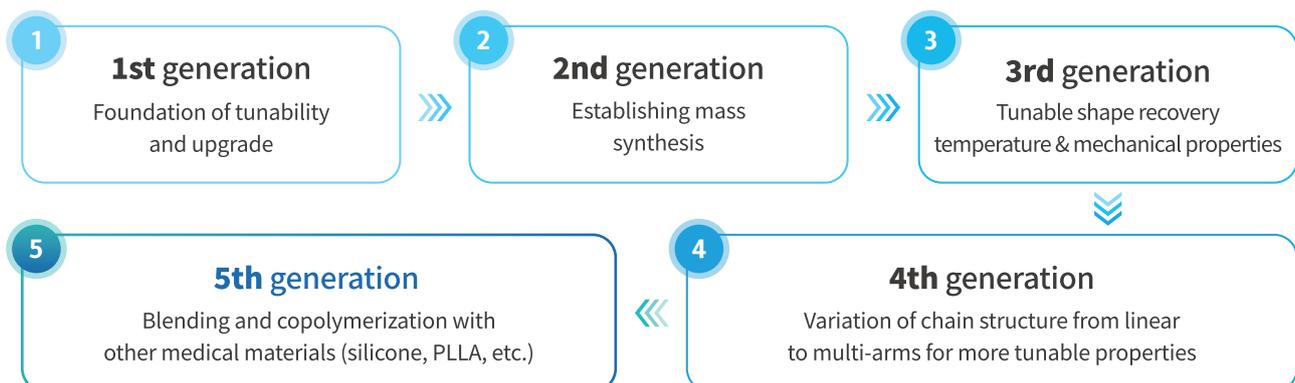


INNOSELF® Programming



Temporary Shape: Always keep the shape when the trigger condition is not met in the temporary state.

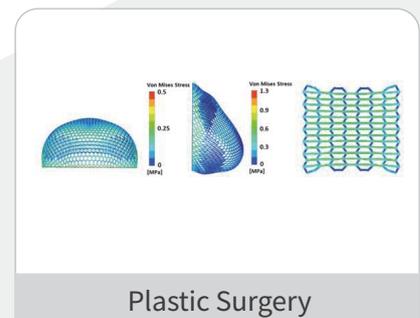
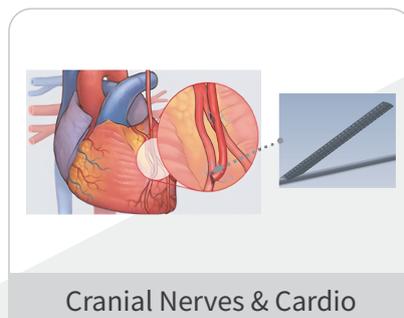
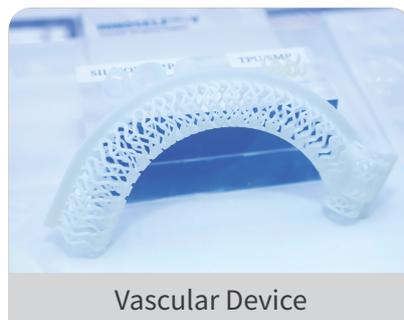
INNOSELF® History



Biocompatibility

- INNOSELF® is PCL-based biocompatible materials.
- PCL (Polycaprolactone) is FDA-approved for usage in the human body.
- Stable and biocompatible for long-term use. (Excellent tissue affinity)
- Suitable for medical device applications.
- Obtained USP <88> Class VI certification.

INNOSELF®			
ID	Test item	Standard	Result
1	Cytotoxicity test	ISO10993-5	PASS
2	Intracutaneous reactivity test	ISO10993-10	PASS
3	Skin sensitization test		PASS
4	Acute systemic toxicity test	ISO10993-11	PASS
5	Pyrogenicity test	ISO10993-11	PASS
6	Genotoxicity test	ISO10993-3	PASS
	(bacterial reverse mutation test)		
7	Genotoxicity test		PASS
	(in vitro chromosome aberration test)		
8	Chronic toxicity test	ISO10993-11	PASS
9	Implantation toxicity test	ISO10993-6	PASS

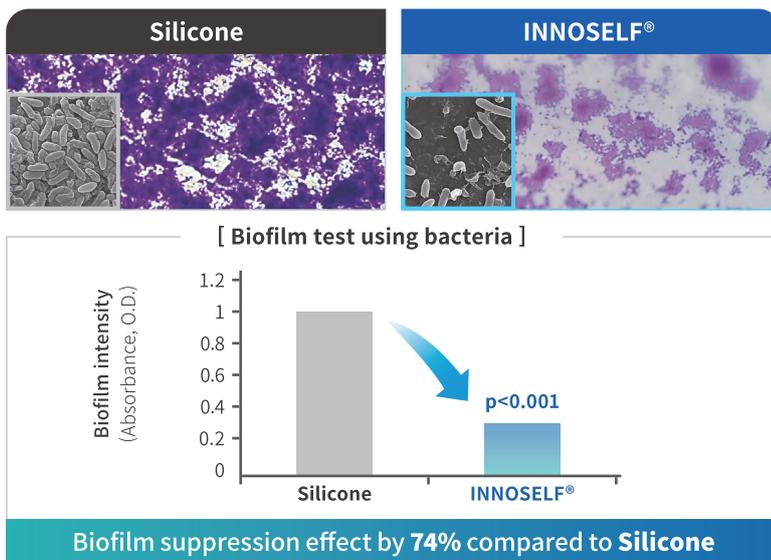


* PCL has been widely used in the human body as (for example) a drug delivery device, suture, or adhesion barrier.

Anti-Biofilm

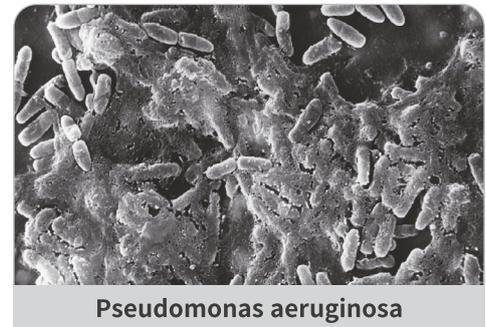
- A material capable of biofilm suppression.
- 74% biofilm suppression effect compared to silicone in biofilm test using bacteria.
- 52% biofilm suppression effect compared to EVA in biofilm test using patient bile.

Silicone vs INNOSELF®



Biofilm Infection

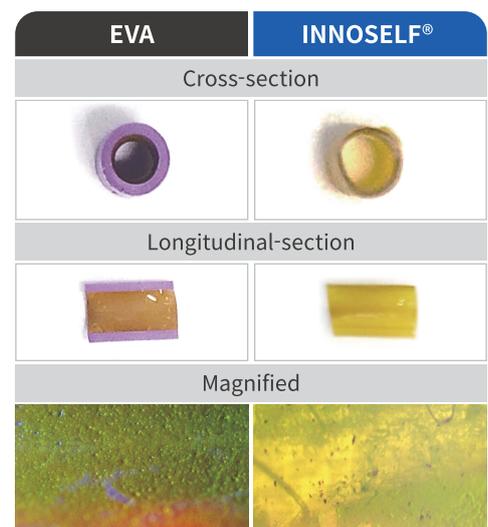
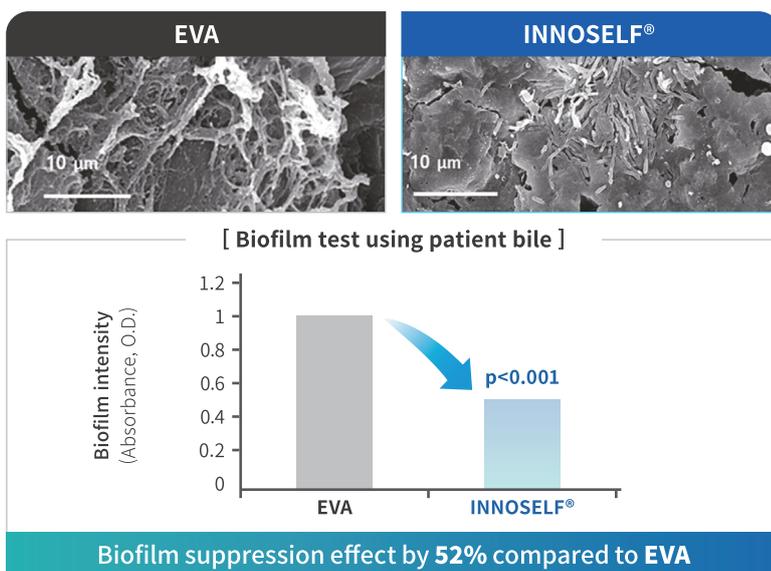
- Constitute several clinical challenges, including chronic inflammation, impaired wound healing, and rapid antibiotic resistance.



* Antimicrob Agents Chemother. 1995 Oct; 39(10) : 2262-2268

EVA vs INNOSELF®

- Plastic stent occlusion : colonization of various bacteria and protein adsorption, etc.
- Stent replacement is required every 3 ~ 6 months.



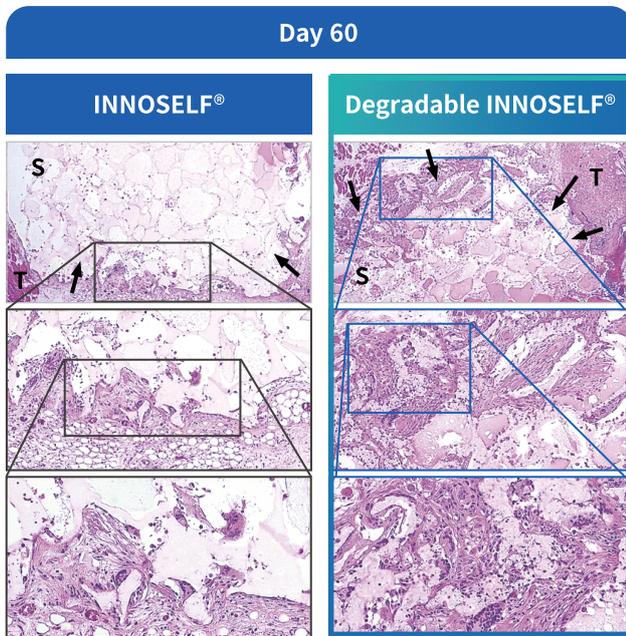
* EVA (Ethylene-Vinyl Acetate copolymer)

* Currently under joint research with the NIST (National Institute of Standards and Technology) about the mechanism of biofilm inhibition (2022).

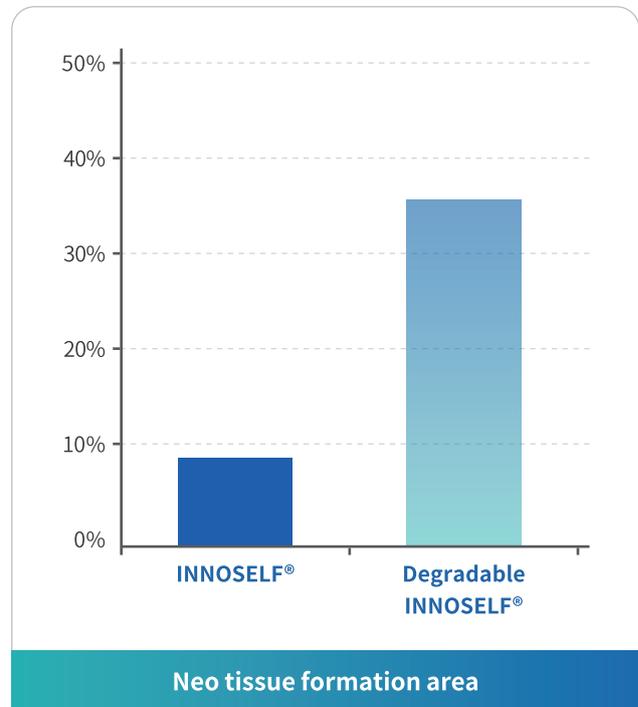
Biodegradability

- An eco-friendly biodegradable material.
- Diversity is ensured by the composition of two types of materials : biodegradable and non-biodegradable materials.
- *In-vivo* degradation test, confirmation of tissue and cell penetration after subcutaneous implantation. (non-inflammation condition)
- *In-vitro* degradation test, degradable up to 47% under slightly acidic conditions (pH 6.5 ~ 7.1) for 7 days.

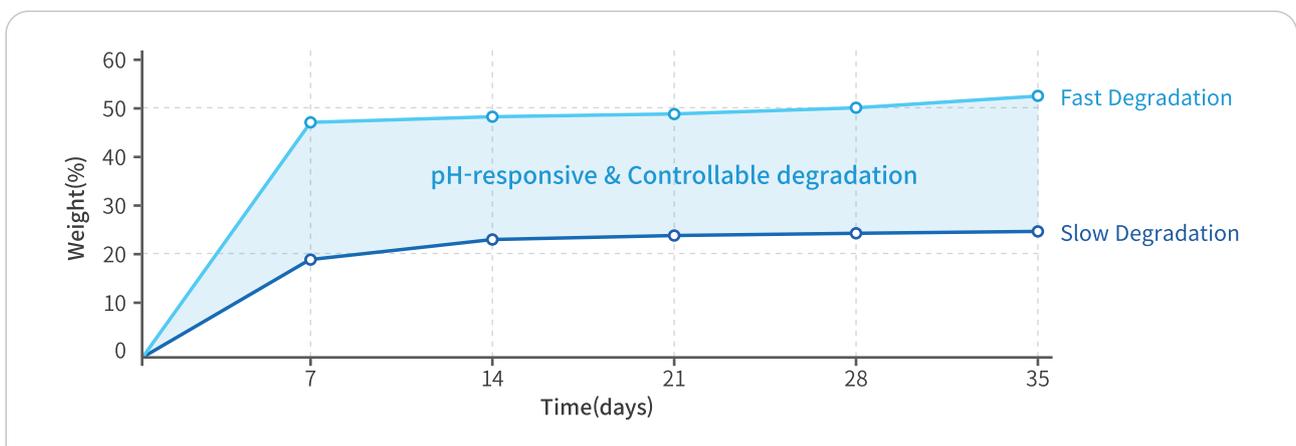
In-vivo Degradation Test



S : Scaffold | T : Tissue | **Arrow** : Direction of cell invasion
 * Scale bar : 100 μ m * Subcutaneous implantation for 60 days

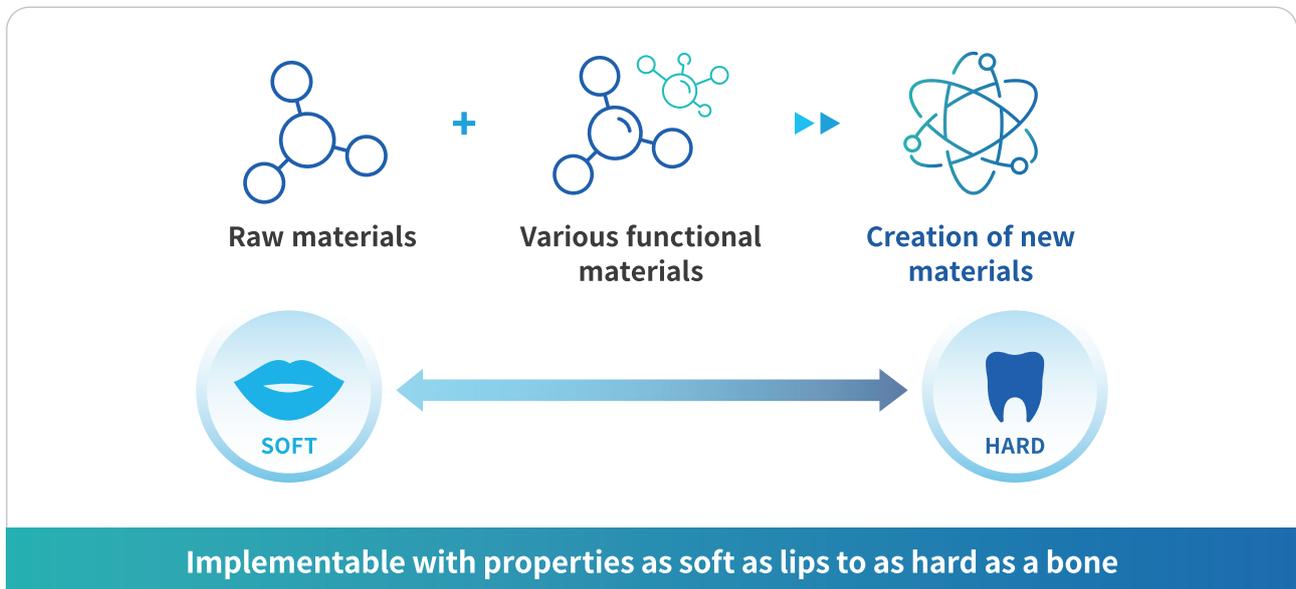


In-vitro Degradation Test



Versatility

- Customer-specific processing possible.
(Shape restoration time adjustable & Wide range of physical properties)
- The temperature range (28°C ~ 49°C) adjustable for recovery of shape.
- The melting temperature, shape restoration speed, shape memory volume, and step-by-step shape restoration controllable.
- Building various physical spectrum through combination with PGMA, Silicone, PLA, etc.
- The various properties adjustable. (ex. strength, hardness, elasticity, and flexibility)
- Building various process methods. (extrusion, molding, 3D printing, etc.)



TPU

PMMA

PDLA

PDLLA

PETG

PGMA

PGLA

PGCL

Silicon

EVA

PLLA

PLCL

PEEK

PTFE

PGA

PGDLLA

PEABAX

PDO

PCL

PDMS

INOSELF[®]

New Material Features

- Original material that retains the main component of the base material.
- Production engineering equipment.
- Predictive shape memory ability.
- Height suppression biofilm function.
- Improved physical properties, mechanical performance, etc.
- Improved decomposition cycle.
- Addition of video footage.
- Possible water canal.
- Other functions possible.

Benefit For Customers

You can upgrade or replace the material of your product with INNOSELF® for better outcomes.

Other Materials	Polyurethane	Silicone	EVA	PE	PTFE	Polyamide
Limitation of Materials	<ul style="list-style-type: none"> • No(or limited) shape memory function <ul style="list-style-type: none"> - Not suitable for use in the body because of relatively high Tm. • Biofilm formation <ul style="list-style-type: none"> - Biofilm forms and fiberize the tissues by bacteria and protein adsorption on the surface of the implanted product. 					
Solution of INNOSELF®	<ul style="list-style-type: none"> • Shape memory ability in the body temperature <ul style="list-style-type: none"> - INNOSELF® can be restored in the body temperature range (30°C to 42°C). • Biofilm suppression compared to silicone & EVA <ul style="list-style-type: none"> - Biofilm forms significantly less by controlling the adsorption of bacteria and protein. - Suppression effect by 74% compared to silicone, 52% compared to EVA. • Wide range of physical properties <ul style="list-style-type: none"> - INNOSELF® can deliver a wide range of materials to meet customer needs. (degradable / non-degradable, shape recovery speed and stimulation sources, mechanical properties, chemical properties, etc.) • Wide range of output type <ul style="list-style-type: none"> - Polymers can be provided in powder, filament, pellet, resin, etc., depending on the manufacturing process and customer needs. 					

**Other
Materials**

SMA (Shape Memory Alloy)

**Limitation
of Materials**

- **Low energy efficiency – passive shape recovery**
- **Complex thermo-mechanical behavior**
- **Complex motion control - non-moldable**
- **Expensive materials**
- **Temperature dependent effect**
- **Poor fatigue properties**
- **Low operational speed**

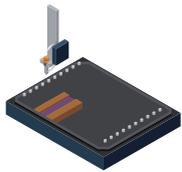
* Source : Micro and Nanosystems, 2016, 8, 79-91

**Solution
of INNOSELF®**

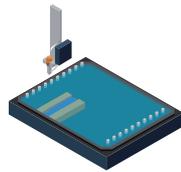
- **Active shape recovery**
- **Underpricing than SMA**
- **Easy operation process than SMA**
- **Higher tensile strength than SMA**
- **Low density than SMA**
- **Higher shape recovery rate (>90%)**
- **Moldability**

Manufacturing Methods

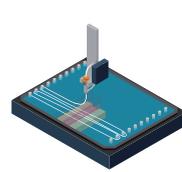
- Extrusion Molding & Injection Molding
- Automatic Injection
- Molding
- Multi-D (FDM - Filament / DLP - Resin)



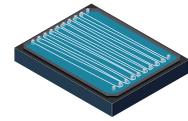
Turn on the automatic injection equipment



Fill the water tank with a liquid solution and install the nozzle and syringes



Operate the program and it starts extrusion and crosslinking simultaneously

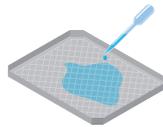


Place the acquired specimen into water

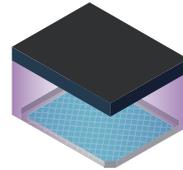
Automatic Injection



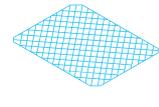
Prepare a mold



Spread a polymeric solution

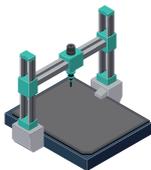


Photocuring process

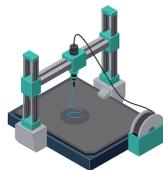


Specimen acquired

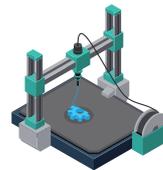
Molding



Fused Deposition Modeling (FDM)



Heated filament cools immediately when it is extruded into a liquid type

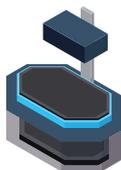


Repeat the same process until it is finished

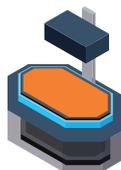


Specimen acquired

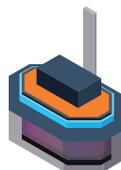
Multi-D (FDM - Filament)



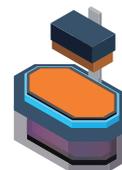
Digital Light Processing (DLP)



Fill the vat with resin



Photocuring process - creates the layer by curing and solidifying the resin



Repeat the same process until it is finished



Specimen acquired

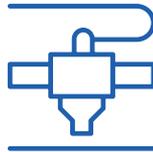
Multi-D (DLP - Resin)

Applications

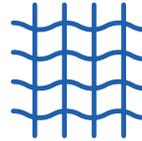
Industry Area



Bio-Medical



Multi-Printing



Textile



Engineering

Output Types

Polymers

- Powder
- Filament
- Pellet
- Resin

- We supply shape memory polymers in various forms such as powder, filament, pellets, and resin.

Semi-finished Products

- Sheets
- Tube & Catheter
- Suture
- Coating Material
- Medical Balloon

- We provide semi-finished products that can be combined and upgraded with the existing products manufactured by customer companies.

Finished Products

- Eyes** • Lacrimal Duct Stent • Punctal Plug • Glaucoma Device Supporting Tube
- Non-Vascular** • Biliary Stent • Ureteral Stent
- Cardio-cerebrovascular** • Vascular Wrapping Support • Vascular Graft • Heart Valve Device • Lymphatic Vein Anastomosis Device • Vascular Occlusion Device • Occluder • Microcatheter
- Drug delivery** • SMP Microneedles • Microspheres/micropowders
- Implants** • Nose Implants • Breast Implants • Hernia Repair Mesh
- Orthopedics** • Cartilage • Bone Nails • Bone Plate • Others
- Dental** • Clear Aligner (sheet / resin) • Power Chain

- We provide finished products through joint R&D, OEM&ODM, licensing out, etc.

Create a Smart world with Smart materials



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