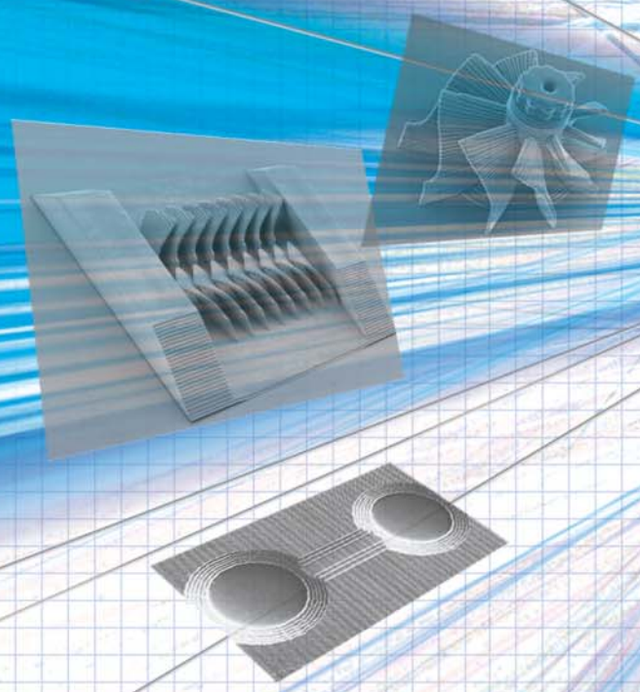
Micro Stereolithography System

ACCULAS®



ACCULAS® received a Good Design Awards 2008.

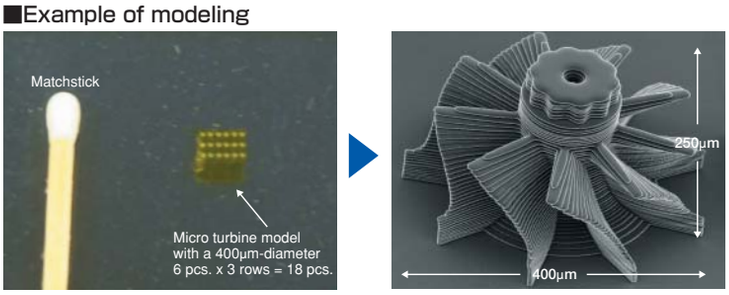
D-MEC

Revolution of 3-D Micro Processing

Micro Stereolithography System ACCULAS®

ACCULAS® enables us to produce 3-D structures in micro meter scale through a photo-fabrication process.
By combining with a custom made UV curable resin, the ACCULAS® makes high precision 3-D micro processing possible. This system is suitable for prototyping and manufacturing of micro devices or MEMS in biomedical and optoelectronics fields.
D-MEC provides the micro stereolithography modeling service responding for customers needs.

■Example of modeling



SEM photo of micro turbine
The time required for the production of 18 pcs. was approximately 1 hour.

Comparison with other micro processing methods

- Using only 3-D CAD data, any 3-D micro structure can be produced in a single process (multi-step processes are not required).
- Automatic production is possible with simple operation.
- Process can be accomplished in a short time.
- Complicated 3-D structures having free form surface and undercut can be produced.
- Delivery in a short period of time with low cost.

■System Specification

Light source	Selectable between LD (405nm) and LED (365nm)	Resin	Custom made high resolution resin
Image modulation	Spatial light modulator	Data interface	Dedicated interface software "Viola" (plug-in for Magics) (*3)
Exposure resolution	1μm (*1)	Power supply	100V AC, 2kVA
Modeling range	150 x 150 x 50mm	External dimensions	1,000 (W) x 1,000 (D) x 1,855 (H) mm (excluding control PC)
Maximum model pitch	50mm square (*2)		
Minimum layer thickness	5 - 10μm	Weight of the main unit	Approximately 600 kg

*1 Optical resolution. It may not match the resolutions of stereolithography models depending on the shapes.
*2 The sizes of stereolithography models differs depending on the physical memory capacity of the PC used for editing.
*3 Custom made direct interface. Magics is the editing software of Materialise NV.

Equipment Manufacture Laser Solutions Co.,Ltd.

Distributor D-MEC

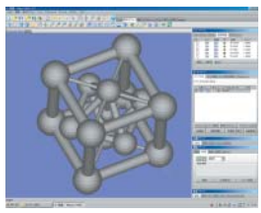
ACCULAS® is a registered trademark of Laser Solutions CO., Ltd.

Outline of ACCULAS® Micro Stereolithography System

■System Outline

By using the light which is modulated with spatial modulator based on the 3-D CAD data, a 3-D micro structure is produced through a photo-fabrication layer stacking method with a resolution of 1 - 2μm range.

CAD Data CG Drawings



Data Processing

Layer Slicing

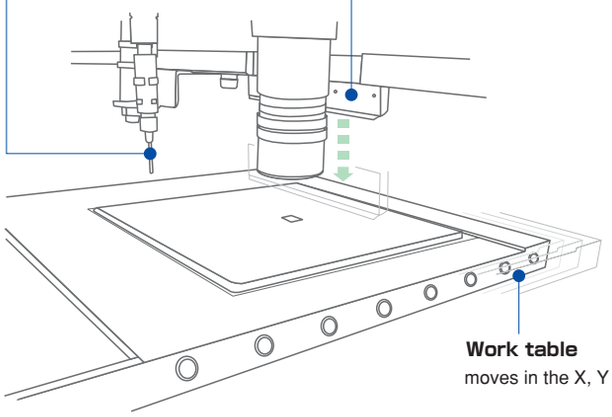
3-D data is sliced with a thickness of 5 to 10μm to yield cross-sectional data.

ACCULAS® Operation Screen

Based on the data transferred from a data processing PC, the micro-mirrors turn ON/OFF to create the images. The images are exposed on the coated UV curable resin sequentially to produce a 3-D micro-structure.

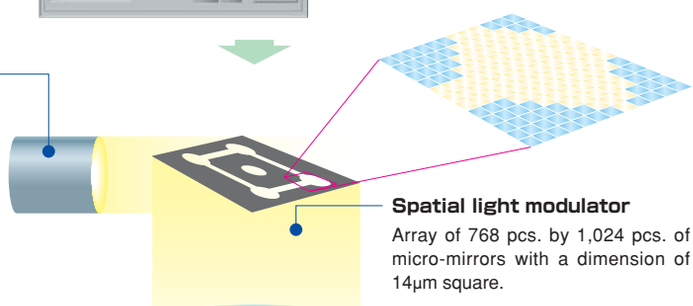
Resin supply nozzle
coats UV curable resin on a substrate.

Re-coater
spreads the coated resin with uniform thickness.



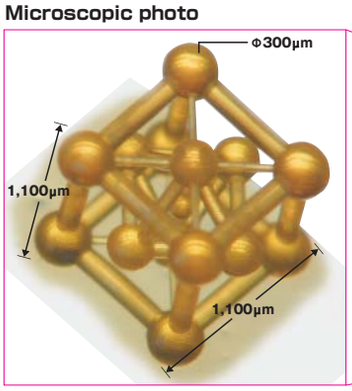
Work table
moves in the X, Y and Z-axes.

Light source
LD 405nm (1W or more) or
LED 365nm (5W) is available.



Spatial light modulator
Array of 768 pcs. by 1,024 pcs. of micro-mirrors with a dimension of 14μm square.

Microscopic photo



3-D micro structure is produced on a substrate.

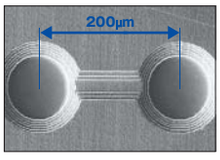
Objective lens
Using an objective lens of 10 times magnification, the image on the spatial light modulator is projected down to 1/8.

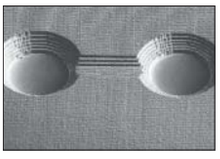
ACCULAS® received a Good Design Awards 2008
in the category, “Pioneering Experimental Design Activities.”

Application Examples

Biomedical Field

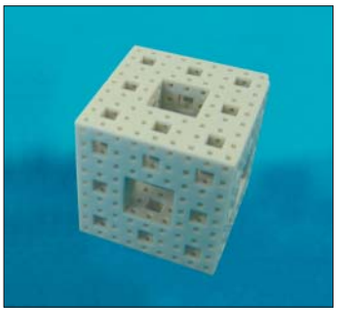
- Bio chips
- Healthcare chips
- MEMS for Medical use
  - Micro actuators
  - Micro catheters





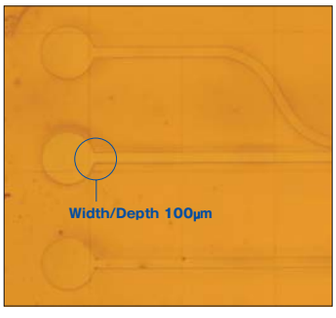
Optoelectronics Field

- Photonics crystals
- Opt-IC chips
- Micro lens arrays
- Light guide plates
- Photo masks
- Micro magnetic devices



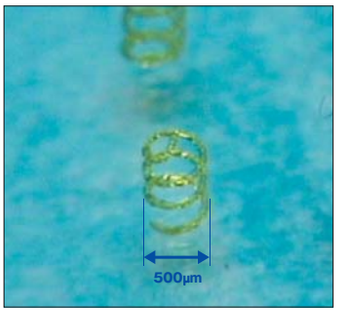
Chemical Field

- μTAS
  - Micro reactors
  - Chemical IC chips
  - Micro analysis chips
- Micro channel



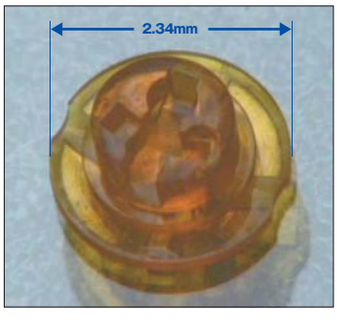
Micromachine Field (MEMS, Microsystems)

- Micro sensors
- Cantilevers
- Probes



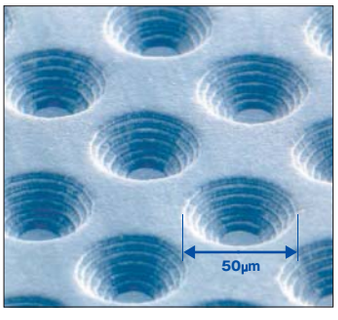
Micro Parts

- Micro gears
- Micro connectors
- Micro parts for Investment casting



Master for Electroplating and Silicon Rubber Mold

- Nano-imprinting process
- Embossing process
- Injection molding process



Need to make prototype 3-D micro structures in a short period of time.

Need to make more complex micro structures that could not be created by the conventional micro processing methods.

Try ACCULAS® modeling for manufacturing micro devices.

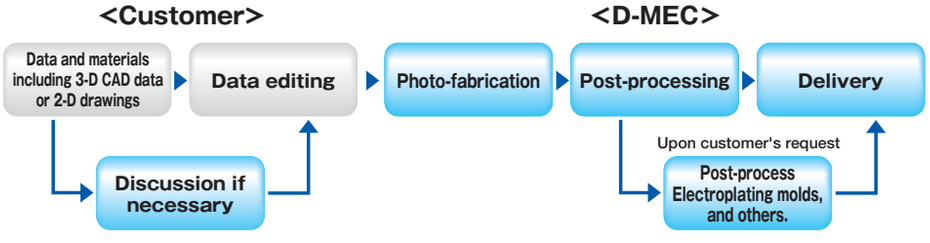
For These Customers

D-MEC MODELING provides the micro stereolithography modeling service by using ACCULAS®.

Service

- Production of 3-D micro structures employing ACCULAS® micro stereolithography technology
- Production of electroplating and other molds using the 3-D micro models as a master

Service Flow



KEY POINT 1

We will estimate upon your STL data output by 3-D CAD, 2-D drawings, sketches and other data.

KEY POINT 2

We will provide post-process, such as electroplating of molds, upon request.

KEY POINT 3

D-MEC and its chain-member group can support the various needs of customers.

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Characteristics of Micro Three-Dimensional Structure Production by ACCULAS®

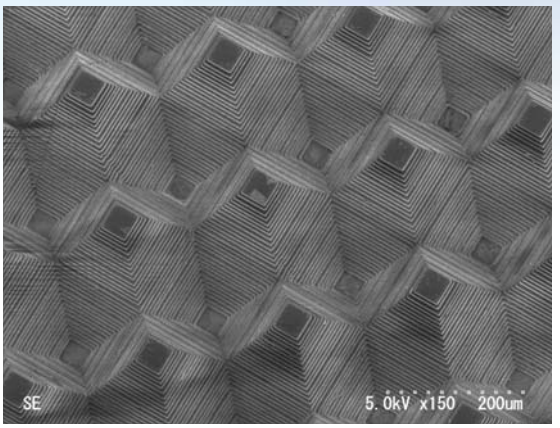
ACCULAS® enables us to produce three-dimensional structures in micro meter scale through a photo-fabrication process.
Pyramid shapes, structures having undercut and free form surface are produced through photo-fabrication layer stacking method in a short period of time.
Applying 3-D CAD data directly, three-dimensional structure are produced in one process.

ACCULAS® can easily provide consecutive convex and concave pyramidal structures in micro meter scale.

●Cutting methods
Convex forms are made by revolving cutter, but concave ones are difficult to be made.

●Photolithography
Multiple photo masks and repetition of exposure and development process are needed to fabricate the micro concave and convex structures.

SEM photo of micro pyramid shape

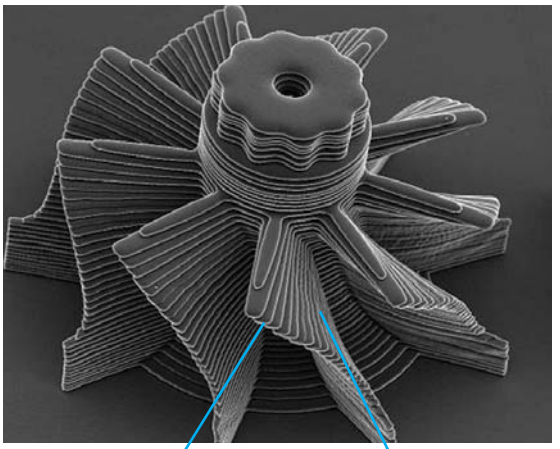


ACCULAS® can provide the structures like turbine blades that are featured by undercut and free form surface.

●Cutting methods
In micro fabrication of free form surface structure, the cutting tool cannot cut in the narrow space and the production may not be completed.

●Photolithography
Multiple photo masks and repetition of exposure and development process are needed.
Additional sacrificial layers are needed to make the structure with undercut.

SEM photo of micro turbine blades



Structure having undercut

Over sailing free form surface structure

Comparison of ACCULAS® and conventional micro-structure production methods

	Producible Shape	Resolution	Material used	Delivery/Cost
Micro photo-fabrication method ACCULAS®	Complicated 3-D structures having free form surface, undercut can be produced.	Resolution is limited by the minimum pixel size, 1.7μm square.	Photo curable resin	Delivery in a short period with low cost because production a single process
Cutting method	Curved surface can be made by employing Multi-Axis Machining.	Limited by a size of cutting tool, and is approximately 10μm.	Metal, resin, glass	Processing speed is limitted for avoiding blade fracture.
Photolithography	A complicated 3-D structures are made by building up 2-D flat shaped layers.	A 32 nm L/S pattern can be produced.	Photo resist	Photo mask production process takes time and cost. Multiple exposure-development process is also time consuming.

ACCULAS® is a registered trademark of Laser Solutions Co.,Ltd

Concept of Form Designing in ACCULAS® ~Construction of 3-D Structure

When producing three-dimensional structure based on 3-D CAD data, elemental basic forms can be developed into desired structure by combining those basic forms.

Figure 1

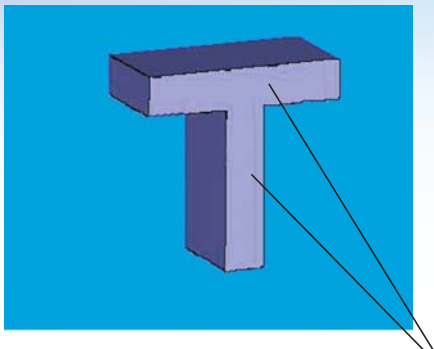


Figure 1 shows a T-shaped basic form composed of two rectangular solids each stacked in a vertical and a horizontal dimension.

A three-dimensional structure of the grillwork is obtained by combining a number of the basic forms as shown in Figure 2.

Combination of rectangular solid

Figure 2

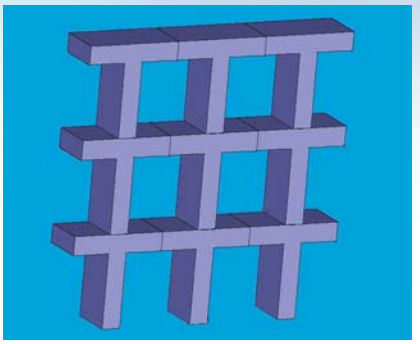
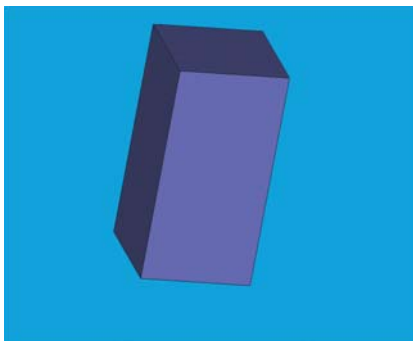
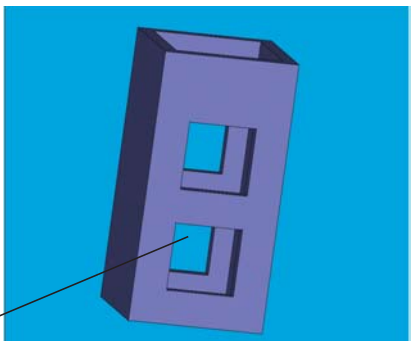


Figure 3



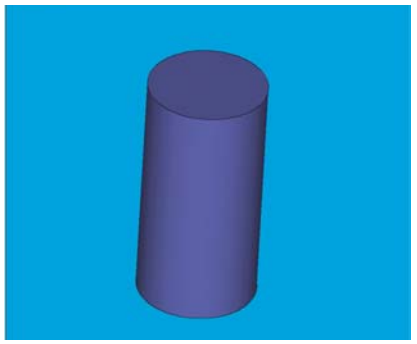
Hollow cavities can be made in vertical and horizontal dimensions through a basic form.
A three-dimensional structure with a plurality of hollow cavities is produced as shown in Figure 4.

Figure 4



Hollow cavities

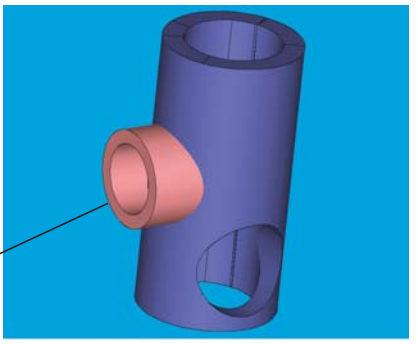
Figure 5



Hollows can be made in vertical and horizontal dimensions through a basic form of round pillar shown in Figure 5. Additional round pillar with a cavity can be connected to make a joint as shown in Figure 6.

Added hollow pillar

Figure 6

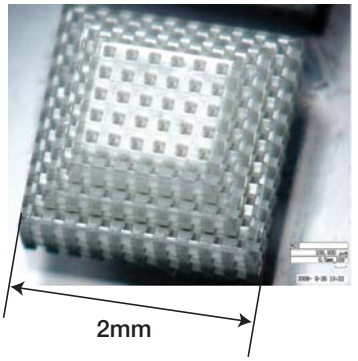


Three-dimensional structures can be produced by combining various elements shown above.

Epoxy resin

Microscopic photo 1

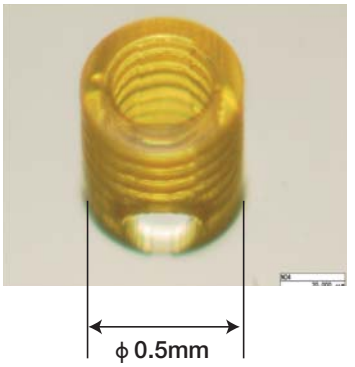
Multiple pore structure



Acrylic resin

Microscopic photo 2

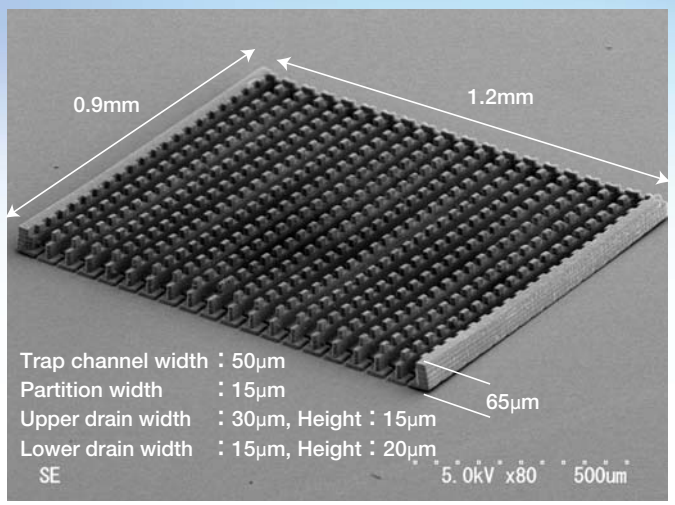
Cylinder structure



ACCULAS® Application Example 1

Micro Trap Equipped with Drain Structures

SEM photo of micro trap equipped with drain structures

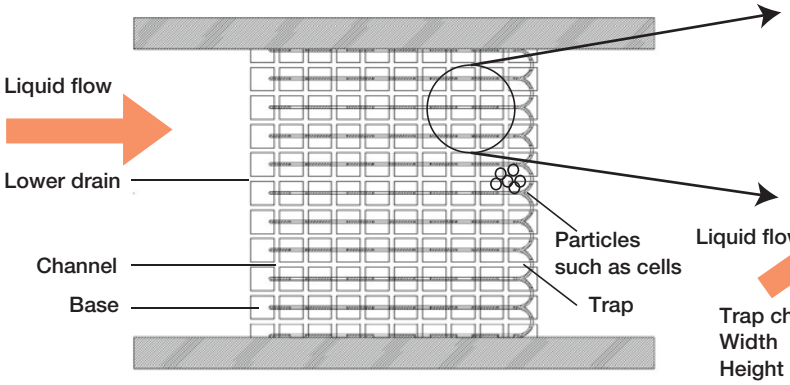


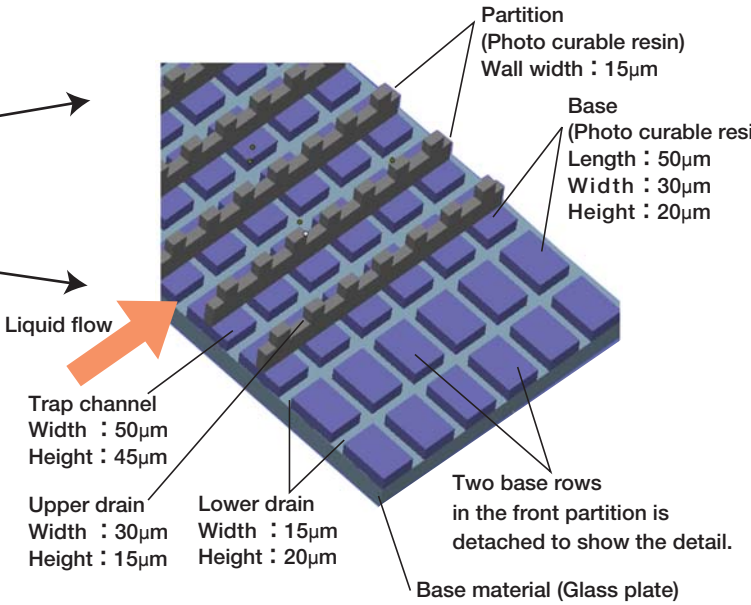
Ceiling cover is detached in the photo.

Micro trap structure equipped with drain which can avoid to be clogged by the trapped matters such as cells and particles.

Material : Photo curable resin (Acrylic)
Time required for production : 1 hour

Top view of the micro trap

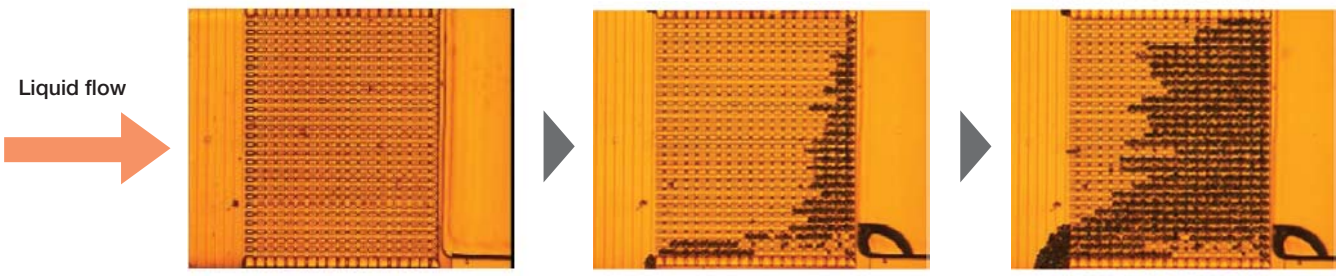




As in the enlarged schematic drawing, a concave is formed at the upper part of partition to produce upper drain, while lower drain is formed by disposing the base as a tile.
Although cells or the like are clogged in the trap, the liquid flows through the drain without causing pressure drop. It is thus possible to set the particles in array.

Experiment of particle alignment

The experiment demonstrates the particles are trapped and aligned without causing any clogging by using micro trap equipped with drain structure.

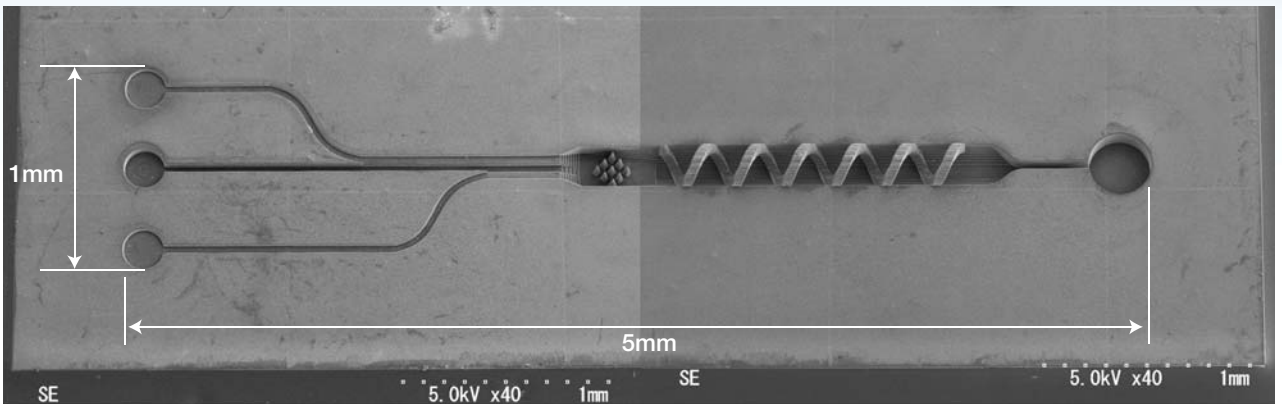


ACCULAS® Application Example 2

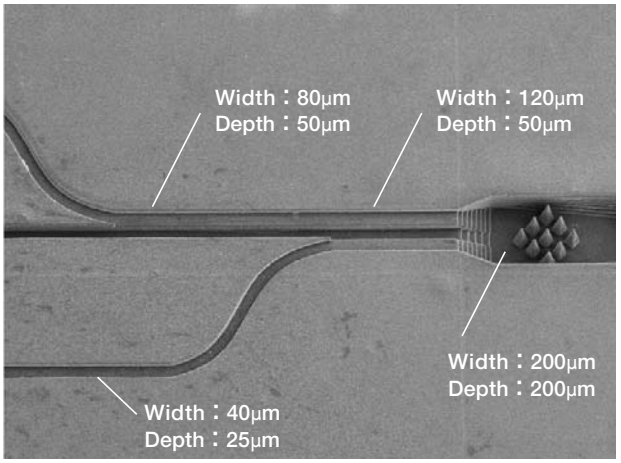
Micro Channel Equipped with Inner Structures

Micro channel having branching and inner structure can be produced at the desired depth and width.

SEM photo of micro-channel equipped with inner structures



SEM photo of the branching point of micro-channel

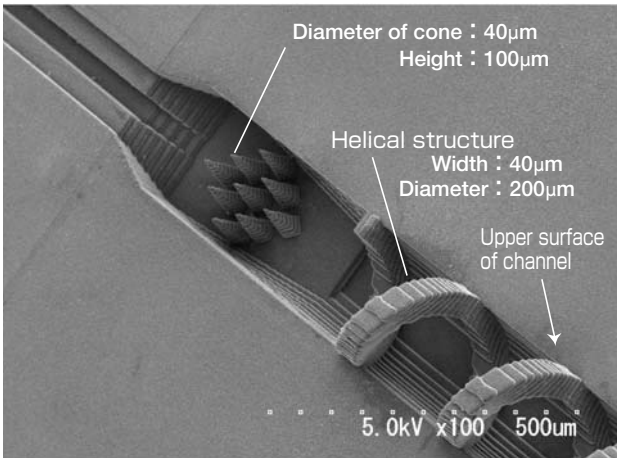


Materials : Photo curable resin
Acrylic (Electroplating mold master)
Epoxy (Functional model)

Time required for production : 4 hours

Vortex flow can be generated by making a helical structure inside the channel.

SEM photo of helical structure in channel



Micro-channel produced by ACCULAS® is also applicable to electroplating mold master.
Application to electroplating mold master is shown in the section of ACCULAS® application example (No. 3), "Proposal of master for electroforming mold production-development to nano-imprint".

The helical structure in the micro channel is used as electroplating mold master by dividing the channel into an upper part and a lower part.

ACCULAS® Application Example ❸−1

Master for Electroplating Mold Production ～Development toward Nano-imprint

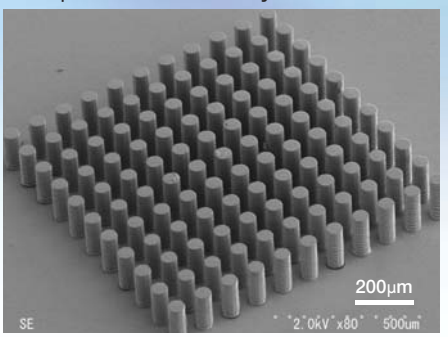
Circular cylinders and circular cones are produced as a master for electroplating mold.

Circular cylinder	Diameter	: 50μm
	Height	: 150μm
Circular cone	Diameter at bottom	: 150μm
	Height	: 150μm

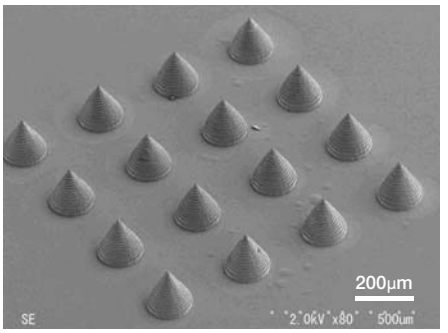
Materials : Photo curable resin (Acrylic)
Time required for production : 1 hour

By using photolithography technique, the same circular cylinders are made by 6weeks, but no circular cone structures was available.

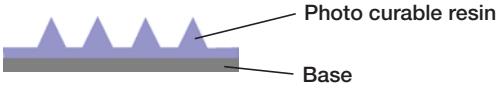
SEM photo of circular cylinder structure



SEM photo of circular cone structures



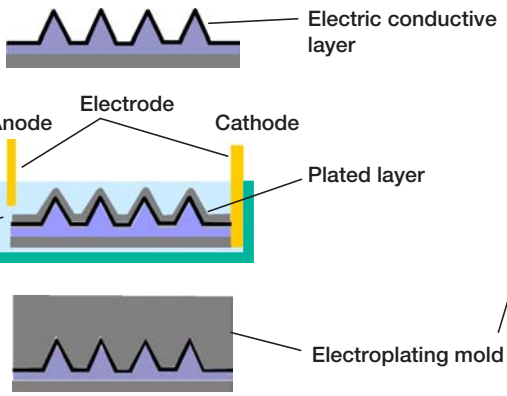
Production of master model



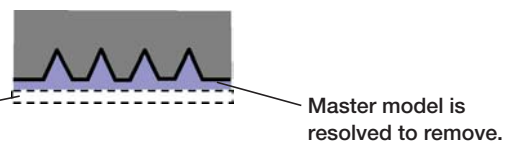
Electroplating is applied to the master model

Electroplating process

【Surface treatment (Cleansing, conductive processing)】



【Removing master model】

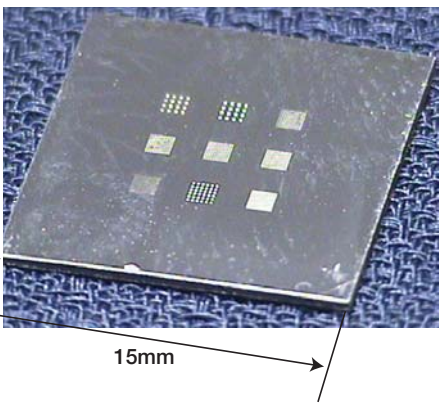


【Completion of electroplating mold】

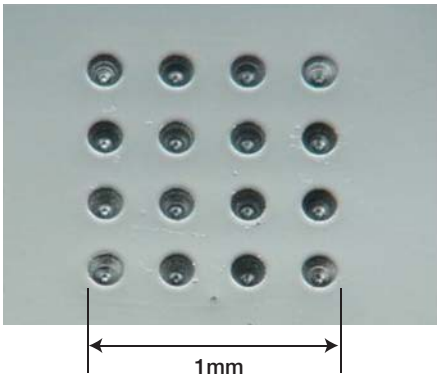
Inverted pattern of master model is produced.

An imprinting mold is obtained by abrading and lining the mold.

Microscopic photo of electroforming mold



Enlarged microscopic photo of the circular cone of the electroforming mold



With collaboration from SCIVAX Co.,Ltd.

ACCULAS® Application Example ❸-2

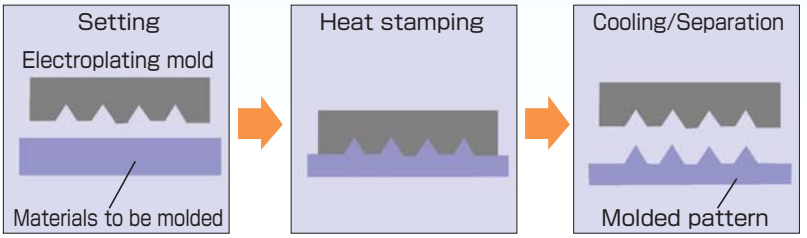
Master for Electroplating Mold Production ～Development toward Nano-imprint

Molding is conducted by using nano-imprint instrument.

A molded article is produced by stamping the electroplating mold to thermoplastics such as "ARTON" or the like as molding materials by using nano-imprinting process.

Photo of nano-imprinting instrument
SCIVAX VX produced by SCIVAX Co.,Ltd.

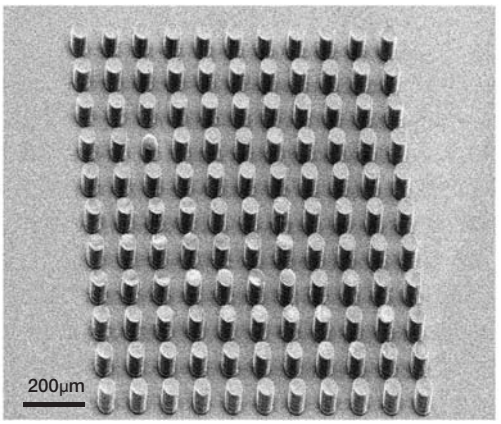
Nano-imprinting process



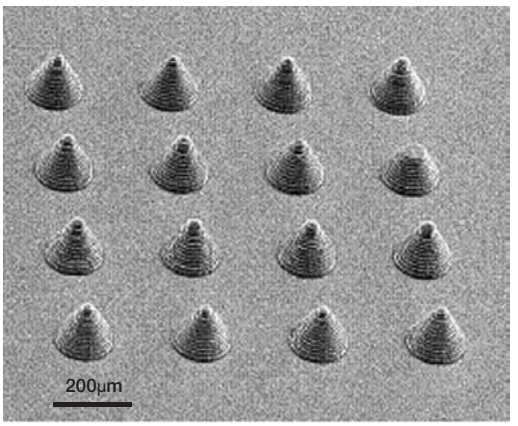
A thermal imprinting is shown above. It is also available to utilize UV curable resin for the materials to be molded.

Photo of molded article by imprint method

SEM photo of molded article having circular cylinder structure



SEM photo of molded article having circular cone structure



With collaboration from SCIVAX Co.,Ltd.

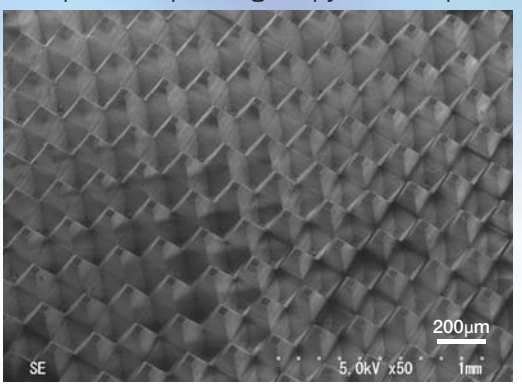
In the examples here, electroplating mold master having concave structure is made and utilized for imprint molding of thermoplastics.
In ACCULAS®, 3-D CAD data are sliced and applied for direct exposure data.

ACCULAS® Application Example 4-1

Master for Silicone Rubber Mold Production ~Development of Vacuum Casting Mold

Convex and concave pyramidal structures are produced as a master for silicone rubber mold.

SEM photo of quadrangular pyramid shape



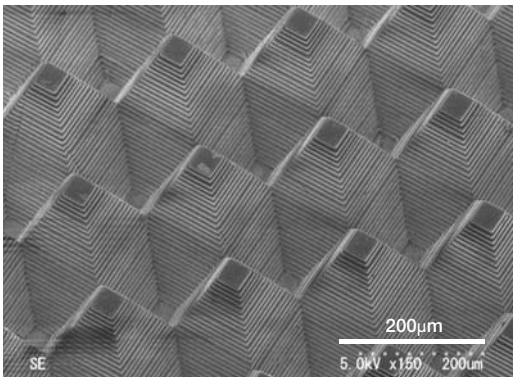
Quadrangular pyramid shape is produced as a master model.

Quadrangular pyramid	Base plane	: 150μm
	Height	: 300μm

Material: Photo curable resin (Acrylic)
Time required for production : 3 hours

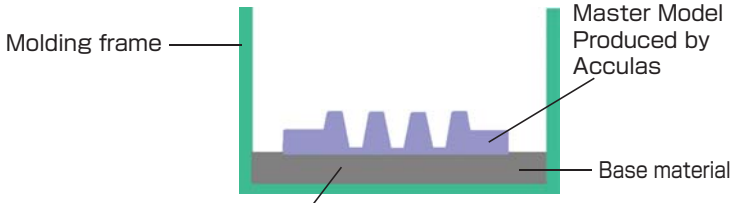
A silicone rubber mold is produced by using the produced master model as follows.

Enlarged SEM photo of quadrangular pyramid shape.



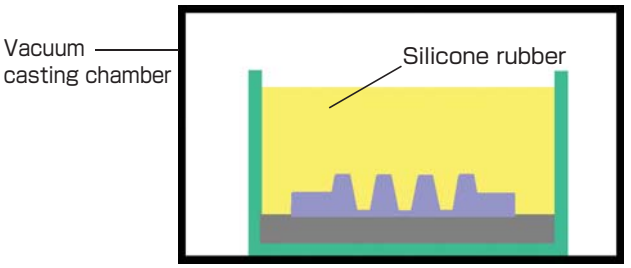
Procedure of silicone rubber mold production

【Production of molding frame】



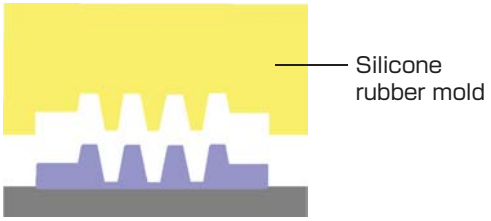
Place the master model into the molding frame.

【Filling silicone rubber】



The molding frame is placed in a vacuum casting chamber and then degassed silicone rubber is poured into the molding frame.

【Completion of silicone rubber mold】



Silicone rubber mold is removed from the molding frame.

Photo of the produced silicone rubber mold

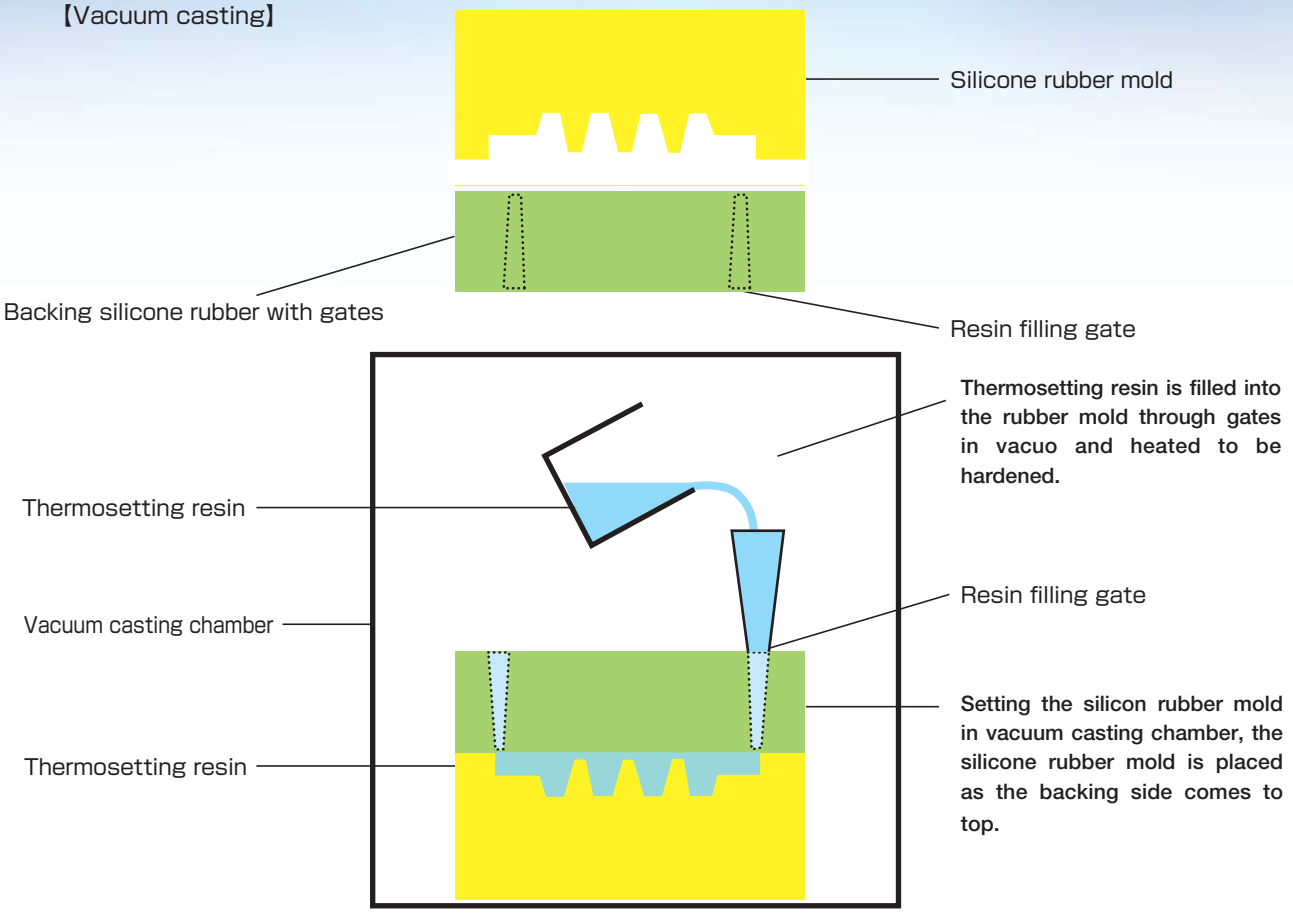
ACCULAS® Application Example ❹-2

Master for Silicone Rubber Mold Production ～Development of Vacuum Casting Mold

Vacuum casting is conducted using the produced silicone rubber mold.

Process of vacuum casting

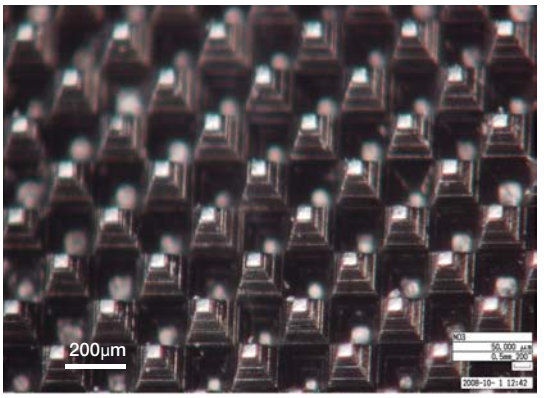
【Vacuum casting】



【Completion of vacuum casting 】

After completion of curing of thermosetting resin, the product is retrieved by opening the rubber mold.

Microscopic photo of the articles produced by silicone rubber molding.



Micro convex and concave pyramidal structure is made through vaccum set up process by using the silicone rubber master mold which was produced by ACCULAS® photo-fabrication method.

ACCULAS® Application Example 5-1

Production of Micro Three-Dimensional Structure

Multiple pore three-dimensional structure

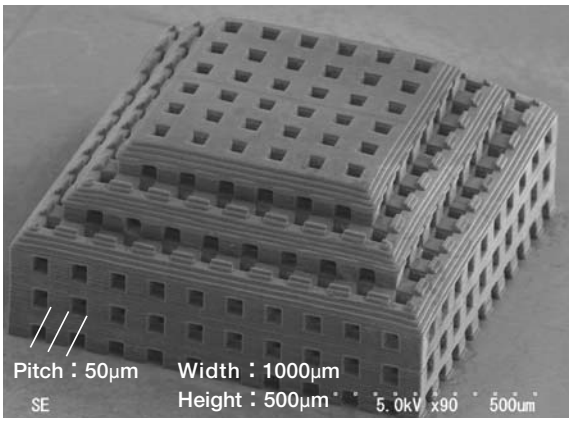
It is suitable for producing cell culturing cells, photonic crystals, and fractal structures.

Pore shape ：angular, circular, oval
Material : Photo curable resin
(Acrylic, Epoxy)
＊Dispersion of inorganic particles is available

Time required for production : 4 hours (9 pieces)

Microscopic photo

SEM photo



Inner processing

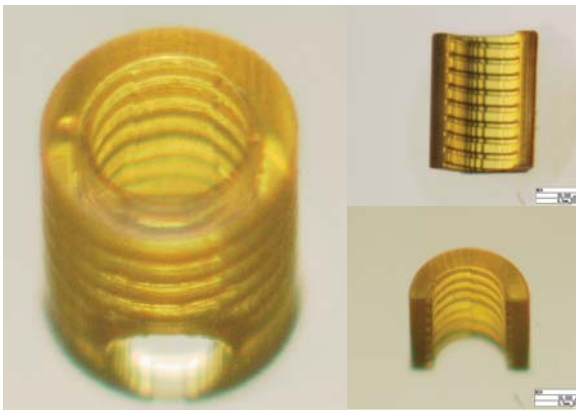
The pipe structures having over-hang and horizontal cave inside is produced.

Material: Photo curable resin
(Acrylic, Epoxy)

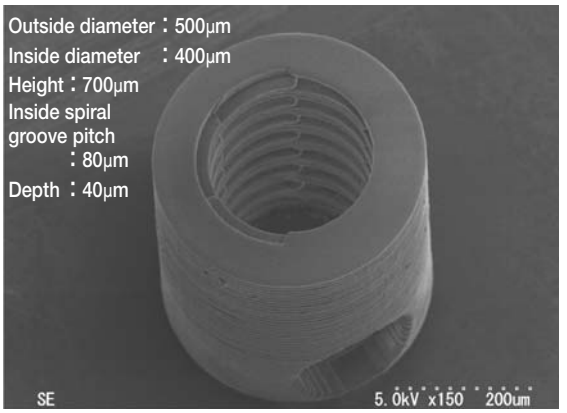
Time required for production : 2 hours (3 pieces)

This element can be used as a joint of micro channel or a tool for a turbulence generation in micro channel.

Microscopic photo



SEM photo



ACCULAS® Application Example 5 –2

Production of Micro Three-Dimensional Structure

Micro fin with curved surface structure

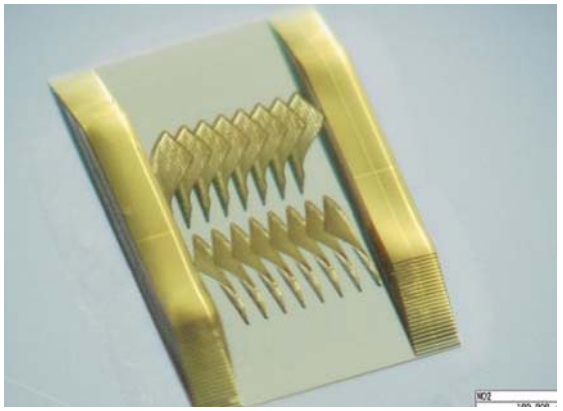
Fin elements having free form surface and undercut structures are producible.

Material : Photo curable resins
(Acrylic, Epoxy)

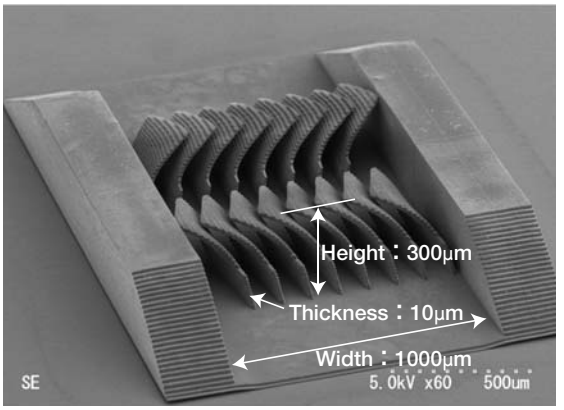
Time required for production : 4 hours (9 pieces)

This elements can be inserted as a part such as a micro-static mixer in micro channel to investigate the occurrence of turbulence.

Microscopic photo



SEM photo



Cells for cell-fusion experiment

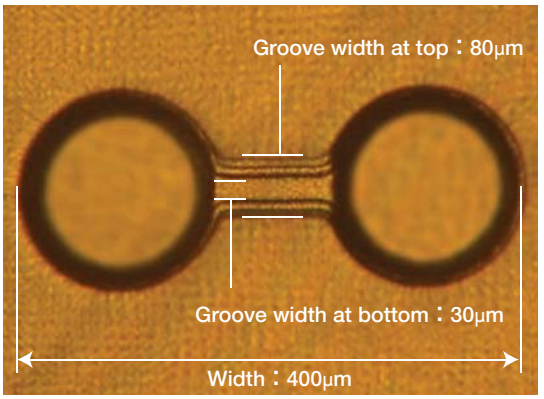
Mortar-like cells having desired taper angle and depth are produced upon request.

Material : Photo curable resin
(Acrylic, Epoxy)

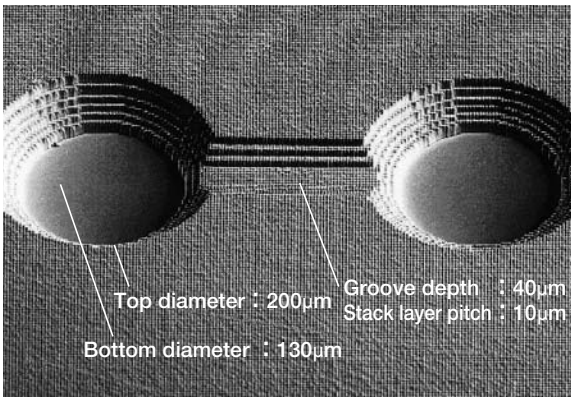
Time required for production : 2 hours (36 pieces)

Cells or particles can be disposed in line by using this device.

Microscopic photo



SEM photo



ACCULAS® Application Example 5-3

Production of Micro Three-Dimensional Structure

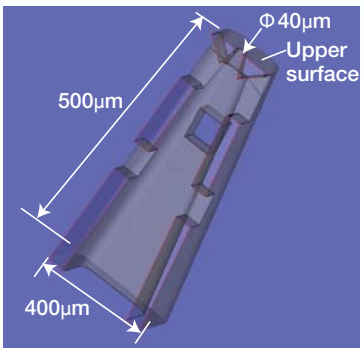
Capillary structure

A number of complicated capillary strucures with hollow cavity produced at one time.

Material : Photo curable resins
(Acrylic)

Time required for production : 4 hours
(35 pieces x 3 sets)

Figure 1



Microscopic photo

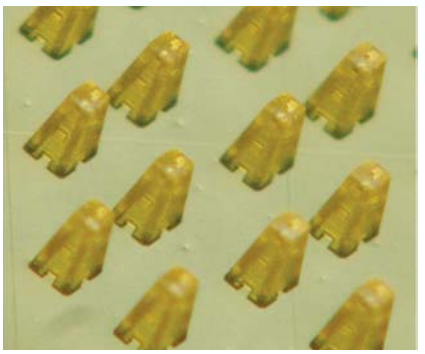
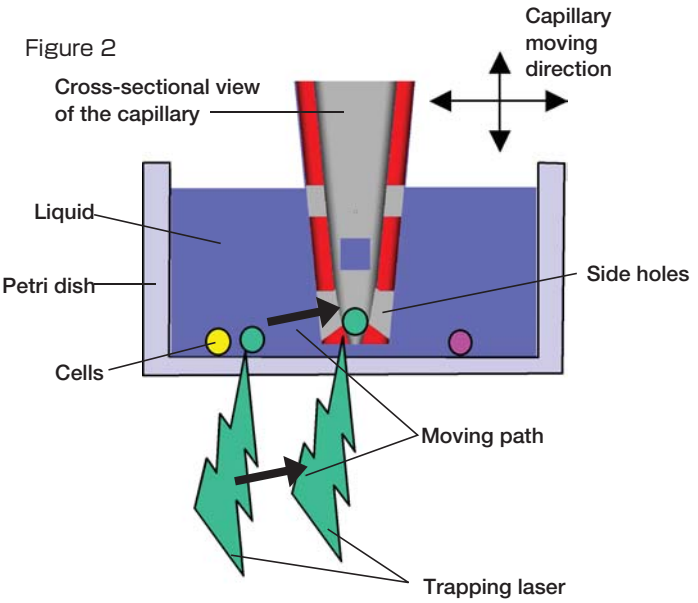


Figure 2 schematically draws the sectional view of a single capillary structure.

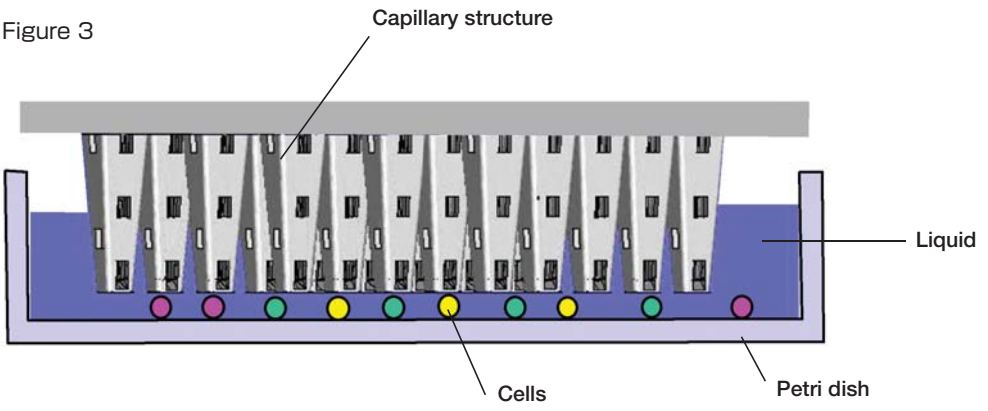
The capillary structure produced here can be used as a tool to capture cells via the side holes into the hole portion of the upper surface as shown in Figure 1 and to move them to other petri dishes or the like.

Figure 2



By using the capillary structure it is possible to handle a plurality of cells collectively in one operation as shown in Figure 3.

Figure 3



ACCULAS® Application Example 6

Introduction of User Examples

ACCULAS® is used for development of micro supports (artificial tendons) for skeletal muscle cultivation.

Proceedings of The 16th Chemistry and Micro-Nano System Association (Autumn 2007)

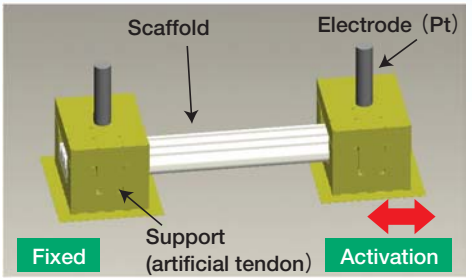
Designing Scaffold for Skeletal Muscle Cultivation

Dept. of Biomedical Engineering Osaka Institute of Technology
● Kou Detani, Kazuya Syakudo, Yusuke Abe, Hiroshi Tsutsui, Kenichi Yamazaki, Tsunehiko Terada, Toshiya Fujisato, Masahiko Yoshiura

Development of cultivation environment for skeletal muscle

Development of a cultivation environment for skeletal muscle from cells has been done to create a flexible actuator using skeletal muscle.

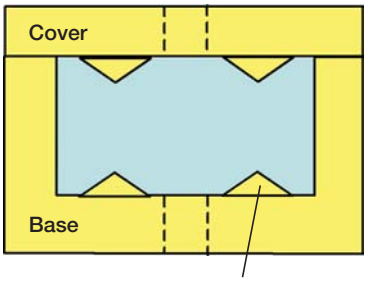
1. **Development of scaffolds which are flexible and elastic**
2. **Development of micro support (artificial tendons) for stimulus loading**
3. **Development of cultivation environment and electrical and mechanical stimulus loading device**



Flexible scaffold and micro-support (artificial tendon)

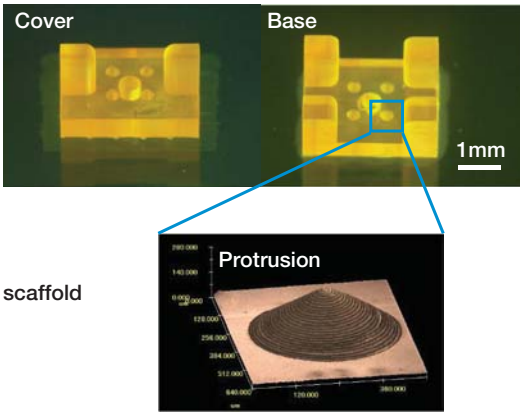
Micro support (artificial tendons) for stimulus loading

Figure of cover/base combination



Protrusion for fixing scaffold

Micro support made of photo curable resin by using Acculas



Fabrication conditions

Layer pitch : 10μm
Number of layers : 205

Size of cover and base

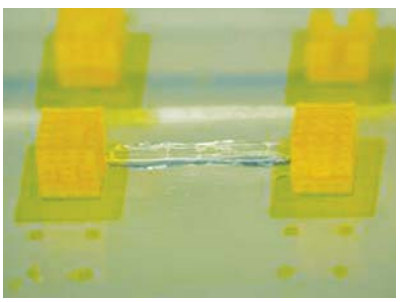
Both base and cover
Length : 4mm
Width : 3mm
Height : 2mm

Size of protrusion

Bottom diameter : 200μm
Height : 300μm

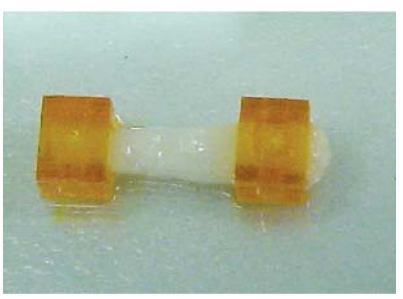
Implementation of scaffold

1) Collagen-like gel scaffold



Flexible collagen scaffold made by electrophoresis from collagen acidic solution (PH1.2).

2) Scaffold derived from a cellular tissue



Scaffold derived from cellular tissue produced from the collagen tissue which is made of arteries of miniature swine by extracting cell and elastin.