Enabling Research, Trial production and Manufacture of Micro devices

By Micro Stereolithography system

JSR Micro Inc.

How to do research, trial production and manufacturing of micro devices

If size is big, there is stereolithography system
or Ink jet print system may be applicable.

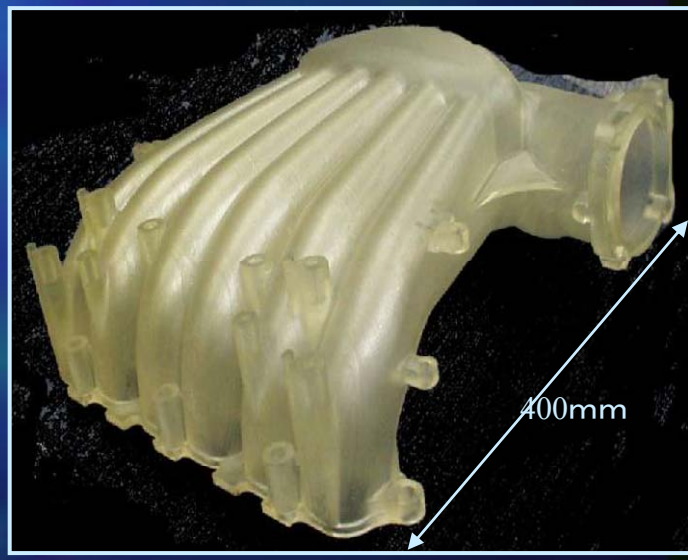
Conventional Stereolithography System (SLA) & Some Models

3D i-Pro8000 SLA Center

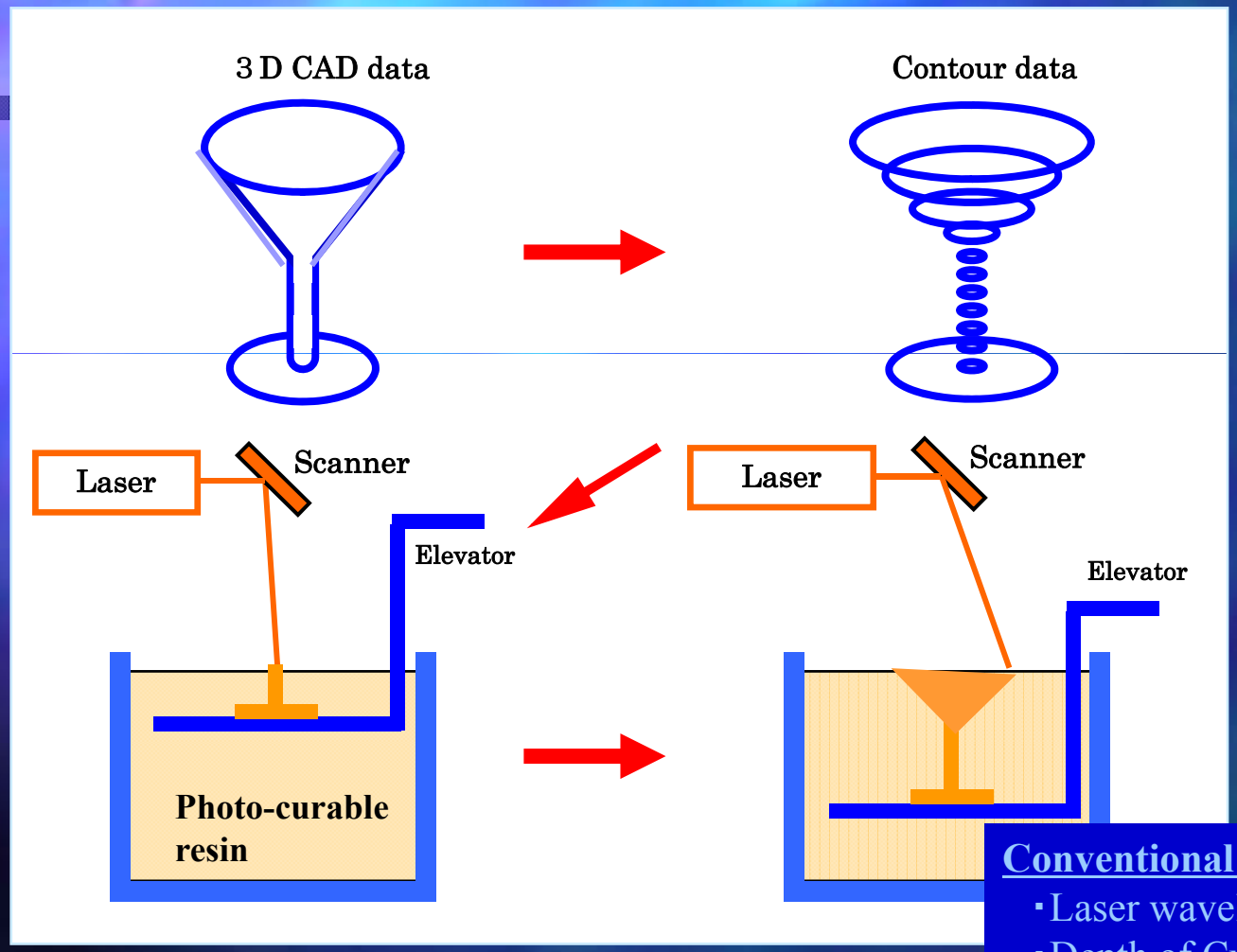
General Use

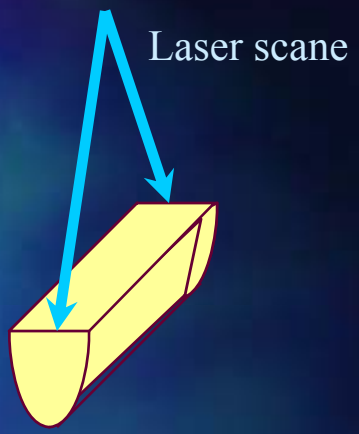
2.3m

355nm Solid State Laser
750 × 650 × 550mm



Process of conventional Stereolithography



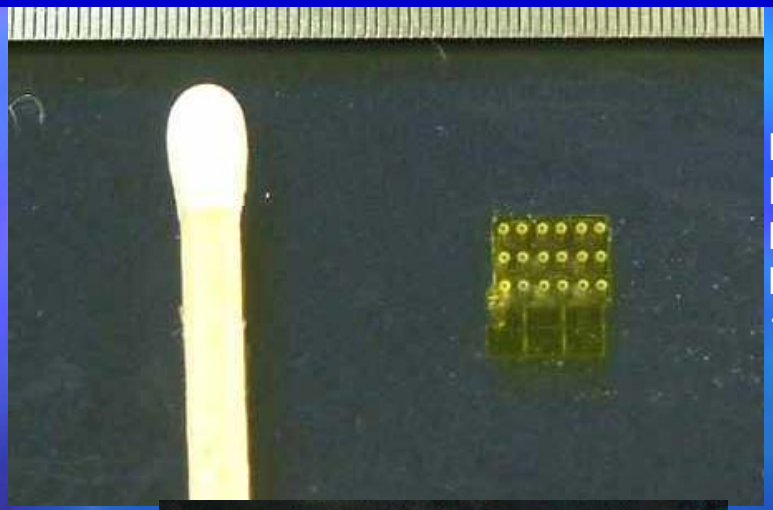


Conventional Technology

- Laser wavelength 355nm
- Depth of Cured Line 200-300μm
- Width of Cured Line 200μm
- Layer Thickness 100-200μm

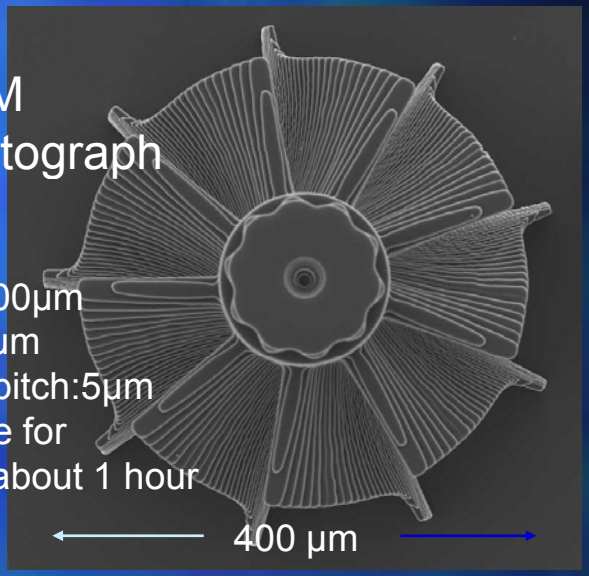
Example: Micro Turbine Models

Built turbine models with ACCULAS
（3 pieces × 6 lines＝total 18 models



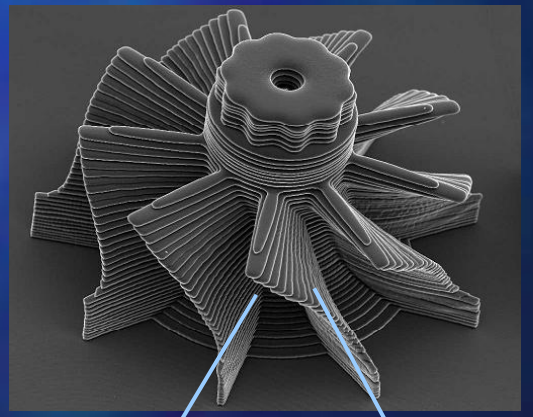
SEM
photograph

Diameter：400μm
Height：250μm
Lamination pitch:5μm
Building time for
18 models：about 1 hour

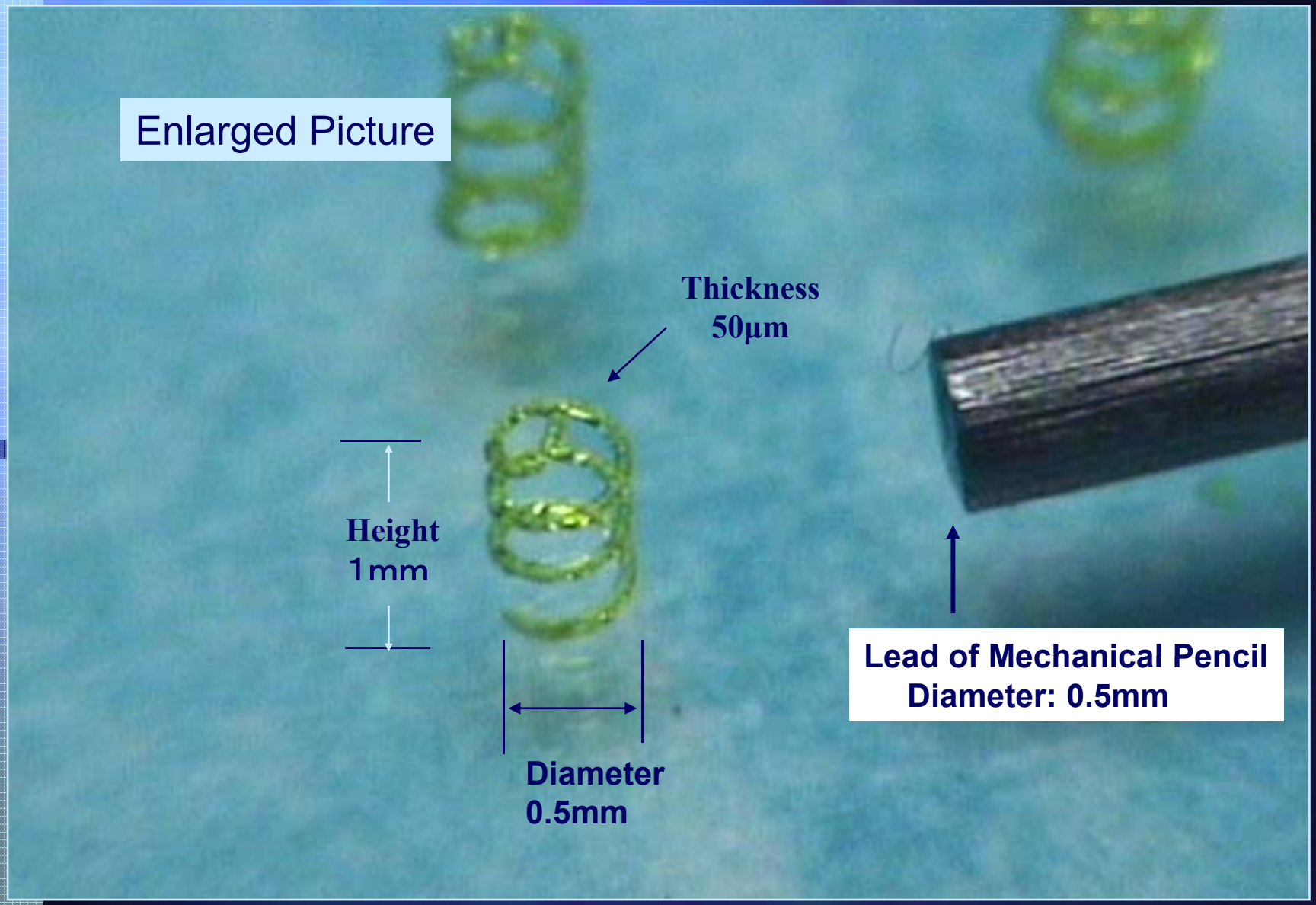


Microscope
photograph

SEM photo of micro turbine blades

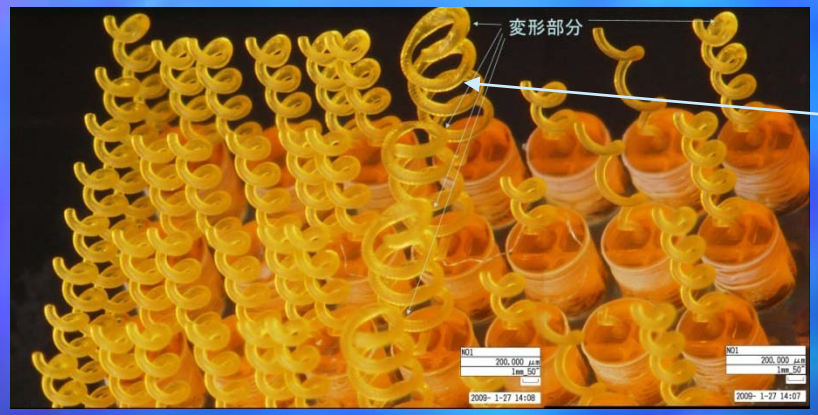


Example Micro coil Model



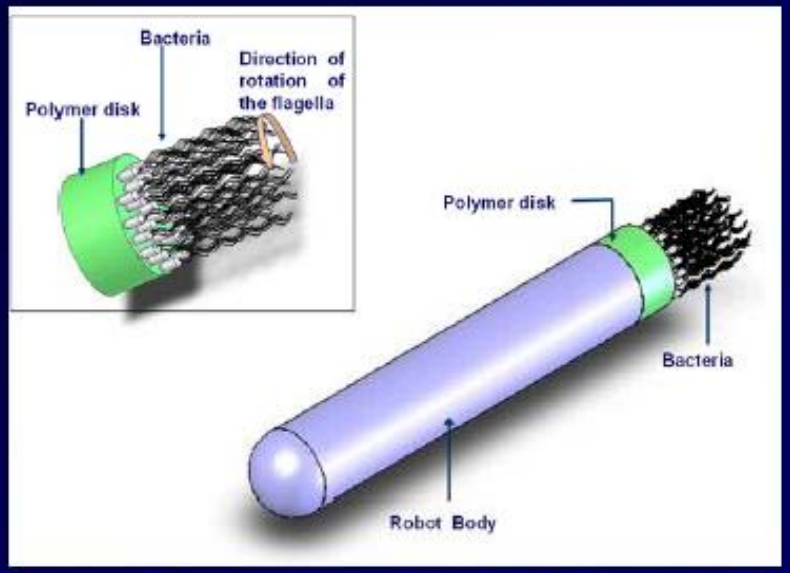
Simulation model for corkscrew like flagella

Carnegie Mellon University
／Associate Prof. Metin Sitti



100μm in deameter

Bacteria, only 0.5 μm in diameter and 2 μm long, are propelled by rotating their corkscrew like flagella at a rate of ~ 300 Hz.
The flagella are only 20 nm in diameter and are about 10 μm long.



By courtesy of Dr.Metin Sitti, Department of Mechanical Engineering and Robotics Institute in Carnegie Mellon University.

Comparison between ACCULAS and conventional stereolithography

- Conventional stereolithography machines use galvano-mirrors to facilitate precise and rapid control of the laser beam. The resolution of the laser beam is limited to 100-200 microns.
- ACCULAS uses a DMD (digital micro-mirror device).
- A DMD device is composed of approximately 1 million mirrors in a size 2 x 2cm. Each mirror can be controlled individually. Although the size of each mirror is about 14 x 14 microns, the resolution can be reached up to **1.7 x 1.7 microns** because the projected image can be scaled down further.

What is ACCULAS ?

- ACCULAS is able to produce three-dimensional structures in micron-scale in one process through a photo-fabrication process with three-dimensional CAD data.
- ACCULAS was developed jointly by **Laser Solutions CO., Ltd.** and **JSR Corporation**.
- Laser Solutions is in charge of tool manufacturing.
- JSR is in charge of development of photo curable resins, rapid prototyping service and follow-up.

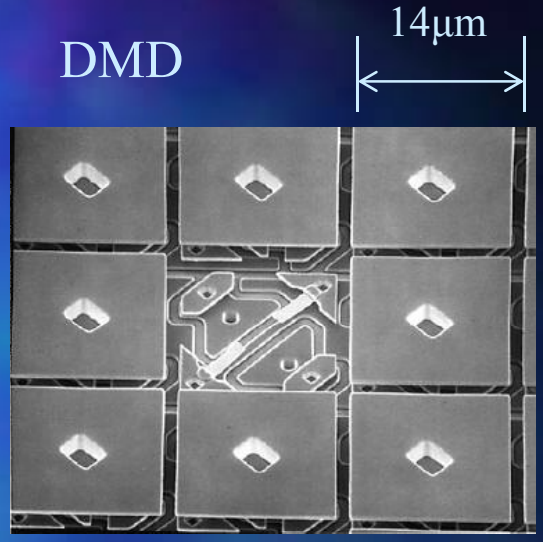
Comparison of Micro 3D modeling methods

	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, 1μm 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 10 μm.	Metal, resin, glass	Processing speed is limited 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.

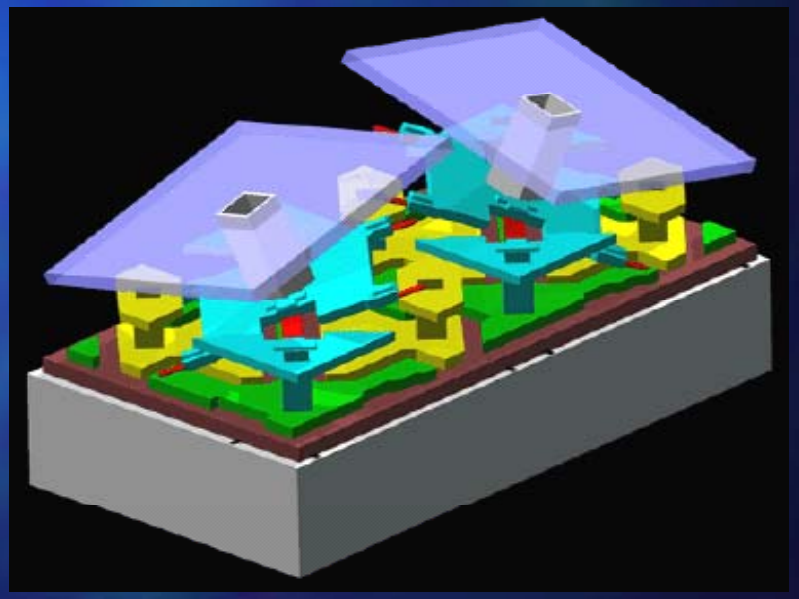
Micro Stereo-Lithography System

ACCULAS

DMD

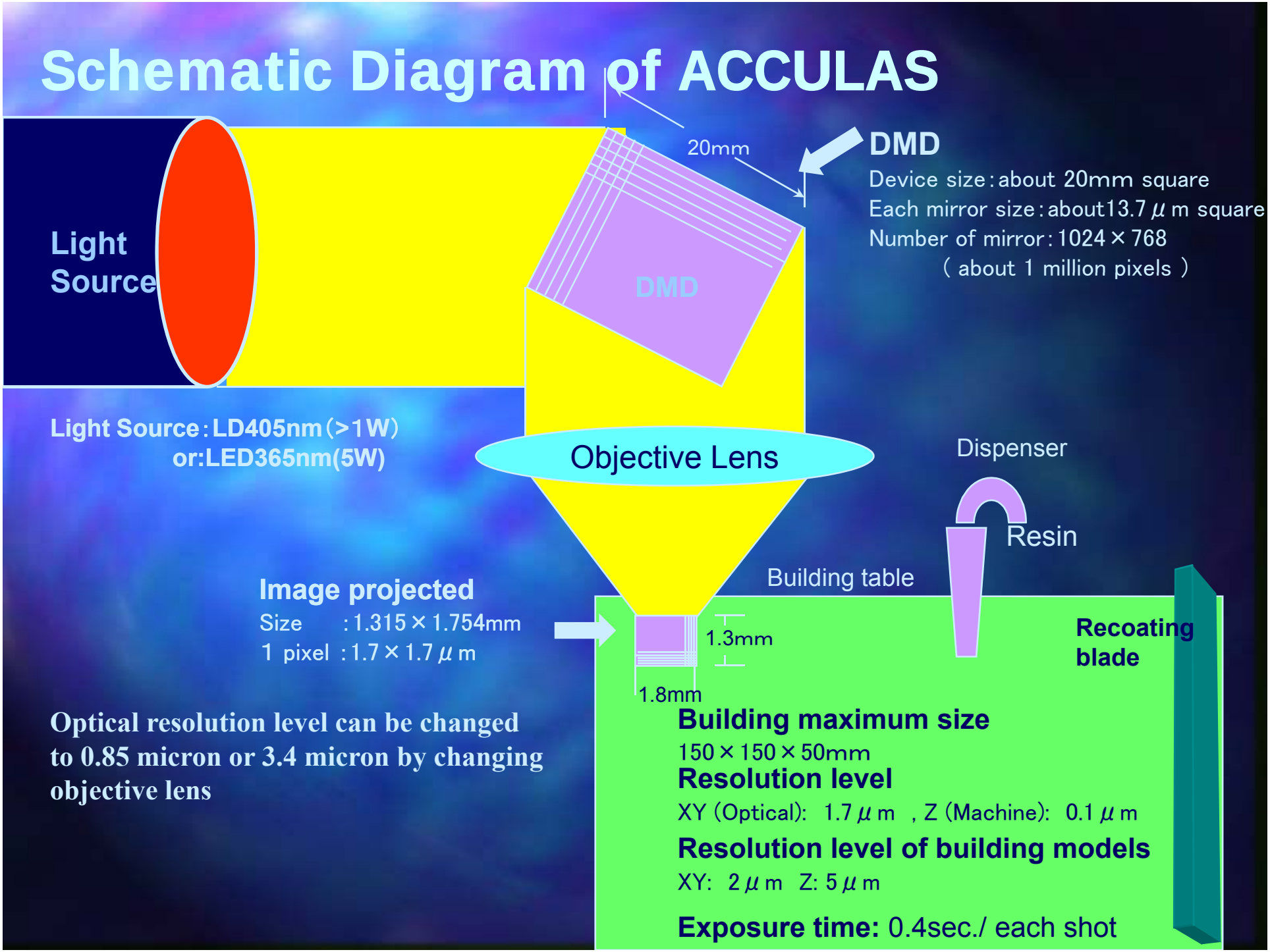


There are about one million mirrors in a small chip

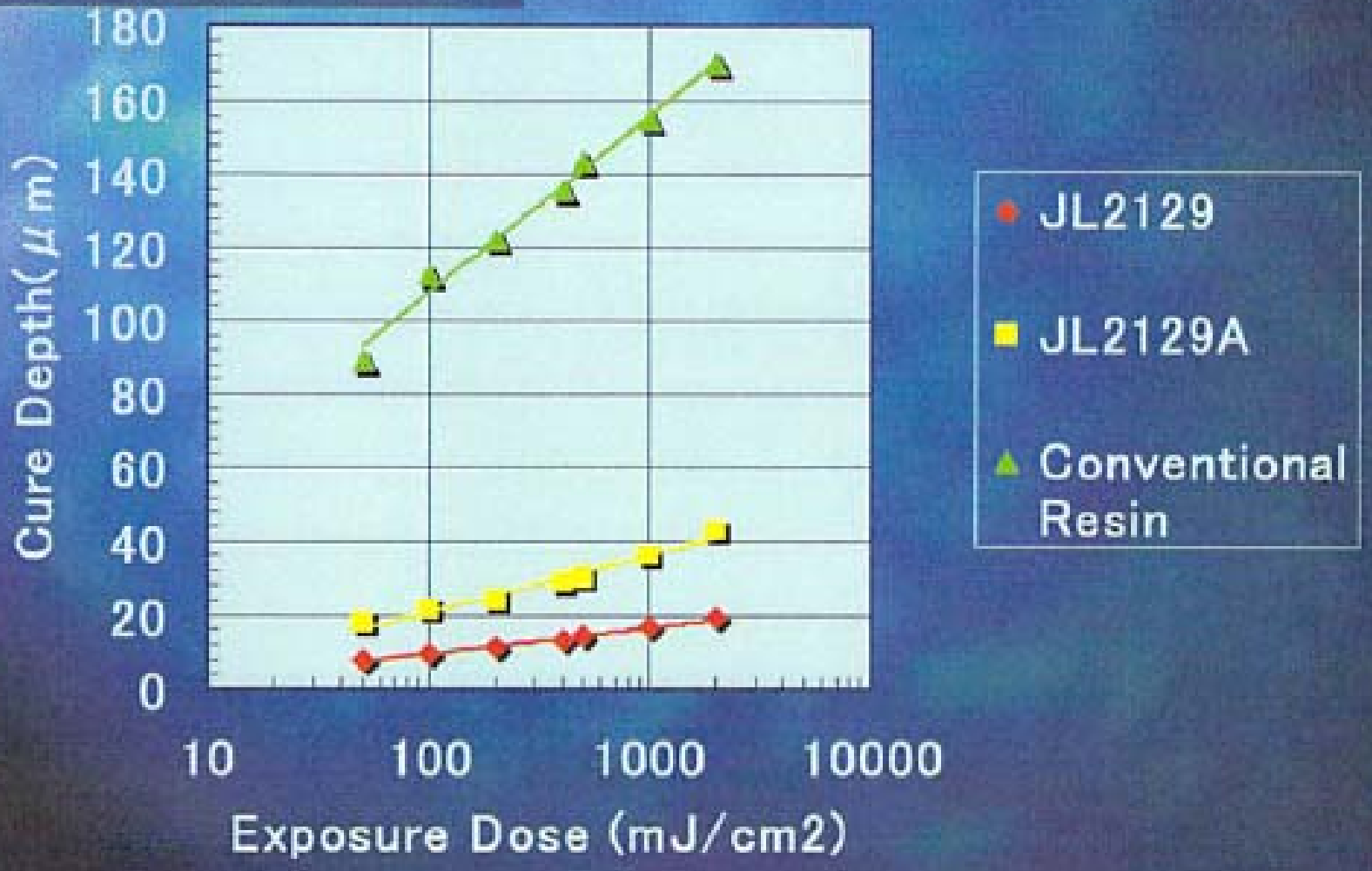


Angel of each mirror can be changed independently

Schematic Diagram of ACCULAS



Curing Property (Working Curve) of The Resin (JL2129) for ACCULAS



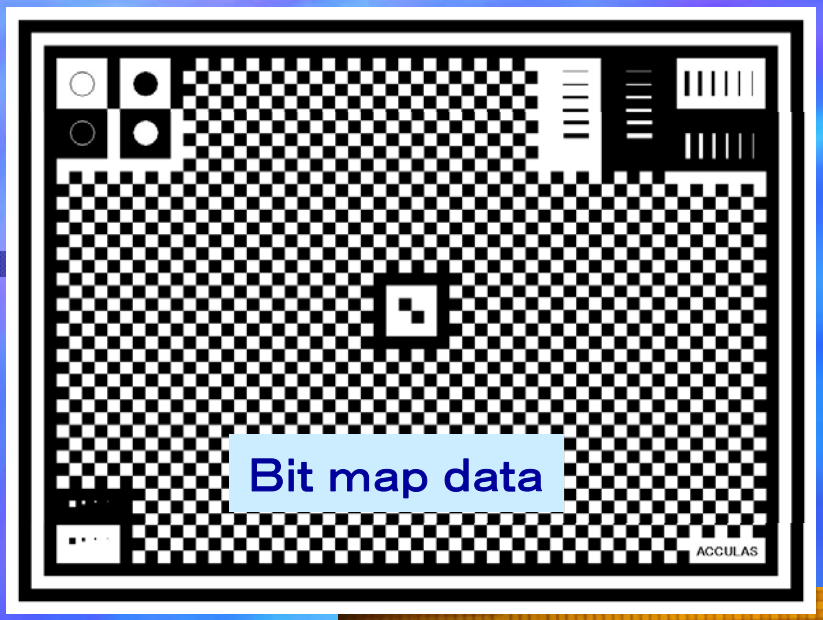
JSR

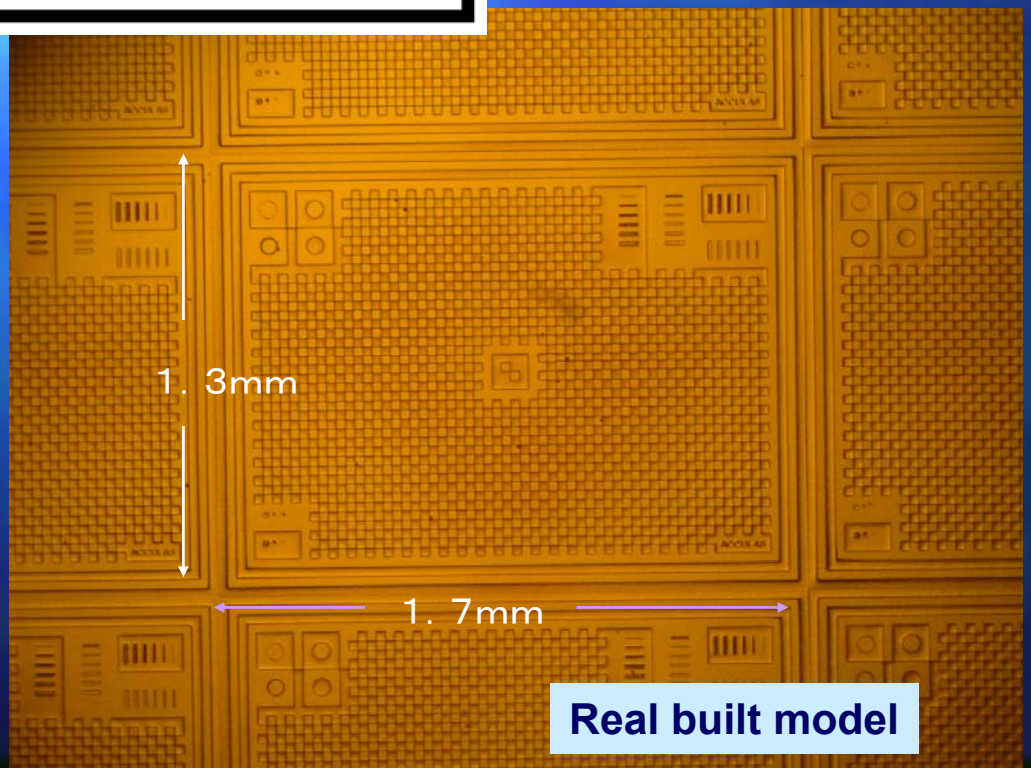
Data sheet of Resin for Micro Model Fabrication by Stereolithography

			JL2129	JL2146	JL2143	KC1207
Main Ingredient			Acrylic			Epoxy／Acrylic
Light Source			405 nm LD			365 nm LED
Characteristic			Standard	Less Deformation	Alkali Developing Few Deformation	Tough Less Deformation
Properties before curing		Viscosity (mPa･s@25℃)	2,000	380	6,000	1,950
		Light Permeation (%T, 10μm)	8.0	8.0	8.0	37.3
		Ec (mJ/cm^2)	4.6	4.0	5.0	38.0
		Dp (μm)	3.0	2.8	3.1	12.0
Properties after curing [1]	Physical properties	Young's Modulus (MPa)	2,300	2,300	2,100	1,200
		Elongation at Break (%)	< 3	< 3	< 3	14
		Tg (℃, @3.5 Hz)	> 200	> 200	> 200	90
		Sheet curve (mm) [2]	26	15	5	5
	Swelling	in Alkaline aquarious[3]	none	none	none	none
	H2O resistance	Contact angle (° @Water) [4]	80	87	91	90
		Water absorption (%)	1.4	2.3	18.3	4.1
	Electrical performance	Surface resistance(Ω) [5]	3×10^{14}	5×10^{14}	3×10^{14}	2×10^{14}
		Dielectric constant (@100 kHz) [6]	3.7	3.5	3.2	3.6

1) Film thickness 40um 1J/cm2 photo cure in Air
2) Film thickness 40um 1J/cm2 photo cure in Air on PET sheet measure sheet curve by 8cm x 8cm square
3) In Alkaline solution at 60C
4) After 1 min.
5) Agilent High resistance meter 4339B
6) Film thickness 1um 1J/cm2 photo cure in N2

Example
Test pattern built with ACCULAS





Potential Applications of Micro Stereo-lithography (ACCLUS)

- **Research, trial production and manufacture of micro devices**
- **Assumption fields used**

◇Biotechnology･medical fields

･Biochip: DNA chip for gene analysis, protein chip for protein functional analysis
･Health care chip: biosensor chip for very-small-quantity inspection in living body
･ MEMS for medical treatments: micro-actuator, micro catheter

◇Chemical reaction

･μTAS：micro reactor, chemical IC chip, micro passage system, micro analysis chip

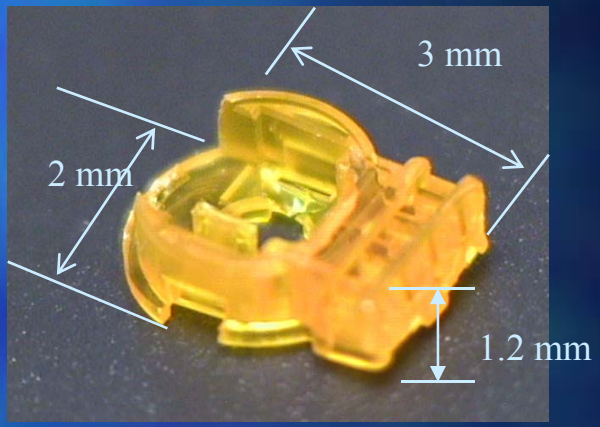
◇Optics & electronics fields

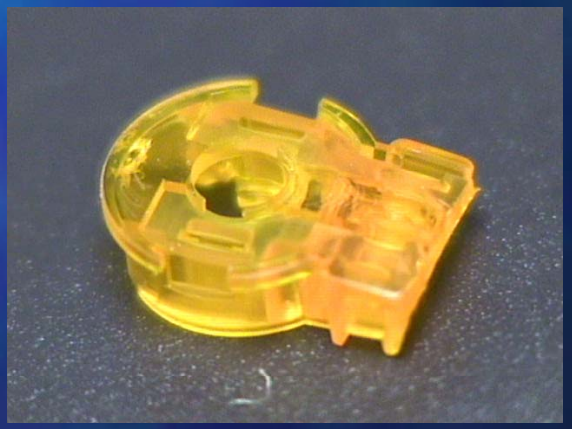
･ Photonic crystal, optical IC chip, micro magnetism device, super-high density memory, micro lens array

◇Micro machine（MEMS)

･ micro gear, optical drive nanomachine

Example: Micro Parts

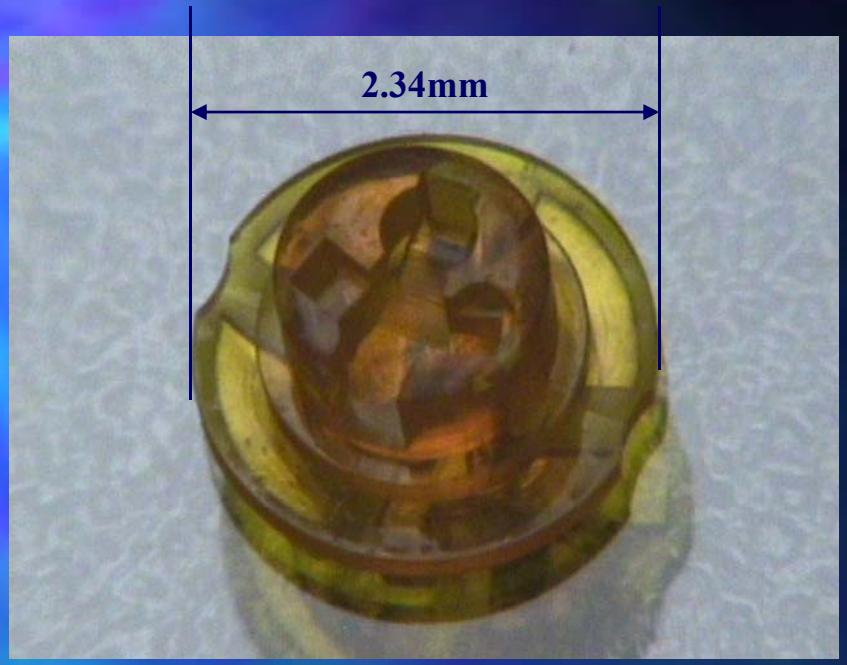




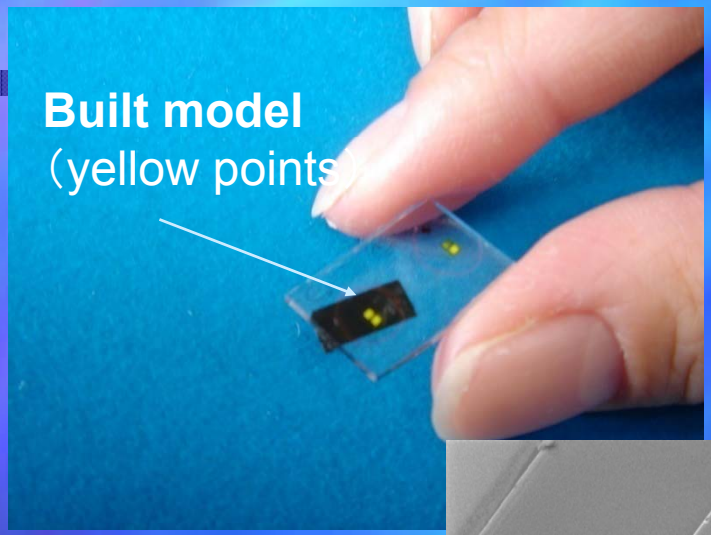
Building time: 7hrs / 6parts

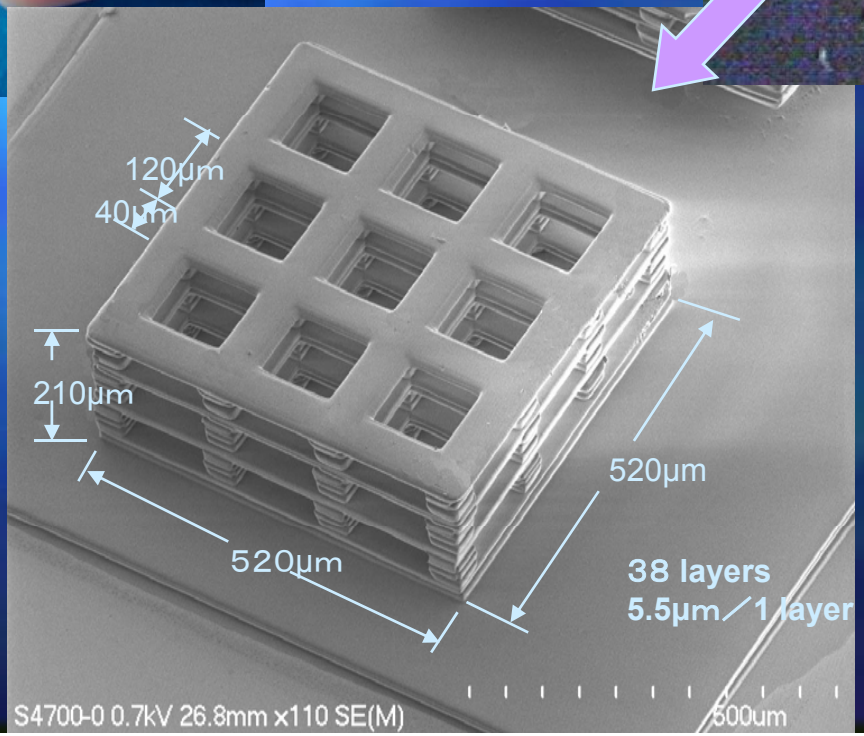
Example Micro Parts

Building time for six parts: 3.5 hrs



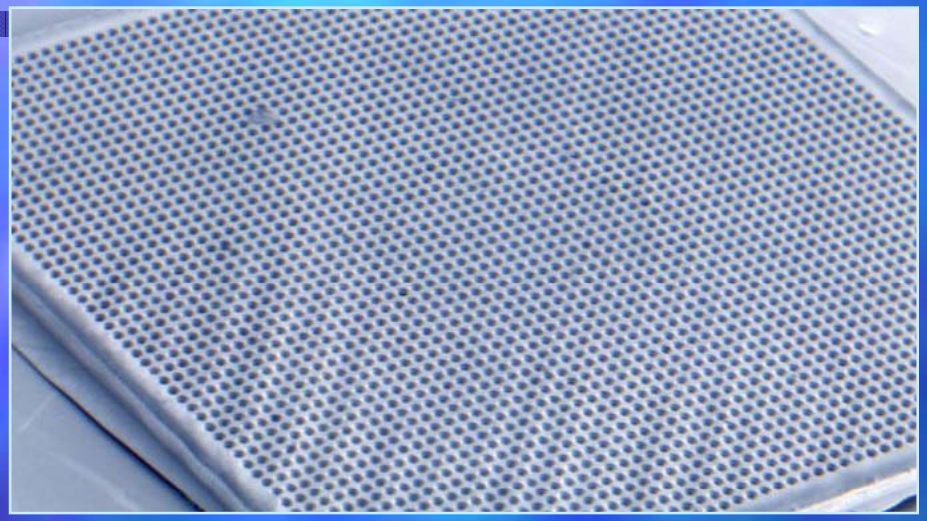
Example Jungle gym model built with ACCULAS



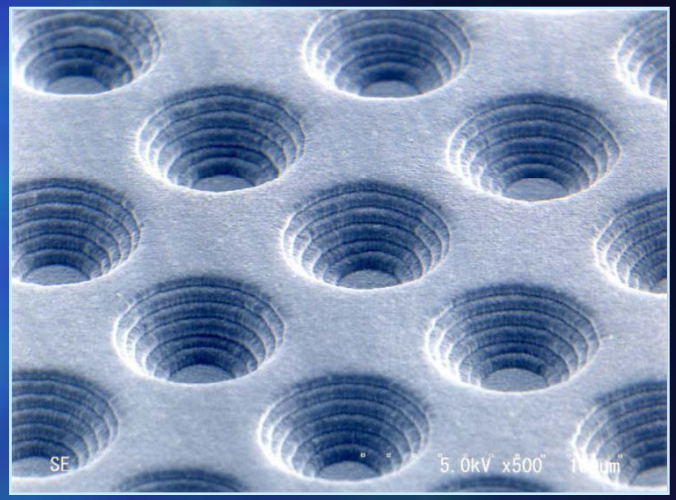


Model size：
520 × 520 × 210μm
Lamination pitch:5.5μm
Total layers: 38 layers

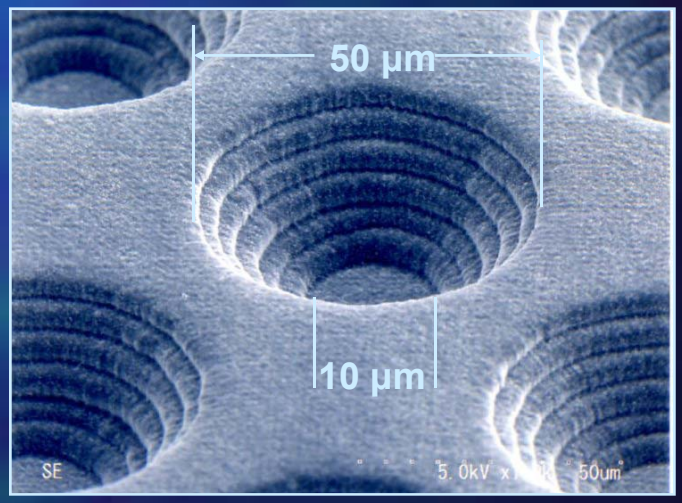
Example Wave Guide



Sample Size：5mm square、thickness 0.25mm
Processing Time： about 1 hour



SEM Photograph



Layer thickness 5µm、
Hole depth 30µm

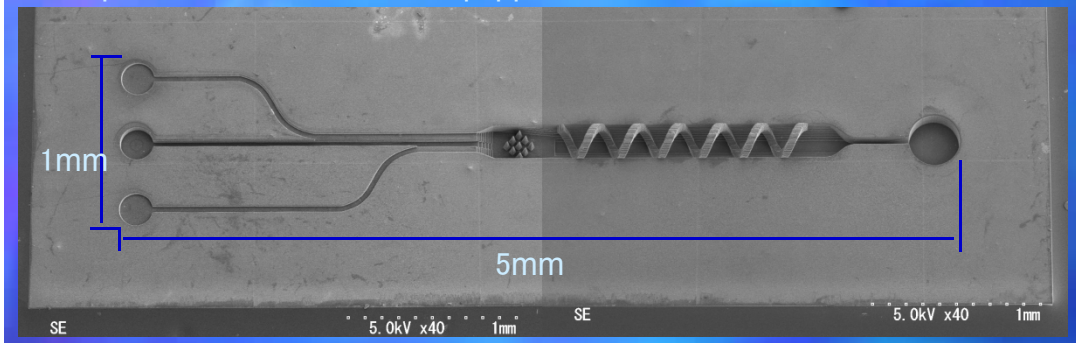
This microstructure is used as a master of electroform plating mold for imprint or emboss processing.

ACCULAS Application Example

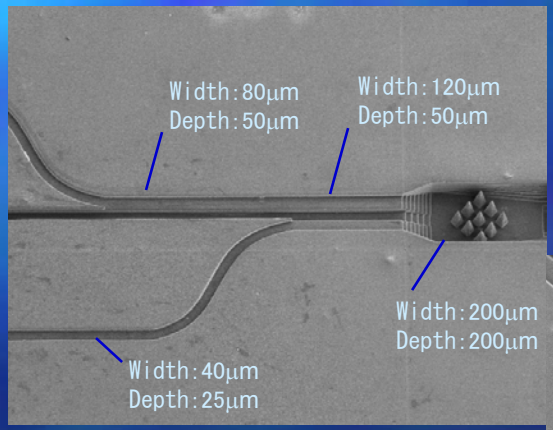
Micro Channel Equipped with Inner Structures

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

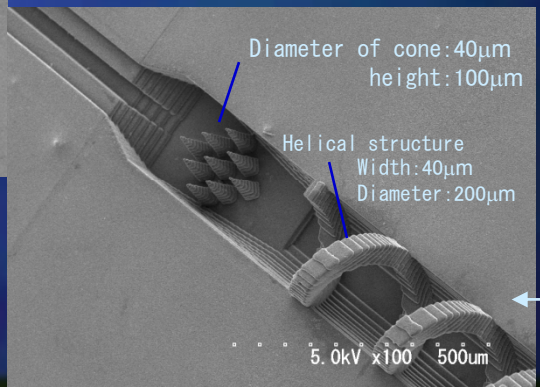


SEM photo of the branching point of micro-channel



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

SEM photo of helical structure in channel



Upper surface of channel

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

Time required for production: 4 hours

ACCULAS Application Example

Production of Micro Three-Dimensional Structure

Multiple pore three-dimensional structure

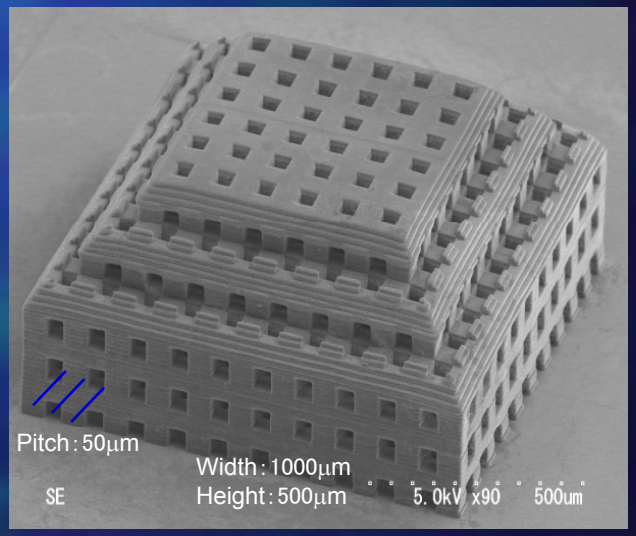
It is suitable for producing cell culturing cells, photonic crystals, and fractal structures.

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

Time required for production : 4 hours (9pieces)

Microscopic photo

SEM photo



Inner processing

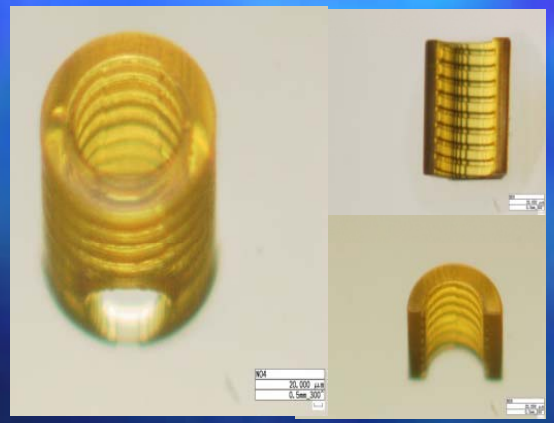
The pipe structures having over-hang and horizontal cave inside is produced.

Material : Photo curable resin (Acrylic, Epoxy)

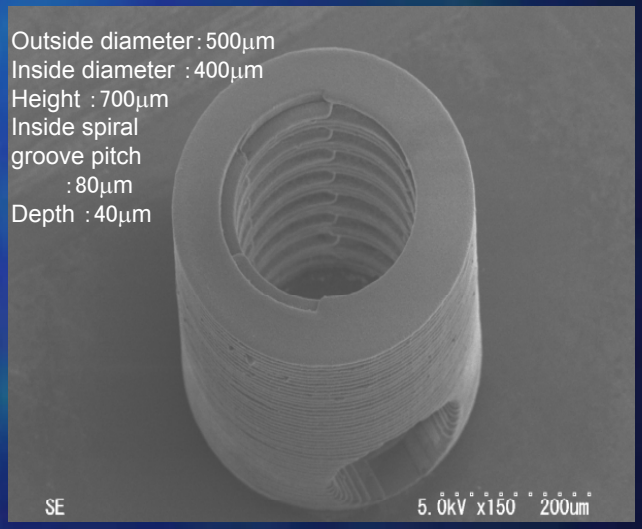
Time required for production : 2 hours (3 pieces)

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

Production of Micro Three-Dimensional Structure

Micro fin with curved surface structure

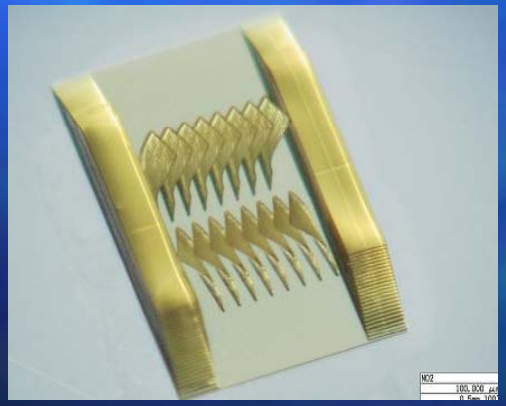
Fin elements having free form surface and undercut structures are producible.

Material : Photo curable resins (Acrylic, Epoxy)

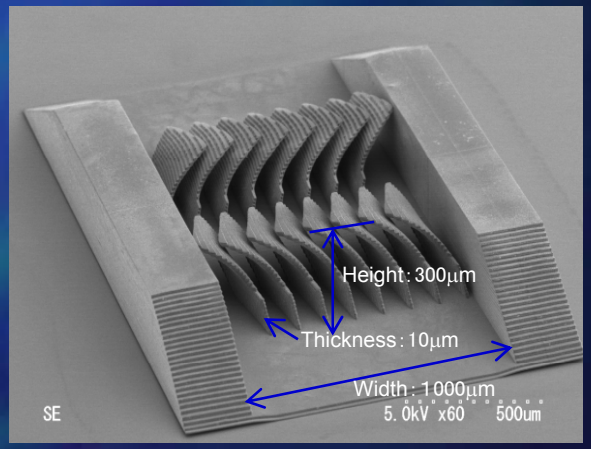
Time required for production : 4 hours (9 pieces)

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

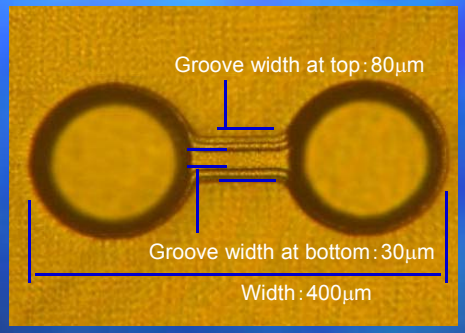
Mortar-like cells having desired taper angle and depth are produced upon request.

Material : Poto curable resin (Acrylic, Epoxy)

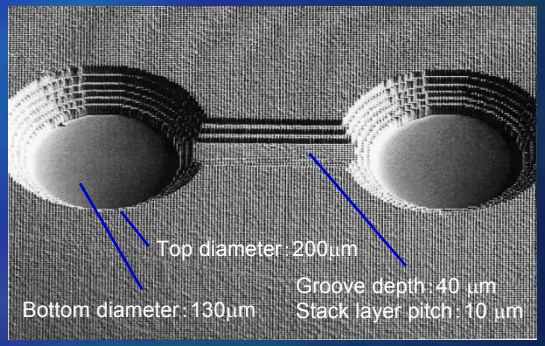
Time required for production : 2 hours (36 pieces)

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

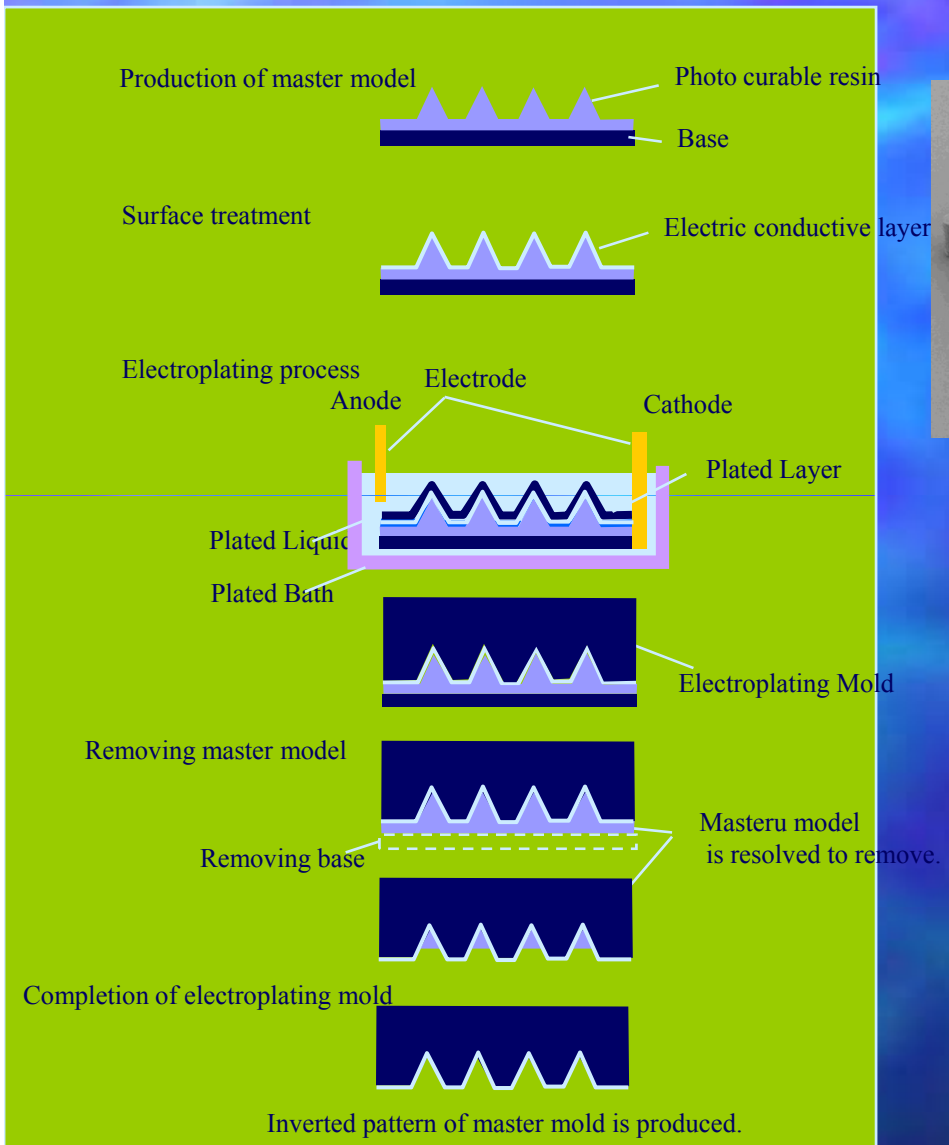
Microscopic photo



SEM photo

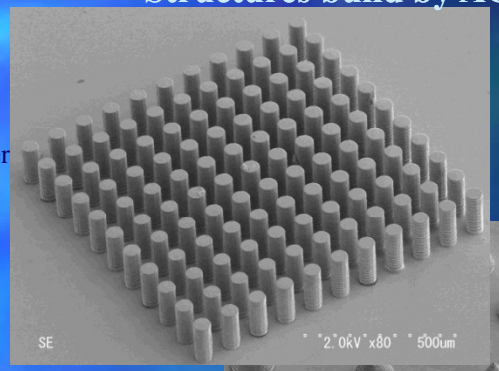


Master for Electroplating Mold Production ～Development toward Imprint

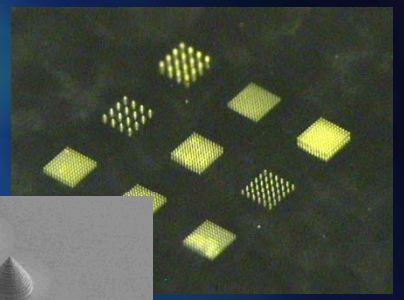


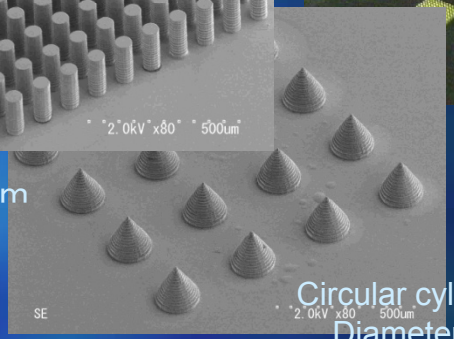
An imprinting mold Is obtained by abrading and lining the mold.

Structures build by ACCULAS



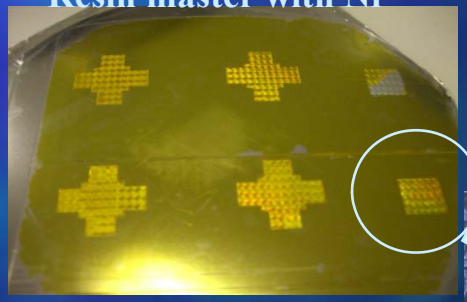
Φ50 × h150μm



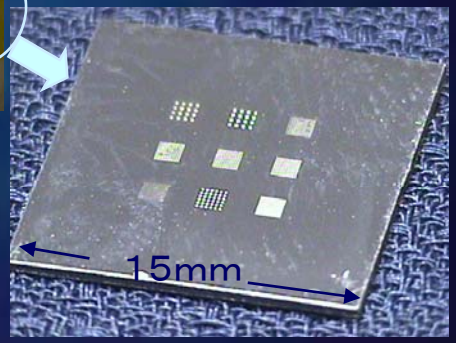


Circular cylinder
Diameter : 50μm
Height : 150μm
Circular cone
Diameter at bottom : 150μm
Height : 150μm

Resin master with Ni

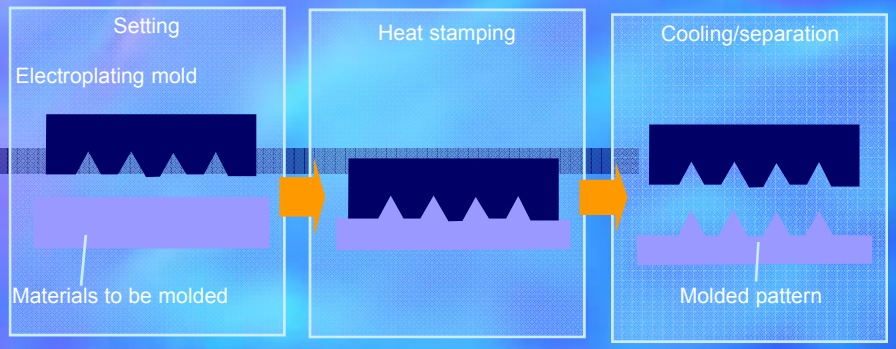


Electroforming mold

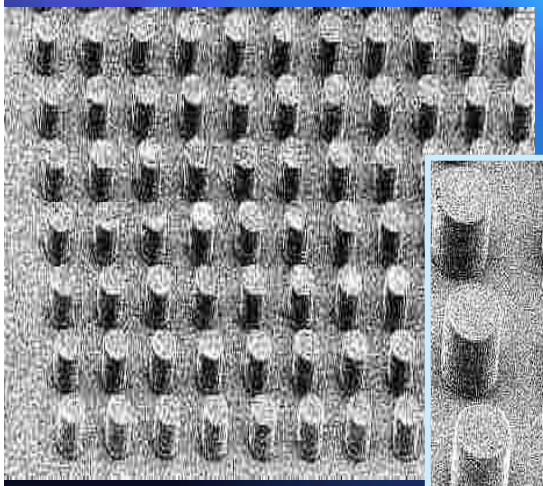


Master for Electroplating Mold Production ～Development toward Imprint

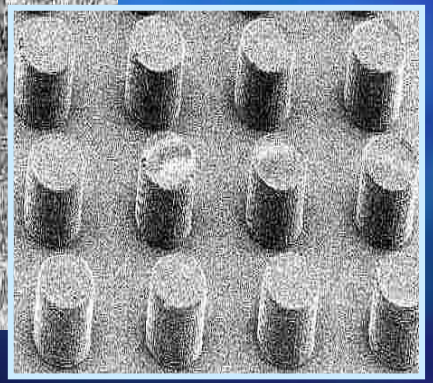
Nano-imprinting process

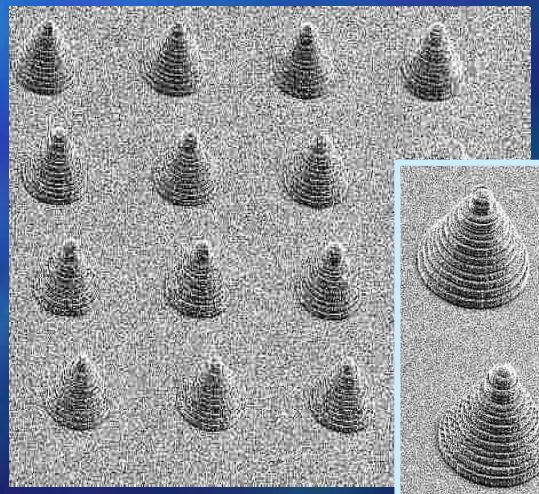


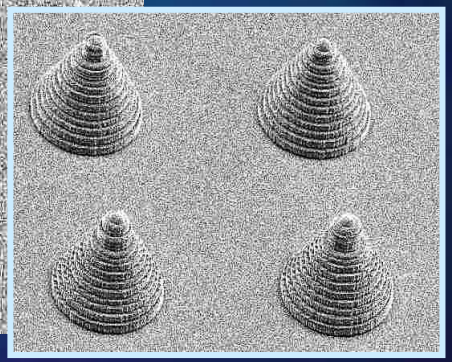
A thermal imprinting is shown above. It is also available to utilize UV curable resin for the materials to be molded.



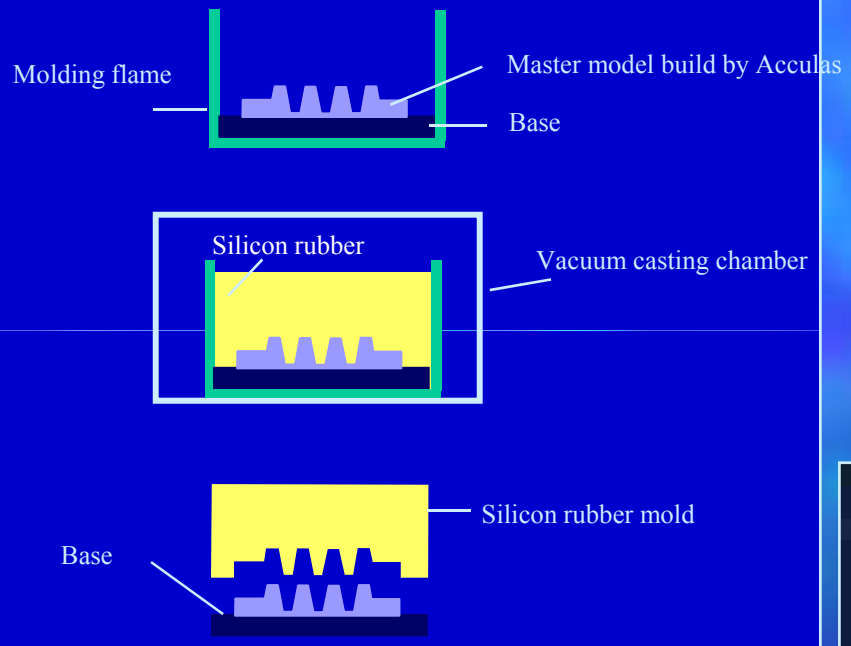
Molded article



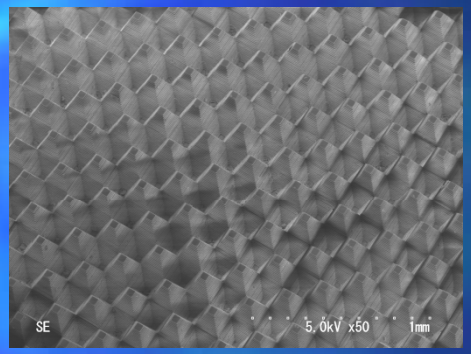




Master for Silicone Rubber Mold Production ～Development of Vacuum Casting Mold



SEM photo of quadrangular pyramid shape



Enlarged SEM photo of quadrangular pyramid sha

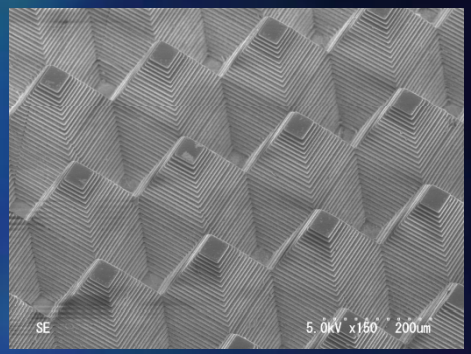
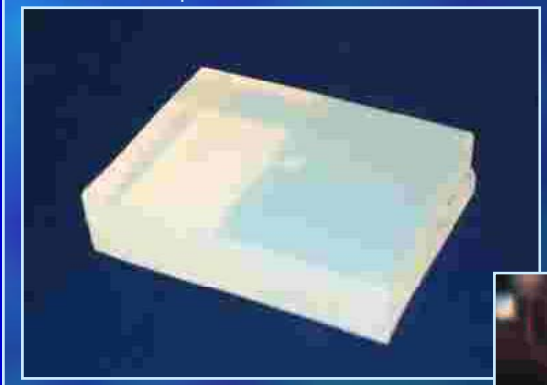
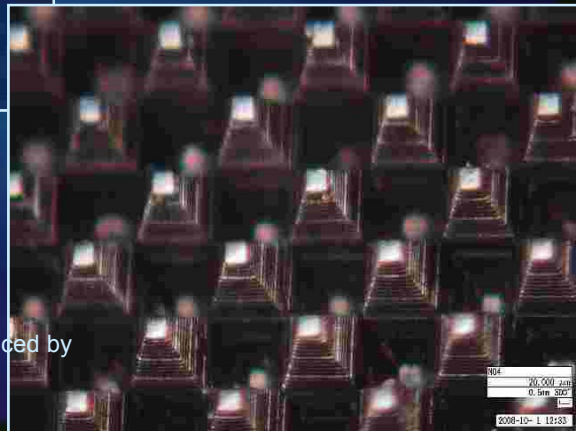


Photo of the produced silicone rubber mold



Microscopic photo of the articles produced by silicone rubber molding.



Usage Examples of ACCULAS

- ACCULAS is used for trial productions in research and test stages of MEMS.
- ACCULAS is used for sacrifice film making process of semiconductor process.
- ACCULAS is used for making objects as master production such as electro casting processing.
- ACCULAS is used for making molds for injection molding, emboss processing, etc..
- ACCULAS is used as last product manufacture equipment.

Micro Stereo-Lithography System

ACCULAS

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