TOHOKU UNIVERSITY

Joint Forum for Dialogue with Regional Industrial Partners

International Collaboration between Universities and Industries

November 25, 2005

21st Century COE (Center of Excellence) Programs at Tohoku University

Shigenao Maruyama

Institute of Fluid Science, Tohoku University,

Sendai, Japan

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1. International Center of Research & Education for Materials, Prof. A. Inoue
2. Future Medical Engineering based on Bio-nanotechnology, Prof. M. Sato
3. System Construction of Global-Network Oriented Information Electronics, Prof. T. Uchida
4. The Exploration of the Frontiers of Mechanical Science Based on Nanotechnology, Prof. T. Shoji
5. International COE of Flow Dynamics , Prof. S. Maruyama

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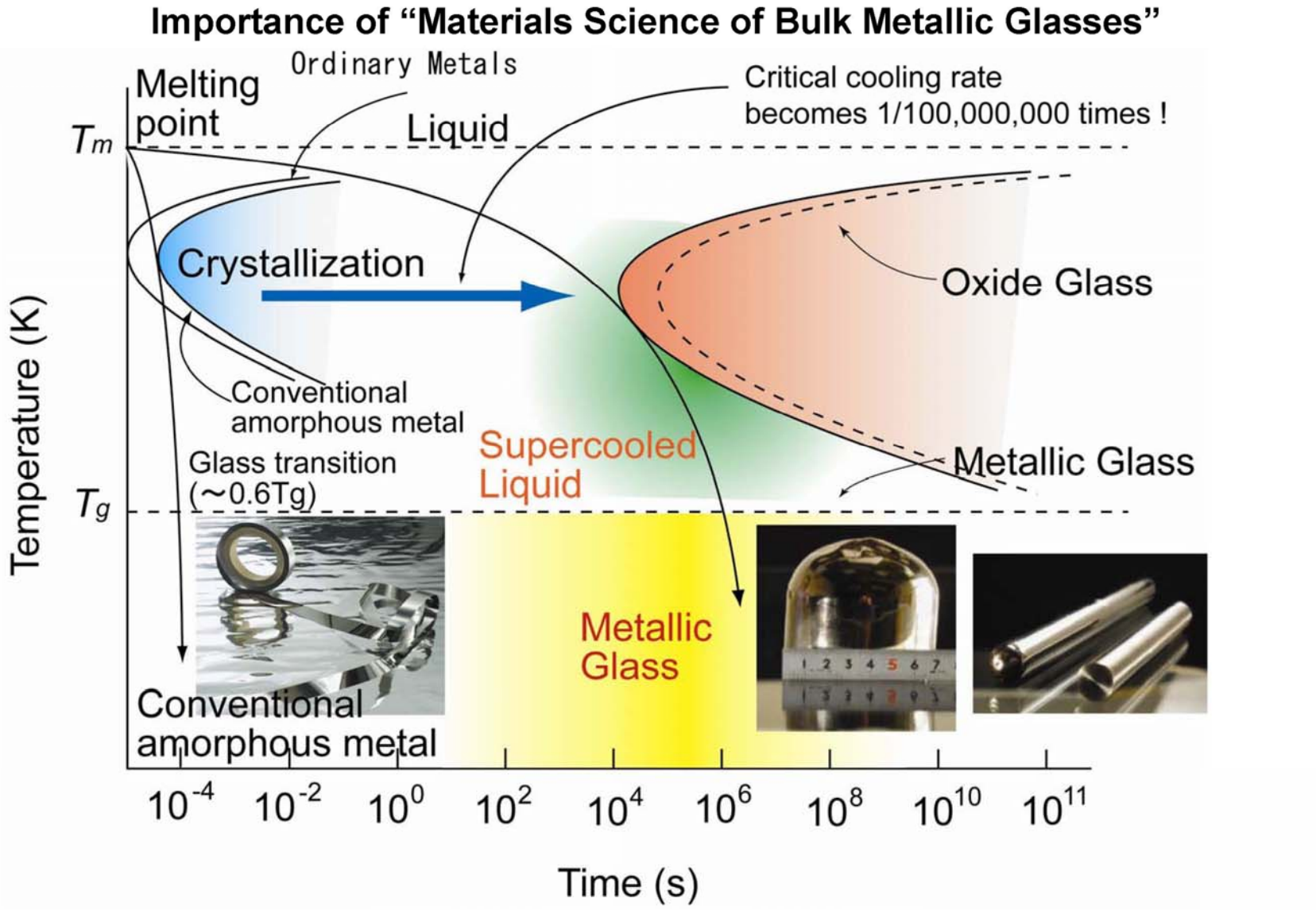
Focused key technologies for Industry collaboration

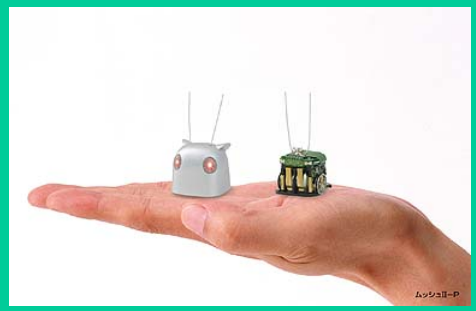
- Bulk Metallic Glasses, Inoue COE
- Bio-Engineering, Sato COE
- Electronic Devices, Uchida COE
- Nano-mechanics, Shoji COE
- Aeronautics, Maruyama COE


Importance of "Materials Science of Bulk Metallic Glasses"
Ordinary Metals
Melting point
Liquid
Critical cooling rate becomes 1/100,000,000 times !
Tm
Crystallization
Oxide Glass
Conventional amorphous metal
Glass transition (~0.6Tg)
Supercooled Liquid
Metallic Glass
Tg
Temperature (K)
Metallic Glass
Conventional amorphous metal
10-4 10-2 100 102 104 106 108 1010 1011
Time (s)

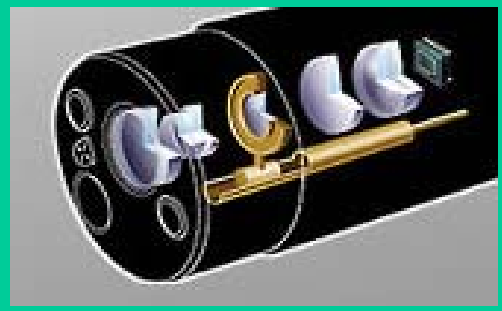
Background - super precision gear

Micromachine → **Key device** → **small & high power motor**

μFR（Micro・flying・robot）
（SEIKO EPSON）



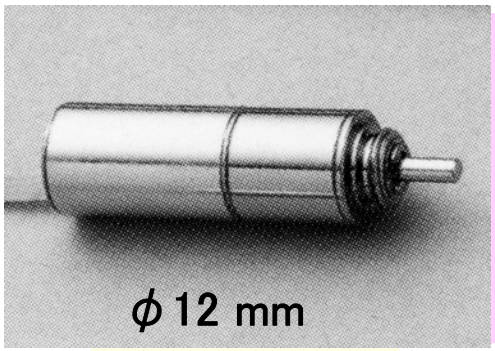
Mush
（SEIKO EPSON）



Micro-zooming mechanism
（OLYMPUS）

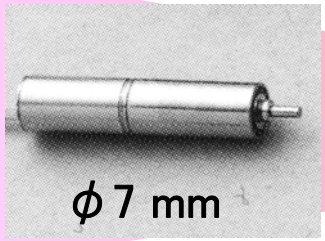
Small → **Super-small**

1980



・Camera
・Handpiece

2000



・Small camera
・Measurement systems

Present
Limit of machining

・Endoscope
・Catheter

(expect)

Technical difficulties of constructing parts
- **Miniaturizing**
- **Strengthening**
- **Precision**
- **Surface flatness**

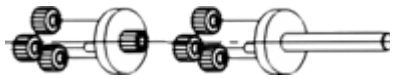
Miniaturizing trend of micro-geared motor

Durability of glassy alloy gears

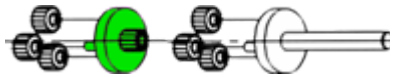
● **Accelerating durability test** for conventional geared-motor with d = 2.4 mm

Construction

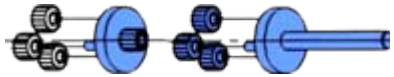
All-steels



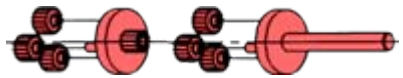
Steels & one glassy alloy gear



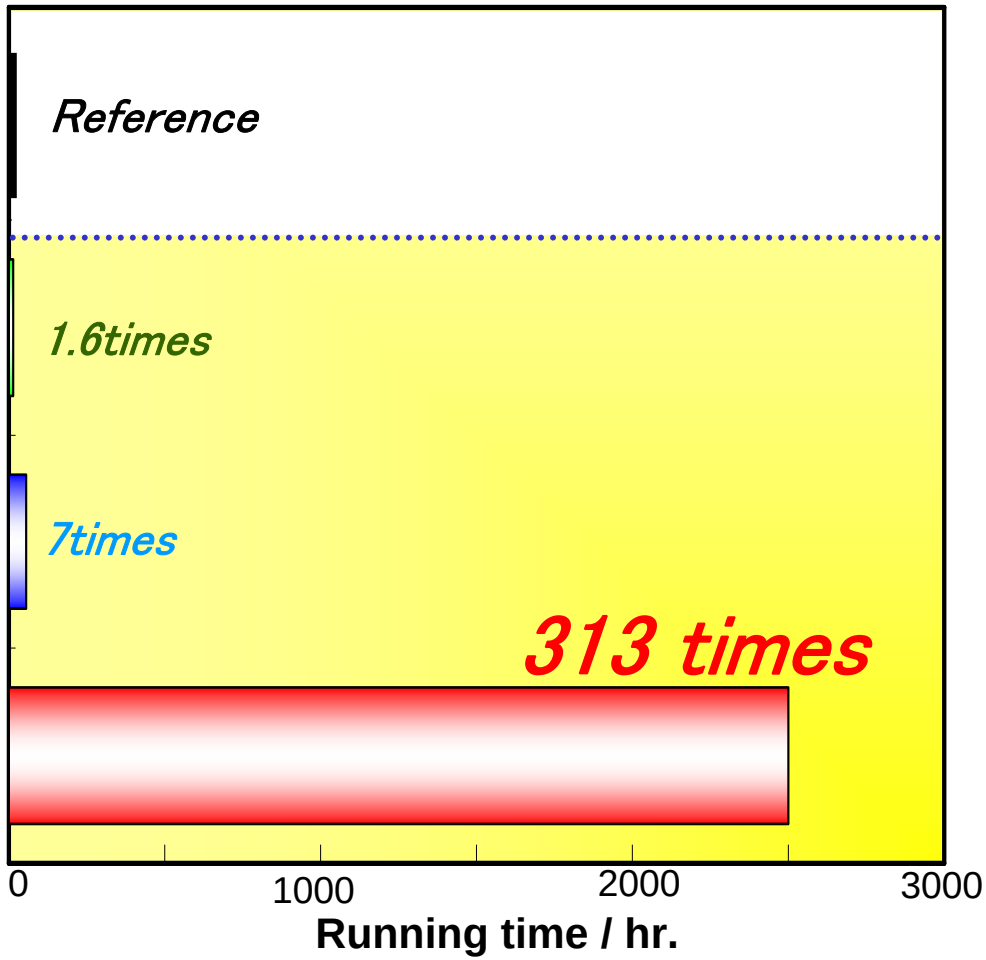
Almost glassy alloy gears



All glassy alloy gears

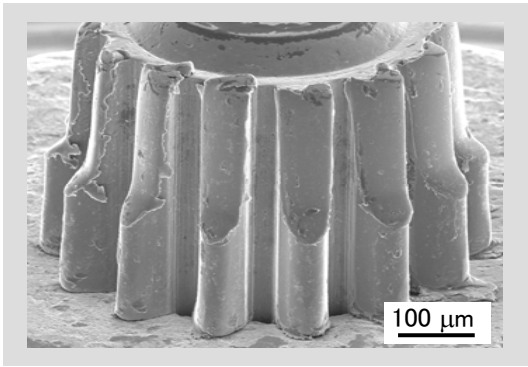


Product Durability



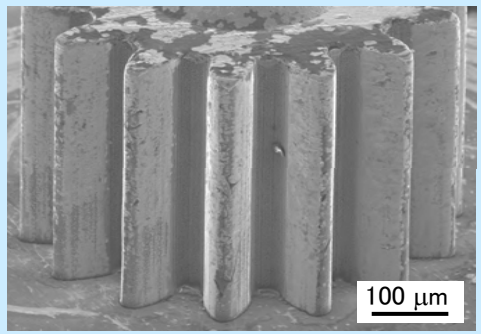
Wear behavior

Steel gear



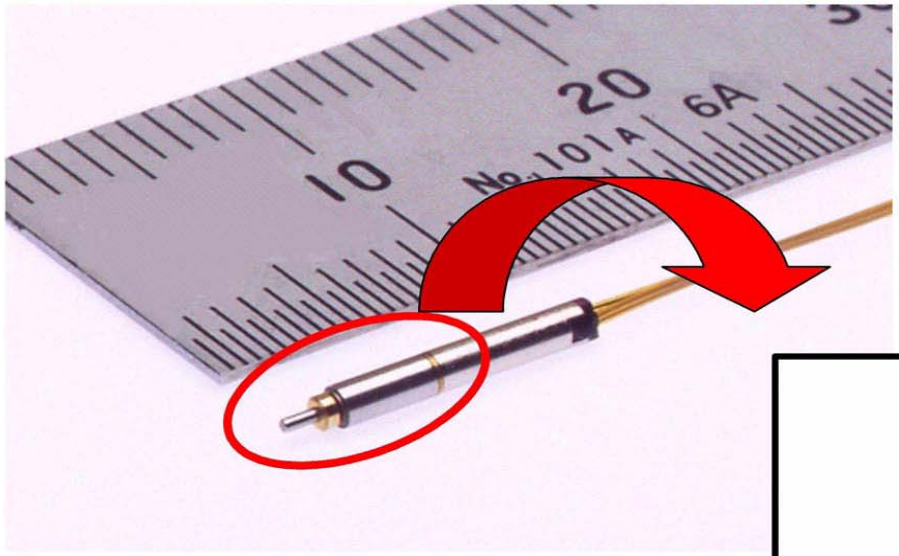
8 hr. (6 million R.)

Glassy alloy gear



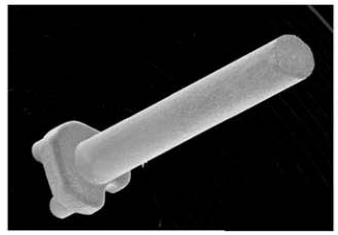
2500 hr. (1875million R.)

Construction of developed geared-motor

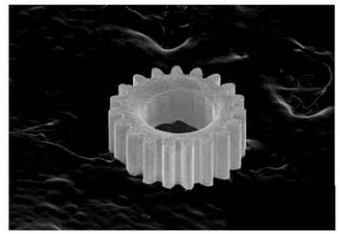


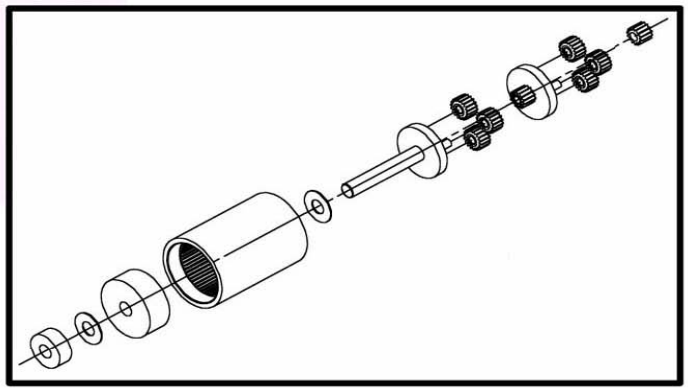
Micro geared-motor

Output shaft with carrier



Planetary gear





Carrier with sun-gear

- **World smallest size with $d = 1.5$ mm、$l = 9.4$ mm**
- **2 stages stacked gear-ratio reduction system**
- **High gear-reduction ratio of 40:1**
- **High rotating torque （0.1mNm） by glassy alloy gears**
- **Higher torque（≧2 mNm） is possible by more stages stacking**

Future vision for commercialization and viability

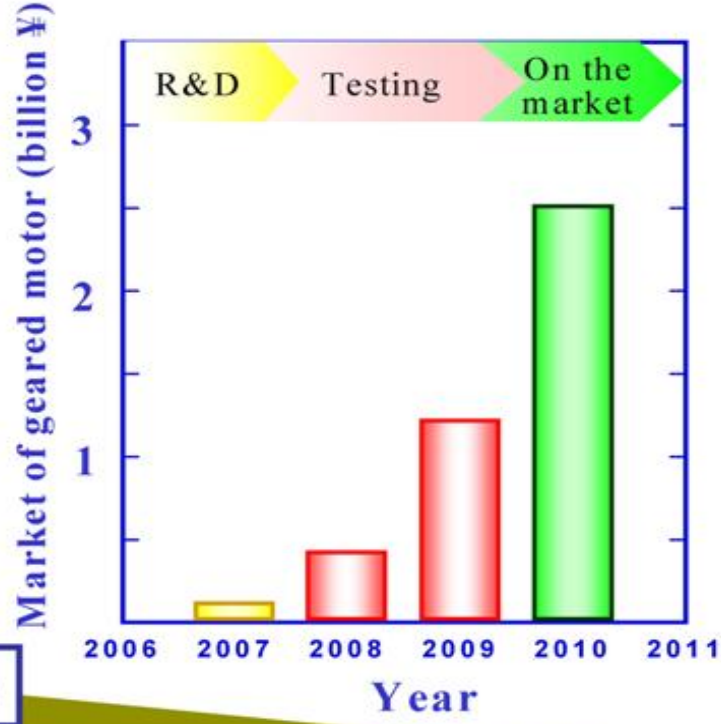
Super small
Long life Heavy loadable

Target products & commercial scale on 2001

Endoscope
48800 p/Year

Rotablator
9800 p/Year

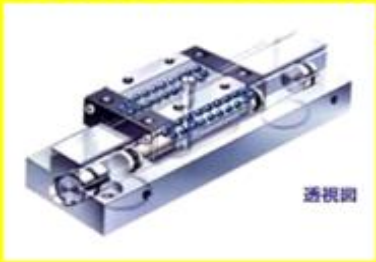
Catheter for thrombus removal
4000 p/Year



Advanced medical equipments

Inspection robot

Precision machine

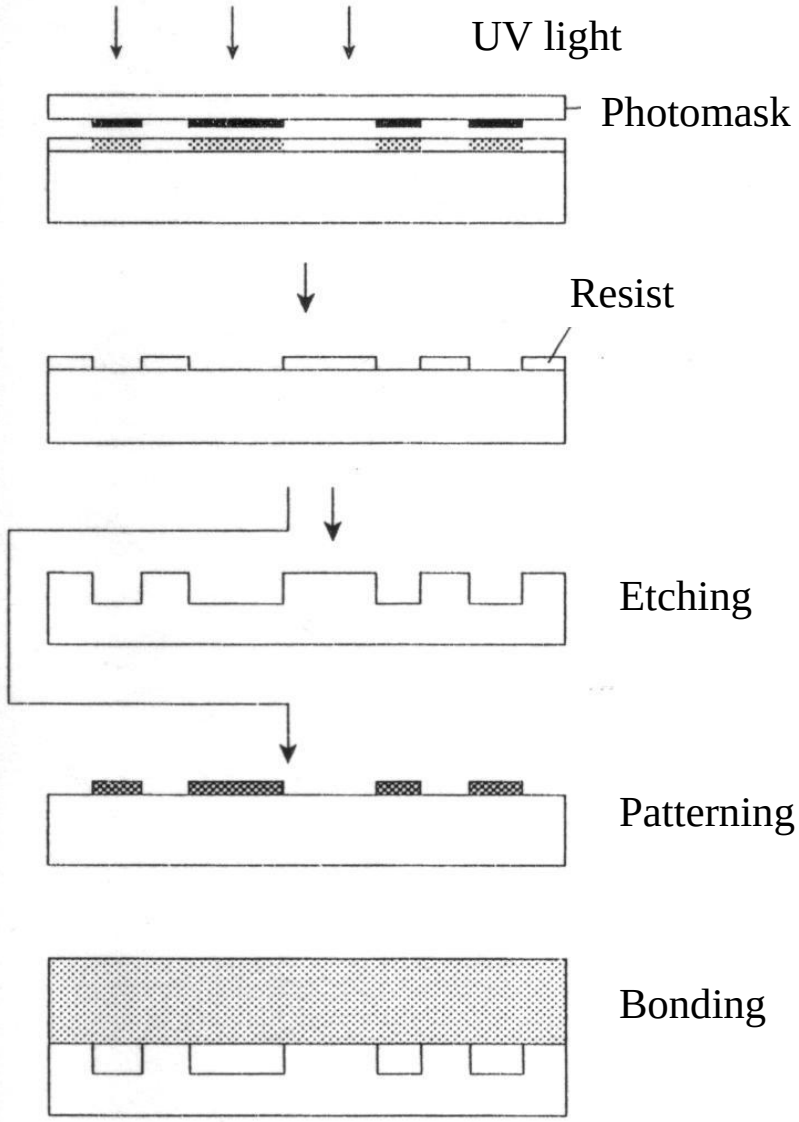


Metallic glass precision parts
$13 billion Market
(2010 expected by METI)

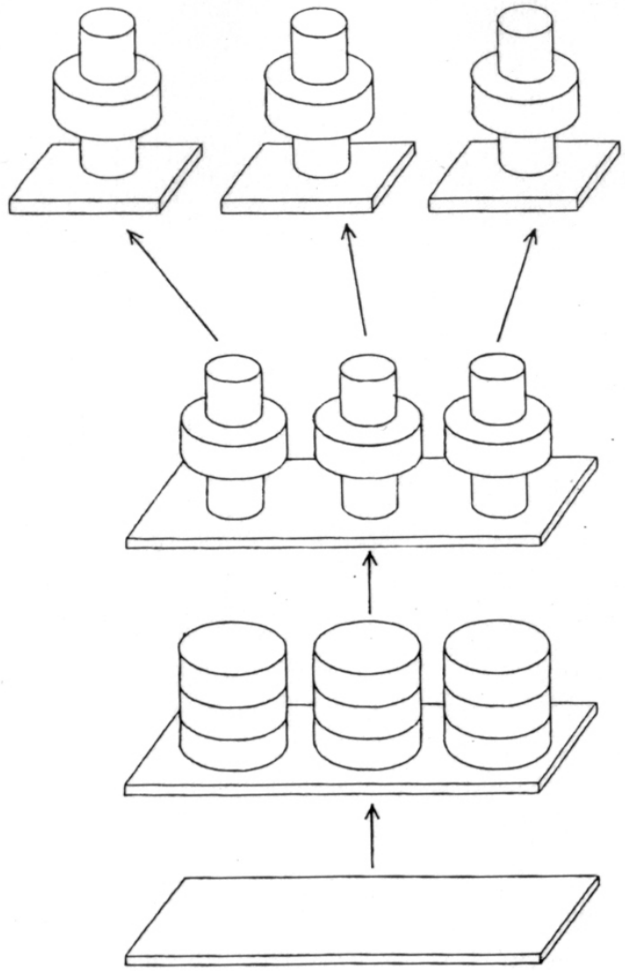
Micro-factory

Robots for home & industrie use

Bio-Engineering using MEMS(Micro Electro Mechanical Systems) Technology, Sato COE

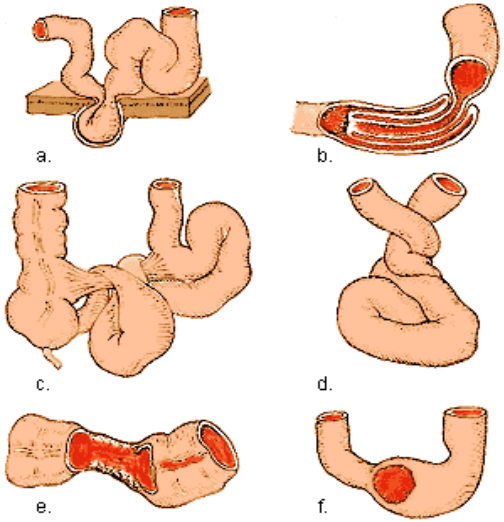


Batch fabrication process

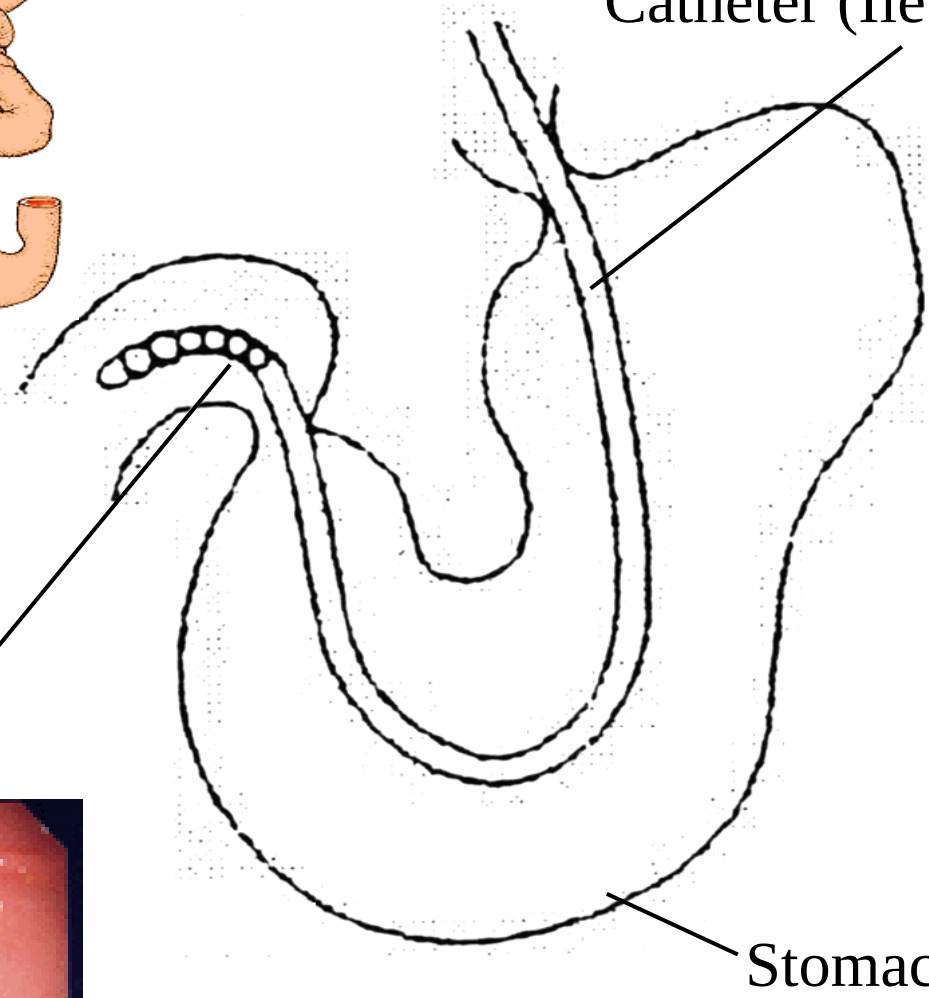


Active Bending Long Intestinal tube

Intestinal obstruction (Ileus)

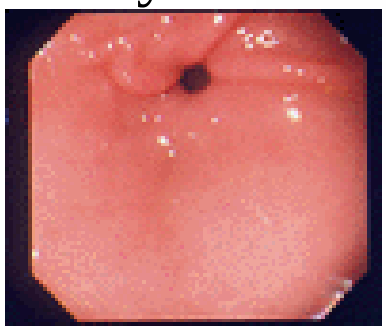


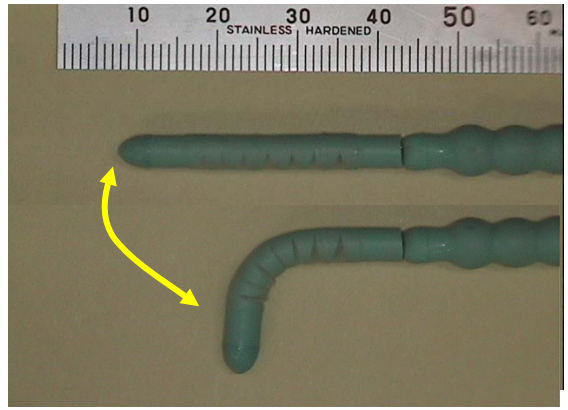
Catheter (Ileus tube)



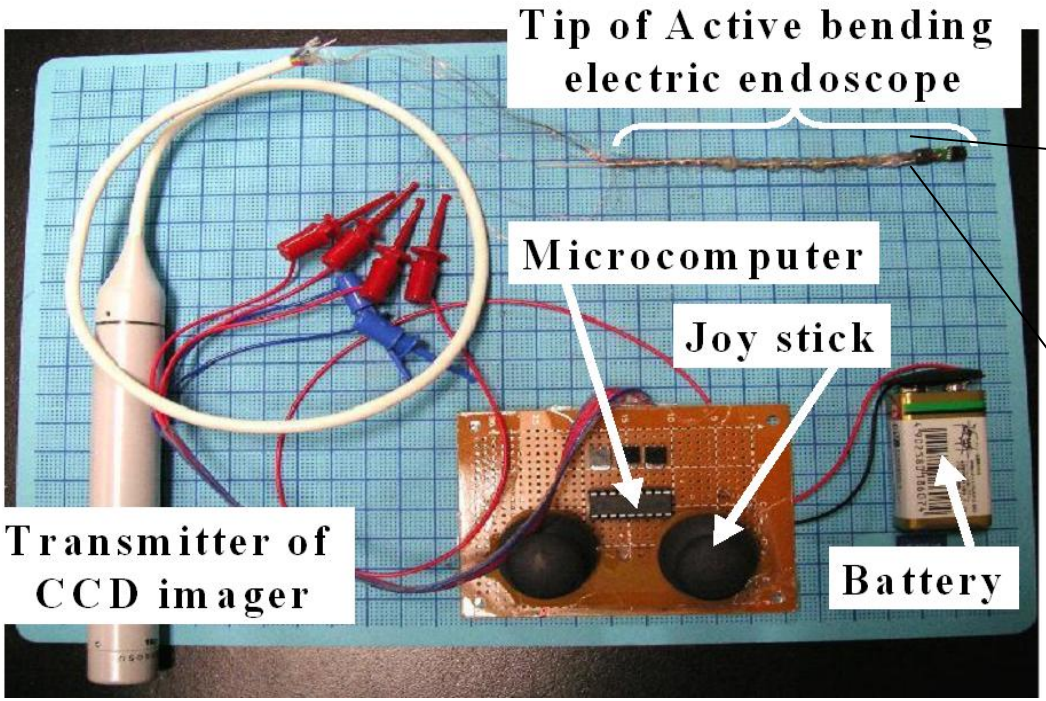
Pylorus

Stomach



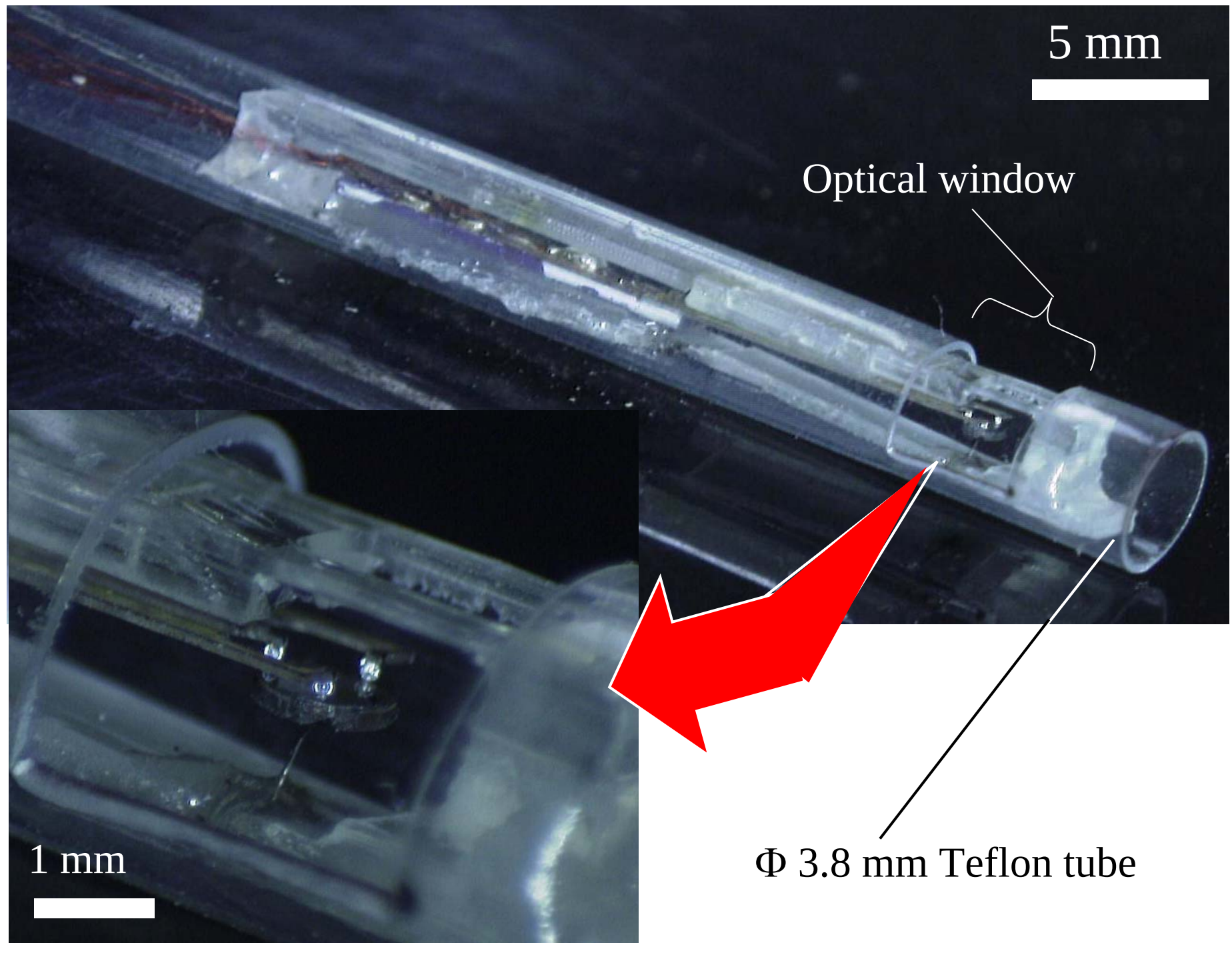


Active Bending Catheter with CCD Imager



using SMA micro coil actuators

External Diameter: 5 mm 、Maximum Bending Angle: 90 degrees
(Curvature Radius: 29 mm)


5 mm
Optical window
1 mm
Φ 3.8 mm Teflon tube

“Liquid crystal displays “

Department of Electronic Engineering,
Graduate School of Engineering, Tatsuo Uchida

(1) Development of Color LCD (Micro Color-Filter Method)

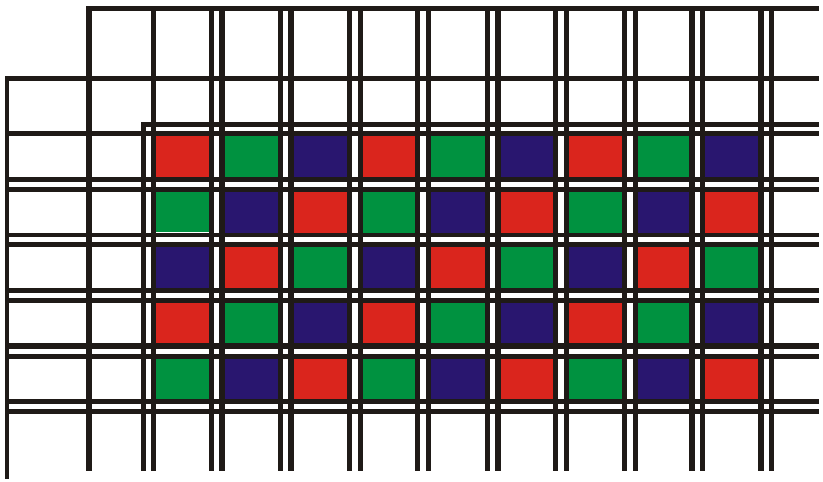
(2) Development of wide viewing angle LCD with fast response (OCB-mode）:

(3) Development of low power LCD without color filter (Color Field sequential OCB-mode LCD)

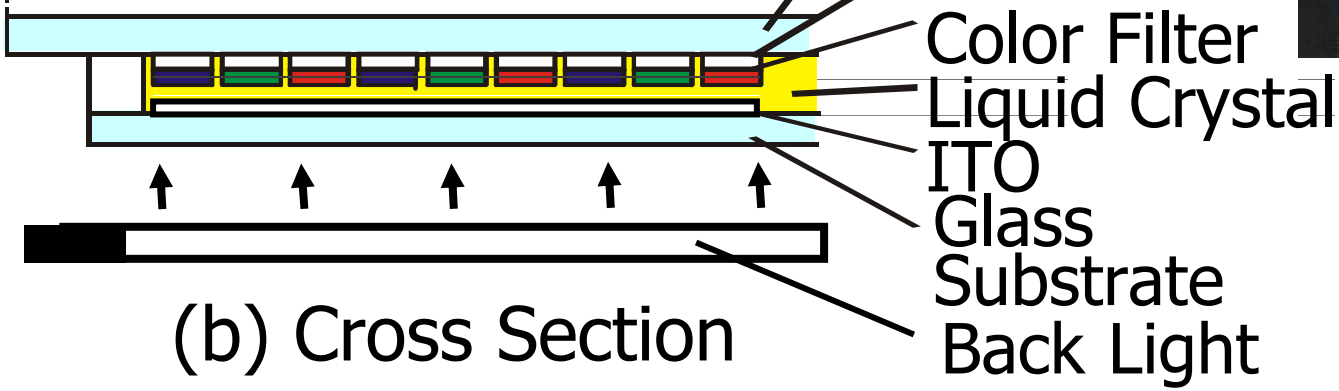
（4）Development of ultra low power LCD（Reflective color LCD without back light ）

(1) Development of Color LCD

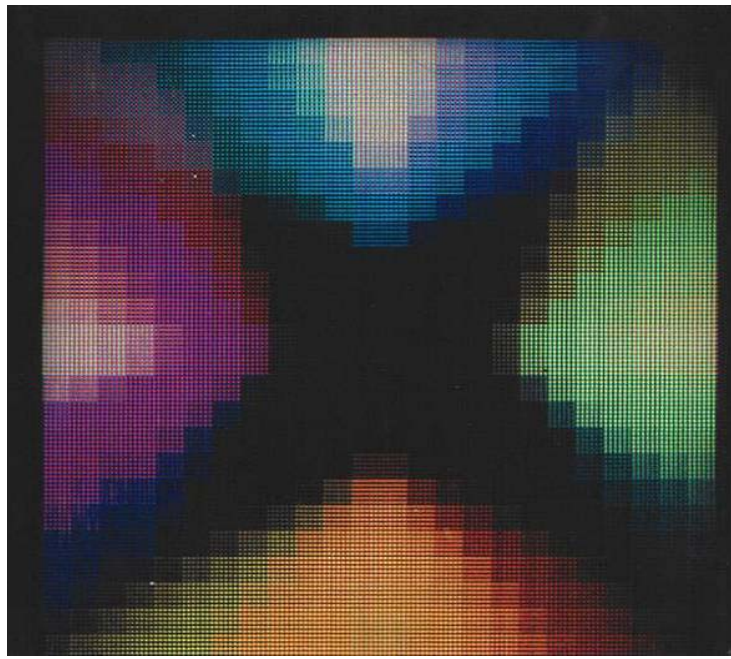
(Micro Color-Filter Method)



(a) Top View



(b) Cross Section



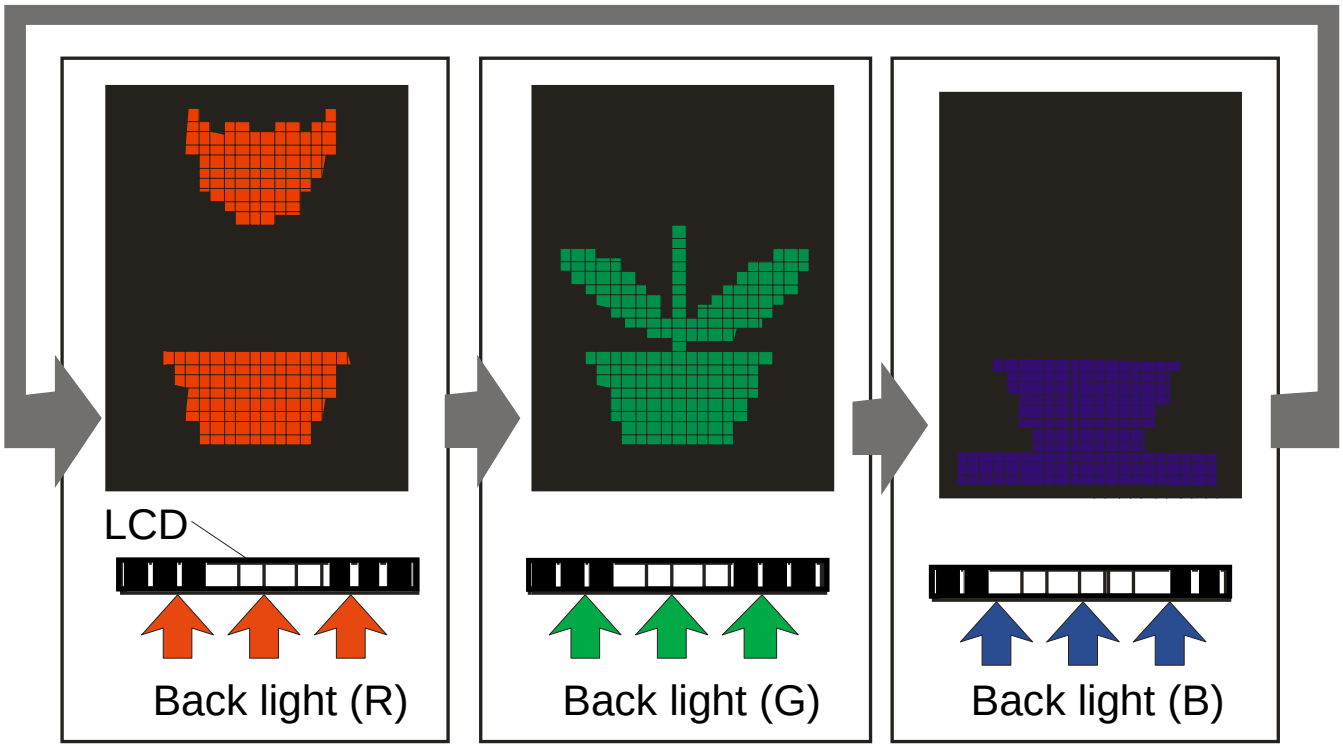
T. Uchida, et al.: Proc. Eurodisplay, p39 (1981), Conf. Rec. of IDRC p.166 (1982), IEEE Trans., ED-30, p.503 (1983).

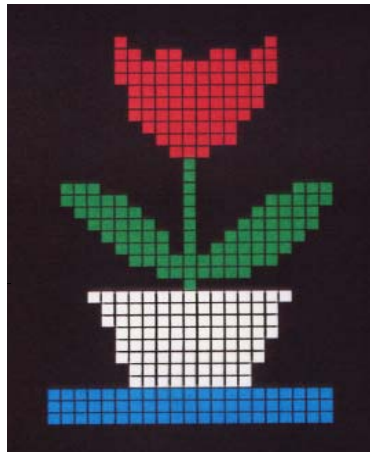
(3) Development of low power LCD without color filter (Color Field sequential OCB-mode LCD)

Red Field (5.5msec)

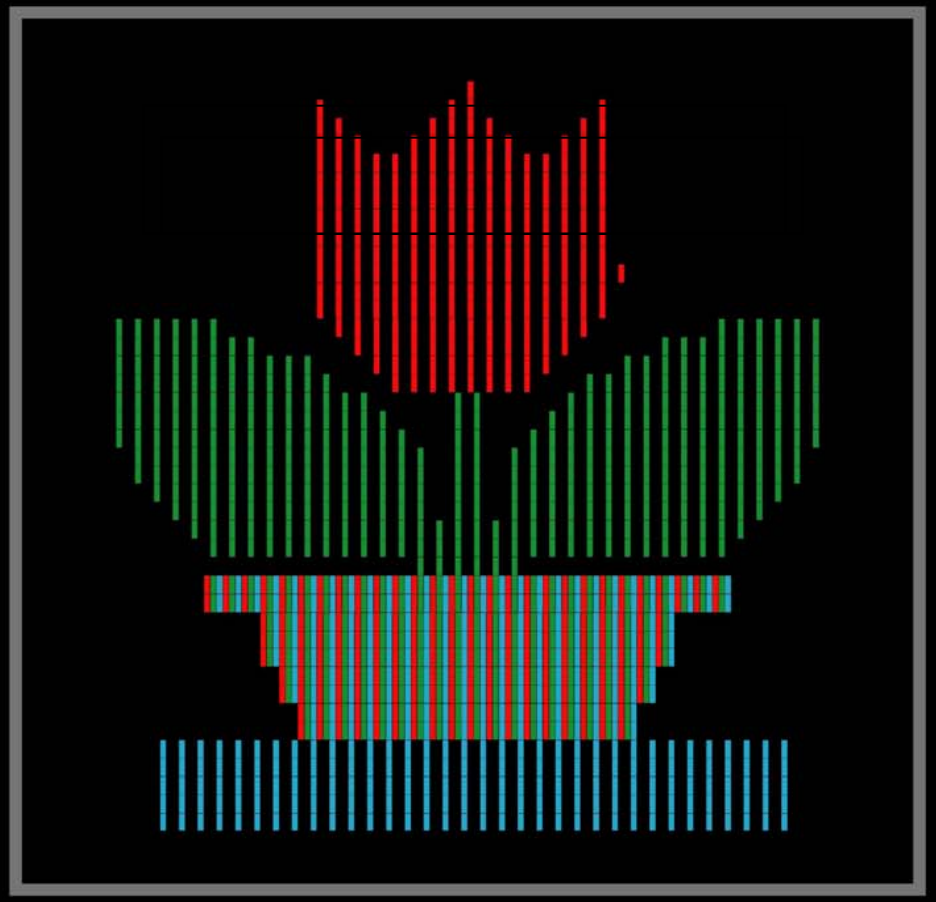
Green Field (5.5msec)

Blue Field (5.5msec)

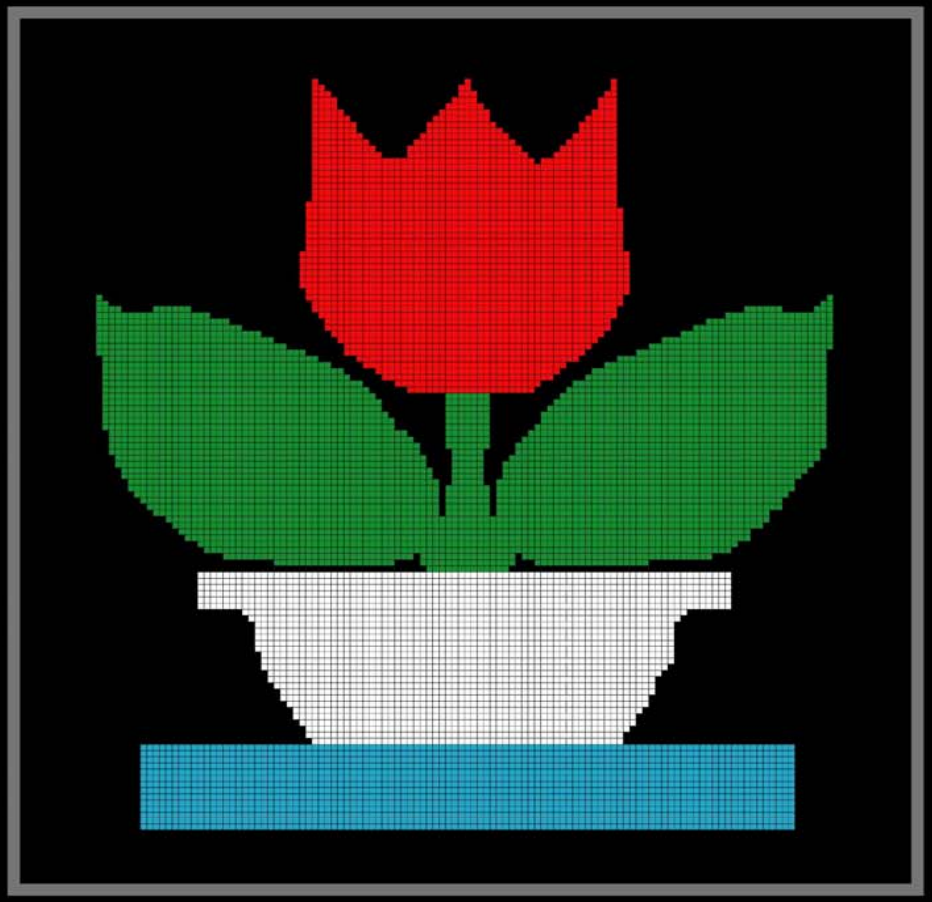




T.Uchida, et al. (Tohoku University): Int'l Display Res. Conf., p.37 (1997).



Conventional color filter type

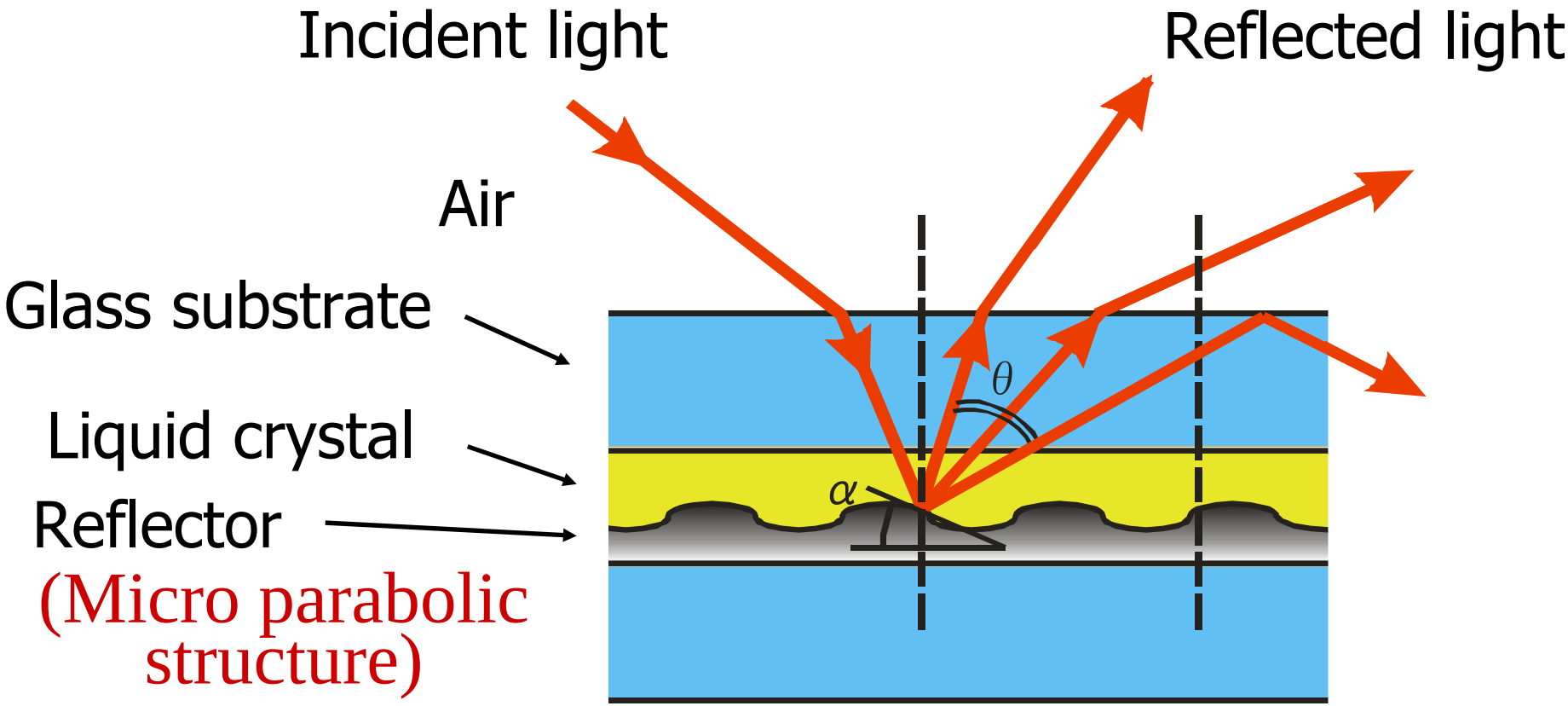


Color field sequential type (color filter less)

- Resolution: 3times higher
- Brightness: 4times higher

6” VGA Field sequential OCB-LCD (Aomori-ken National Project)

(4) Development of ultra low power
(Reflective color LCD without back light)



T. Koizumi and T. Uchida: Proc. SID, 29 (2), pp. 157-160 (1988).

Reflective color liquid crystal display (Sharp Corp. PDA)

Y.Ishii and M.Hijikigawa (Sharp Corp.):
Asia Display, p.119 (1998).

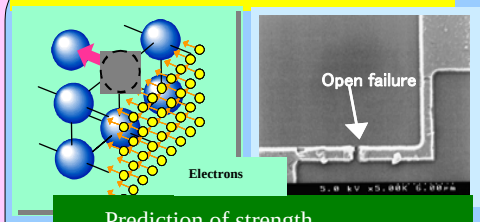
Reflective color liquid crystal display
(ALPS Electric Corp.)

Most recent reflective color LCD
(Test-fabricated in our laboratory)

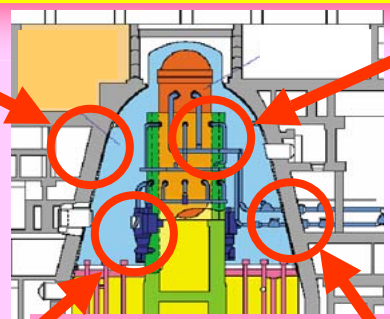
Shoji COE

High Quality Safety Design and Evaluation of Power Plants Based on Nano - scale Mechanical Science

St rength and reliability of nano - materials

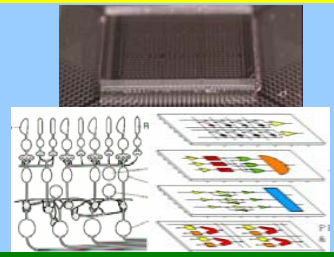


Prediction of strength of nano - materials



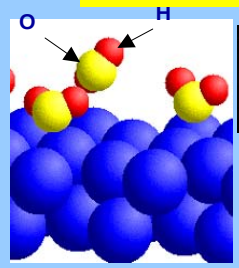
Design, Manufacturing, and Maintenance of Mega - System

Nano - machines and systems

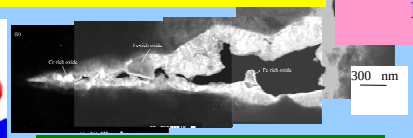


Detection of nano - scale damage by artificial eye sensors

Nano - mechanochemistry

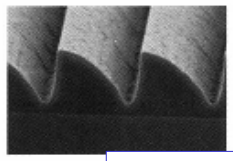


Water absorption process



Fracture analysis by quantum - mechanics and chemistry

Nano - materials and processing



Improvement of surface quality by nano - processing

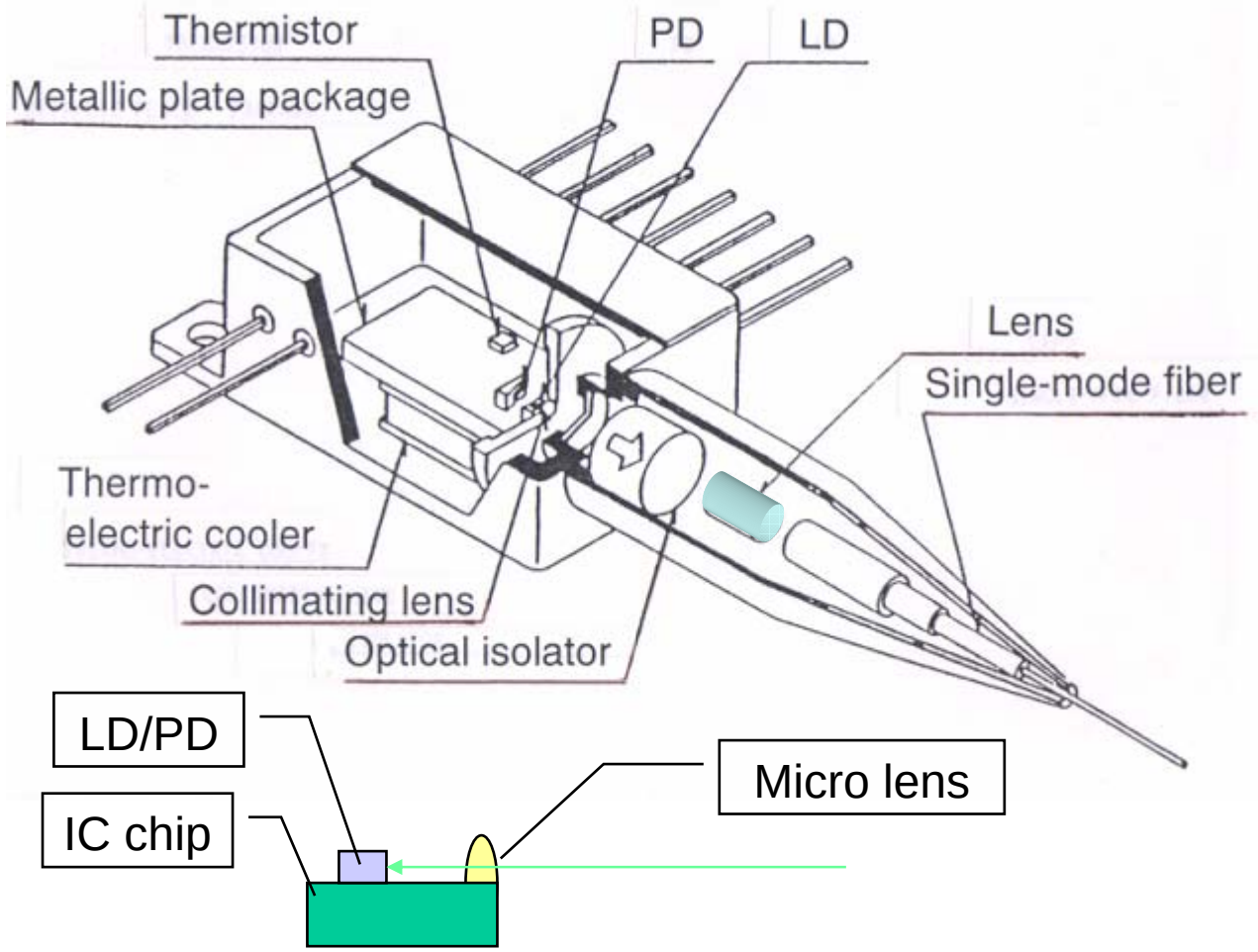
Surface roughness : 0.1 ～ 1 nm
Accuracy : 1 ～ 5 nm

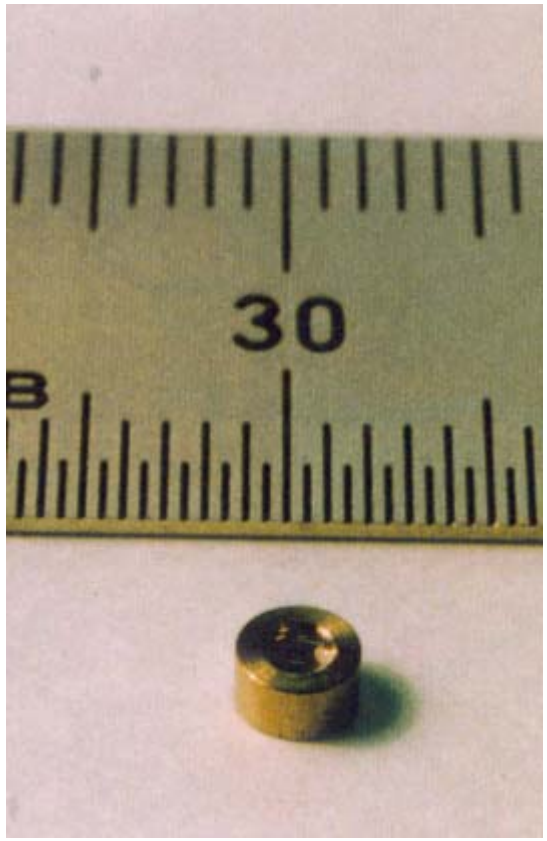
Example research project

High Quality System for Designing and Evaluating Safety and Lifetime of Power Plants and Equipment

Micro opto-electrical devices

Precision Machining Lab., Tohoku Univ.



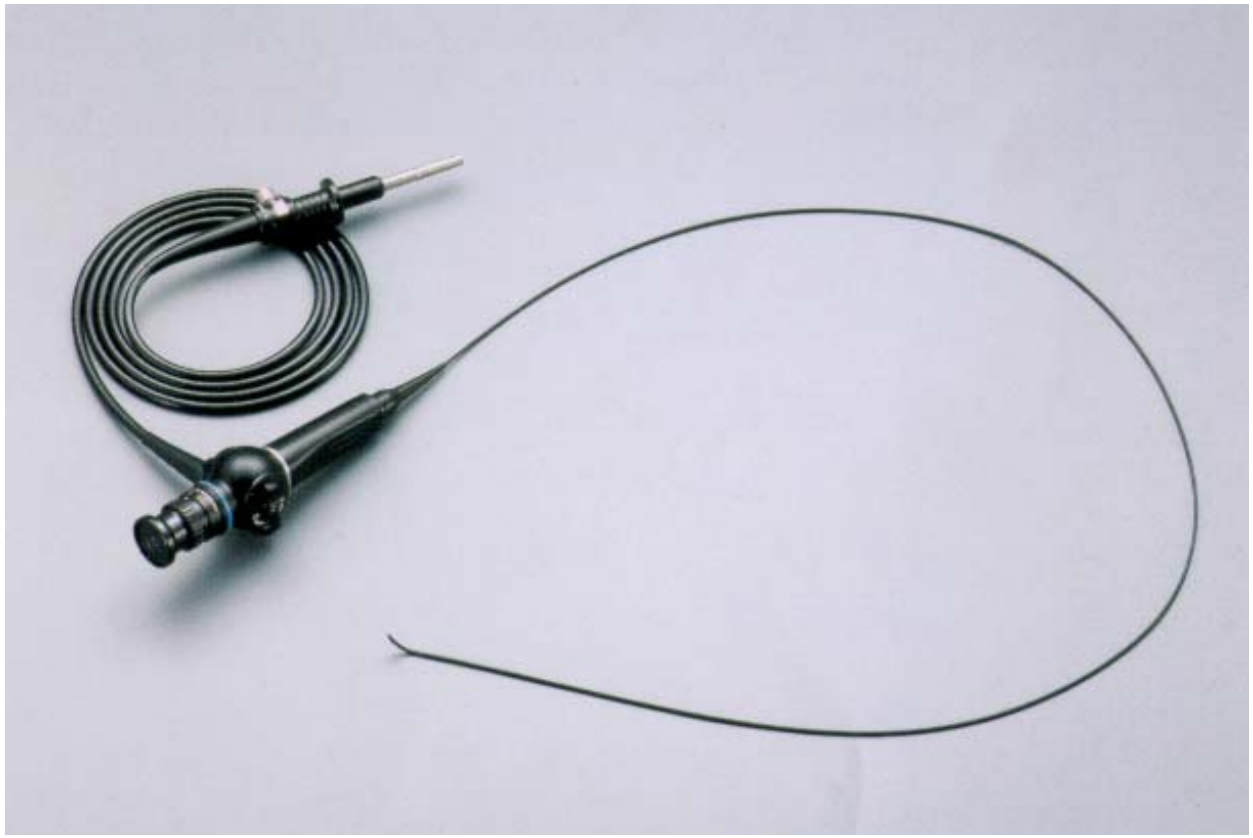


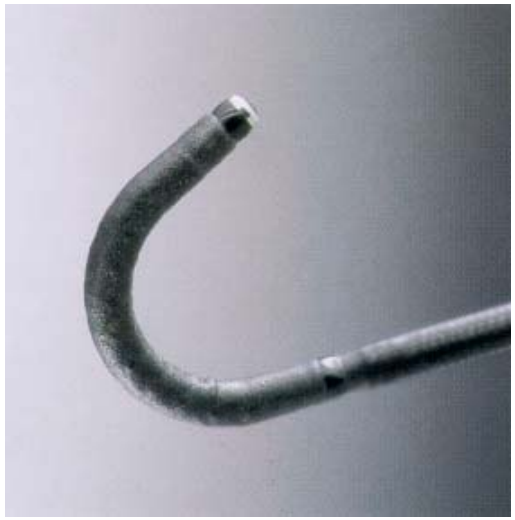
Chip Scale Optics

Ultra-thin fiberscope

Precision Machining Lab., Tohoku Univ.

Photograph by OLYMPUS

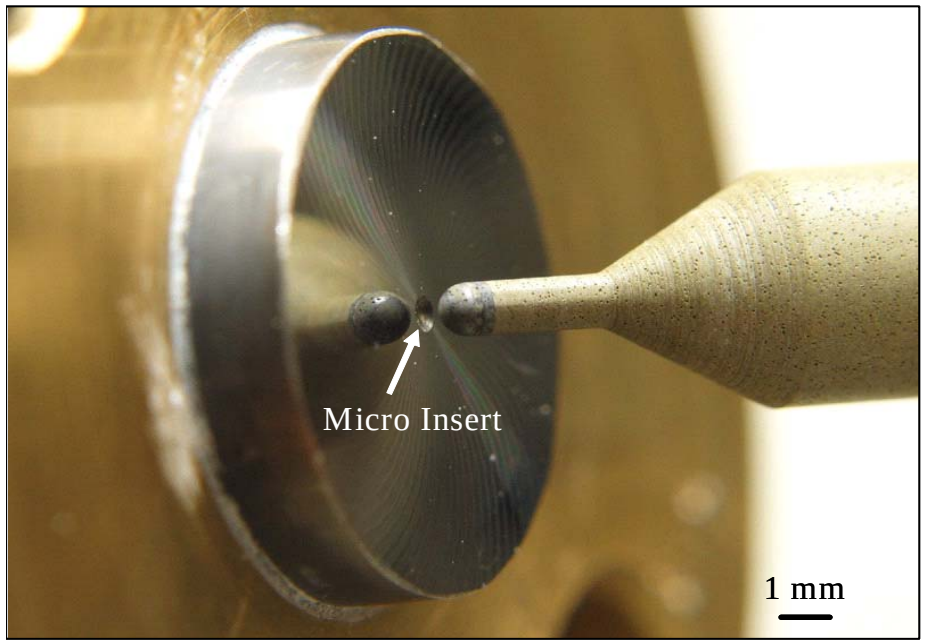




Intravascular Endoscopes
(2.2 diameter)

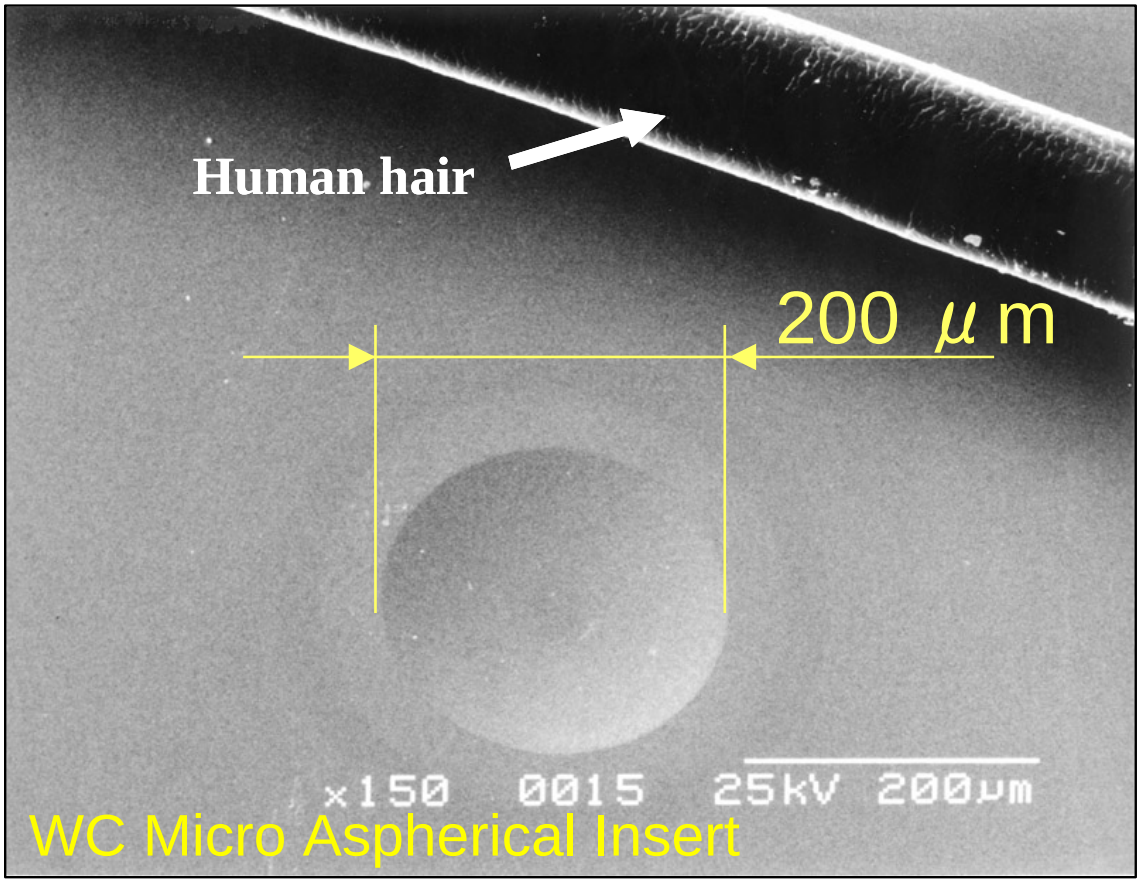
Micro-grinding of WC dies

Precision Machining Lab., Tohoku Univ.



Ground micro-aspherical WC dies

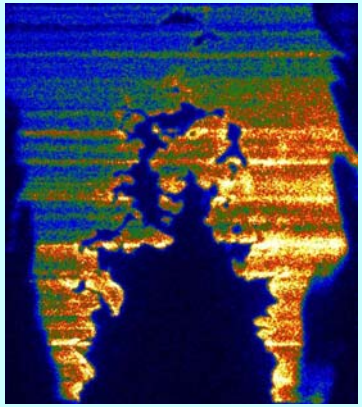
Precision Machining Lab., Tohoku Univ.



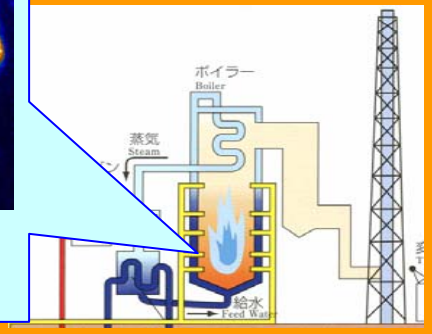
Micro Aspherical Dies:

R = 0.567 mm
K = -1.684802
A4 = 0.8901
A6 = -0.276

Flow Dyanamics, Maruyama COE

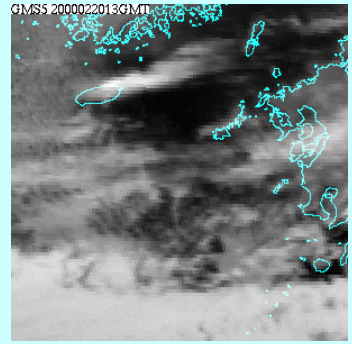


high-pressure turbulent flame

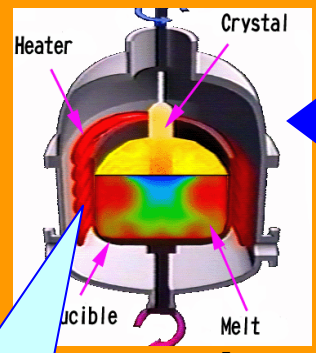


Energy

Environment



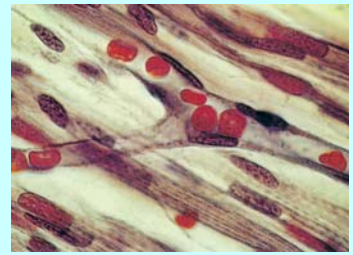
Vortex after islands



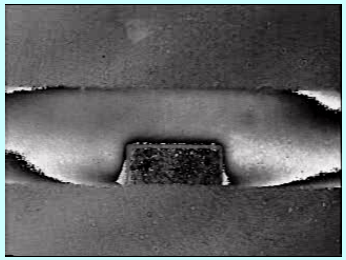
Materials

Academic Area

Medicine

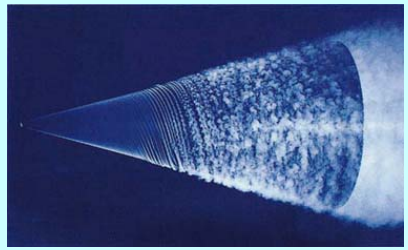


Intravascular bloodstream



Flows around crystal

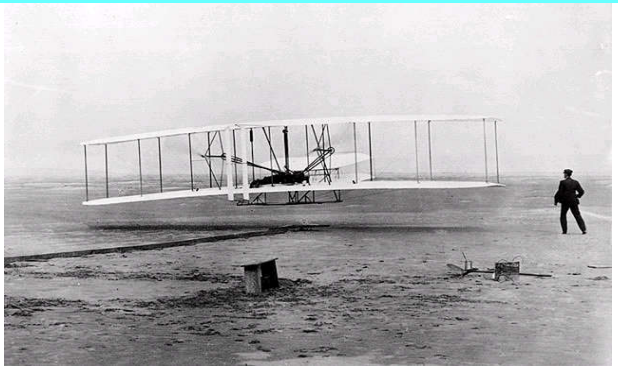
Aerospace



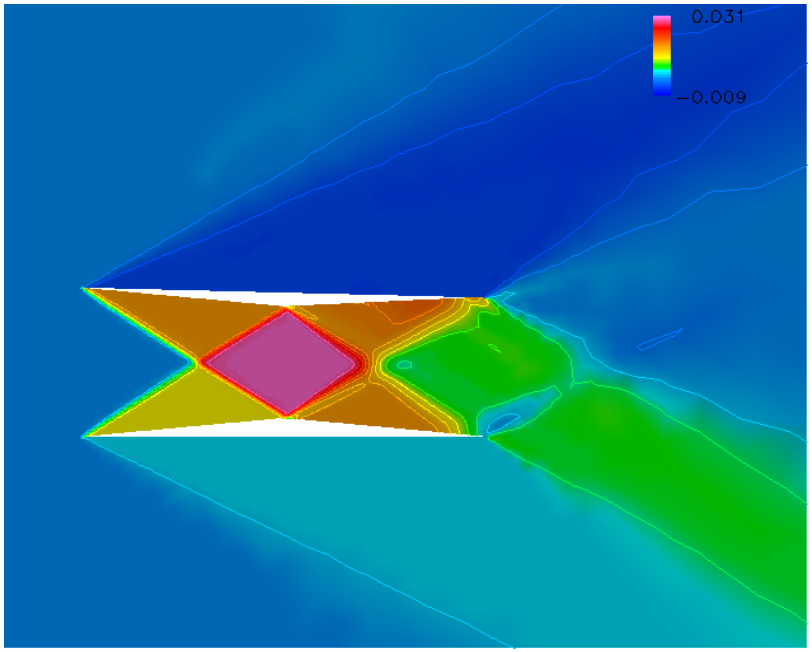
Unstable flow on a wing

Boomless Supersonic Transport

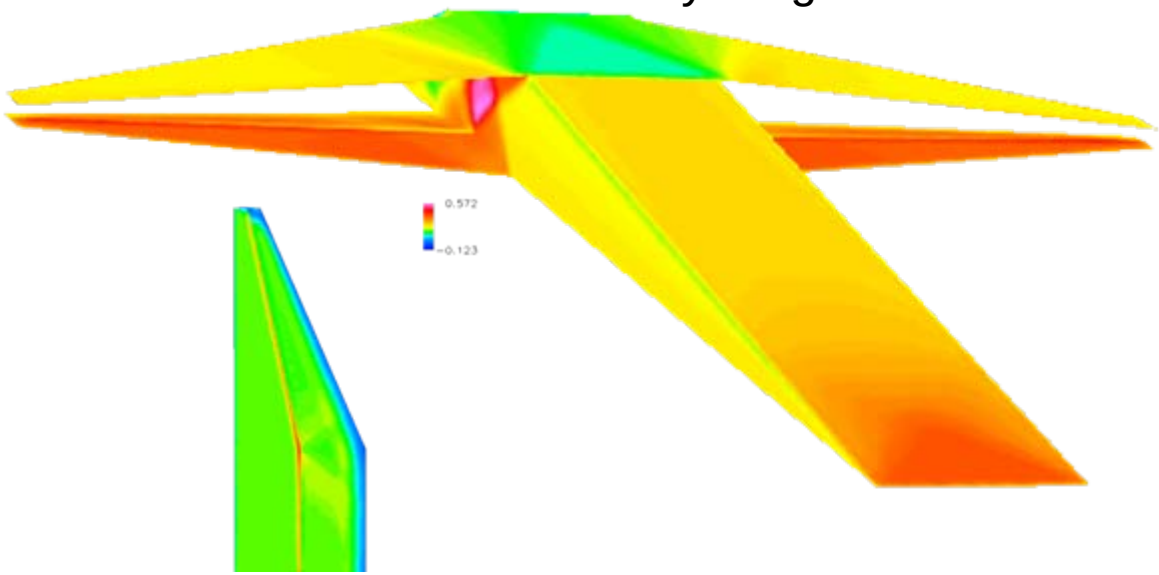
- Proposal of Supersonic Biplane by Busemann's Concept
- Prof. Obayashi et al.



The first airplane
by Wright brothers



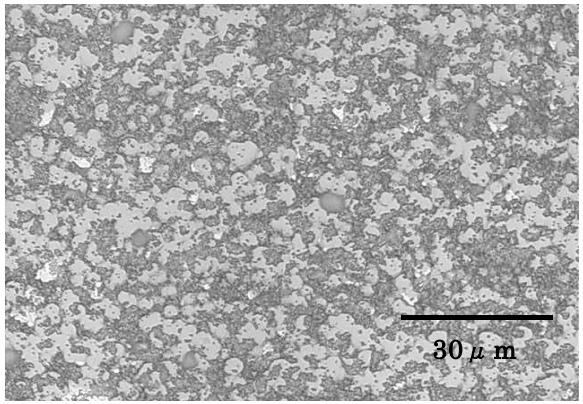
M=2.0, t/c=0.05, Alpha=1deg.
Cl=0.1047, Cd=0.00625, L/D=16.75

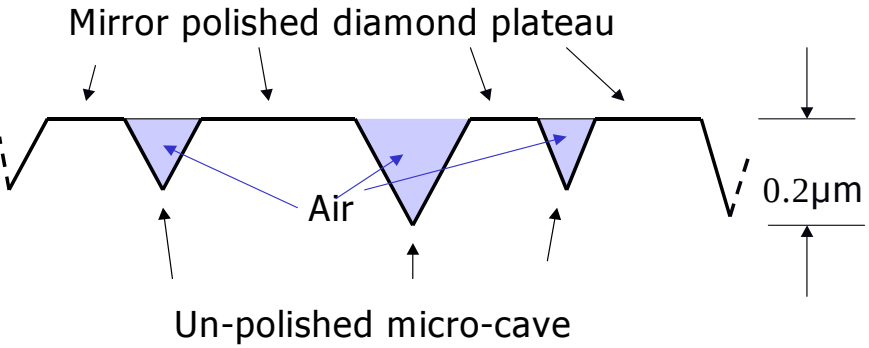


3-D Numerical Simulation

Development of Diamond Slider

CVD Diamond Specula Surface





Diamond and
Its ultra-smooth polishing

Application

Linear Slider

Prof.T. Takagi, et al., IFS, Tohoku Univ.

TOHOKU UNIVERSITY

Thank you for your attention

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