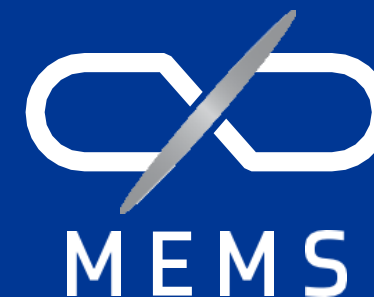
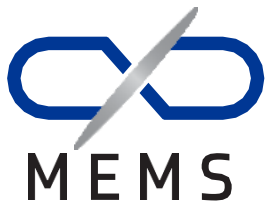


Device Commercialization Support Service by MEMS-Infinity



**MEMS Infinity
Sumitomo Precision Products Co., Ltd.**

Outline



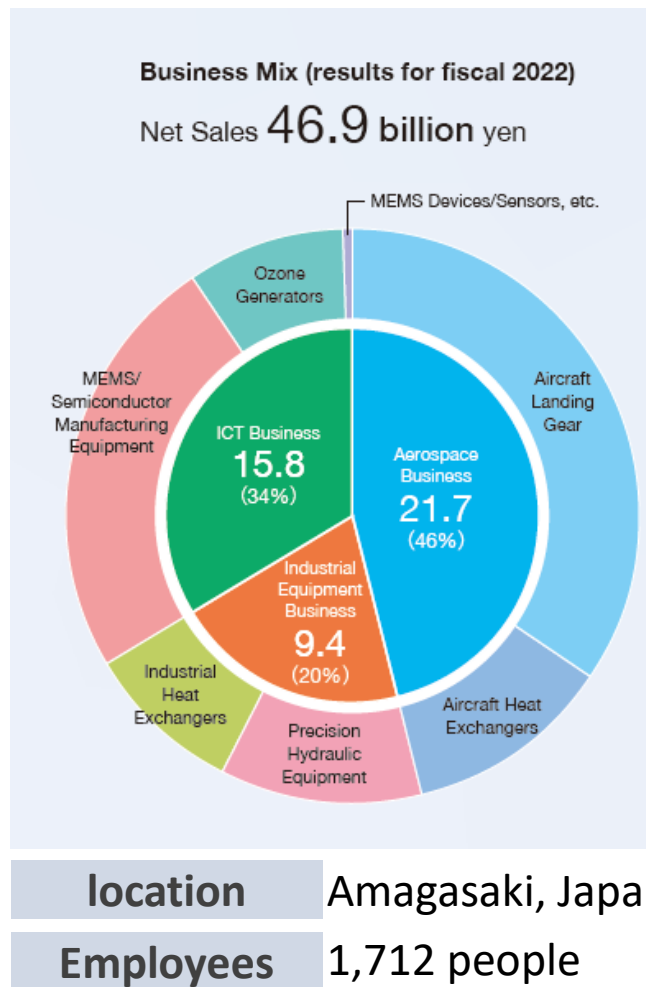
- Company profile of Sumitomo Precision Products
- MEMS business in Sumitomo Precision Group
- MEMS Infinity's device commercialization support service
- MEMS Infinity's technological strength
- Summary

Company profile of Sumitomo Precision Products

Company Profile



Three businesses: Aerospace, Industrial Equipment, and ICT



Aerospace Business

Landing gear



Heat exchanger



Industrial Equipment Business

Industrial heat exchanger

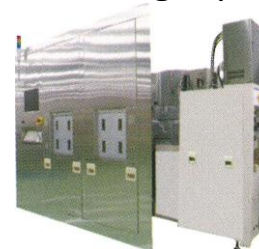


Hydraulic equipment



ICT Business

Manufacturing equipment



MEMS device/ Foundry



Ozone generator



MEMS Business – History



MEMS business with over 30 years of history

1992 MEMS Manufacturing equipment, IX200 on sale. Hands-on lab was founded.
Fundamental study on MEMS device started.

1995 Silicon deep RIE equipment (Si-DRIE) on sale



Equipment Development
SPP Technologies Co., Ltd.

1998 MEMS accelerators were on manufactured and on sale



Device Development
Sumitomo Precision Products

1999 Joint venture with BAE Systems in UK was founded for
manufacturing and sales of MEMS gyroscope



Foundry
SILICON SENSING

2009 Launch of inertial system attitude angle detector (AMU)



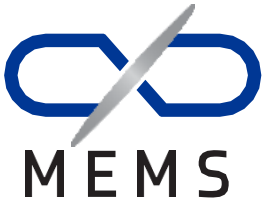
Inertial Systems Division

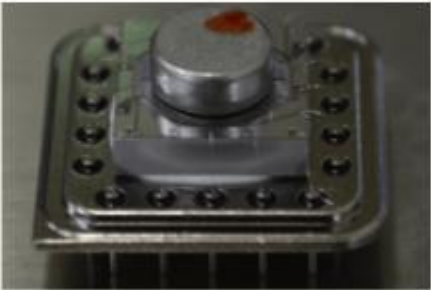
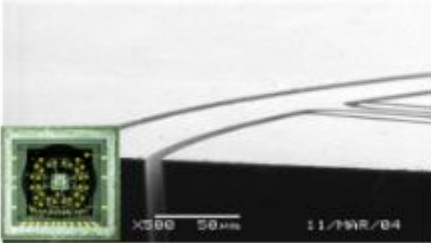

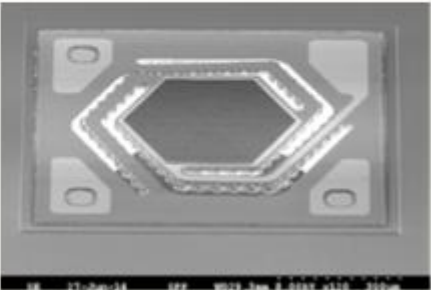
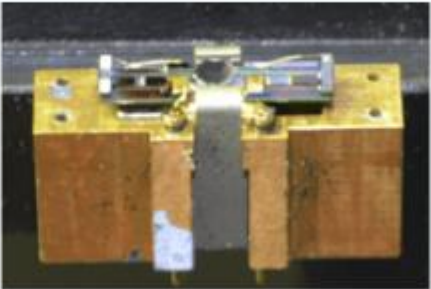
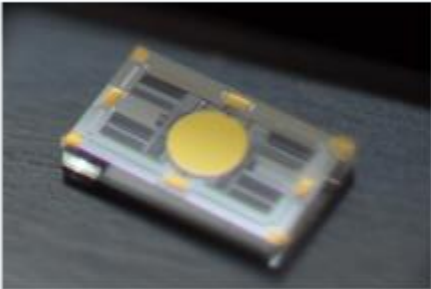
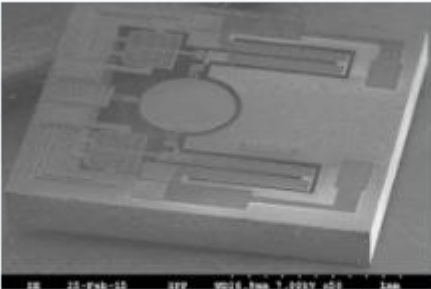
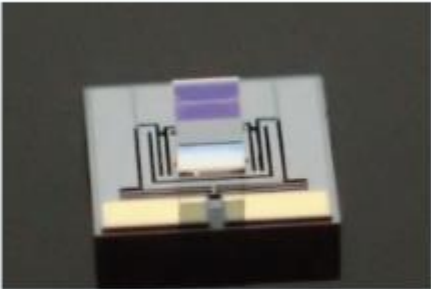
2023 Establishment of new organization MEMS ∞ (infinity)



MEMS ∞

Experience in developing all types of MEMS devices



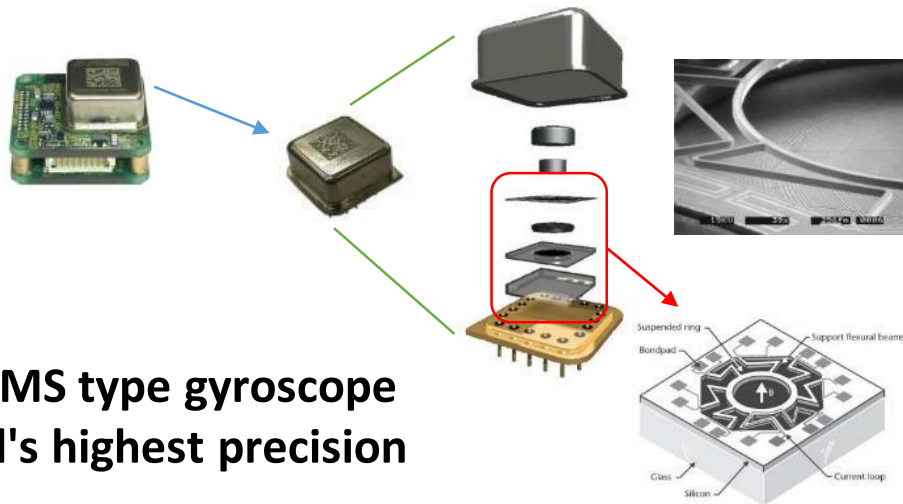
	Electromagnetic	Electrostatic	Piezoelectric	others
Example of sensor design	 <p>Gyroscope</p>	 <p>Gyroscope</p>	 <p>Gyroscope</p>	 <p>Infrared sensor</p>
Example of actuator design	 <p>Scan mirror</p>	 <p>Mirror switch</p>	 <p>VOA</p>	 <p>Wavelength filter</p>

MEMS devices and system products

Developing products that apply high-sensitivity inertial sensors



Model: CRH03



In MEMS type gyroscope
World's highest precision

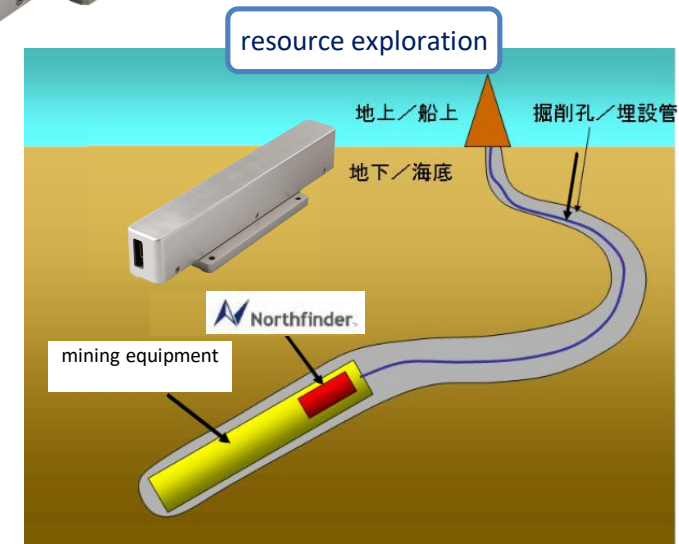
Developed by Sumitomo Precision Products,
Manufactured and sold by Silicon Sensing Systems
Cumulatively sold about 30 million inertial sensors



Detecting true north from the
earth's rotational angular
velocity

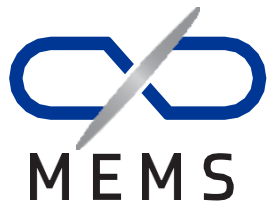


Inertial sensor with 6 degrees
of freedom is installed inside
the system product



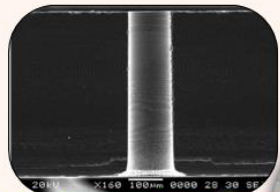
MEMS foundry

Our foundry services are strong in PZT thin film deposition and Si deep etching processing, and we will utilize our own MEMS gyroscope sensors production experience to mass produce MEMS devices that meet customer needs.

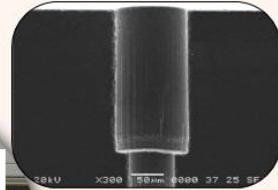


Amagasaki factory (6"/8" fab)

Operated under "Japanese quality" standard



Single mode fiber alignment guide



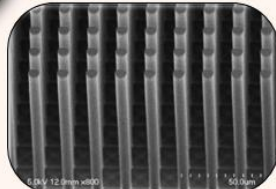
High Aspect Multi-stage Etching



Taper Etching



High Aspect Slit Etching

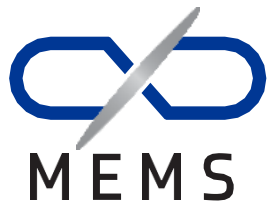


Fine pillar etching



MEMS/semiconductor manufacturing equipment

SPT not only has well-known Si DRIE, but also has a variety of film deposition and etching equipment.



All designed & Manufactured in Japan



SiC, compound/oxide film etching equipment
Sirius/Spica



Silicon DRIE equipment
Predeus/Proxion



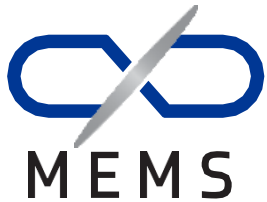
Silicon oxide sacrificial layer etching
equipment
Vetelgeuse



PECVD equipment for oxide film/nitride film
Cetus

MPM24-018

Our reputation in MEMS industry ~case 1~ (IEEE MEMS 2024)



AUSTIN, TEXAS 21-25 JANUARY
MEMS 2024

Home

MEMS 2024 **CONFERENCE OFFICIALS**

PROGRAM COMMITTEE (continued)

Ruochen Lu	University of Texas, Austin, USA
Jianmin Miao	Shanghai Jiaotong University, CHINA
Hiroshi Miyajima	Sumitomo Precision Products Co., Ltd. JAPAN
Farnaz Niroui	Massachusetts Institute of Technology USA

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Gold Benefactor

MEMS 2024 **ROBERT BOSCH AWARD RECIPIENT**

THE 2024 IEEE ROBERT BOSCH AWARD

SUSUMU KAMINAGA

For Development and Commercialization of Deep Reactive Ion Etching Technology

The Robert Bosch Micro and Nano Electro Mechanical Systems Award was established by the IEEE Electron Devices Society in 2014 to recognize and honor advances in the invention, design, and/or fabrication of micro- or nano- electromechanical systems and/or devices.

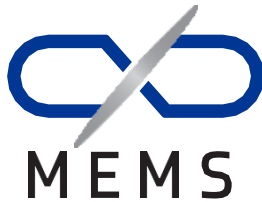
The 2024 Bosch Award will be presented on Monday, 22 January at 08:30.

Susumu Kaminaga studied mechanical engineering at the University of Tokyo before joining Sumitomo Precision Products (SPP), Japan in 1969. Through his career with technological background in the industry, he made a lot of achievements for MEMS, especially, R&D and commercialization of deep reactive ion etching (DRIE) technology based on Robert Bosch invented Bosch Process. Initially, he ran Surface Technology Systems (STS) in U.K. to take initiative of the R&D and commercialization of DRIE technology under collaboration with Robert Bosch. The world first DRIE tool was introduced into the market in 1995. The technology has enabled many new MEMS devices to emerge and contribute to rapid growth of MEMS application for automotive, inkjet printers, displays, smartphones, healthcare and IoT. It has been said in the MEMS society that those applications could not be made available without the development and commercialization of DRIE technology. He founded SPTS Technologies and SPP Technologies (SPT) as SPP's affiliated companies to focus on further development and commercialization of MEMS technologies. He is keeping involved even now in supporting further development and commercialization of DRIE technology. He has given hundreds of speeches at academia, industry and international conferences including many IEEE organized ones. His talks inspired researchers, engineers and managers to develop MEMS technology for the purpose of new business creation in the world of IoT and smart societies. He was a member of External Advisory Board of the Mechanical Engineering Department at the University of California, Berkeley from 2007 to 2014.

IEEE Electron Devices Society with Financial support from Robert Bosch LLC.



Our reputation in MEMS industry ~case 2~ (PiezoMEMS-2024)



We have sponsored in PiezoMEMS 2024
(Mar19-20, 2024, Aachen, Germany).



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Sumitomo Precision Products



SUMITOMO PRECISION PRODUCTS CO., LTD.



11:45 – 12:10 The latest updates in SPP PZT thin film development

Sumitomo
Precision

Mario Kiuchi



Our reputation in MEMS industry ~case 3~ (Hilton Head Workshop)



The Complete PZT Solution:

AMFitzgerald and MEMS Infinity

 + 

Driving Innovation in PZT MEMS Products

Our alliance checks all the boxes

- Delivers all the benefits of piezoelectric MEMS in a superior thin-film material: performance, thickness, environmental robustness
- Optimizes sensing and actuation for performance-intensive MEMS devices
- Provides application-specific advantages for ultrasound transceivers, micro-speakers, micromirrors, microfluidics and more
- Unlocks commercial potential of emerging piezoelectric MEMS devices

We provide an integrated product development experience

We work together to guide your design seamlessly from concept development and prototype through test and volume fabrication.

We are AMFitzgerald and Sumitomo Precision Products Co., Ltd.

Learn more:



AMFitzgerald



MEMS Infinity



SUMITOMO PRECISION PRODUCTS CO., LTD.



SOLID-STATE SENSORS, ACTUATORS, AND MICROSYSTEMS WORKSHOP

HILTON HEAD

2-6 June ★ 2024 — South Carolina, USA

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General Chair

Jenna F. Chan, DEVCOM Army Research Laboratory

Program Chair

Swaminathan Rajaraman, University of Central Florida

Invited Speakers: 40 Years of MEMS Success



FORTY YEARS OF MEMS INNOVATION AT HILTON HEAD WORKSHOP: FROM EMERGING TECHNOLOGIES TO COMMERCIAL PRODUCTS
Alissa M. Fitzgerald, Ph.D.
AMFitzgerald, USA

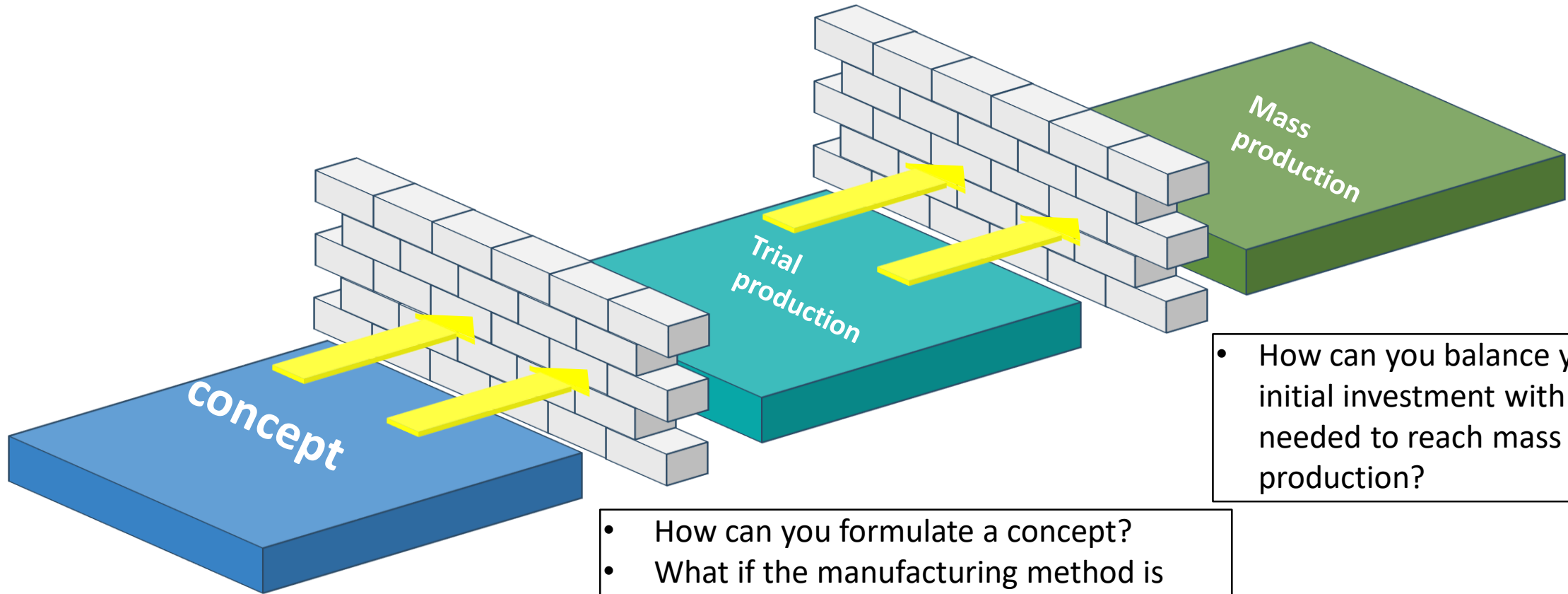


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12

MEMS Infinity's device commercialization support service

Overcoming the major barriers of each stage of commercialization

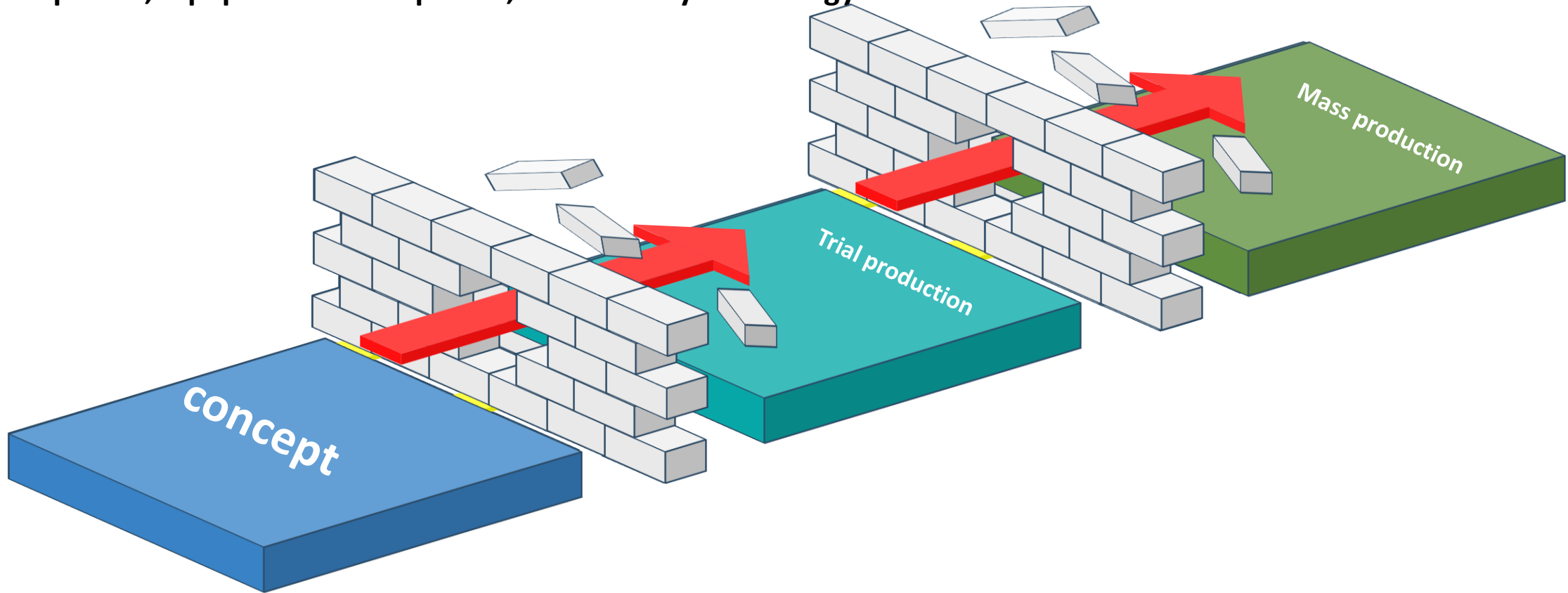
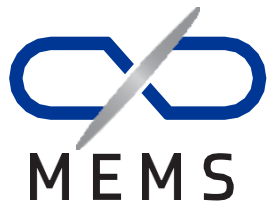


- How can you formulate a concept?
- What if the manufacturing method is unknown?
- What if there are problems with manufacturing equipment?

- How can you balance your initial investment with the time needed to reach mass production?

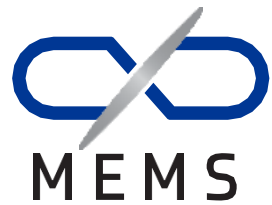
MEMS Infinity is ready to help

We have the expertise to break through the barriers of device development, equipment development, and foundry technology

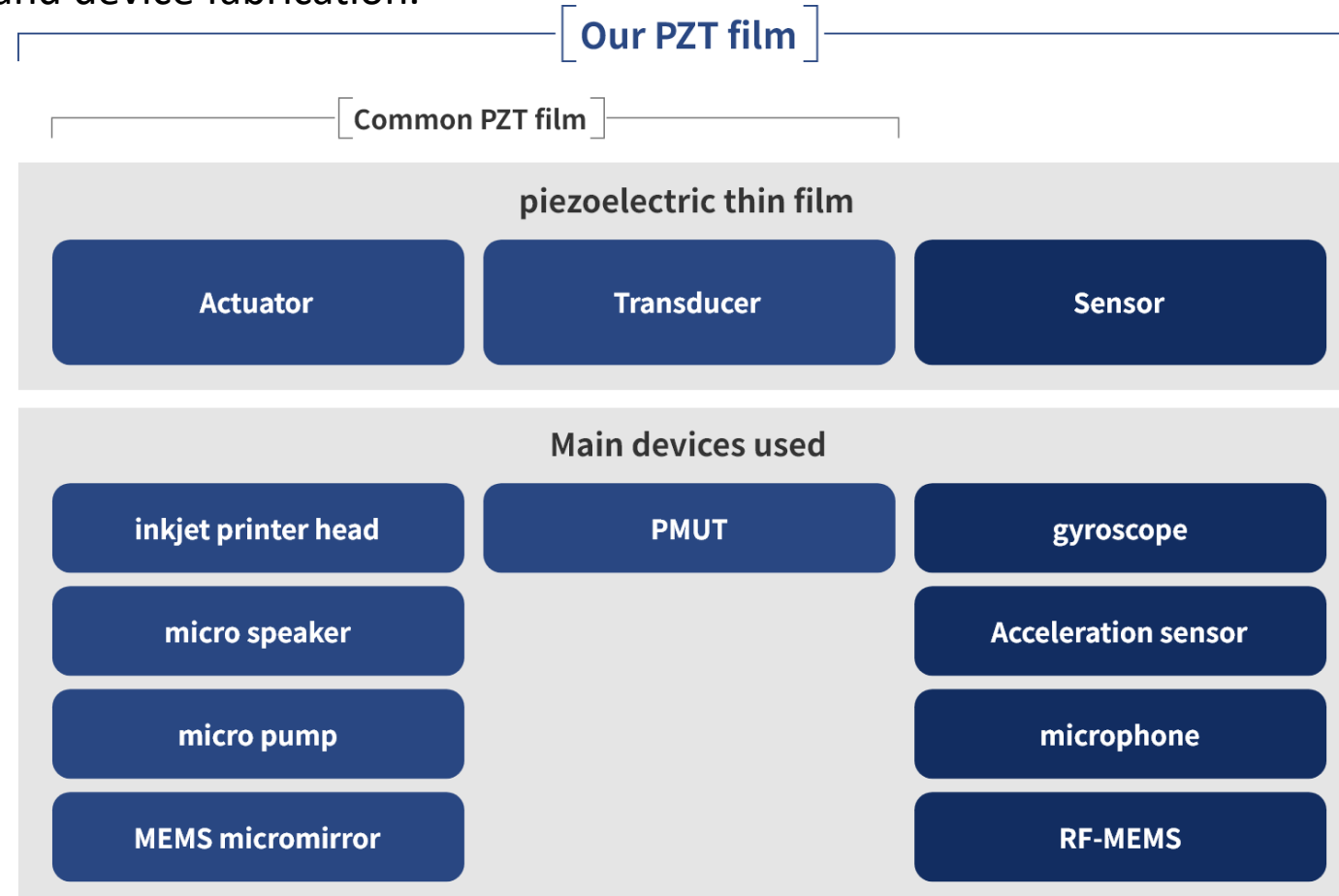


MEMS Infinity's technological strength

PZT thin film technology



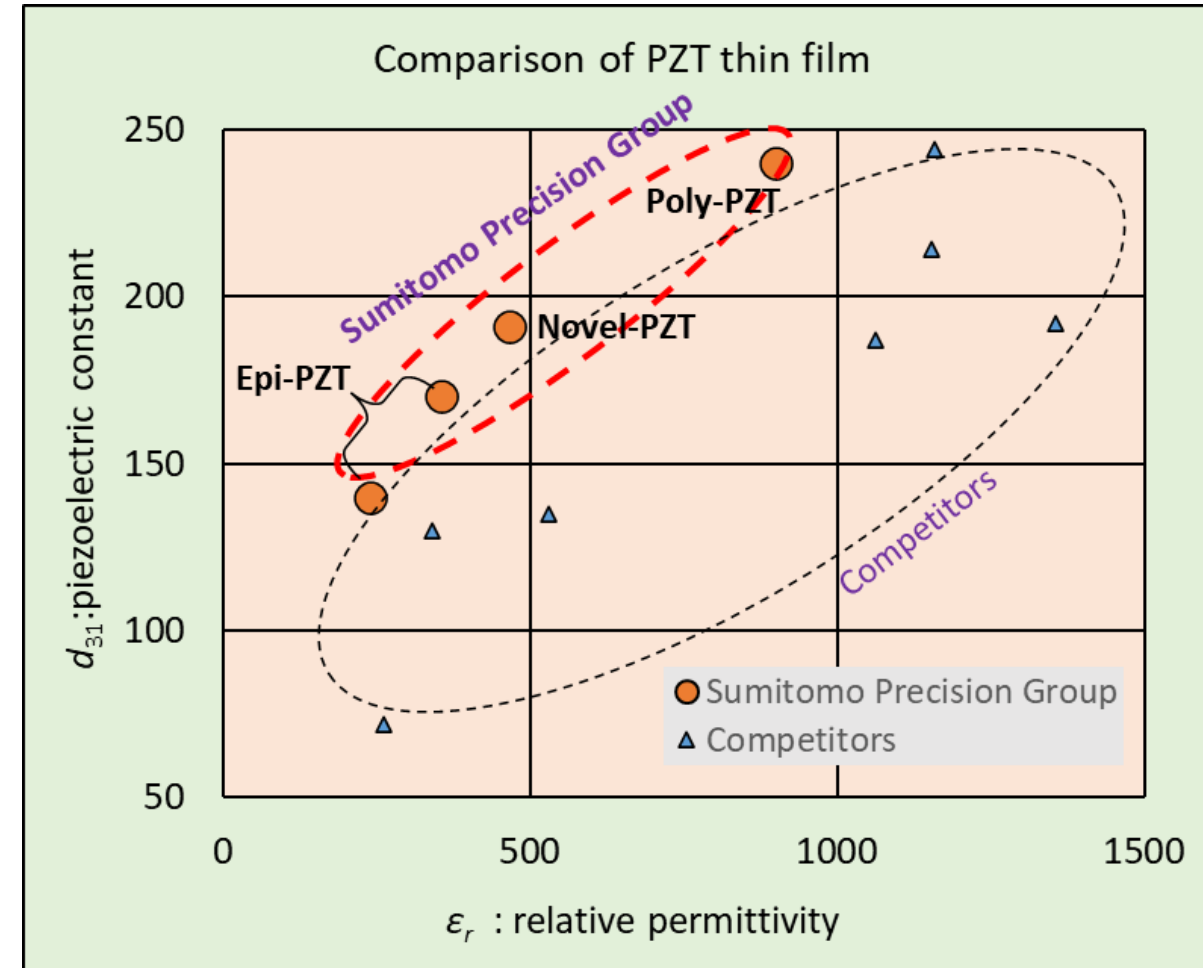
Together with our affiliated companies, we have decades perfecting PZT thin films in MEMS manufacturing—sputtering deposition and device fabrication.



Comprehensive PZT thin film line-up

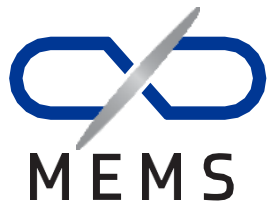
- Our PZT thin film offerings having higher d_{31} and lower ϵ_r
- Our Poly-PZT has high FOM (Act-FOM) for actuators
- Our Epi-PZT has high FOM (Tr-FOM) for transducers (i.e., emitting and receiving device)
- Our Novel-PZT has intermediate feature between Poly-PZT and Epi-PZT.

Type	Novel-PZT	Epi-PZT		Poly-PZT
PZT composition	MPB	Ti-rich	MPB	MPB
ϵ_r	465	239	354	900
Act-FOM ($=-d_{31}$)	191 pm/V	140 pm/V	170 pm/V	240 pm/V
($=-e_{31,f}$)	14.3 C/m ²	10.4C/m ²	12.7C/m ²	17.9 C/m ²
Tr-FOM ($\propto (d_{31}^2)/\epsilon_r$)	50 GPa	52 GPa	52 GPa	40 GPa
$\tan\delta$	<0.03	<0.03		<0.03
Stress (tensile)	89 MPa	200 MPa		30 MPa
Wafer type	Bulk Si or SOI	Bulk Si or SOI		Bulk Si or SOI
Wafer size	6" or 8"	6" or 8"		6" or 8"
PZT thickness	2 μm	2 μm		1~5 μm



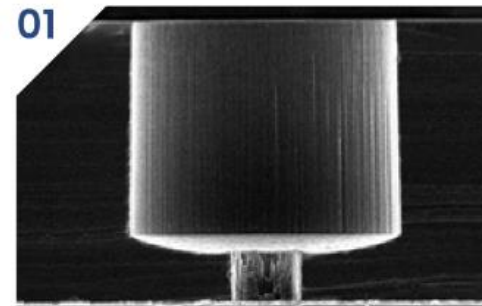
MPM24-018

Our technological strength: Silicon deep etching

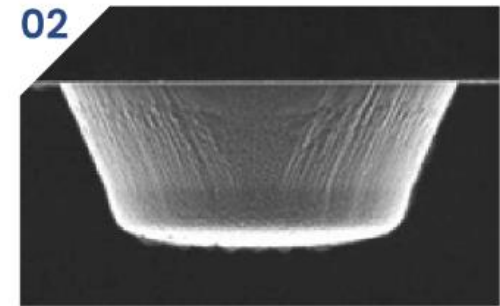


We've achieved the world's highest level of high selectivity and high etch rate while optimizing verticality, side wall roughness, and CD loss.

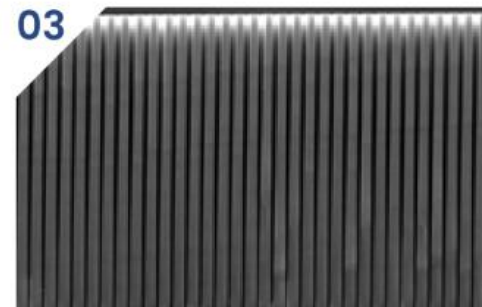
Processing example



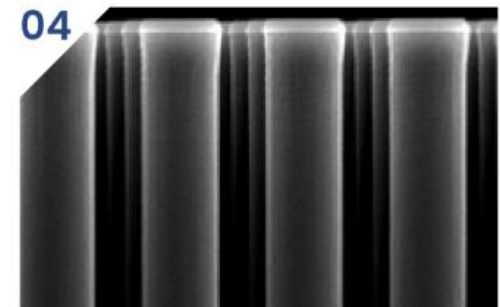
High aspect ratio Multi-steps



Tapered shape



High aspect ratio slits



Micro pillars

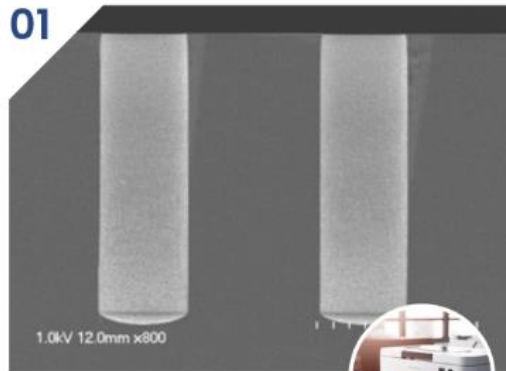
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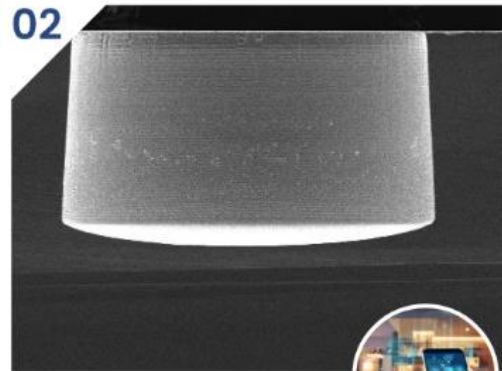
SUMITOMO PRECISION PRODUCTS CO., LTD.

Our technological strength: Silicon deep etching

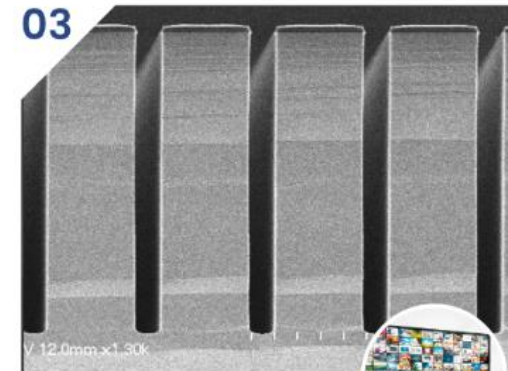
Example devices realized through Silicon deep etching process



Example) Inkjet head



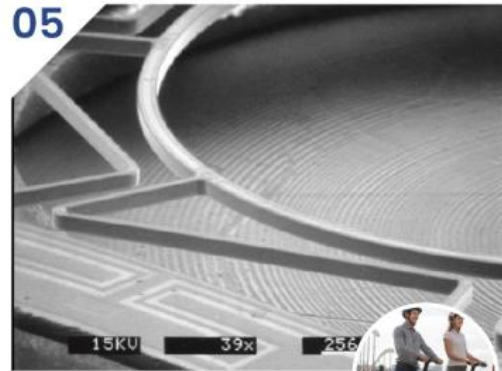
Example) Silicon microphone



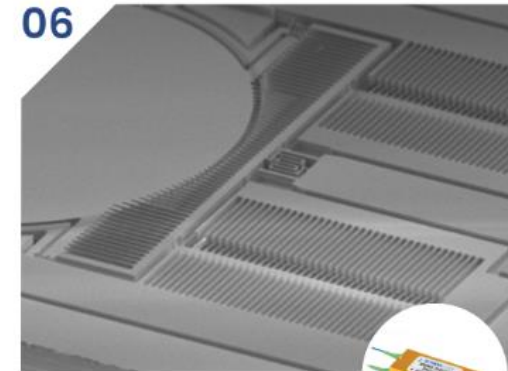
Example) Power device



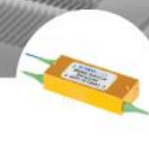
Example) Accelerometer



Example) Gyroscope sensor




Example) MEMS optical switch

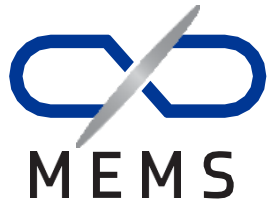


MEMS Infinity vs. the competitors



Comparison table for service areas between our company and other companies	MEMS design		Wafer process		Volume production
	Structure	Process	6 inches or less	Over 6 inches	
Design development service provider	●	●	●		
Foundry [From concept verification to small volume production]		●	●	●	
Foundry [focused on Volume production]				●	●
MEMS 	●	●	●	●	●

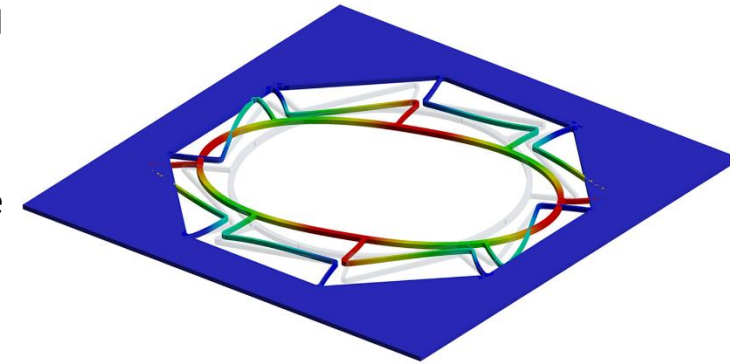
We have MEMS device design covered



- We provide development support from the design stage of MEMS devices to bring product ideas to life.
- We offer support from device design to simulation.
- Through collaboration with our in-house fab and university institutions, we provide valuable services.

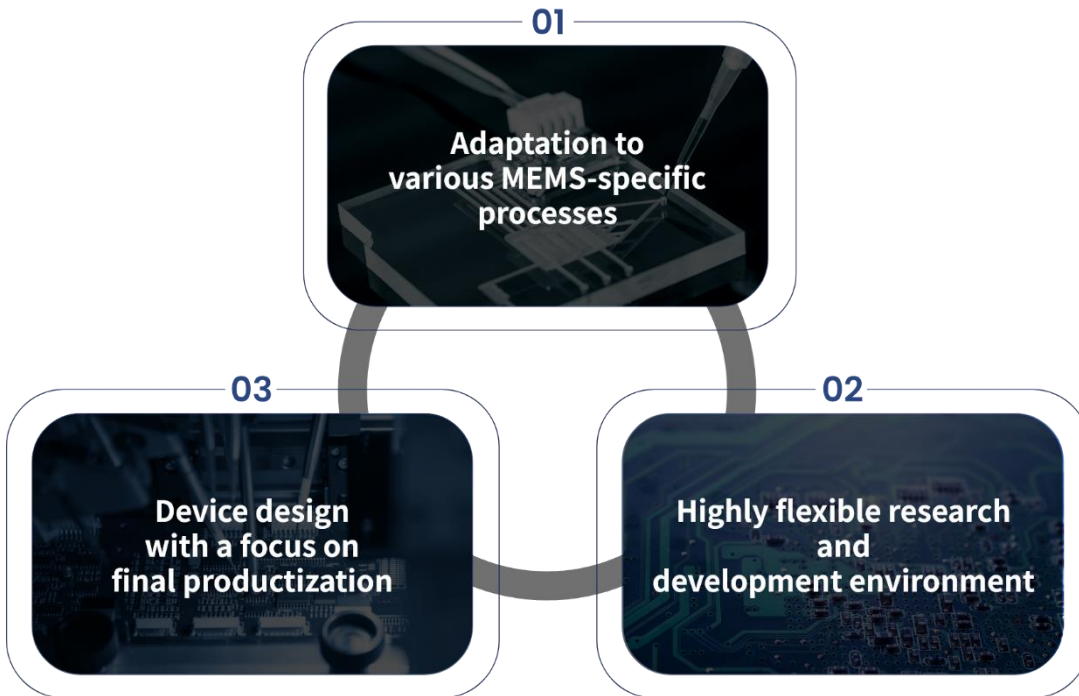
Structural design/simulation

We will listen to your requirements and conduct concurrent design and development from the initial structural design. By performing model analysis using FEM (Finite Element Method), we can analyze the behavior of different materials under load, vibration, and heat, and derive the optimal structure.

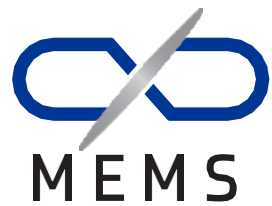


Process design/prototype production

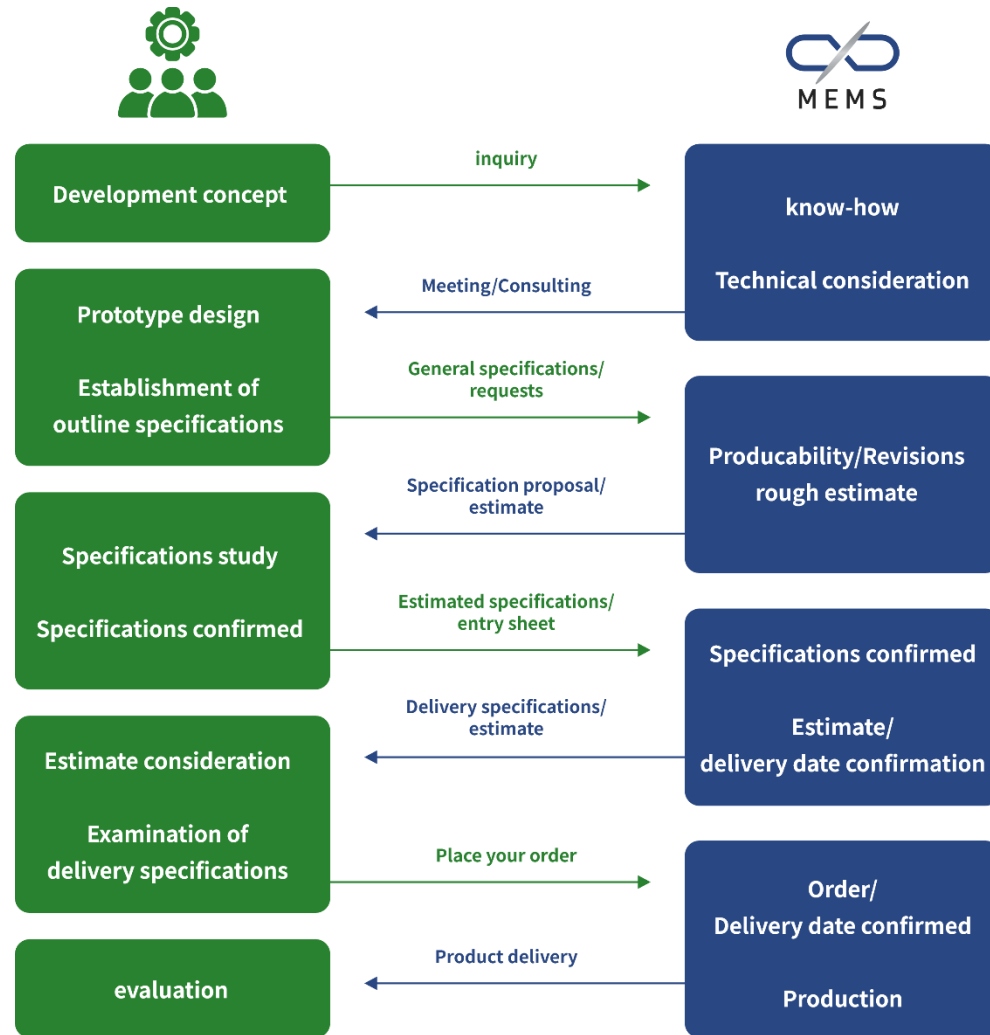
After simulation, the device and process design will be carried out. The formation of piezoelectric elements, as well as processes such as film deposition, dry etching, and wet etching, will be repeated to prototype the MEMS device.



Foundry Service (MEMS device development)



Service flow



Prototype process

Wafer (Si or SOI)
Wafer cleaning (SC1)
Thermal oxidation



PZT patterning
(wet etching)



Bottom electrode deposition (Ti/Pt)
PZT film deposition (standard 3μm) (1-5μm)
Top electrode deposition (Ti/Au or Ti/Pt)



PZT/bottom electrode/
Si oxide patterning
(dry etching)



Top electrode patterning
(dry etching)



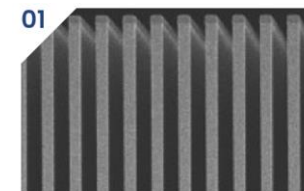
Si or SOI patterning
(Deep RIE)



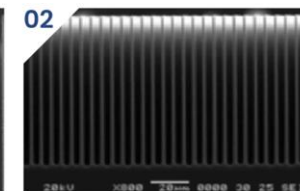
Wafer thinning
(Back grinding)



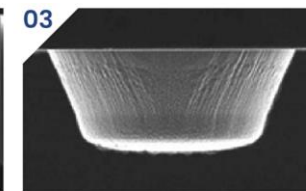
Si deep etching process



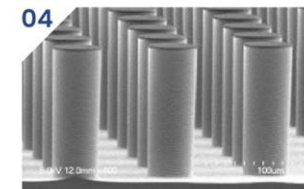
01 低スキャロップ加工: 100nm



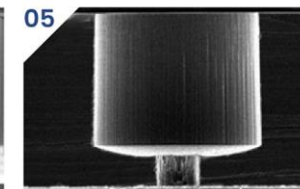
02 高アスペクト



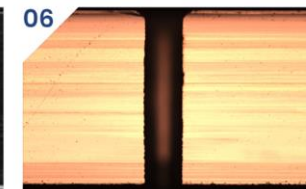
03 テーパー加工



04 マイクロブLOWER加工



05 二段加工



06 貫通ストレートホール加工



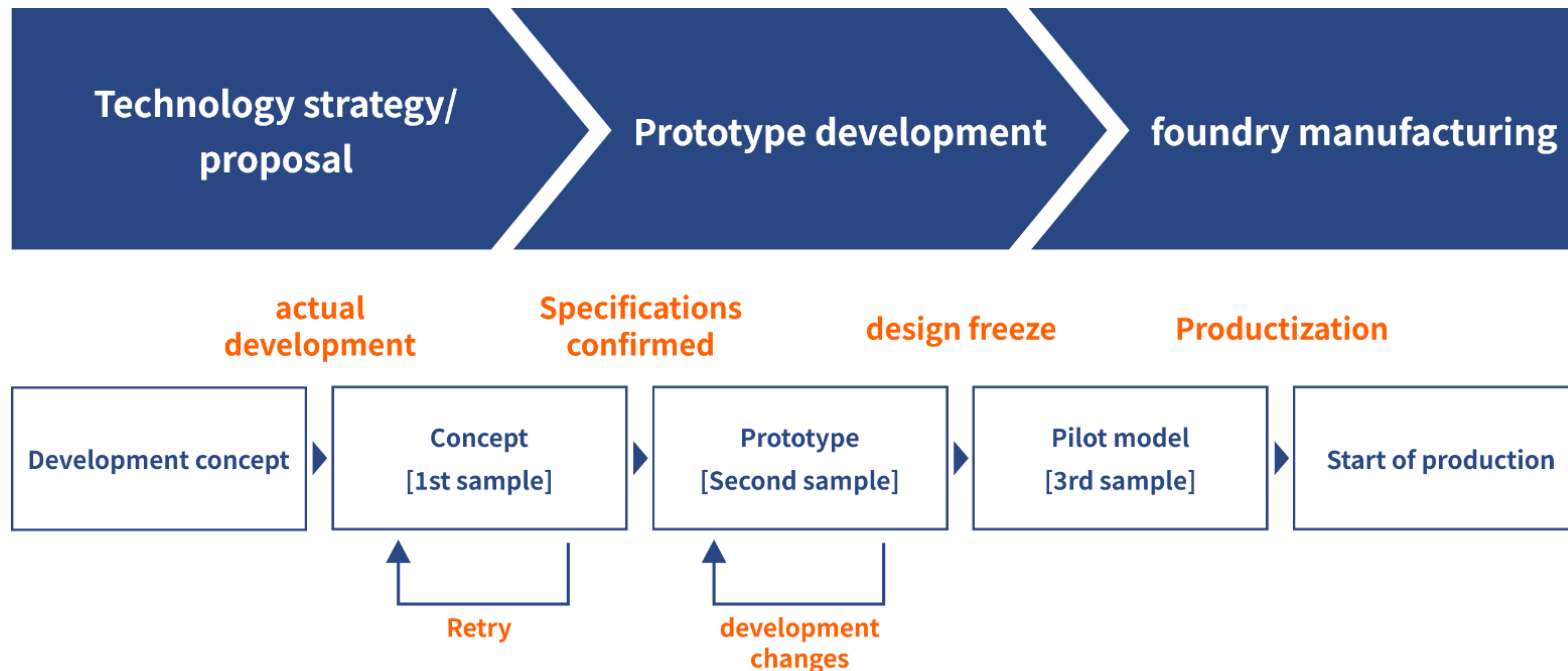
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Foundry Service (Volume production)

Unlike traditional semiconductor devices, MEMS have mechanical elements within microstructures, so it is important to measure the behavior of dynamic mechanical systems through reliability and durability tests. By creating APQP and summarizing the procedures and processes from product planning and development to mass production from a quality assurance perspective, we gain a high level of trust from our customers and ensure a high degree of mutual understanding in all processes.

Quality assurance system



Summary

Reasons to choose MEMS Infinity

- We will propose the optimal solution for customers who are considering MEMS device design, development, prototyping, and mass production
- Based on our proven high-volume production technology of PZT film deposition for gyroscopes, we offer seamless services from film deposition to device processing--all tailored to your needs
- You get access to Predeus, a product from SPP Technologies that is already proven for mass production of MEMS devices
- We provide high-quality processing with world-class high selectivity and high etching rates while maintaining verticality, minimal sidewall roughness, and minimal CD loss.

Website



LinkedIn



Thank you

mems-infinity@spp.co.jp

<https://www.spp.co.jp/infinity/en/>

<https://www.linkedin.com/showcase/mems-infinity/>

