

# **“New age of MEMS large wafer scale production”**

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**Feb.10/2011**

## **OUTLINE**

- 1. DNP COMPANY OVERVIEW AND MEMS FOUNDRY**
- 2. LARGE SCALE WAFER BUSINESS IN JAPAN**
- 3. TECHNOLOGY FOR LARGE SCALE WAFER PRODUCTION**
- 4. TIA JOINT PROGRAM (MICROSYSTEM,BEANS)**

**Feb.10/2011**

## Electronics

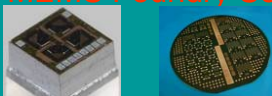
Semiconductor (Photomask, Lead Frame, PCB)



Displays (Color Filter PDP, large mask)



MEMS Foundry Service



Soft Drink  
Bottle Printing

## Information and Communication

Consumer Printing



Industrial Printing



Multi media



Business form



## Life industrial

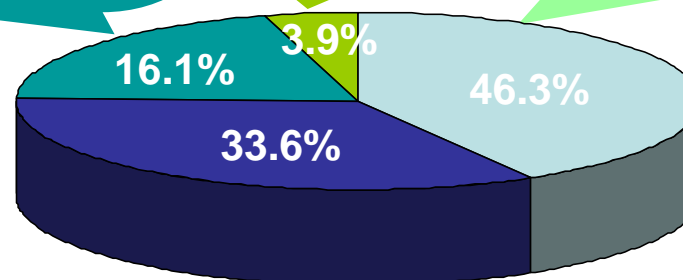
Package Printing (Food, Drink, medication)



Living decorative material



Industrial material (Opt Film, Li battery, Ink ribbon)



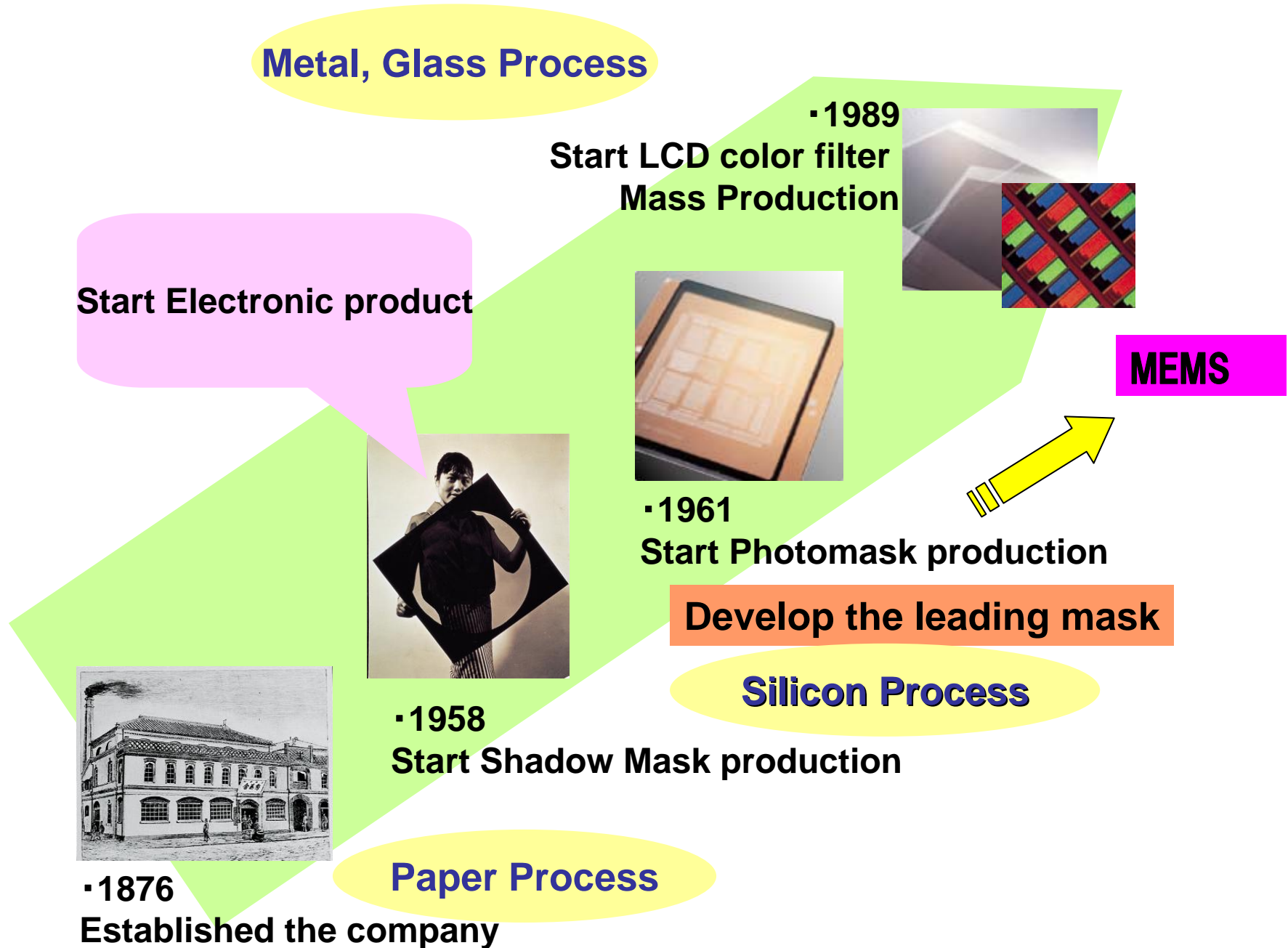
Sales Ratio of each division

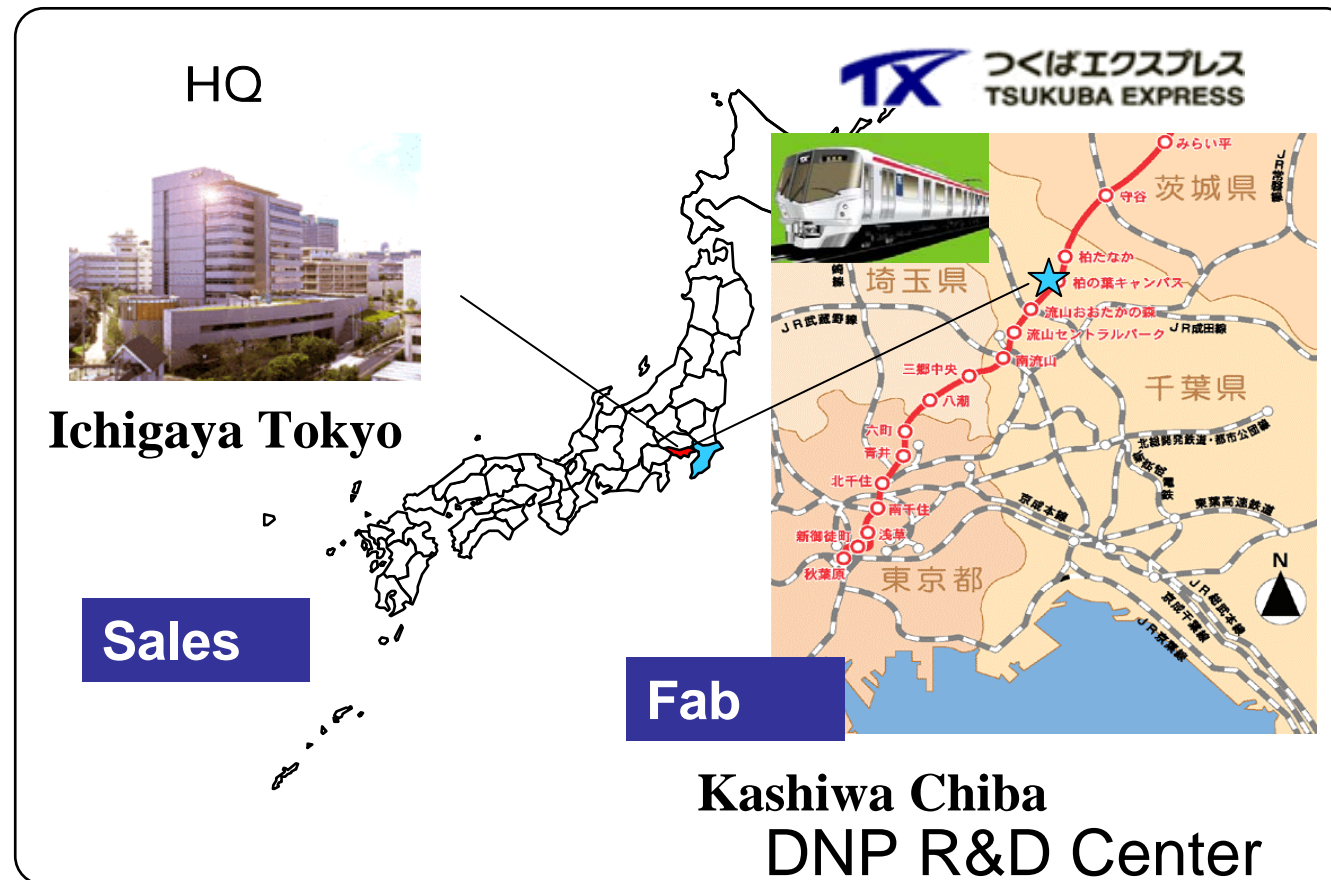
**2009 Sales Total**

**Sales: 1,583B Yen**

**Operating Profit: 66.5BYen**

**Recurring Profit: 68.8B Yen**

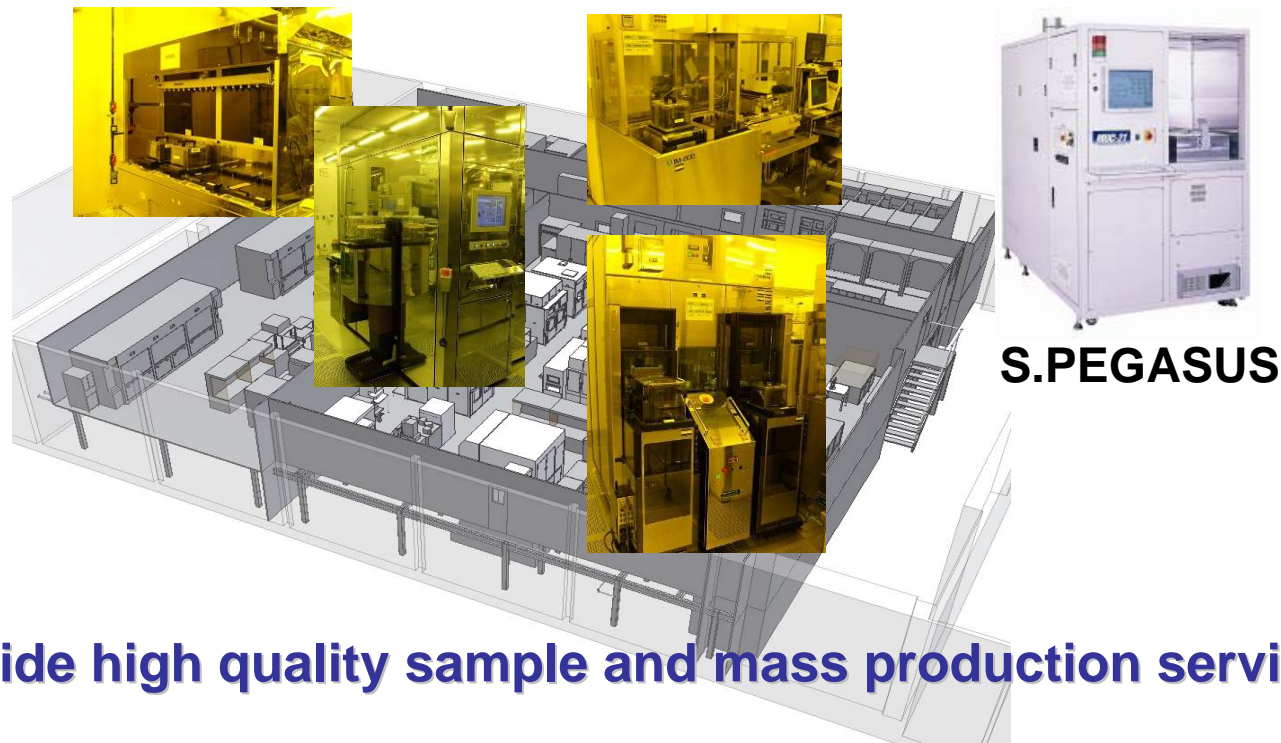




- >2001 Aug MEMS Sample Service Released
- >2004 Oct MEMS Design Service Started
- >2004 Nov Mass Production Service Started
- >2006 Aug MEMS clean room completed
- >2007 April MEMS team start
- >2007 Summer 1st MP line started

## ■ New MEMS Mass Production Line

- 6 Inch、8Inch wafer equipment
- Separate clean rooms with class 10、1000、10000
- Install SMIF equipment for photo lithography process



**Provide high quality sample and mass production services**

## ■ Film deposit Equipment

- Spatter (DC, RF)
- Evaporate coating
- LP-CVD
- PE-CVD
- **MO-CVD**

## ■ Furnace

- Oxidation (wet, dry, pyro)
- Diffusion
- Doping (B,P)
- Annealing

## ■ Dry Etching

- **Deep-RIE**
- Oxide RIE
- Asher

## ■ Photo Lithography

- Spin/Spray Coater
- Both side alliner
- i-line stepper
- Developer (Paddle, Spray)

## ■ Wet Etching

- **Si wet etching (alkali)**
- SiO<sub>2</sub> wet etching
- Metal wet etching
- Organic wet etching
- POCl<sub>3</sub> (SiN strip)

## ■ Other wet etching

- Electro Plating
- RCA cleaning
- Resist strip
- descum

## ■ Post Process

- **Anodic bonding**
- Dicing

## ■ Metrology

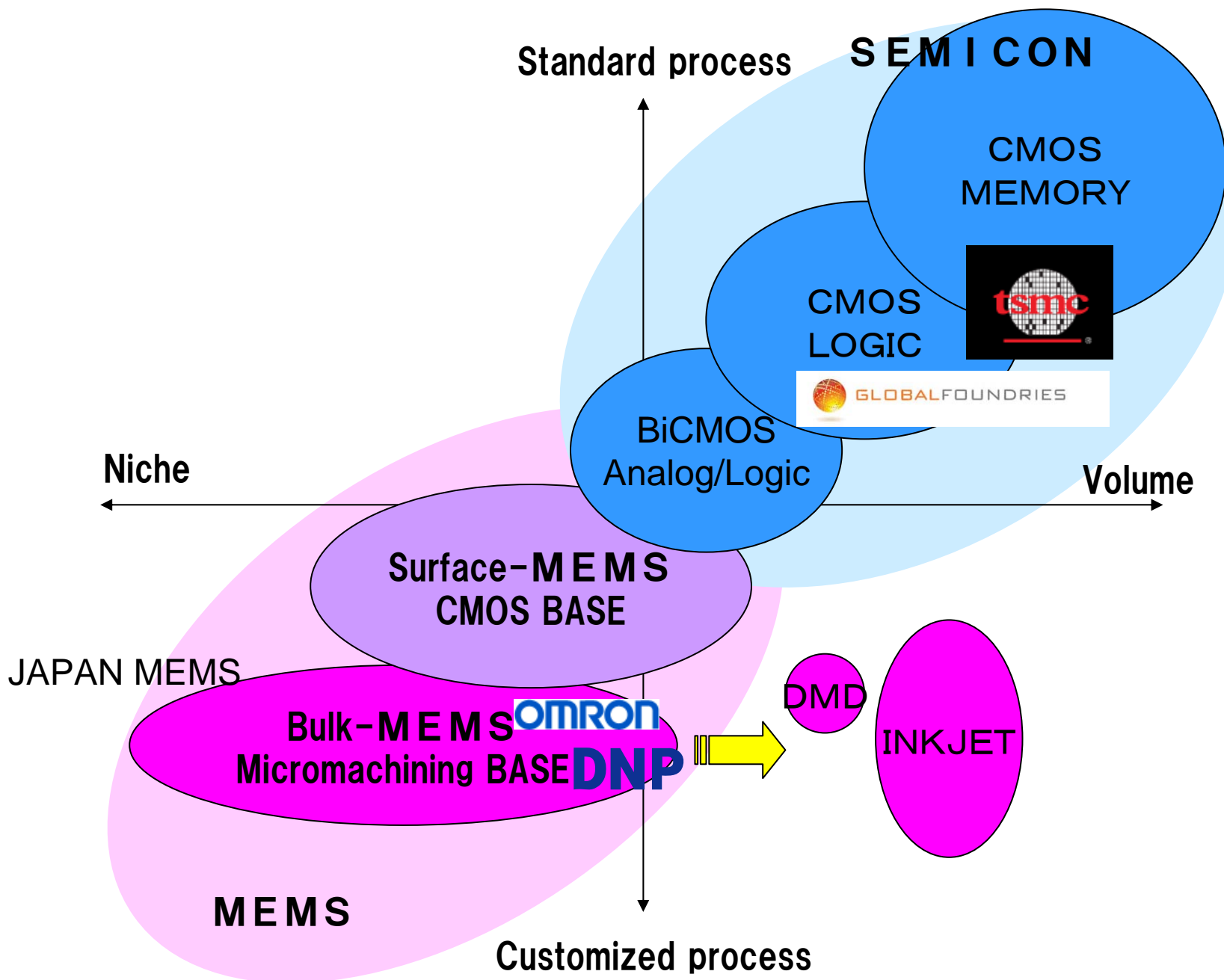
- CD-SEM, Tilt-SEM
- Optical Microscope
- 3D LASER distancemeter
- Step measurement
- Optical thickness measurement
- TREX
- Ellipsometri
- warpage measurement
- Spreaded resistance measurement
- Probing system
- Defect inspection system

## ■ Design/Analysis

- **MEMS design and analysis software**
- Electromagnetic field simulation software

- All equipments using wafer edge handling system
- 0.3~3mm thickness wafer can be handled.



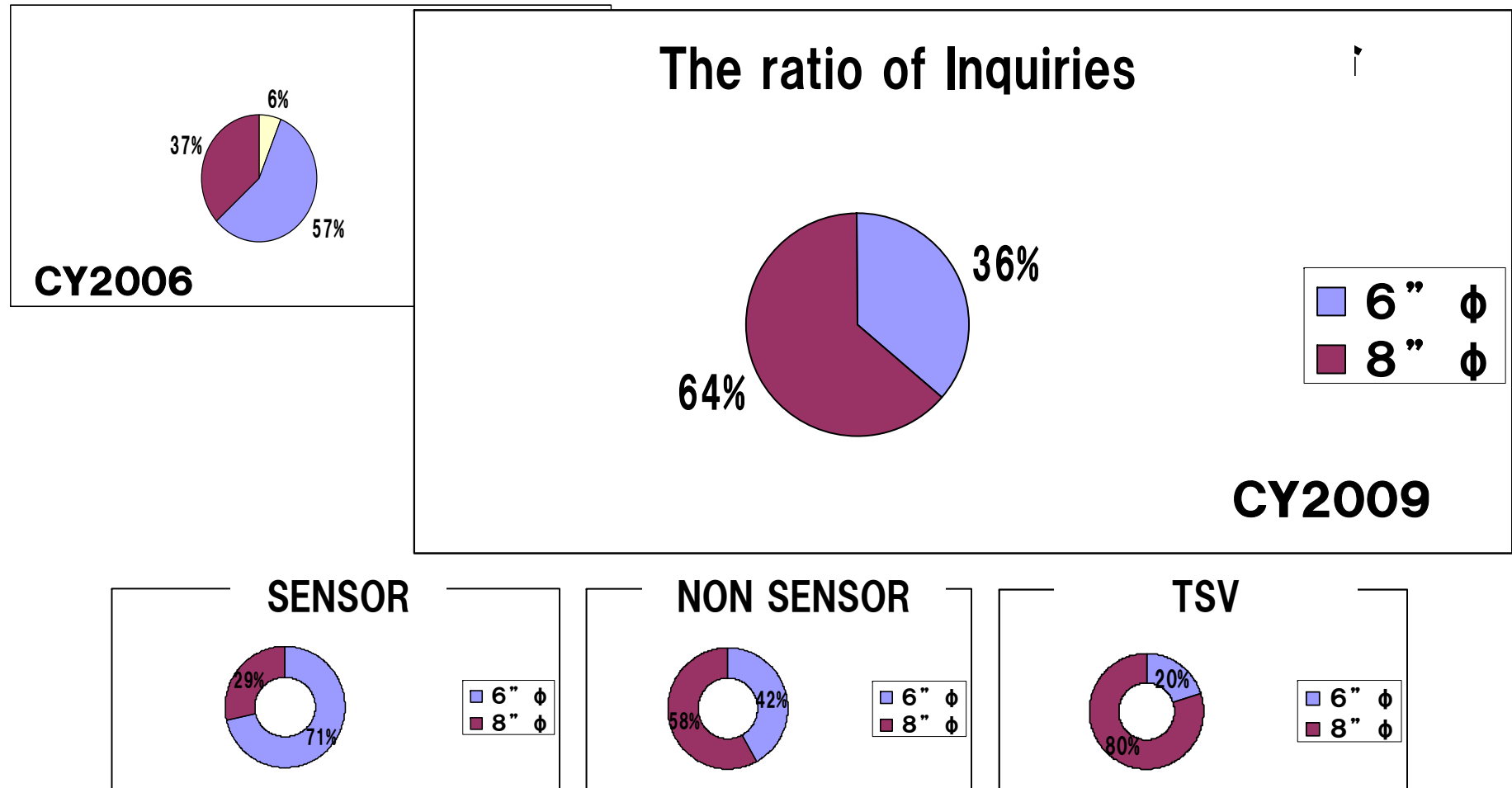




# OUTLINE

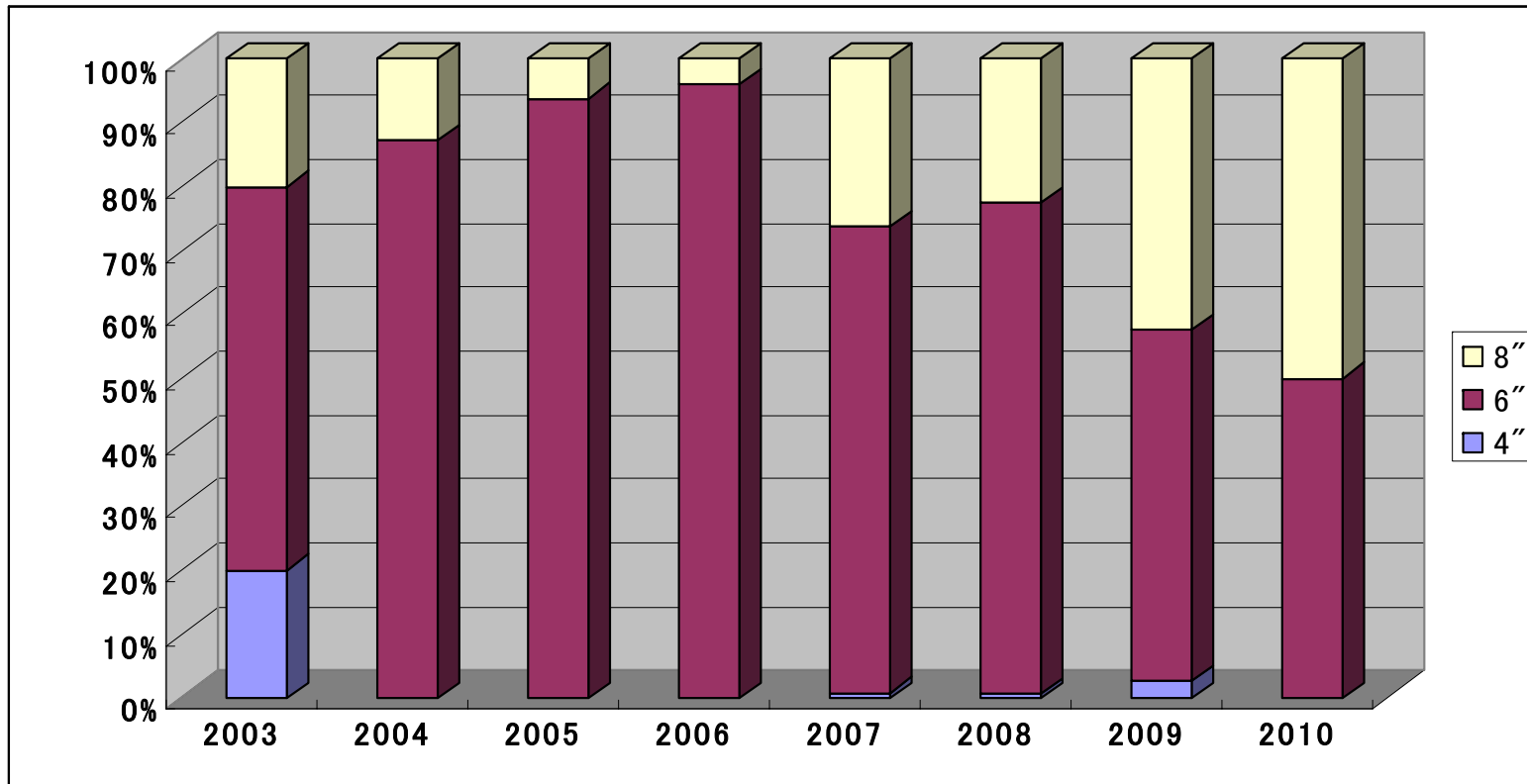
1. DNP COMPANY OVERVIEW AND MEMS FOUNDRY
2. LARGE SCALE WAFER BUSINESS IN JAPAN
3. TECHNOLOGY FOR LARGE SCALE WAFER PRODUCTION
4. TIA  $\mu$  JOINT PROGRAM

**Feb.10/2011**



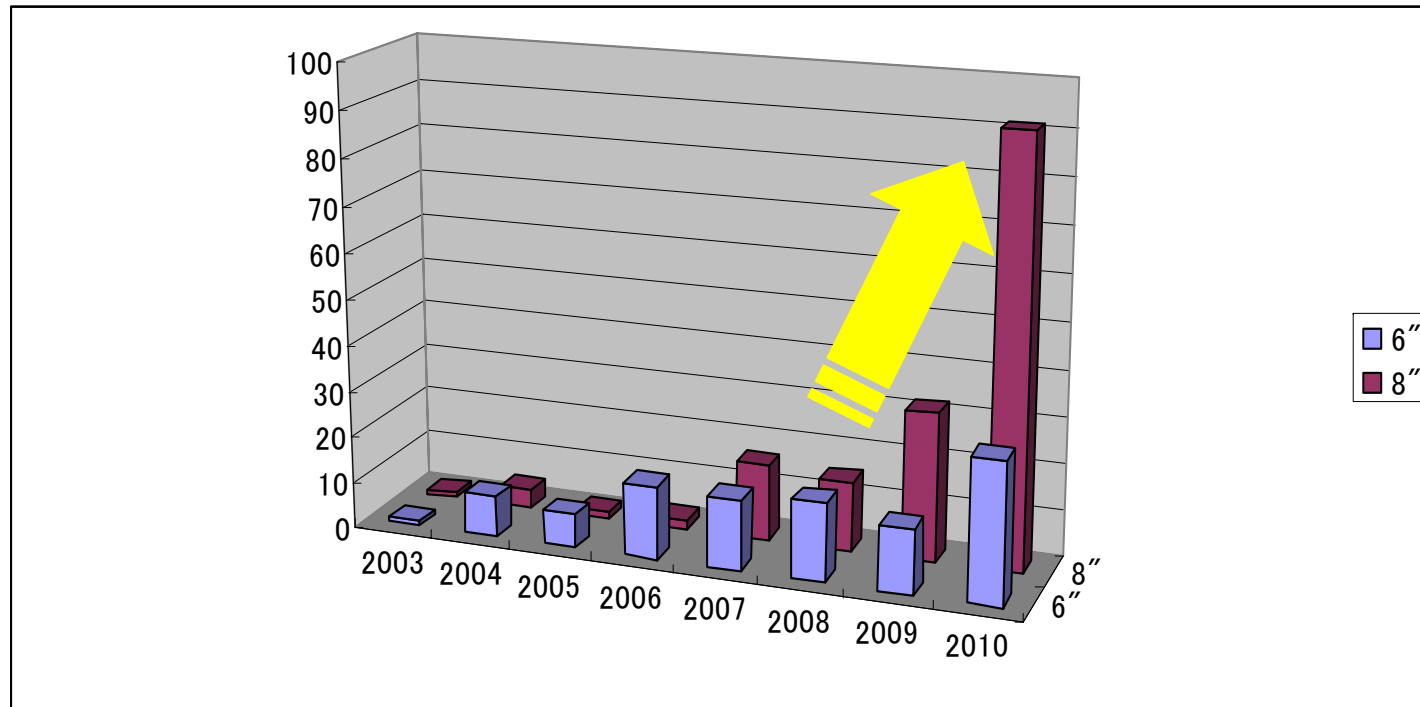
The ratio of 8inch inquiries are over 60% in 2009.  
 Especially, in the case of TSV,80% inquiries are for 8inch processes.  
 And sometimes there are some 12inch inquiries.  
 TSV application need for 8 or 12 inch processes,  
 Also MEMS non sensor processes is going to large scale wafer

### Transition of the ratio of P.O. numbers as a function of wafer diameter



**The peak of 6inch P.O. ratio is in 2006.  
After that, 6inch ratio is decreasing, 8inch ratio is increasing rapidly**

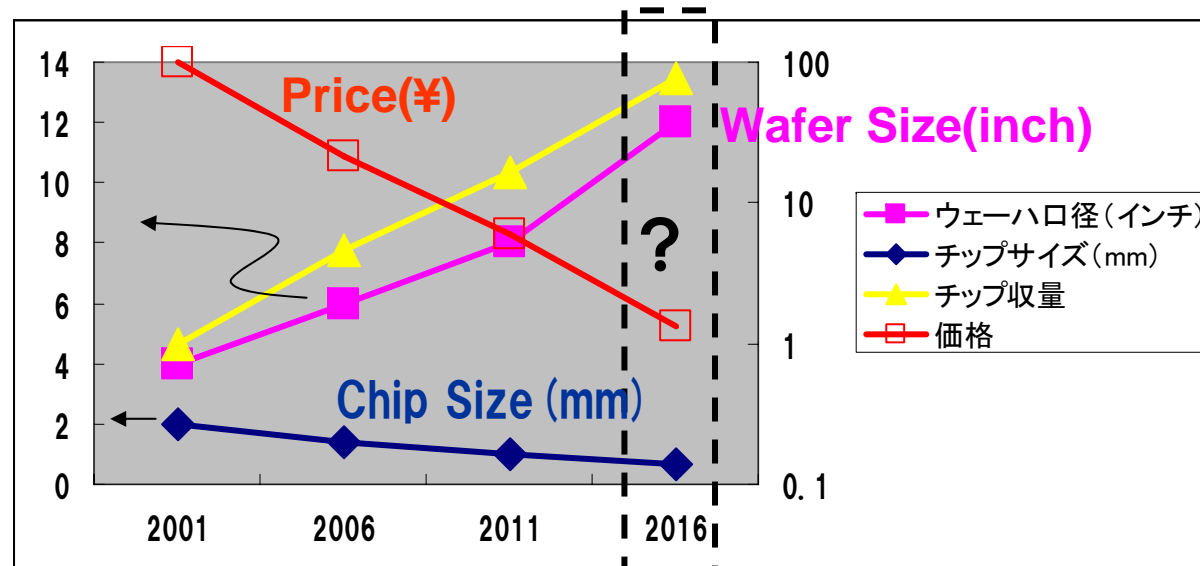
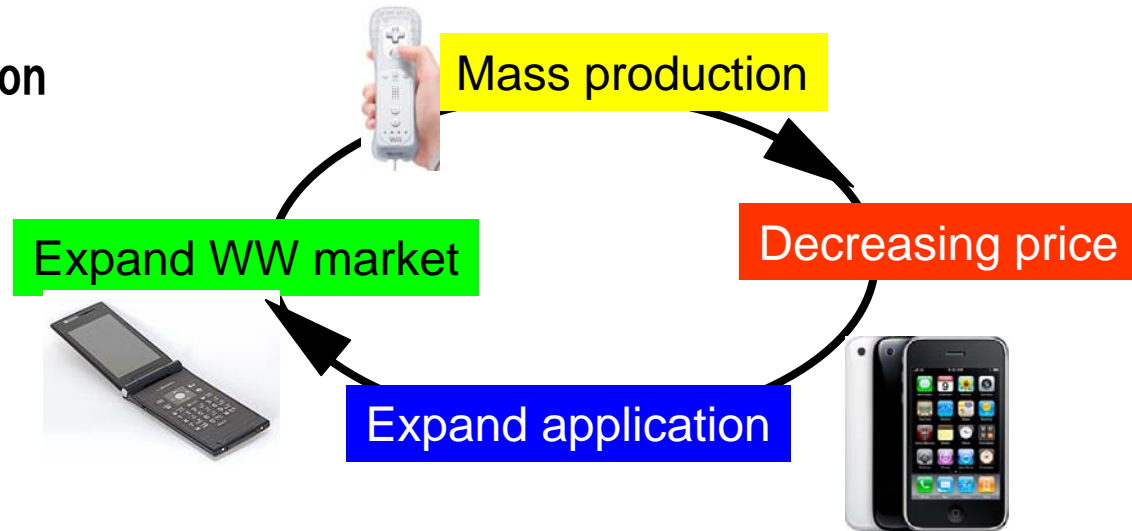
### Normalized numbers of P.O. to DNP (@2003 PO as 1)



Compared with 6" and 8", 8" P.O. numbers are increasing rapidly after CY2009. Especially, P.O. numbers in 2010 are 3 times higher than that in 2009.

## MEMS huge market coming on

- 3 axis accelerometer
- 3 axis gyroscope
- Silicon microphone



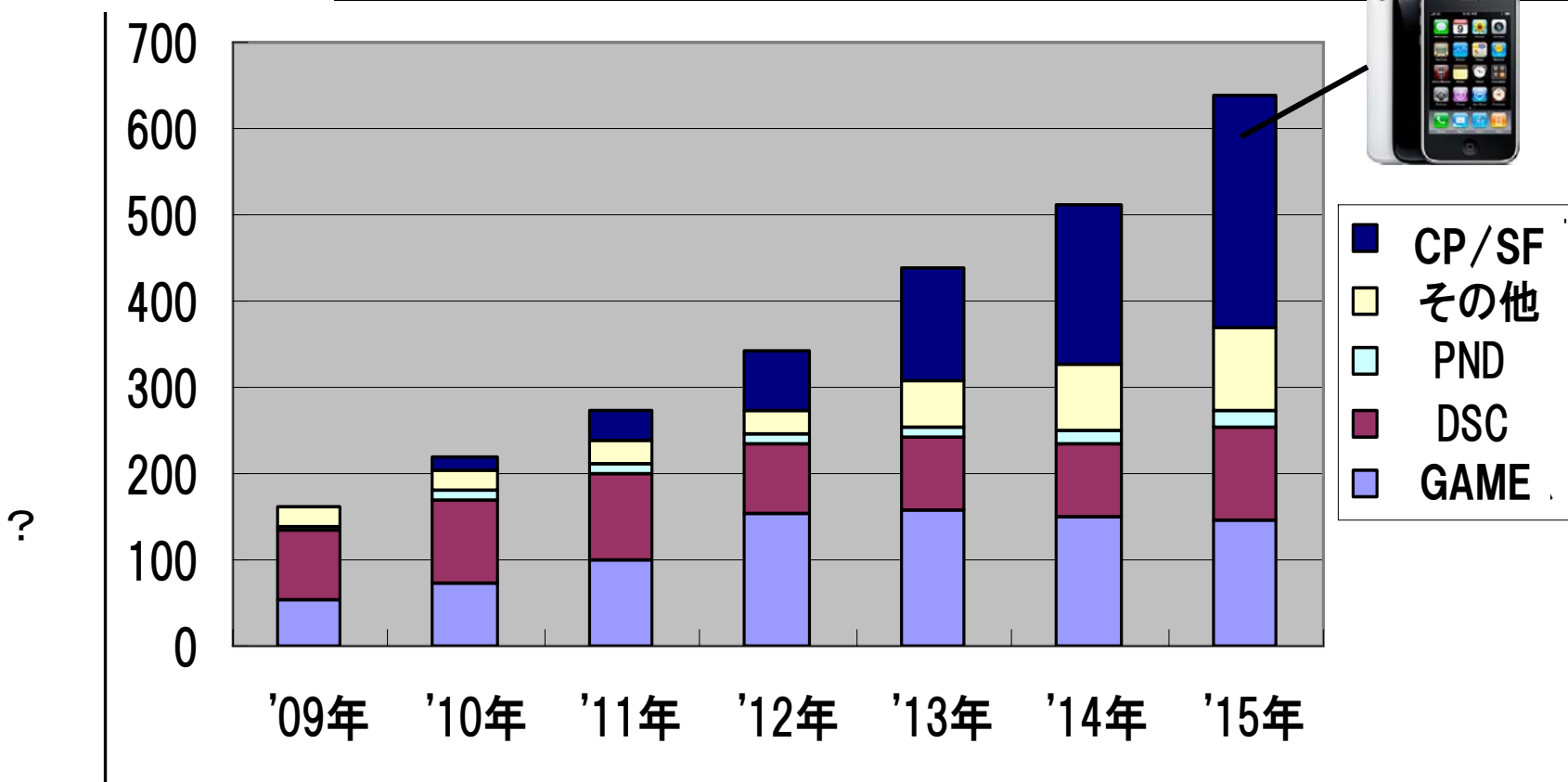
MEMS volume application has come.

Cost reduction and higher quality push using larger wafer and shrinking chip size.

**MEMS** huge market coming on

### WW Gyroscope Market

Million Pieces



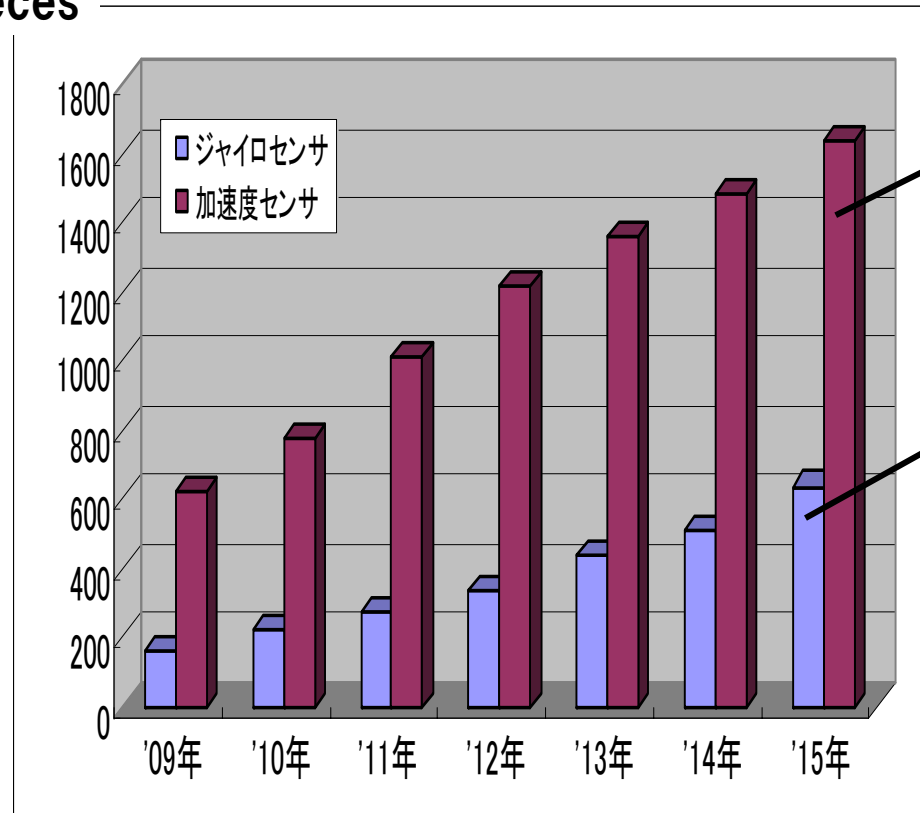
**MEMS Gyroscope Market will be expanded by Smart Phone application.  
In 2015, Smart Phone application will occupy over 40% market.**

Source by YOLE

### MEMS huge market coming on

#### Motion sensor Market

Million Pieces



ACC



Gyro



?

**MEMS motion sensor market will be continuously being expanded to 2015.  
Mass production for MEMS motion sensors are needed Large Scale Wafer Fabs.**

Source by YOLE



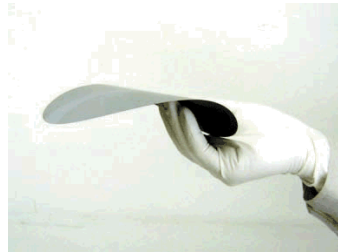
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## Issues of the Large Scale Wafer Production

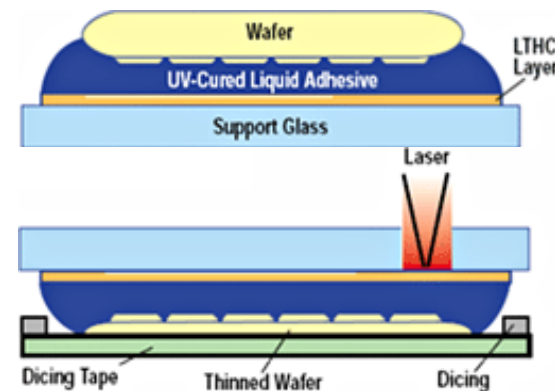
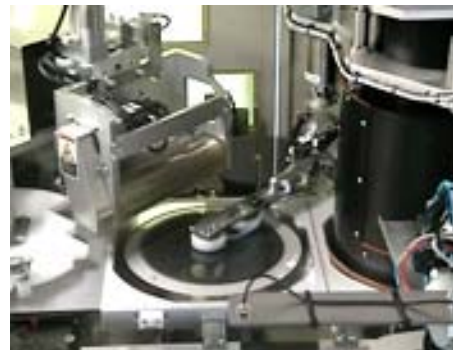
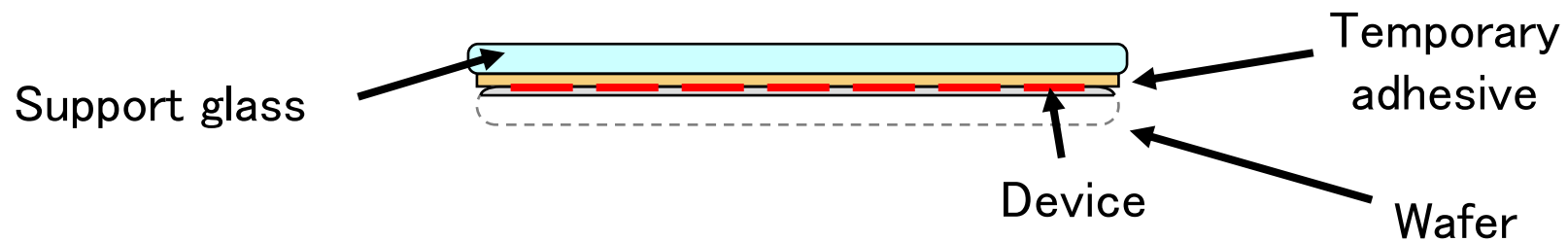
- **Thinned wafer handling => Wafer Support System**
- **SOI wafer cost and quality => SOI wafer supplier**
- **Film stress effect => Stress control process**
- **DRIE uniformity within wafer => Equipment vender**
- **Wafer level packaging process => Large scale wafer bonder**

## Wafer support system



Thinned down to 20 $\mu$ m

Support glass: for thinned wafer handling

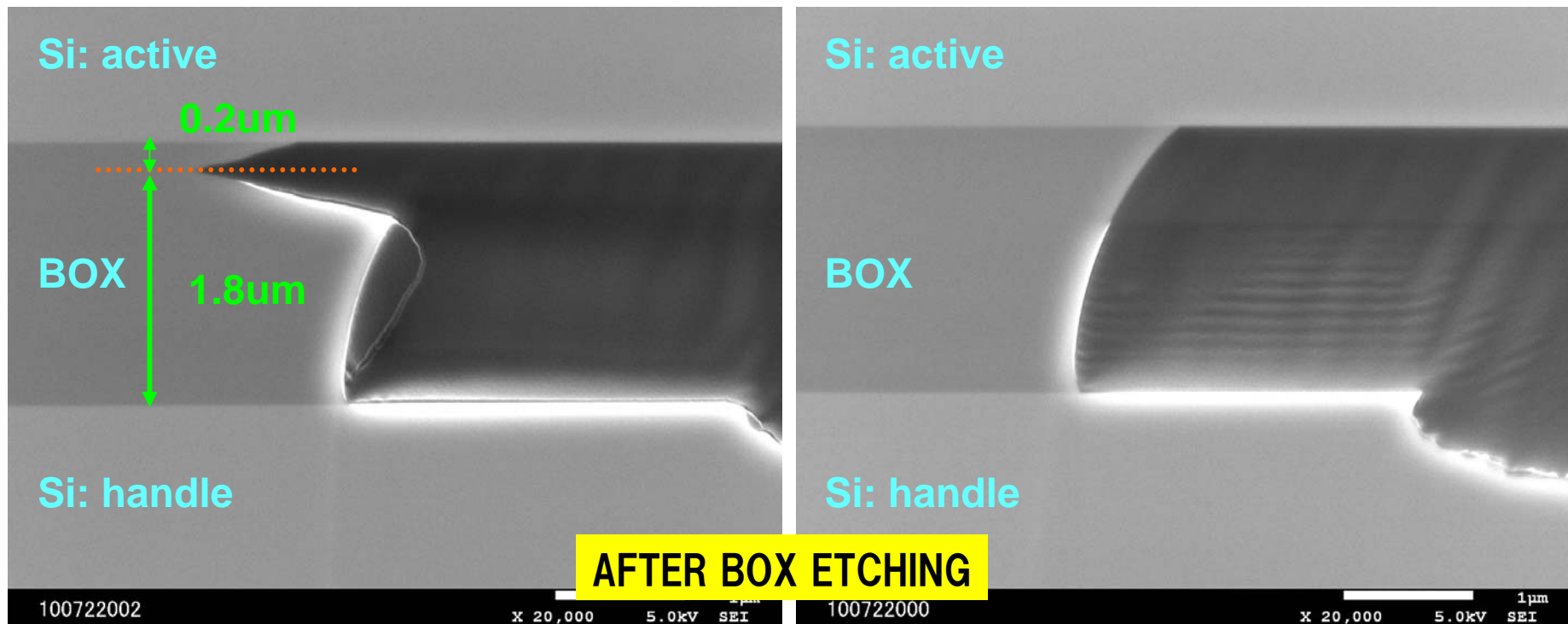


3M

## 8"SOI wafer problem

**Supplier A : No good**

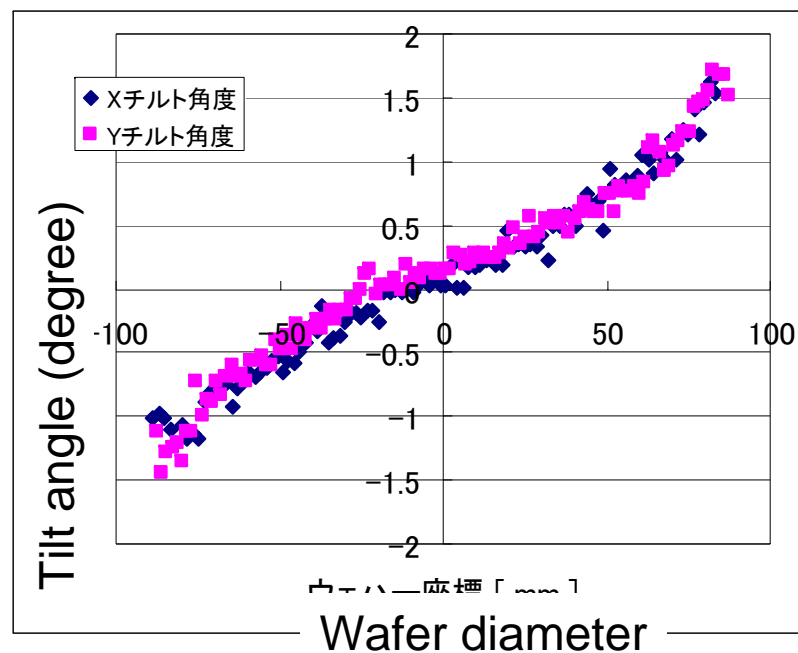
**Supplier B : good**



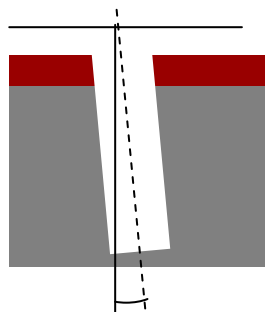
It was caused by a bonding process between active wafer and handle wafer.

# DRIE Tilt Problem

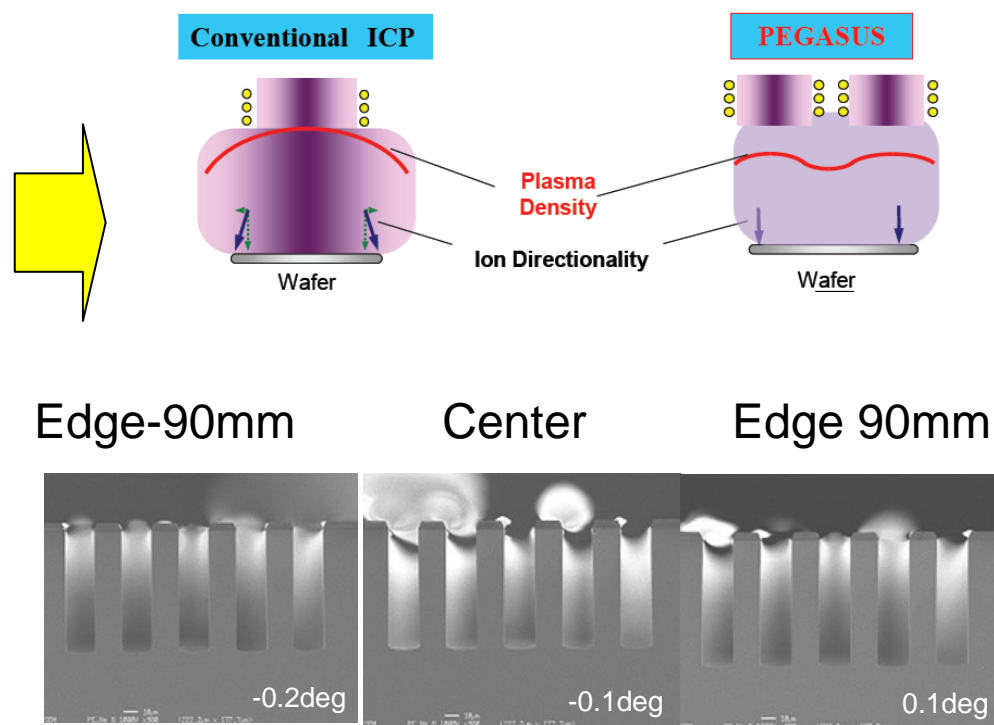
Old Process



Tilt angle

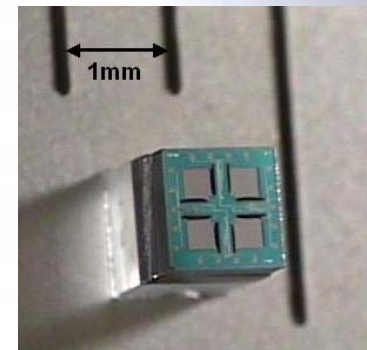
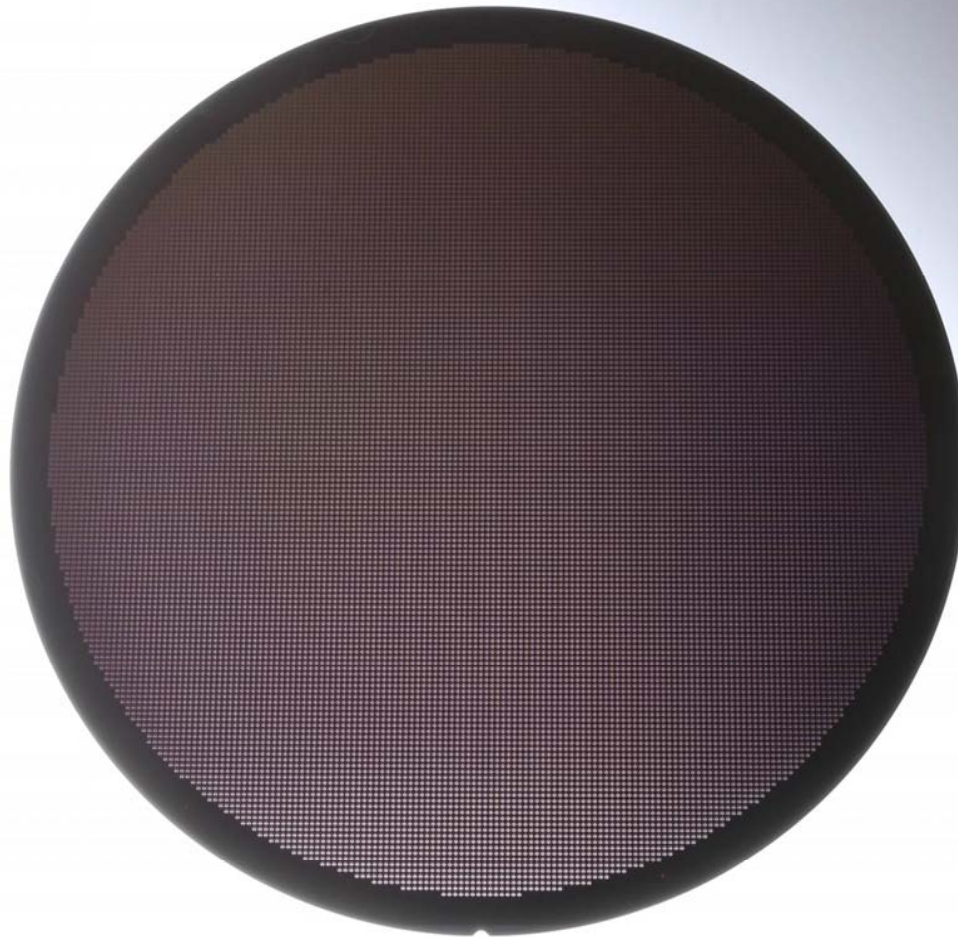


New Process



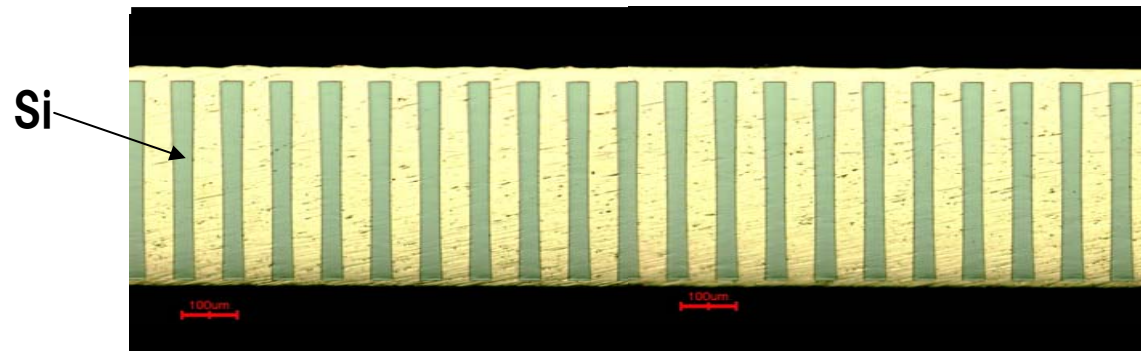
Tilt angle < 0.5 degree

## Piezo resistive 3 axis accelerometer with using 8inch SOI wafer

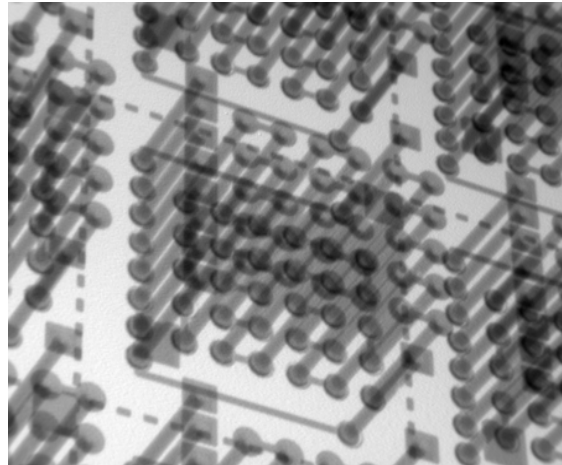


**Chip Size: 0.92mm $\square$ 、•Chip numbers: over 20kp/w**  
**Cost effective process even if commodities market.**

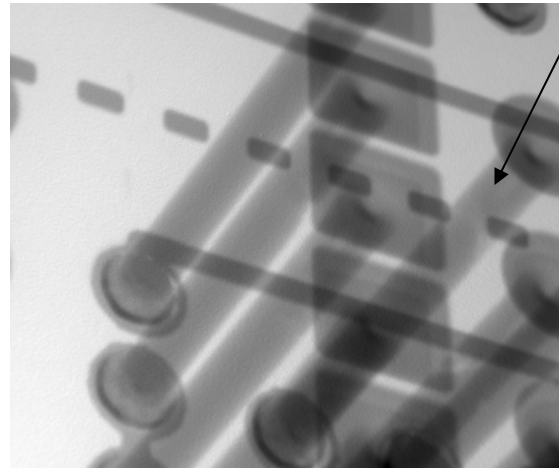
## Cross-Section for interposer with TSV



Polished Cross-Section



X-Ray CT Image

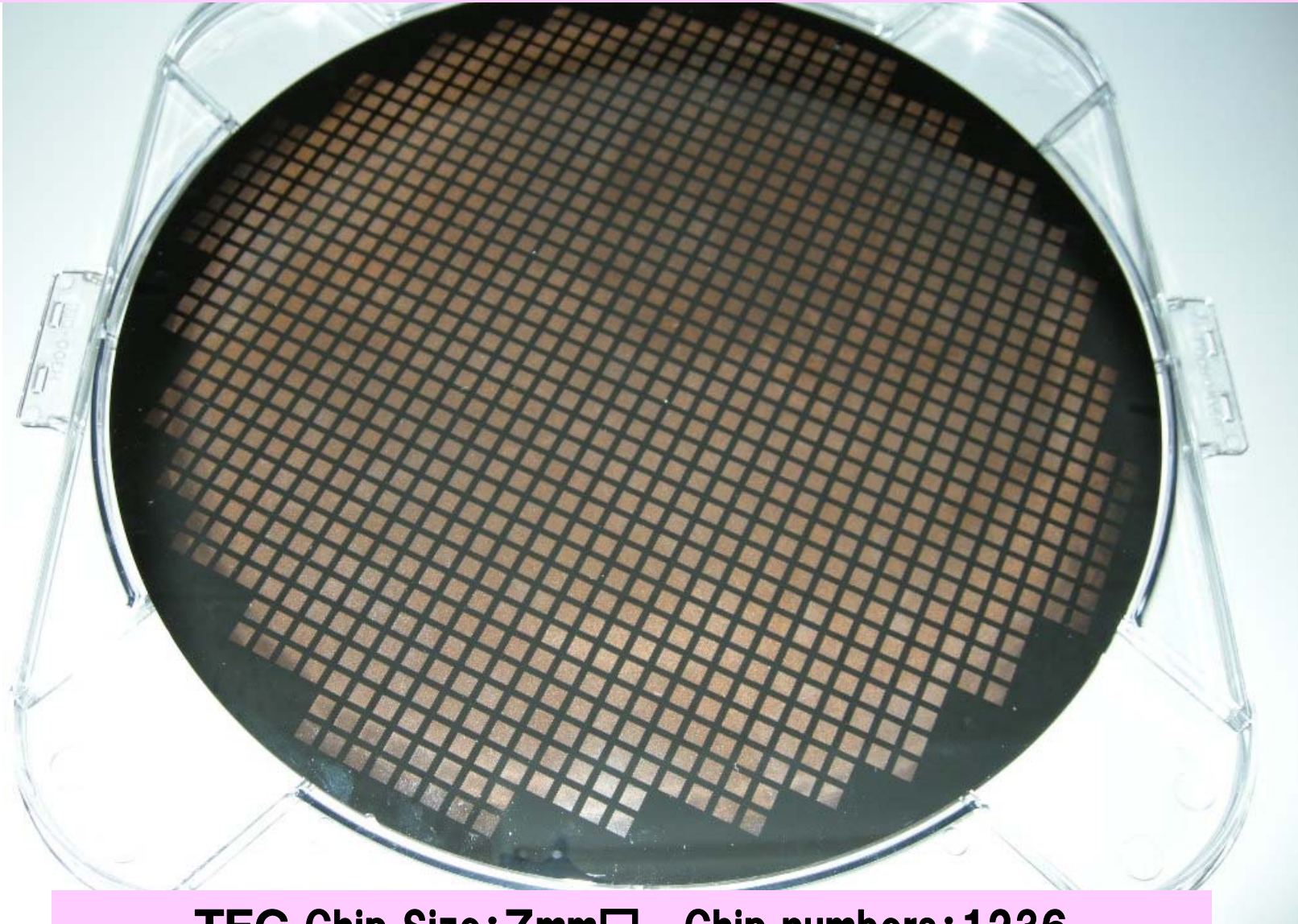


TSV filled with Cu

**No Voids or Cracks**

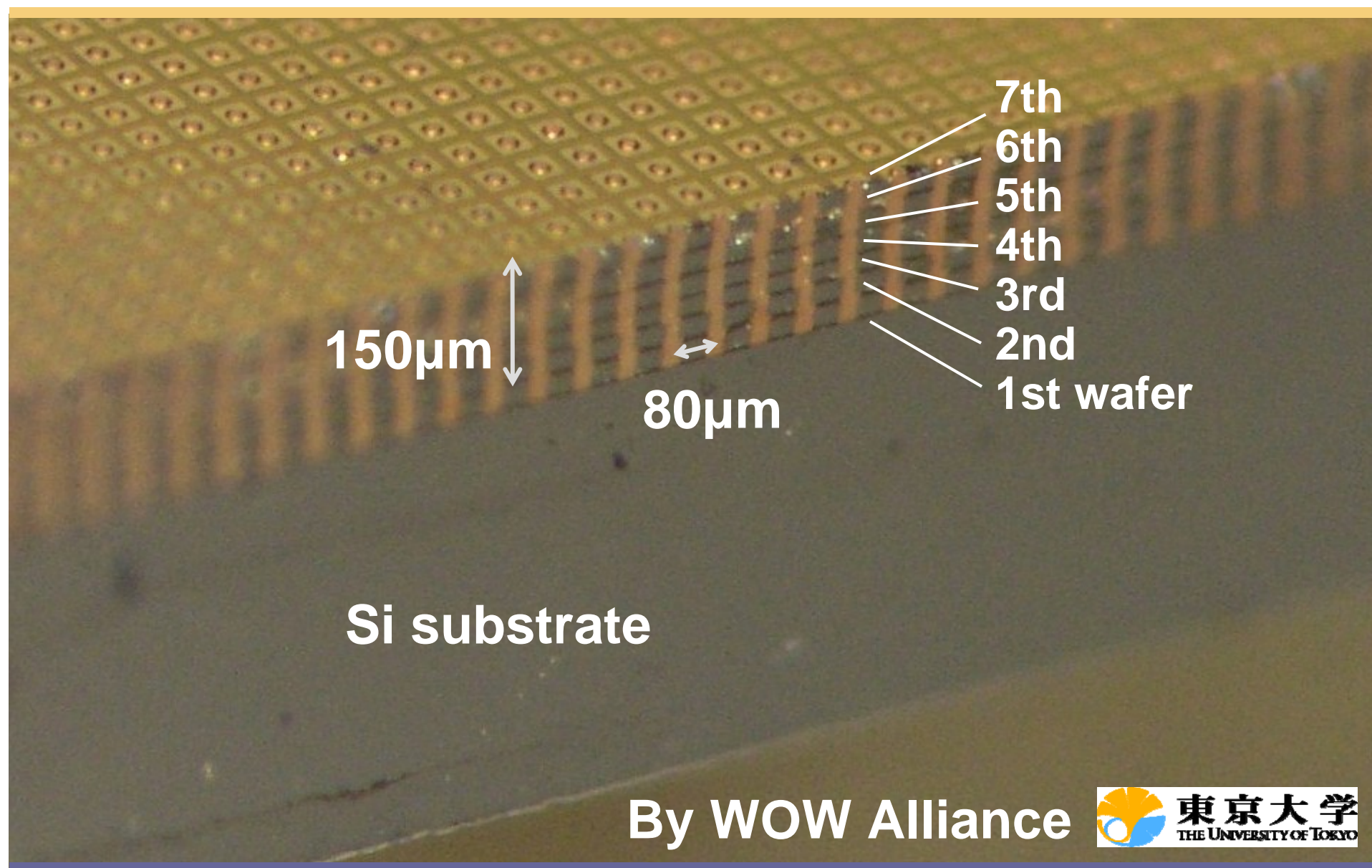


**TSV interposa TEG sample with using 12 inch 500  $\mu$  thickness wafer**



**TEG Chip Size: 7mm $\square$ 、 Chip numbers: 1236**

## Thinned 7-wafer Stack application with using 8"TSV technology

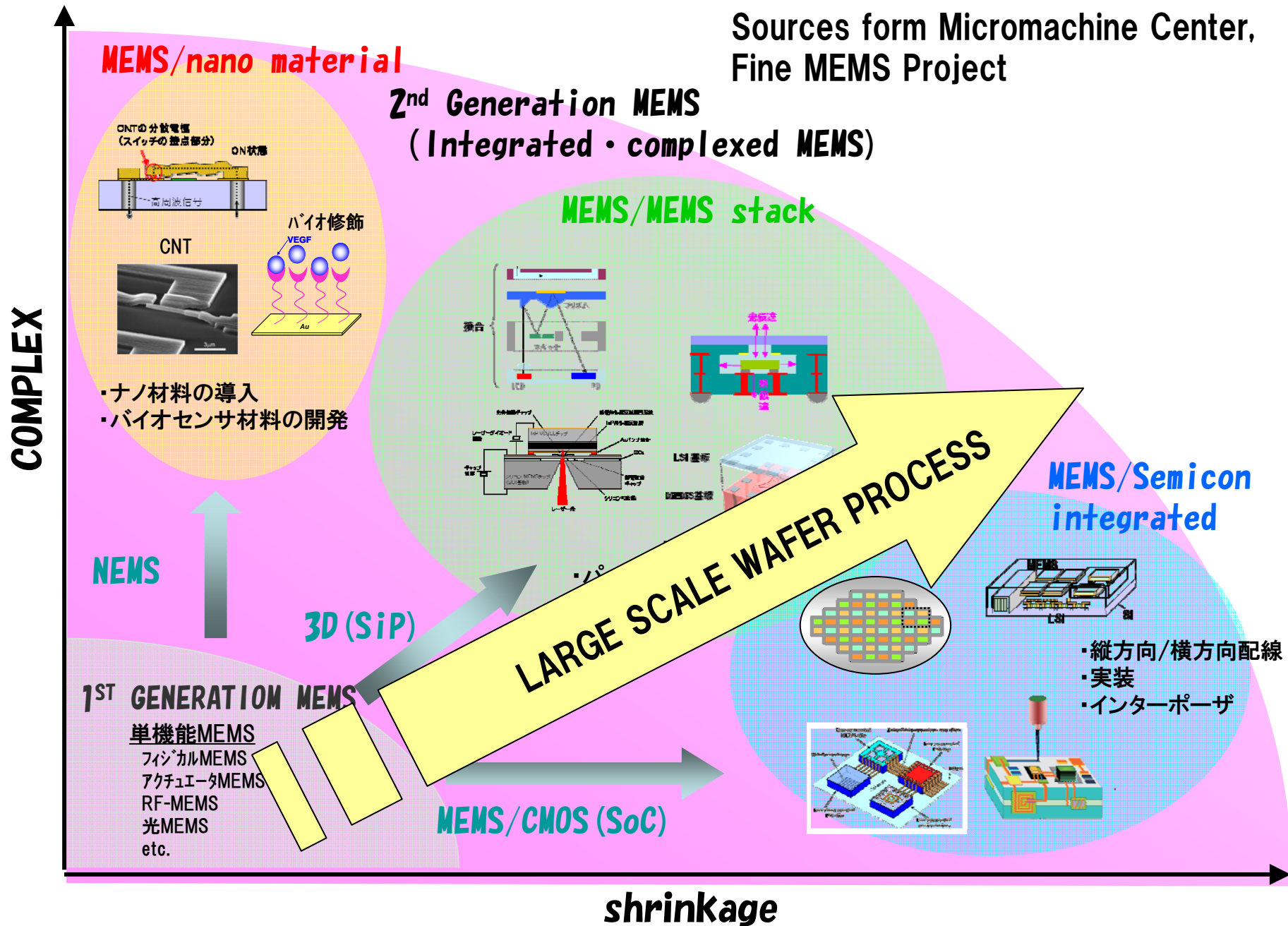


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Sources form Micromachine Center,  
Fine MEMS Project



Gdevice @BEANS

NEDO委託:異分野融合型次世代デバイス製造技術 (BEANS)

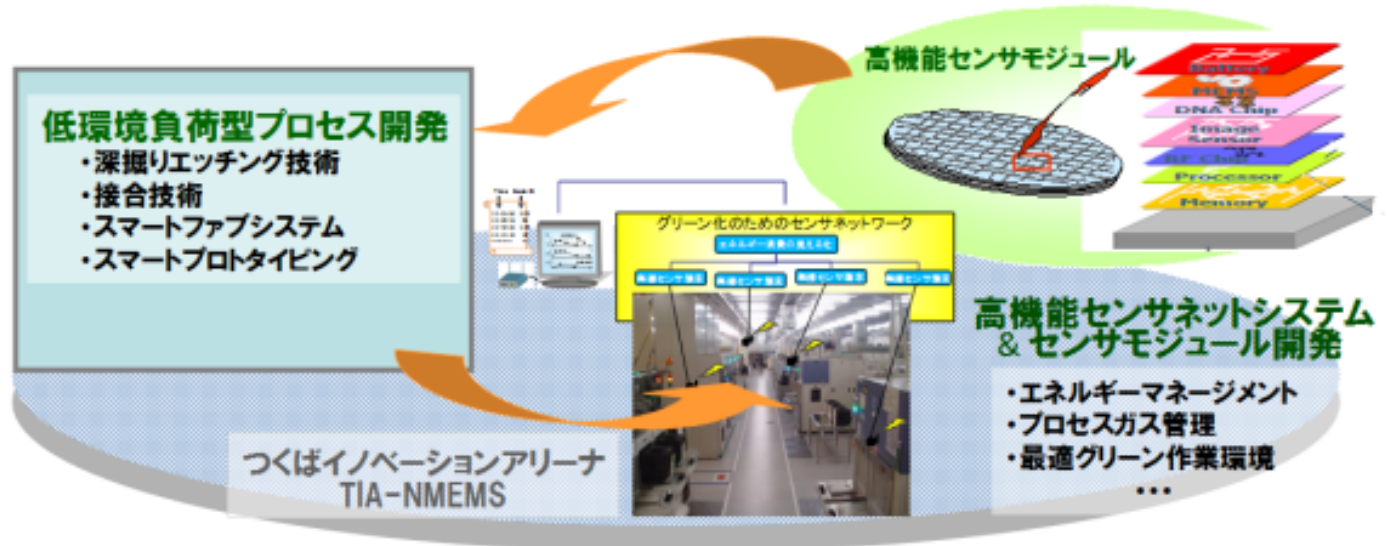
## 高機能センサネットワークシステムと低環境負荷型プロセス

## 1. 高機能センサネットワークシステム開発:

- ・大口径MEMS用クリーンルームにおける消費エネルギー、温度、圧力、風量、異物粒子、ガスなどをセンシング。省エネルギー、低炭素化などに関する効果を分析するための、センサネットワークシステムを試作。
- ・高機能集積化センサチップの開発に向け、ワイヤレス通信、エネルギーのワイヤレス自立、小型・薄型化、高感度センシング機能や新たなセンシング原理を開発。

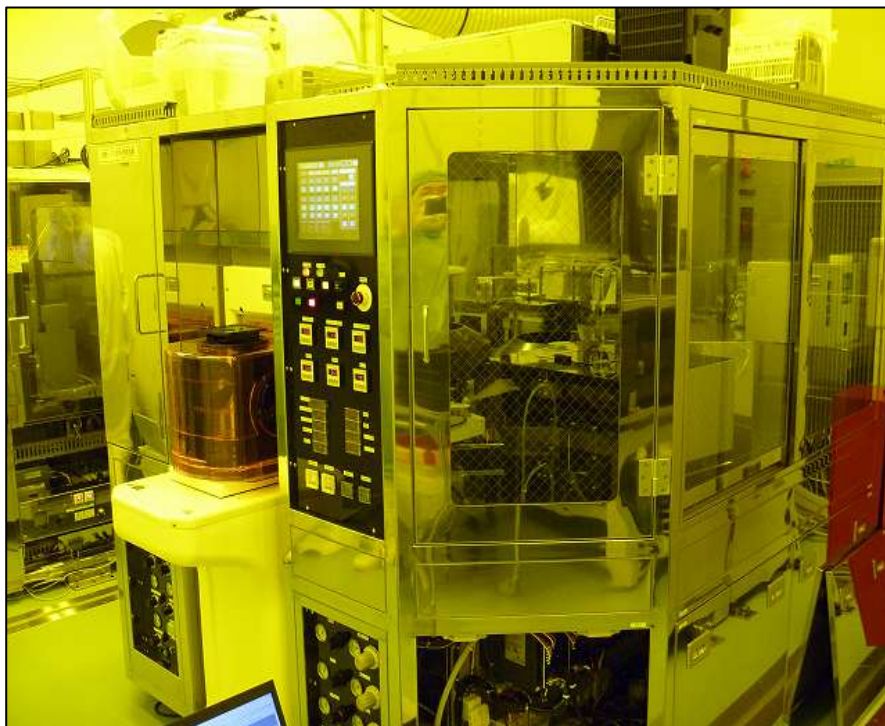
## 2. 低環境負荷型プロセス開発:

- ・シリコン貫通深掘り加工でのSF<sub>6</sub> から代替ガスなど環境負荷の小さい高効率なエッチングプロセス。
- ・様々な異種デバイスをウェハレベルで一括集積化・ポリマーMEMS化による環境負荷低減プロセス・デバイス。
- ・大口径TEGのデバイス・プロセス設計及び試作と設計・検査間の情報共有化、検査計測データを設計にフィードバックによる、歩留まり・品質、スループットの向上・デバイス設計時から環境負荷を考慮した情報共有化。



DNP joins G-device @BEANS Project .=&gt;200mm MEMS

AIST Microsystem program =&gt; 300mm TSV



JAPAN CREATE  
COATER/DEVELOPER

200, 300mm AUTO

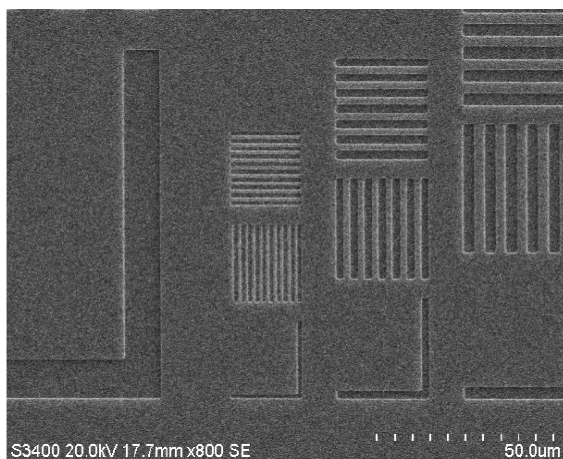




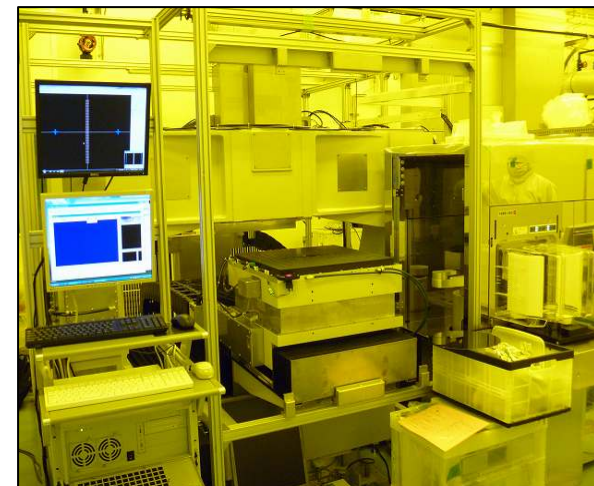
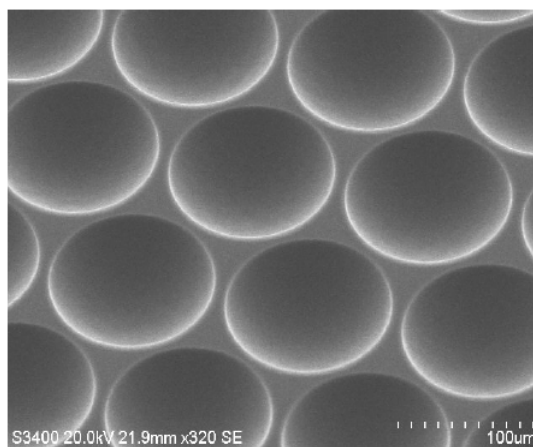
# Maskless lithography

TOSHIBA MACHINERY  
MASKLESS  
LITHOGRAPHY

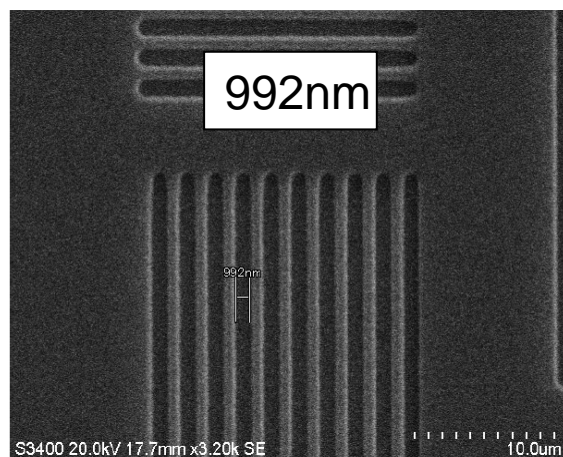
Resolution 1um



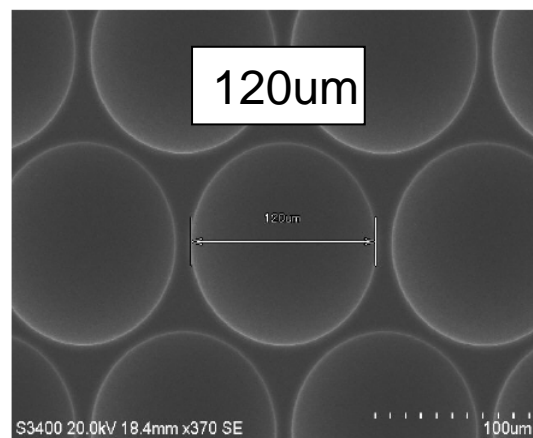
Grayscale lithography



992nm



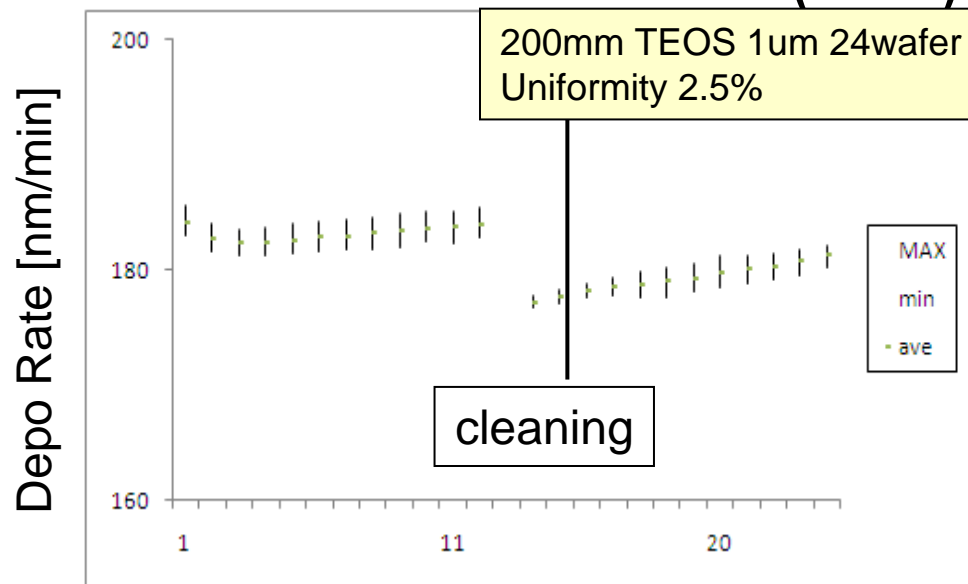
120um



500x500mm対応ステージ  
最小画素1  $\mu$ m  
DMDスキャニング方式  
グレースケール画像  
薄い透明基板にも対応  
~100  $\mu$ m以上のレジストに対応



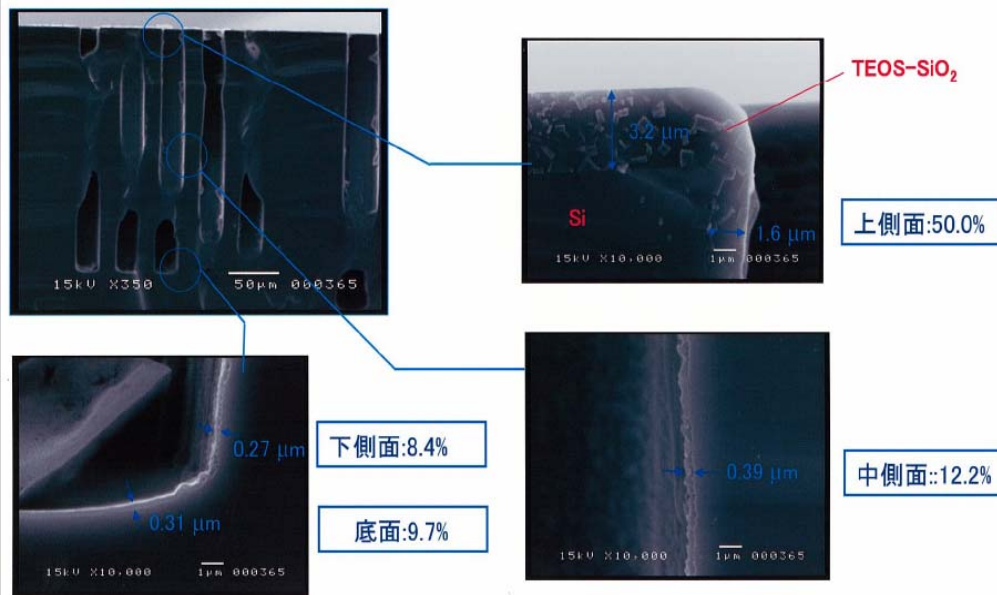
# PE-TEOS (CVD)



SUMCO PECVD  
PD-330STLC



アスペクト比11.3 (開口20  $\mu\text{m}$ , 深さ226  $\mu\text{m}$ )へのカバレッジ評価 (資料②)



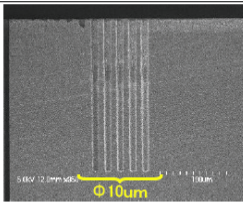
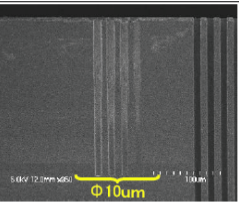
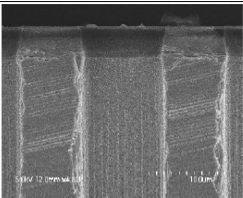
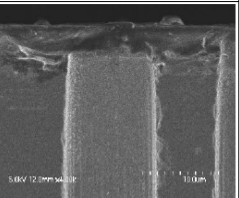
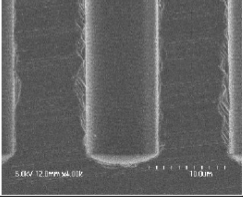
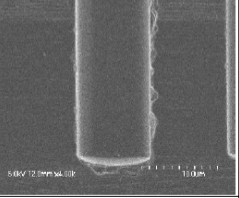
200, 300mm wafer  
< 200°C process

# STS DRIE Pegasus300

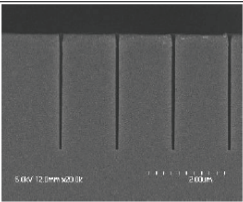
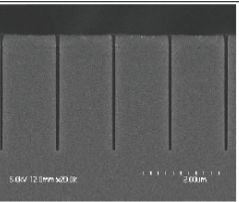
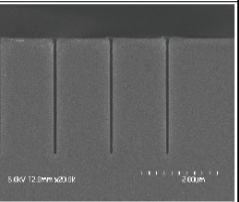
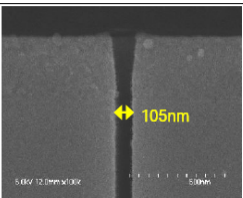
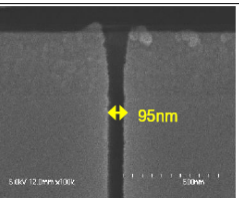
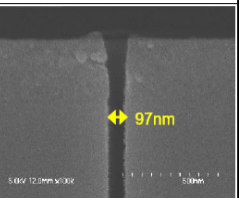
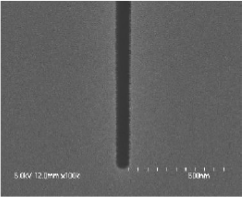
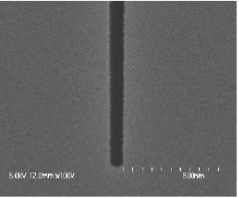
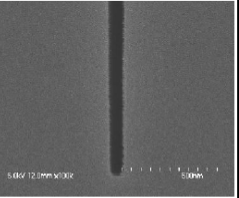


## DRIE300

10um Via, 低レート条件

	Center	Right
全体図		
エッチ深さ	208.7um	215.4um
エッチレート	3.0um/min.	3.1um/min.
	Center	Right
上部拡大図		
下部拡大図		
側壁角度	89.8°	89.8°
側壁荒さ	48nm	48nm
PR選択比	24	25

100nm trench, 3min  
etching

	パターン左端	パターン中央	パターン右端
全体図			
エッチ深さ	2.5um	2.5um	2.5um
エッチレート	0.8um/min.	0.8um/min.	0.8um/min.
	パターン左端	パターン中央	パターン右端
上部拡大図			
下部拡大図			
側壁角度	89.8°	89.8°	89.8°
側壁荒さ	~12nm	~8nm	~8nm
PR選択比	9	9	9

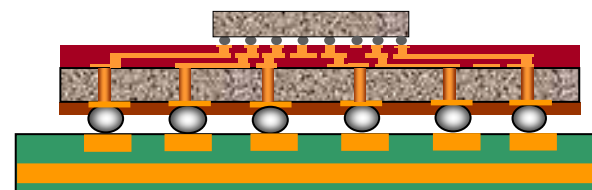


**UMEMSME**



300mmTSV interposa  
200mm Piezo MEMS

**INTERPOSER  
& PACKAGE**



**3D-LSI**

More than moore



**300mmMEMS  
SOCMEMS**



**DNP is developing 200,300mm Process for MEMS and TSV interposa.  
DNP supplies high quality and low cost processes for our costumers.**

**Thank you !**



Mt. Tsukuba