

MEMS

Mikro Elektro-Mekanik Sistemler

10 μ m

OSMAN SAYGINER

www.sayginer.com

17 Mart 2011

Sunum Planı

1. MEMS Nedir?

- 1a. MEMS Terminolojisi
- 1b. Ne kadar küçük?
- 1c. Nerelerde kullanılır?
- 1d. Hareket ilkeleri

2. Uygulama Alanları

- 2a. İvme ve hareket algılama
- 2b. Akışkanlarda basınç algılama
- 2c. Optik ayna ve mekanik anahtar uygulamaları
- 2d. Mikromotorlar
- 2e. BioMEMS Uygulamaları

3. Üretim Teknikleri

- 3a. Kullanılan malzemeler
- 3b. Üretim örneği

4. Üretim ve Satış Oranları

5. Genel MEMS Resimleri

6. MEMS Tanıtım Videoları

7. Kaynaklar

MEMS Nedir?

□ Micro Electro Mechanical Systems

□ MEMS, mikron-milimetre ölçeğinde elektronik tümdevre (chip) üretimine benzer şekilde silikon bir taban üzerinde inşa edilen her türlü hareketli ve kompleks mekanik yapıları içermektedir.

□ MEMS yapılar tümdevre (chip) içersinde elektronik devrelerle birlikte kullanılmaktadır. Böylece algılanan büyüklük elektriksel veriye anında dönüştürülerek işlenebilmektedir.

ASI 10.0kV 12.5mm x5.00k SE(M)

10.0um

Neden MEMS – MEMS'in Avantajları ?

- Hızlı çalışma ve tepki süresi
- Seri Üretime uygunluk
- Ucuz maliyet
- Üretim kolaylığı
- Düşük enerji gereksinimi
- Küçük ve hafif boyutlar
- Güvenilirlik

Dünyada MEMS Terminolojileri

- MEMS (ABD)
- Micro Systems Technology (MST) (Avrupa)
- Micromachines (Japonya)
- Silicon Micromachining
- Microsensors, microactuators
- Solid-State Sensors

Ne kadar küçük?

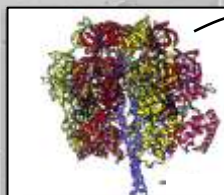


Dust mite
→
200 μm

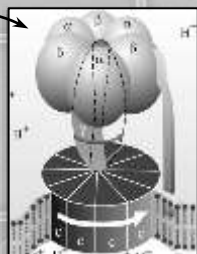


Human hair
~ 60-120 μm wide

Red blood cells
(~7-8 μm)



~10 nm diameter



ATP synthase



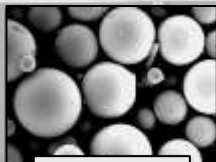
DNA
~2-1/2 nm diameter



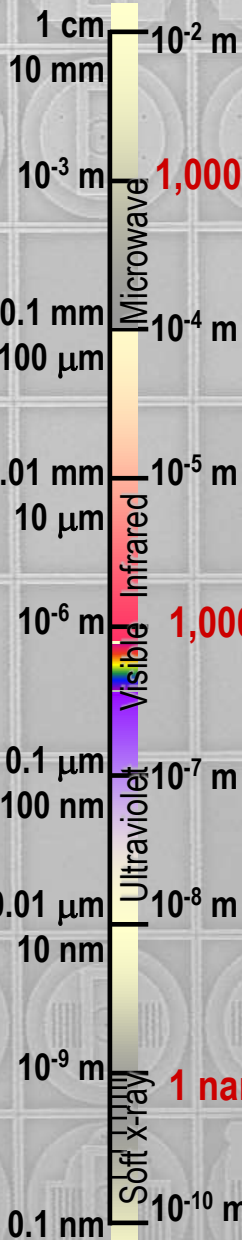
Atoms of silicon
spacing 0.078 nm



Ant
~ 5 mm



Fly ash
~ 10-20 μm



1,000,000 nanometers = 1 millimeter (mm)

1,000 nanometers = 1 micrometer (mm)

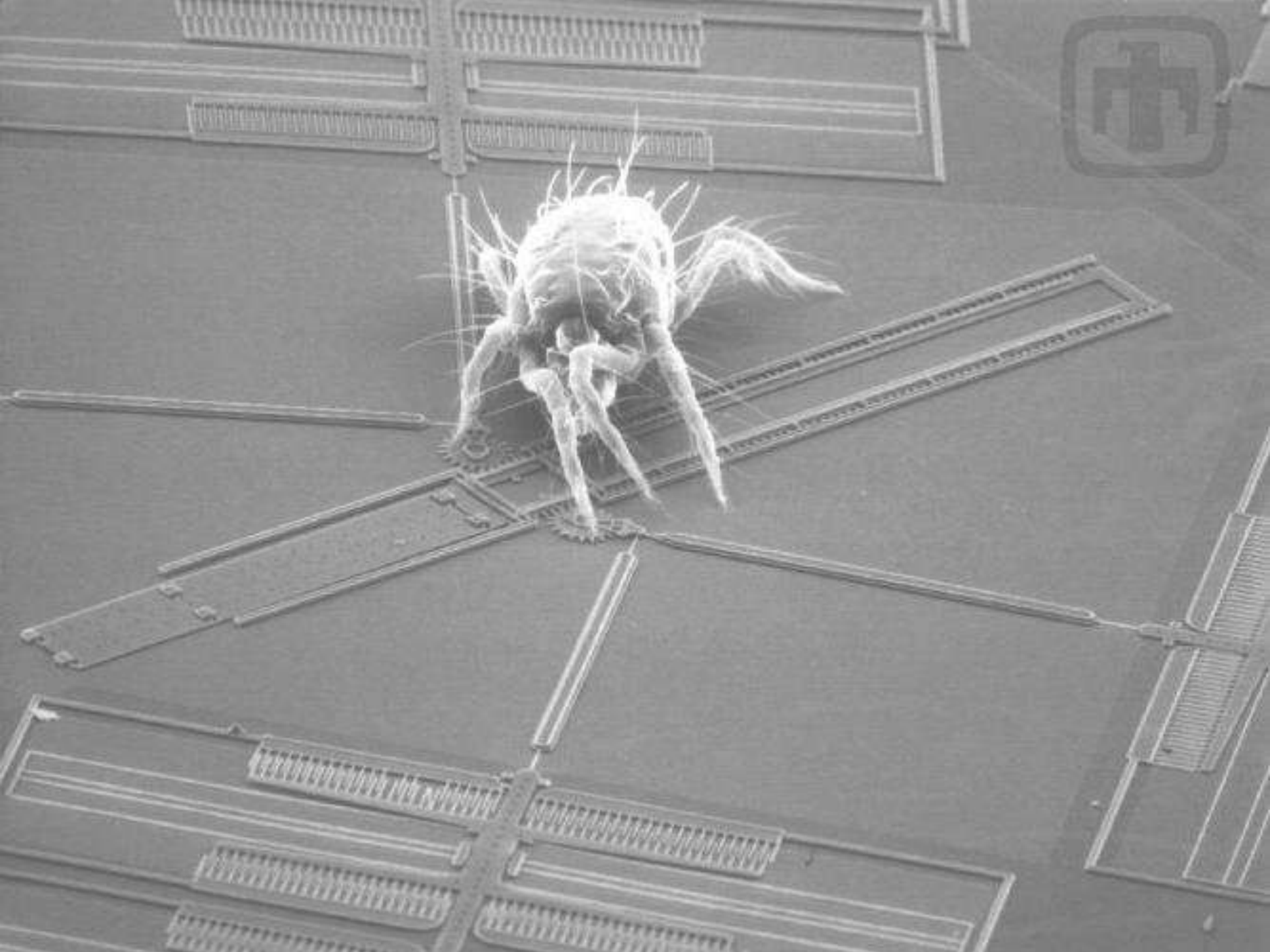
1 nanometer (nm)

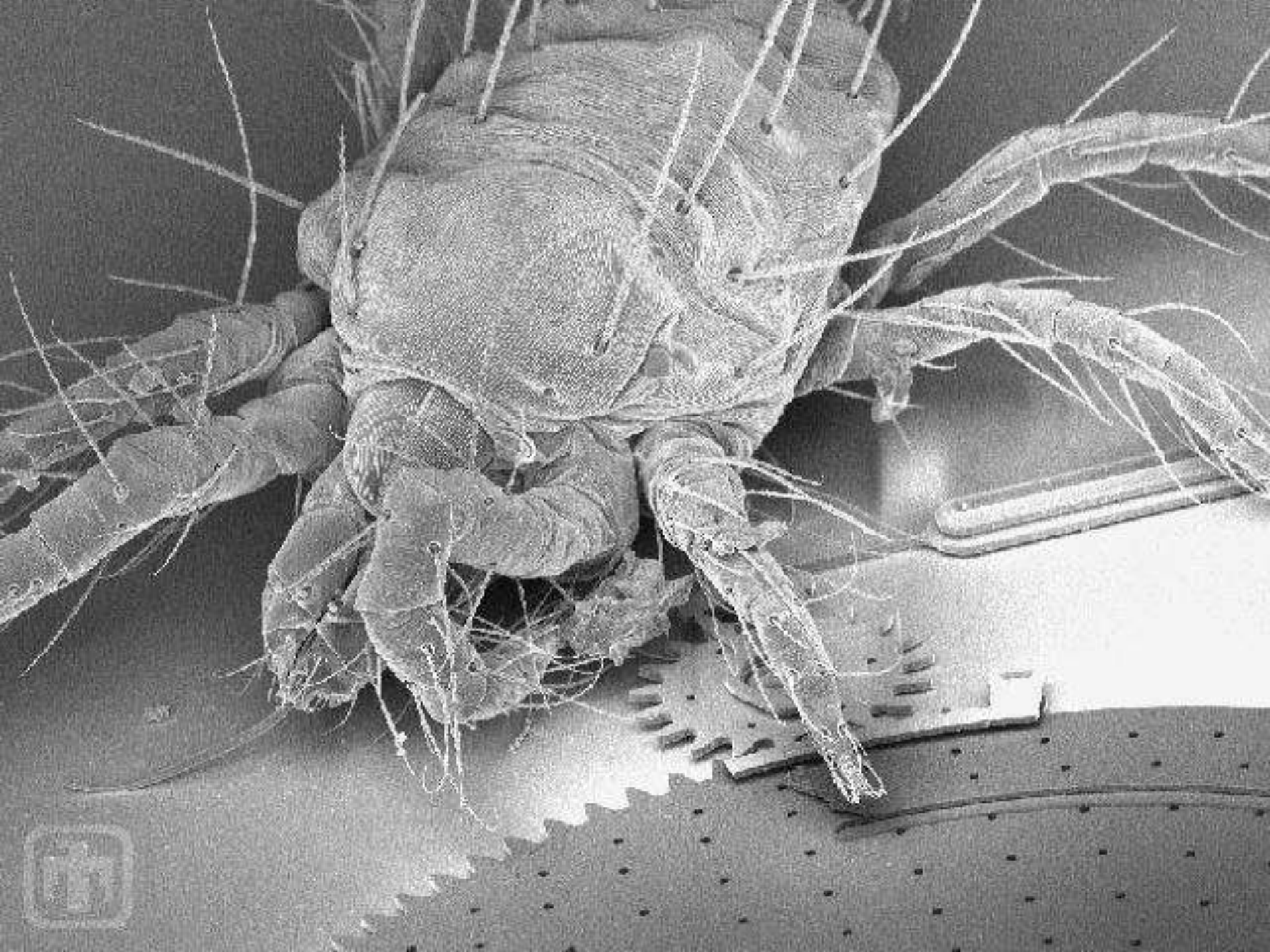


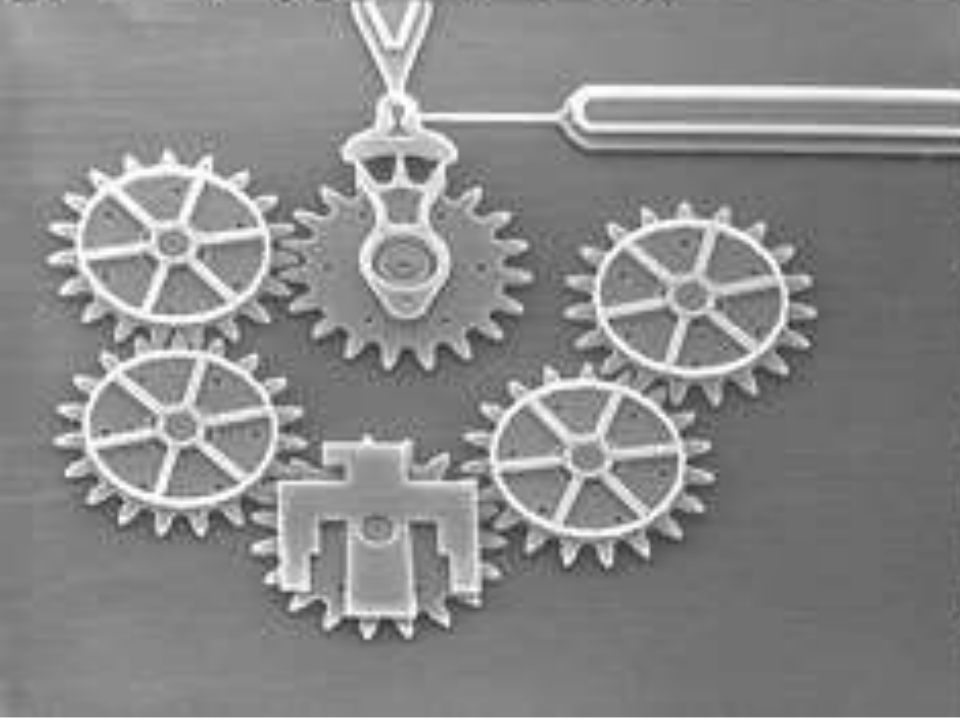
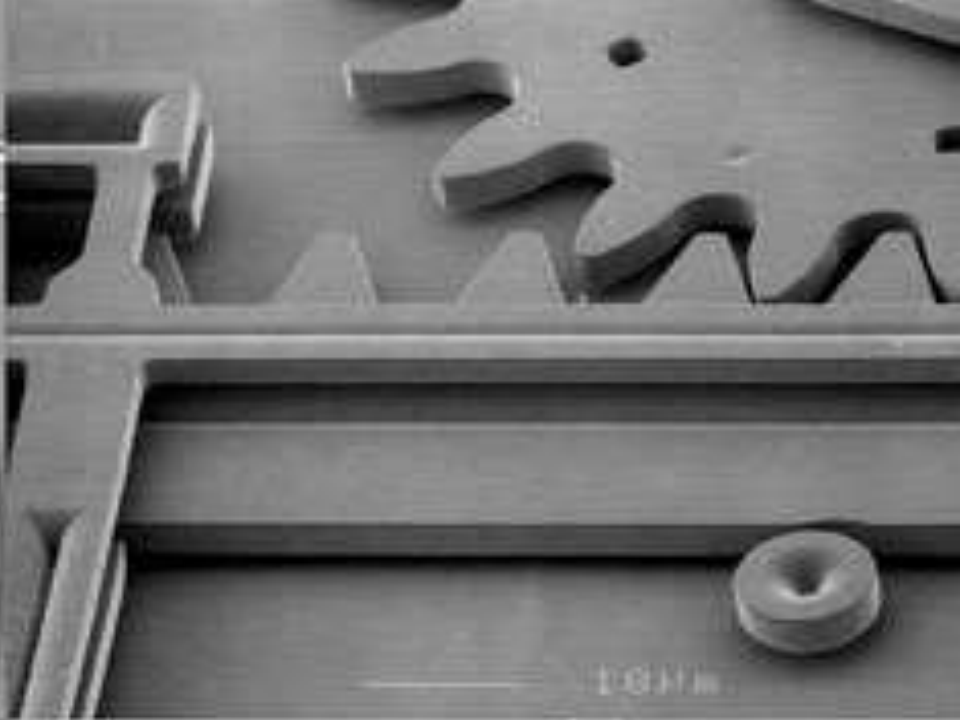
Head of a pin
1-2 mm

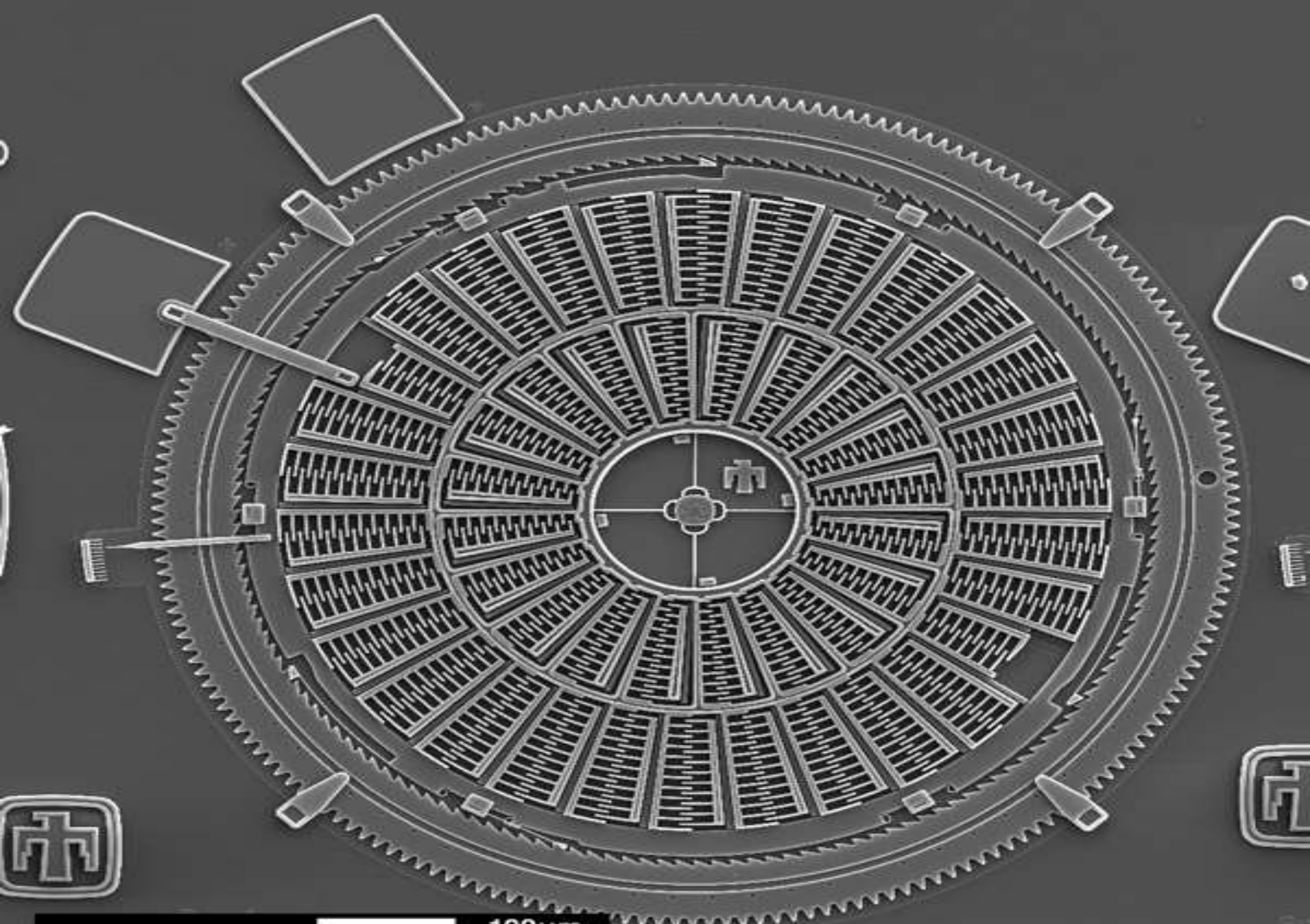
Micro-technology
"The Micro World"

Nanotechnology
"The Nano World"





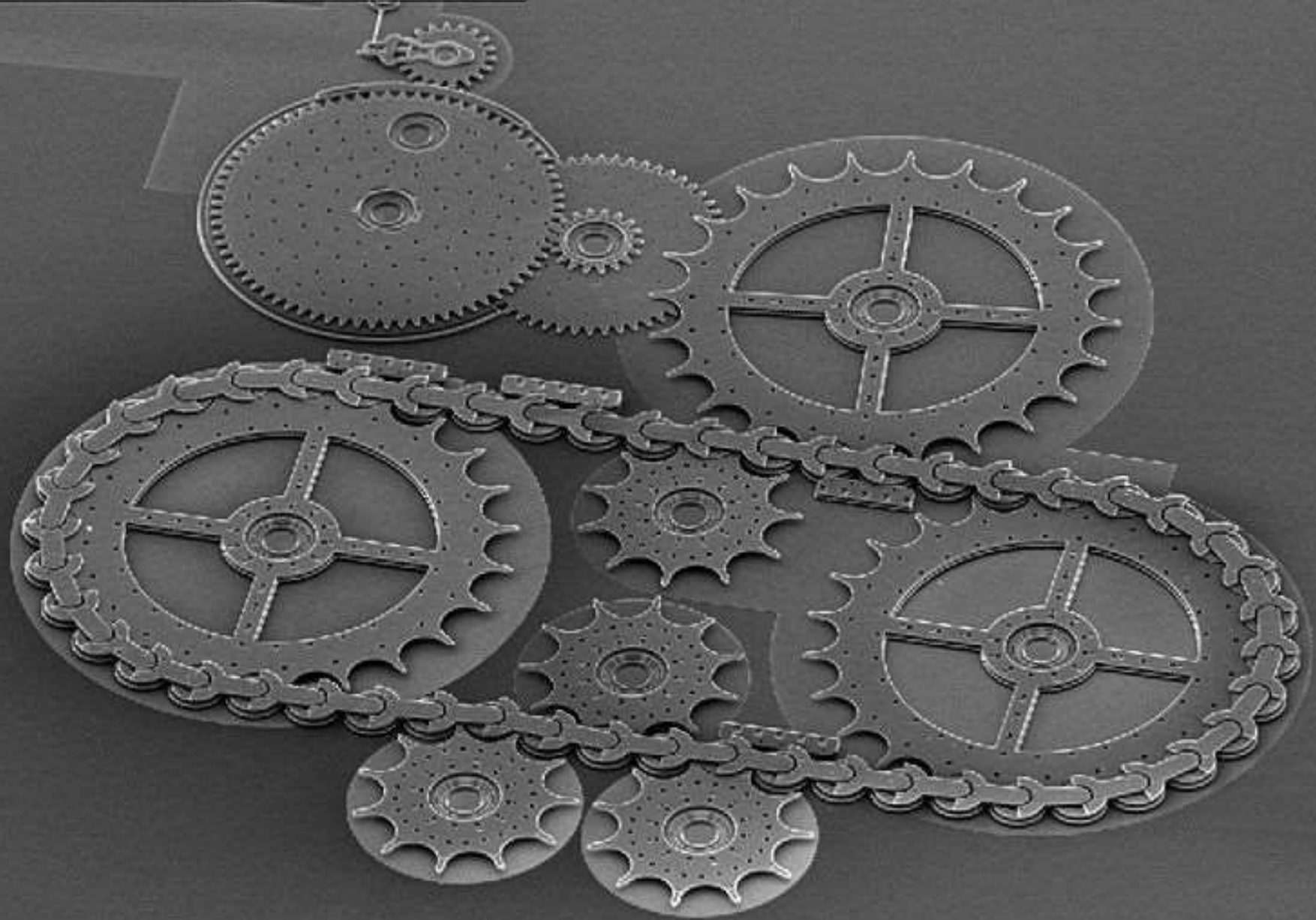


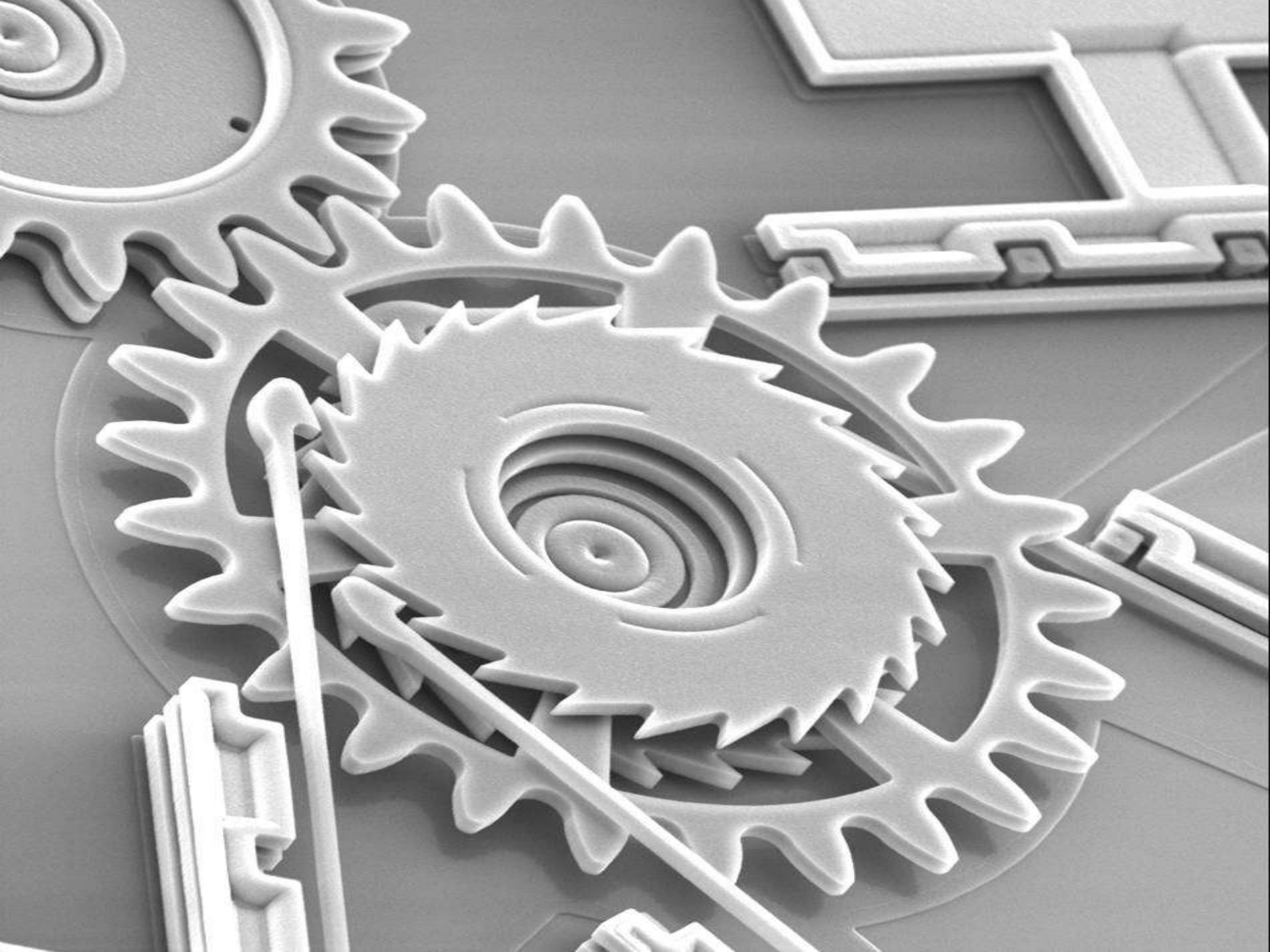


00041 os1949_011 20kV X95 15mm

100um

500µm





MEMS nerelerde kullanılır?

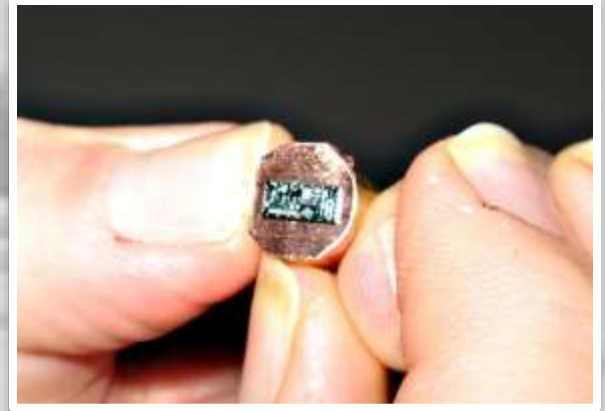
- Uçakların hızları ve ivmeleri nasıl ölçülür?
- Projeksiyon cihazı nasıl çalışır?
- Inkjet yazıcılar nasıl çalışır?
- Araç hava yastığı nasıl çalışır?
- Yeni nesil akıllı telefonlarda hareket nasıl algılanır?
- Tıpta kan tahlilleri nasıl gerçekleşir?

Spot 3	Mag 500 X	FWD 4.827	E-Beam 3.00 kV	Tilt 60.0°	Det SED	HFW 608 µm	100 µm
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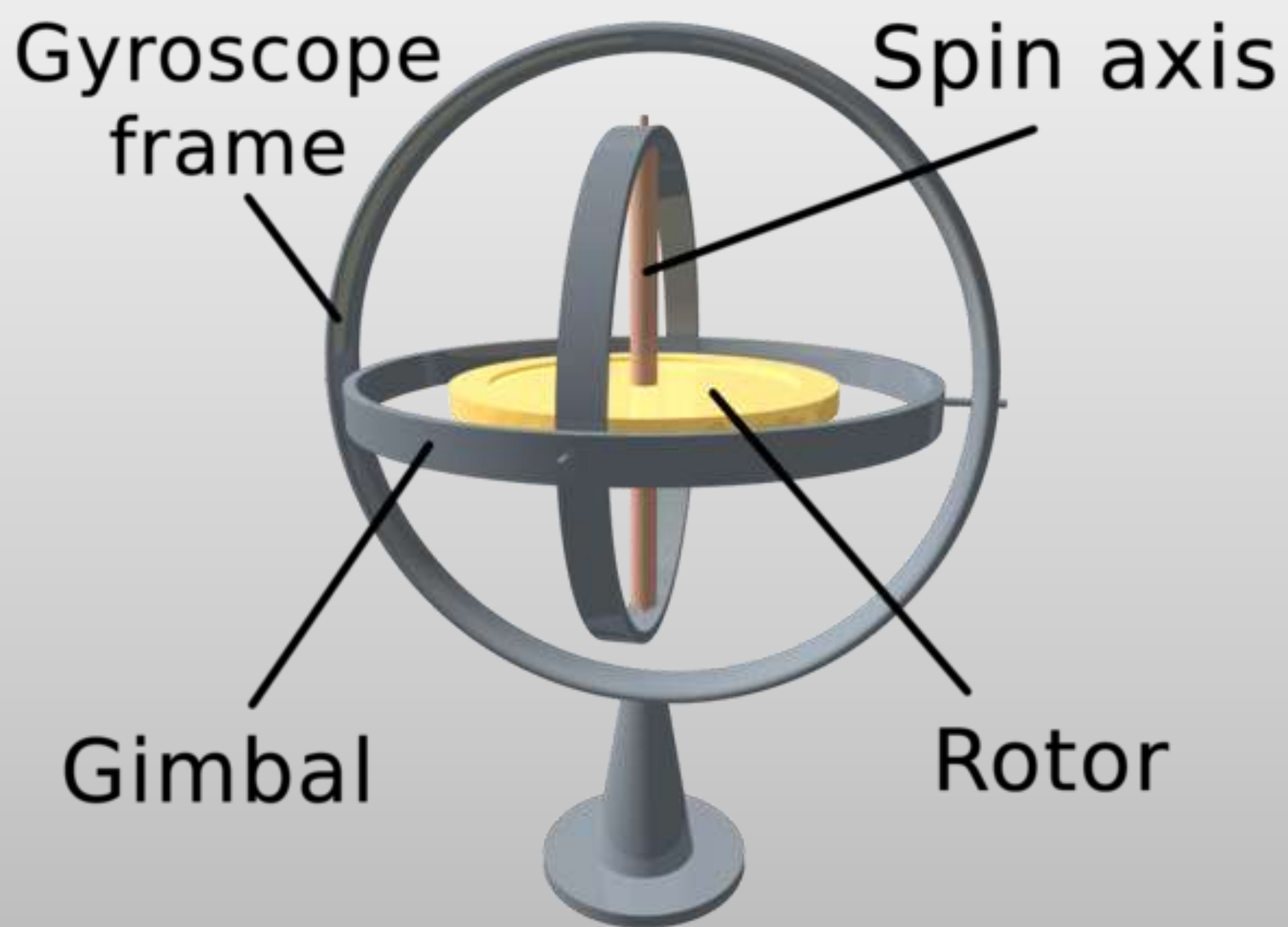
MEMS Uygulama Alanları

- İvme ve hareket algılama
- Akışkanlarda basınç algılama ve ölçümü
- Optik ayna ve mekanik anahtar uygulamaları
- Mikromotorlar
- BioMEMS uygulamaları

ivme ve hareket algılama



MEMS sistemleri kullanılarak ivme yönü ve şiddeti ölçülebilir.



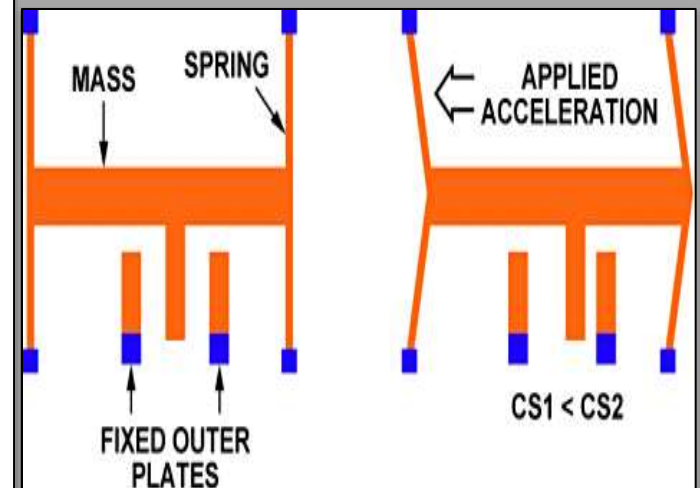
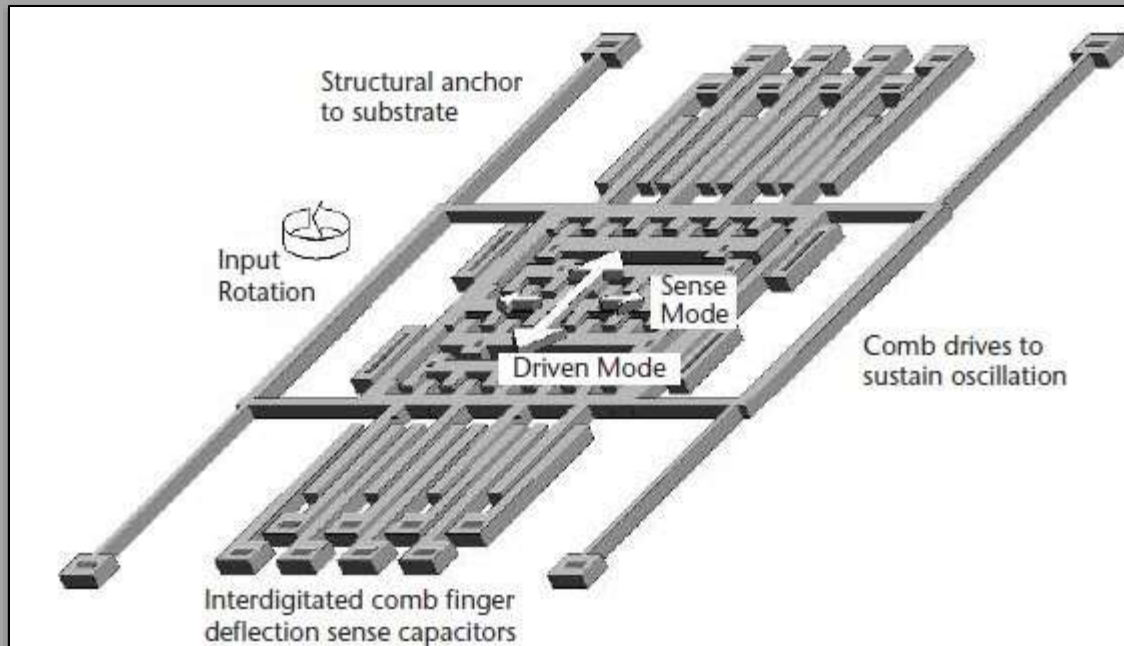
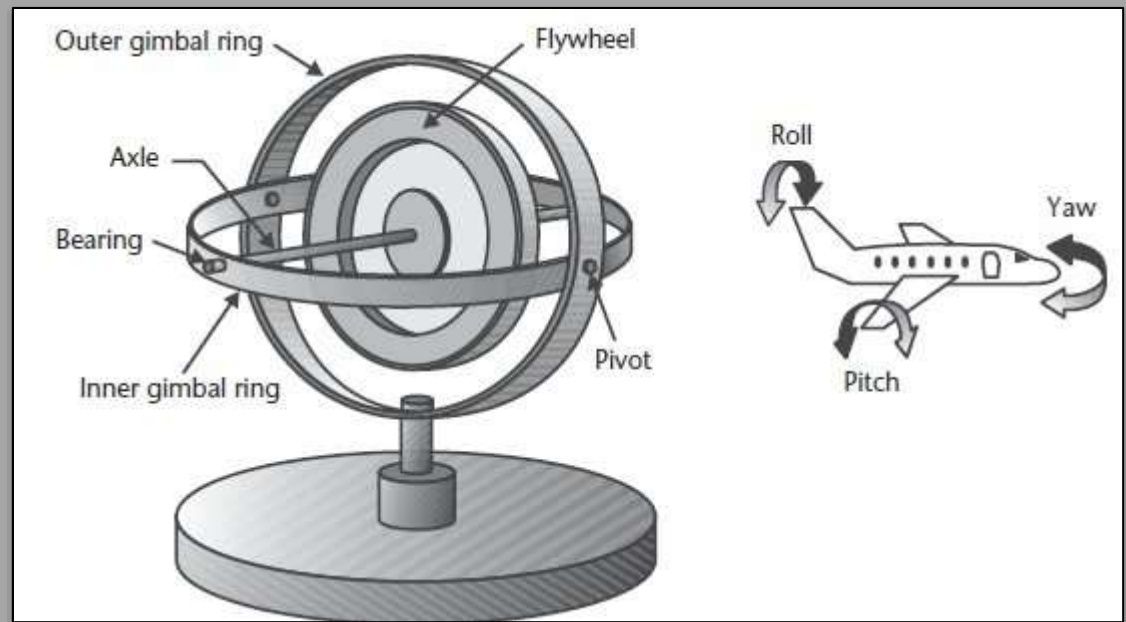
Gyroscope
frame

Spin axis

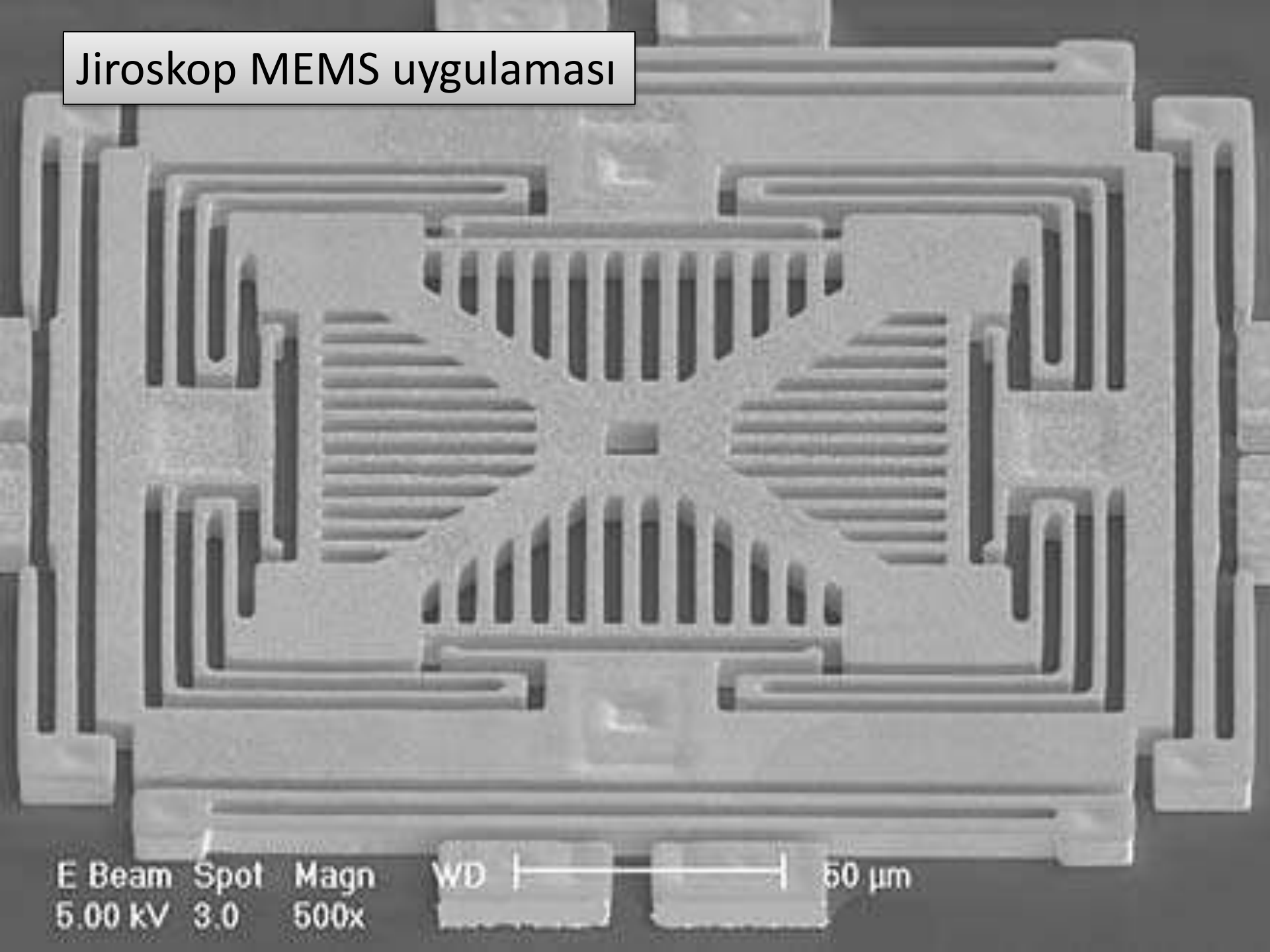
Gimbal

Rotor

Jiroskop'un MEMS uygulaması

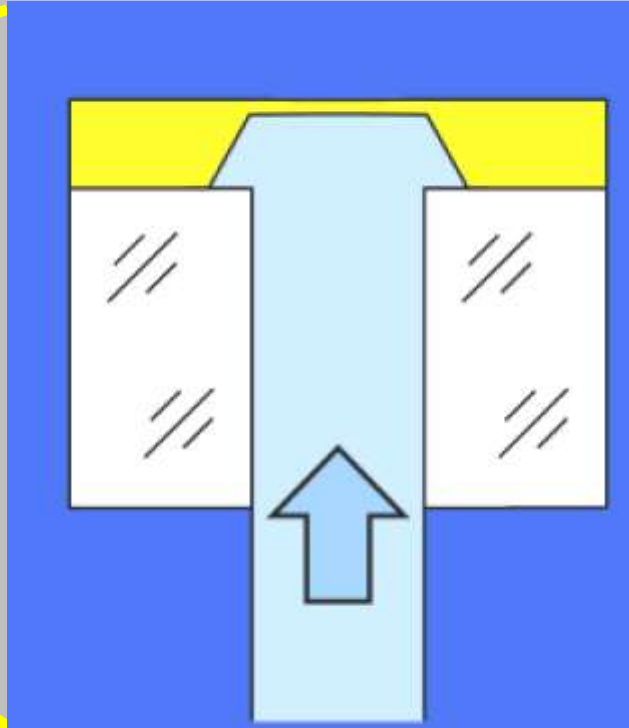
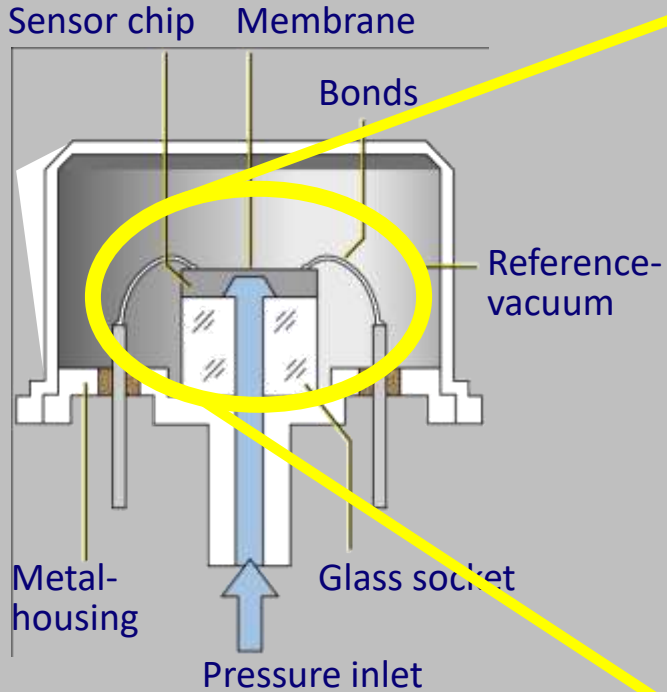


Jiroskop MEMS uygulaması



E Beam 5.00 kV Spot 3.0 Magn 500x WD |-----| 50 μ m

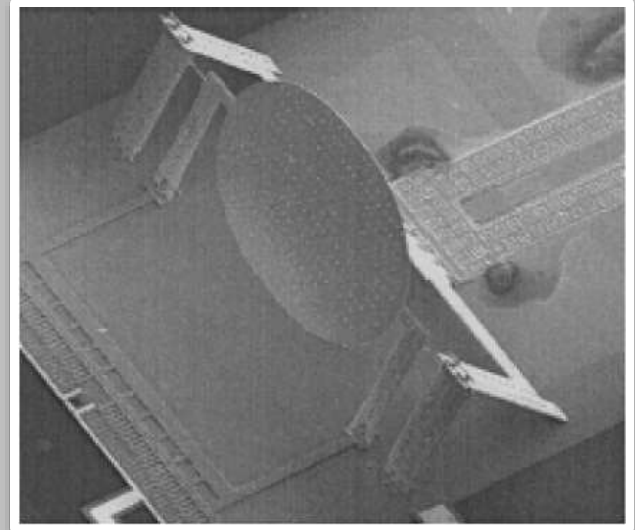
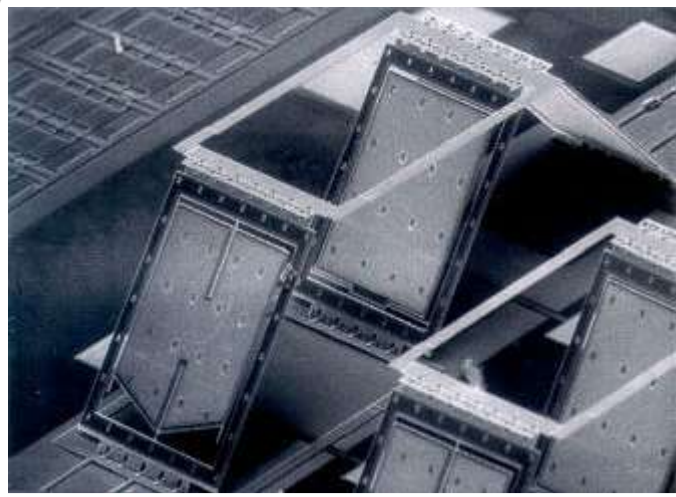
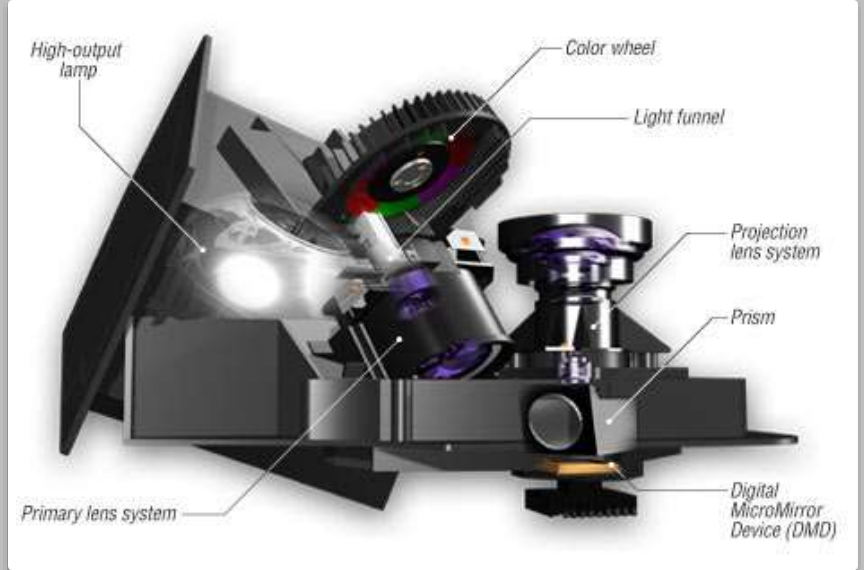
Akışkanlarda basınç algılama

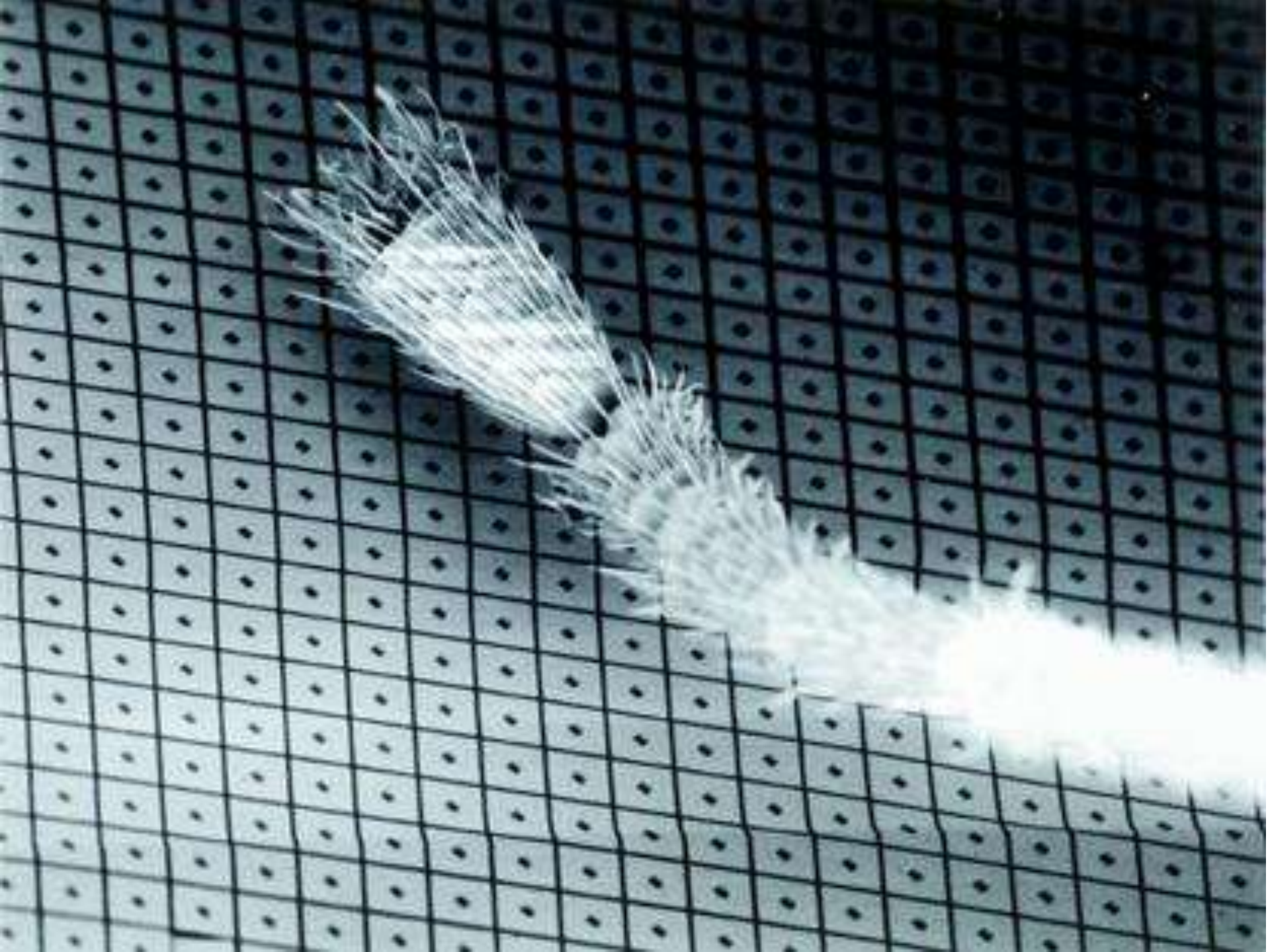


Bazı araçların tekerleklerinde bulunan MEMS basınç sensörleri ile lastik basıncı sürekli olarak ölçülebilmektedir... Sistem, düşük basınç durumunda sürücüye anında bilgi verebilmektedir.

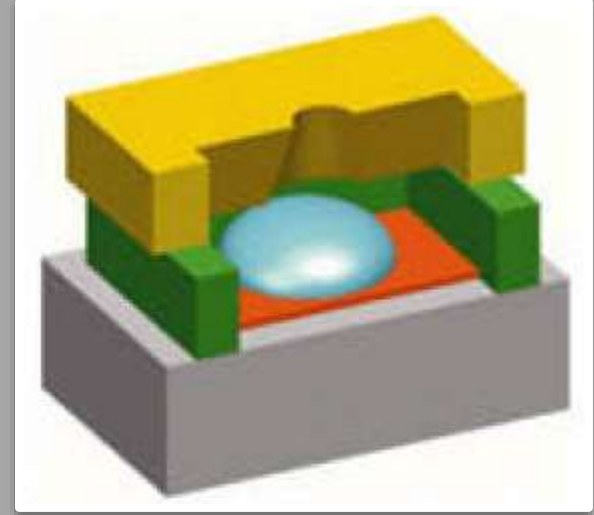
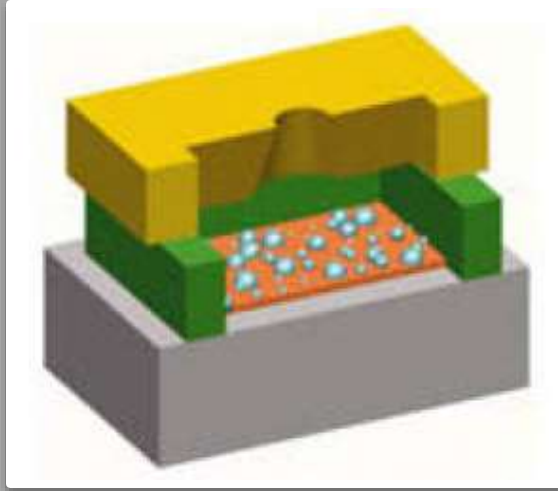


Optik ayna ve Mekanik Anahtar Uygulamaları

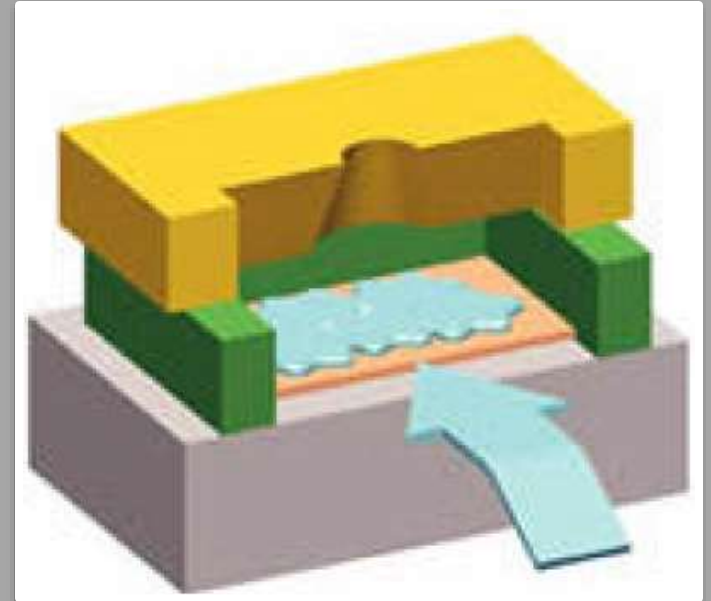
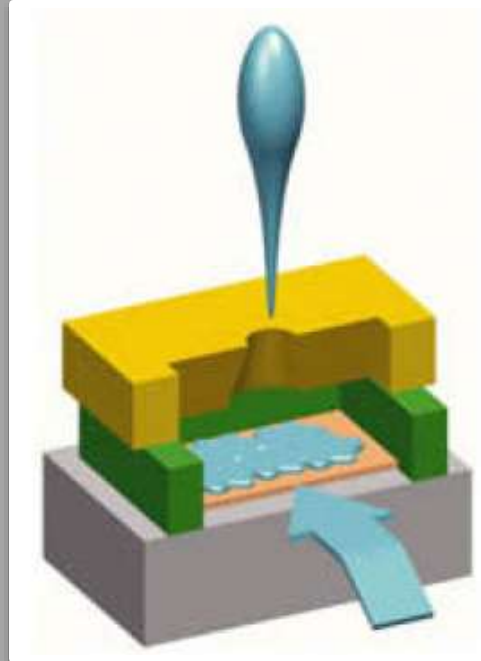




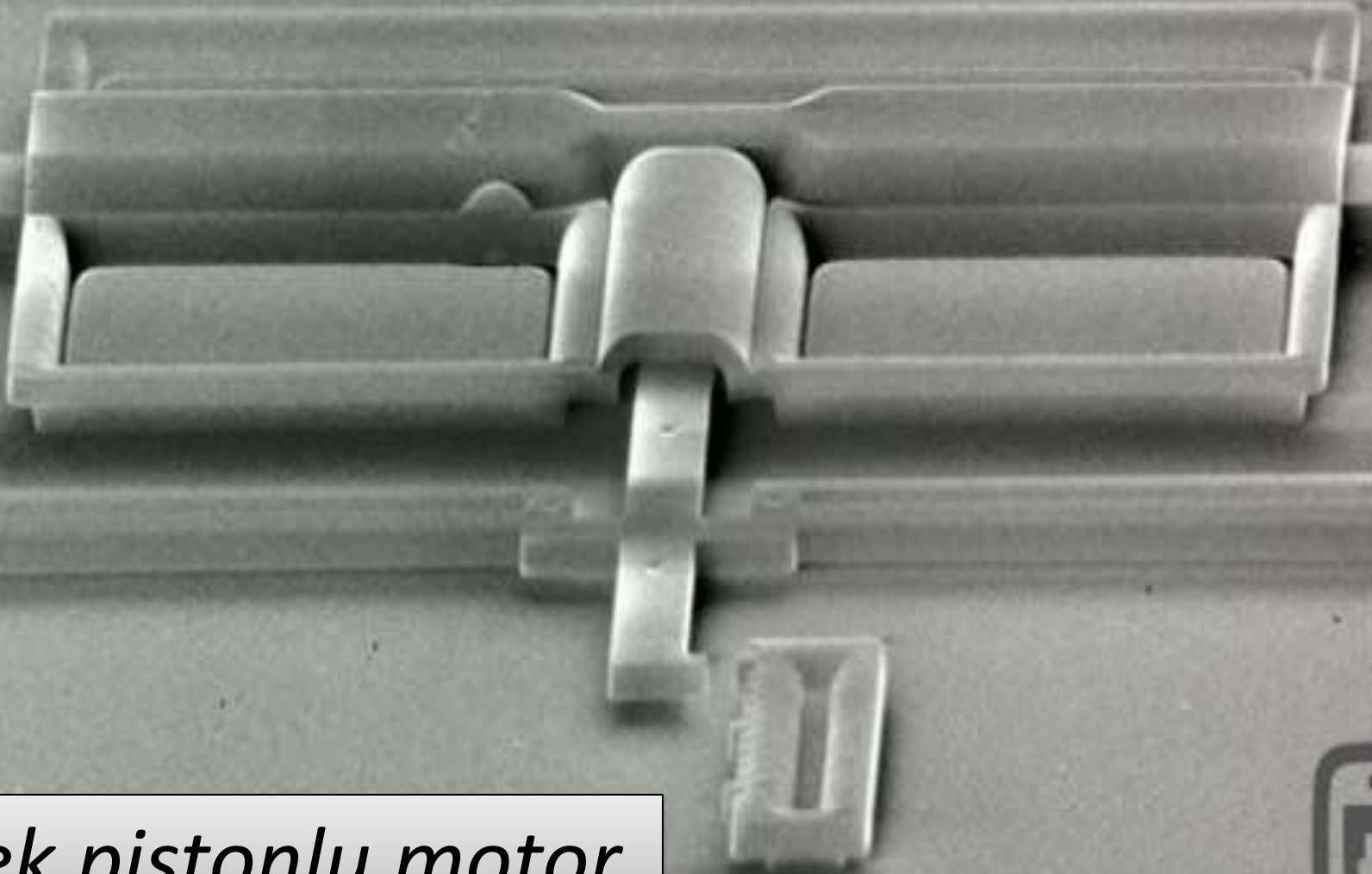
Inkjet yazıcılarda MEMS uygulaması



Inkjet yazıcılarda MEMS kullanılarak mürekkep püskürtülür.



Mikromotorlar

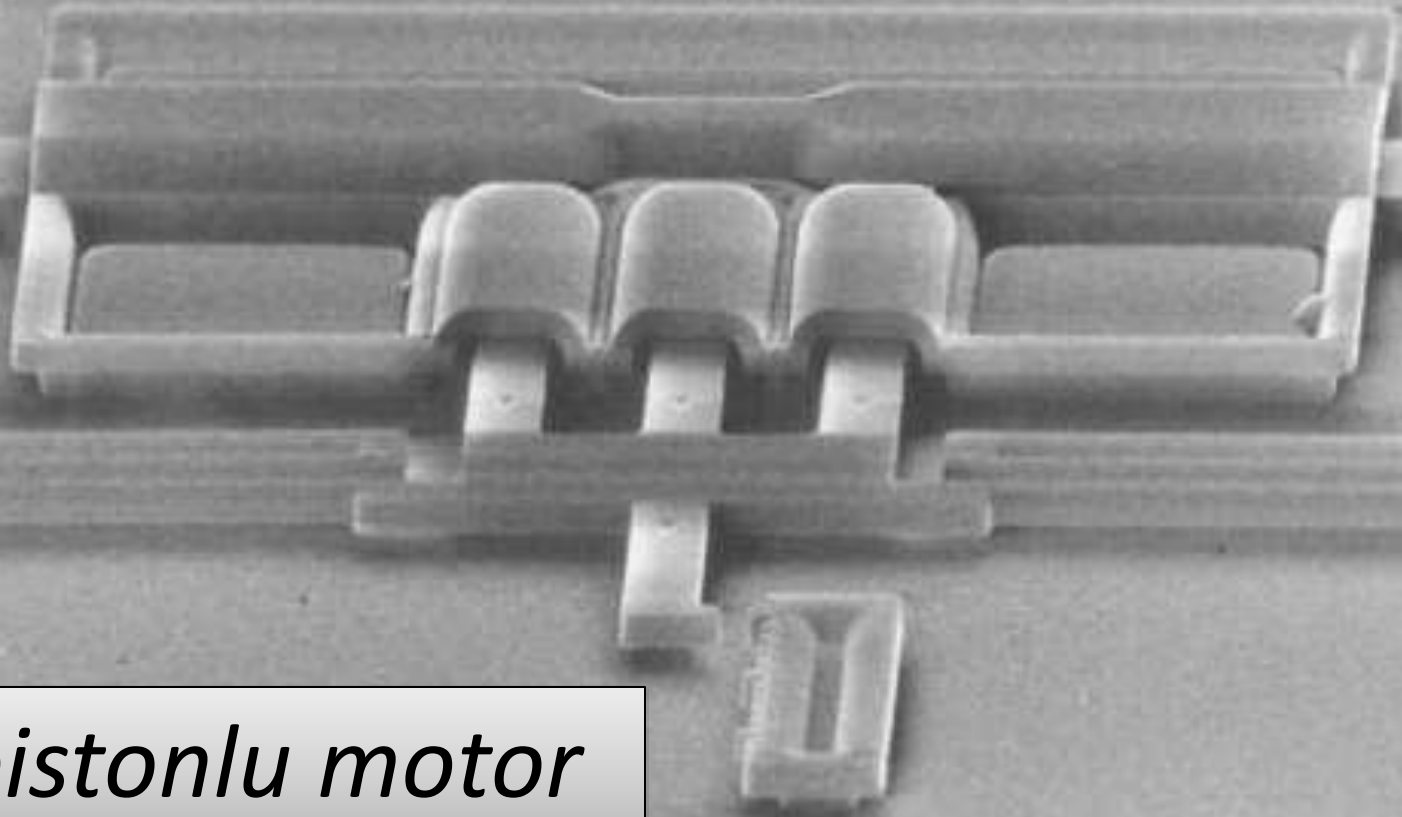


Tek pistonlu motor



MICROSTEAM ENGINE
MULTI-PISTON

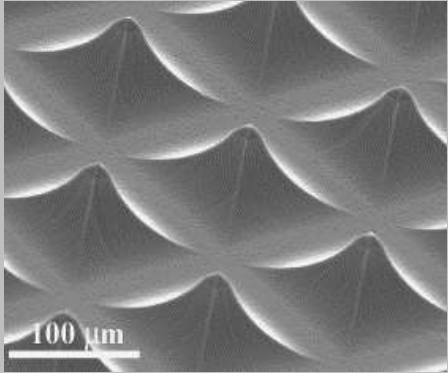
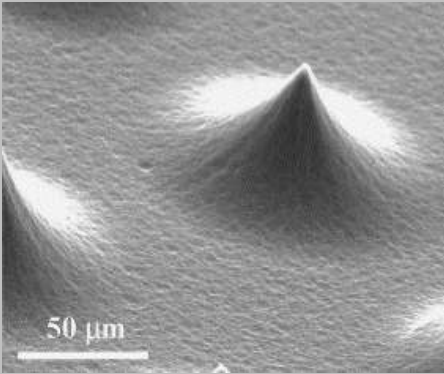
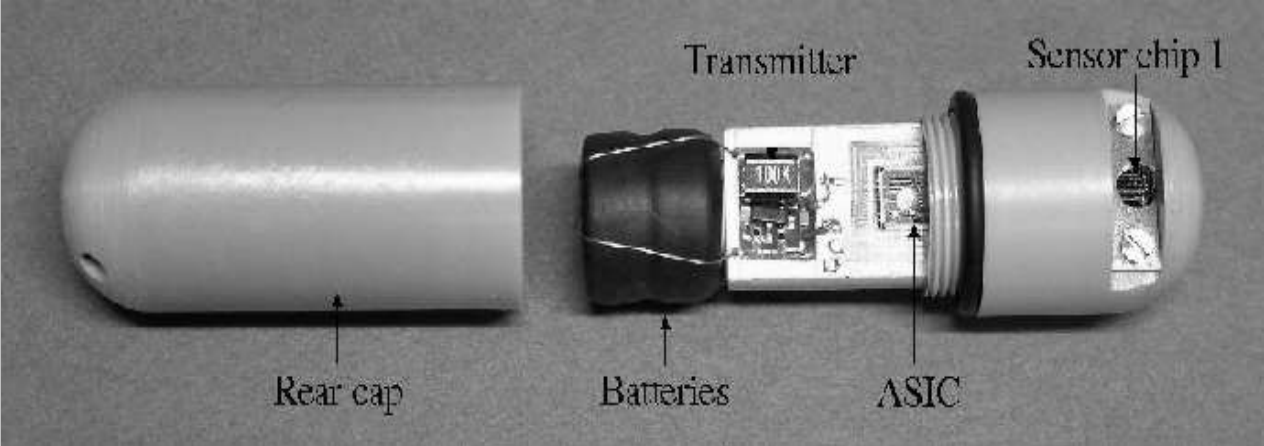
Mikromotorlar



Üç pistonlu motor



BioMEMS uygulamaları



MEMS – Kullanılan Malzemeler

Yarı iletkenler

- Silikon (Silisyum)
- Poly-Si
- GaAs (III-V grubu)
- SiC (Silikon Karbür)
- Elmas

Metaller (Al, Ni, W, Au, Ag)

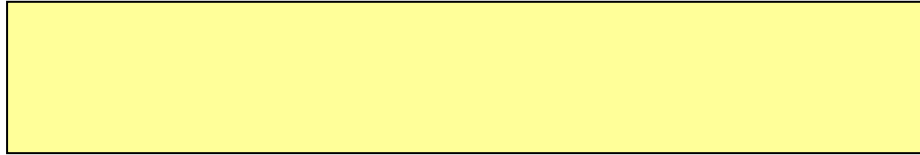
Yalıtım İçin

- SiO₂ (Silikon Oksidi)
- Silisyum Nitrit
- Quartz (piezoelektrik)

Polimerler

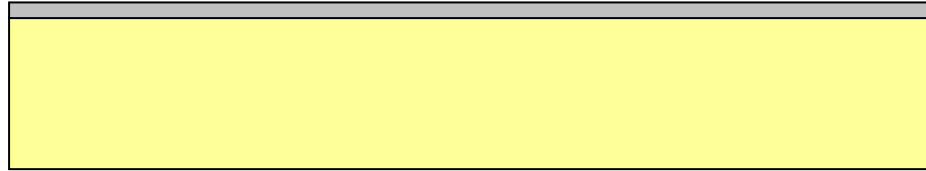
Spot 3	Mag 500 X	FWD 4.827	E-Beam 3.00 kV	Tilt 60.0°	Det SED	HFWD 608 µm	100 µm
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Üretim Örneđi



Si Bulk

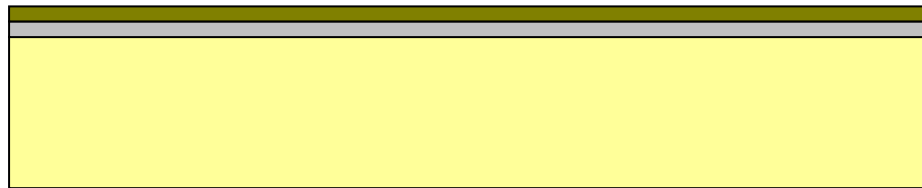
Üretim Örneği



Al Metal

Si Bulk

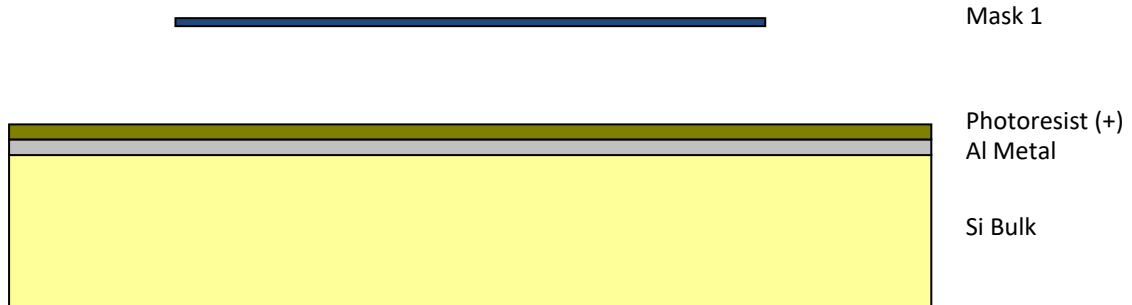
Üretim Örneği



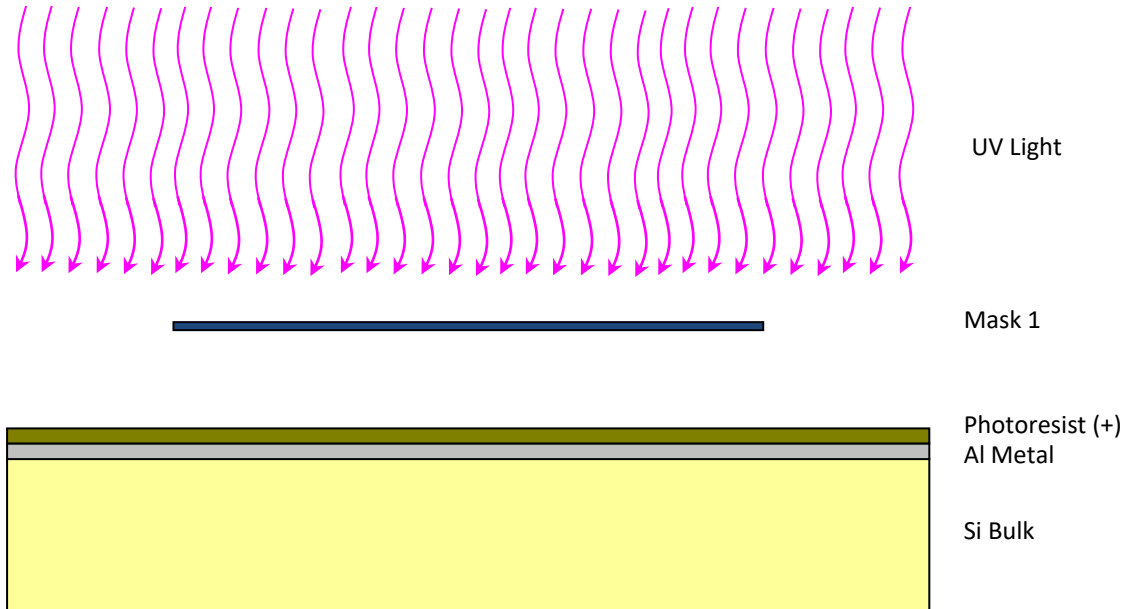
Photoresist (+)
Al Metal

Si Bulk

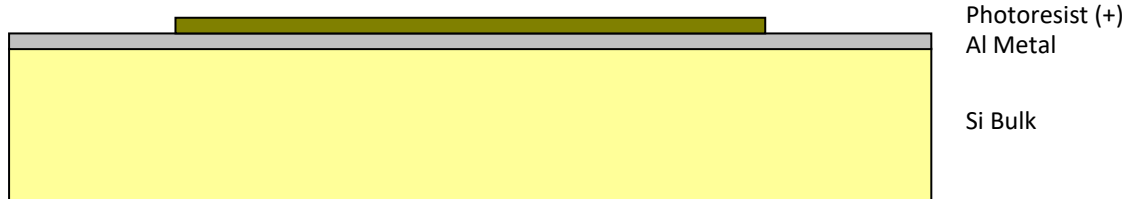
Üretim Örneği



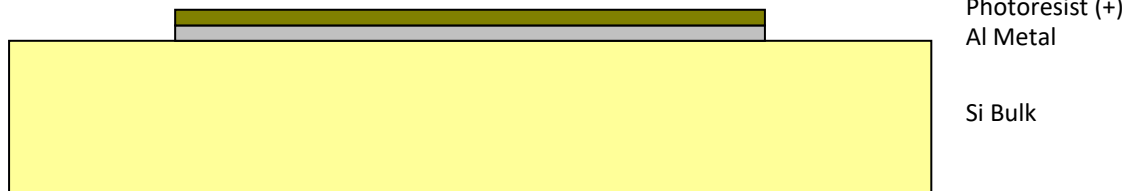
Üretim Örneği



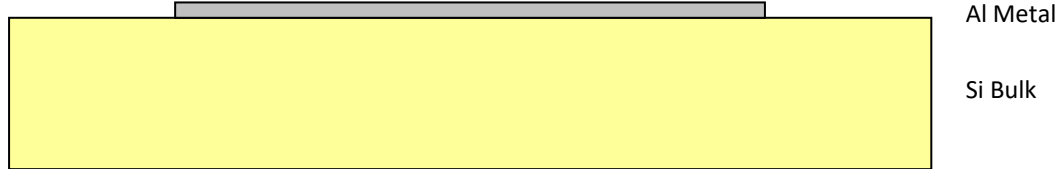
Üretim Örneği



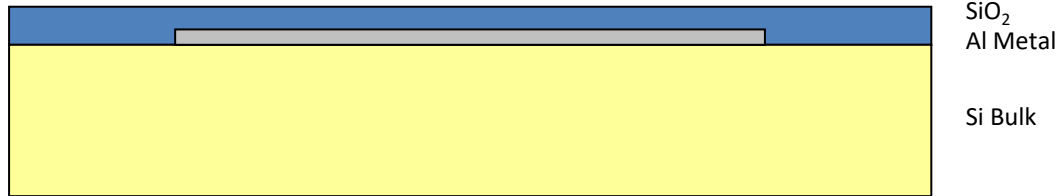
Üretim Örneği



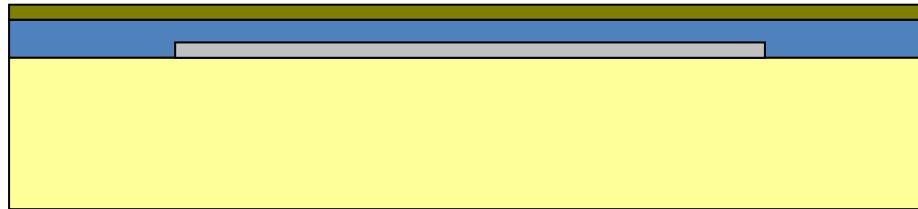
Üretim Örneği



Üretim Örneği

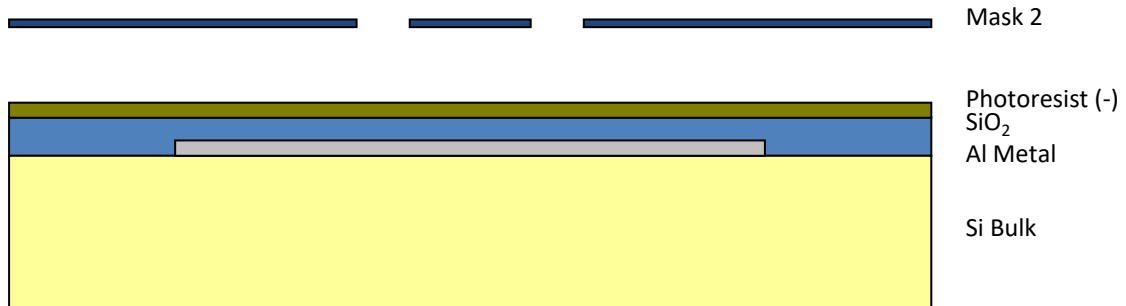


Üretim Örneği

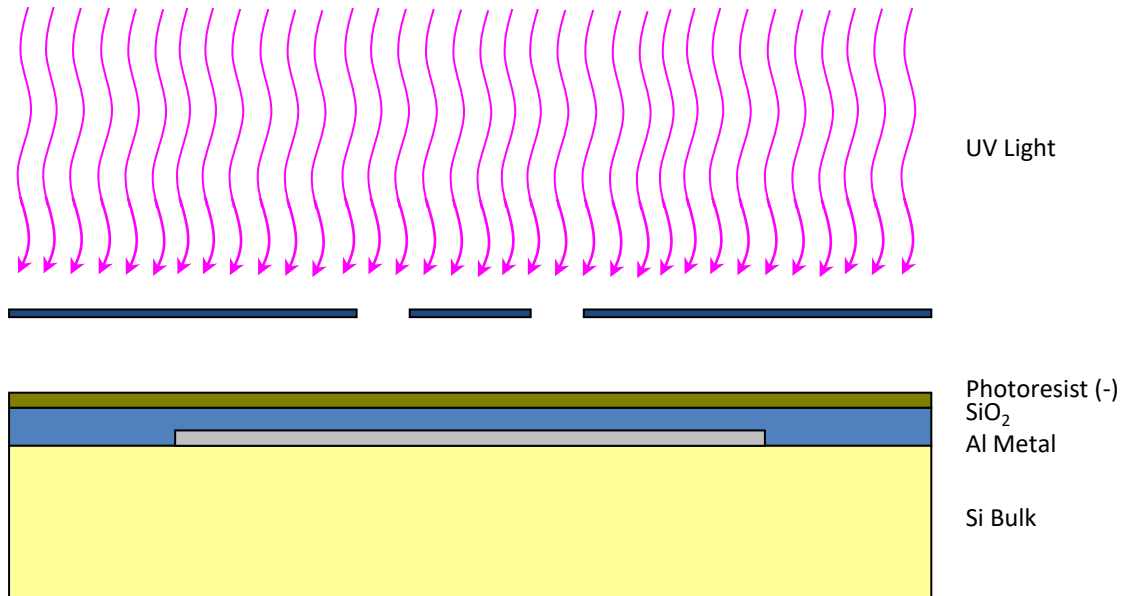


Photoresist (-)
SiO₂
Al Metal
Si Bulk

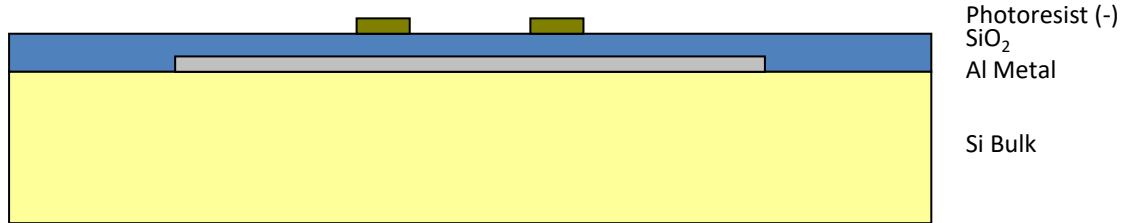
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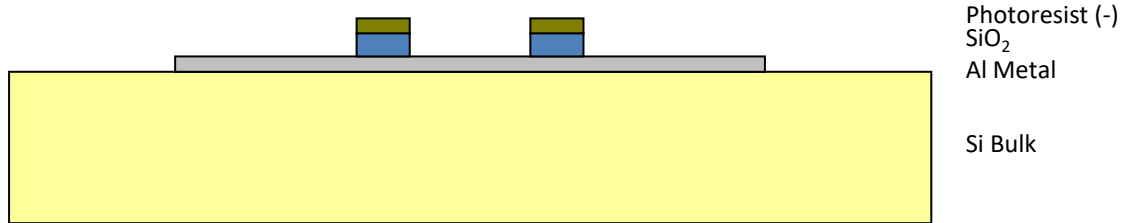
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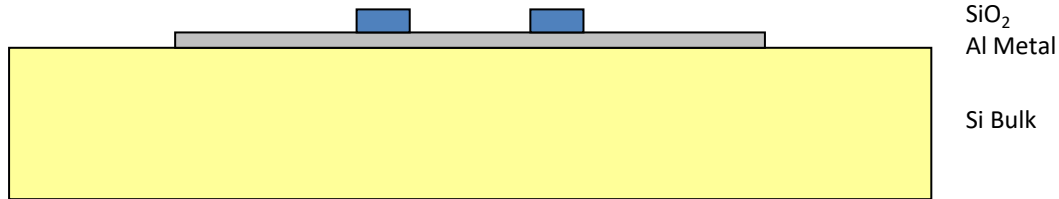
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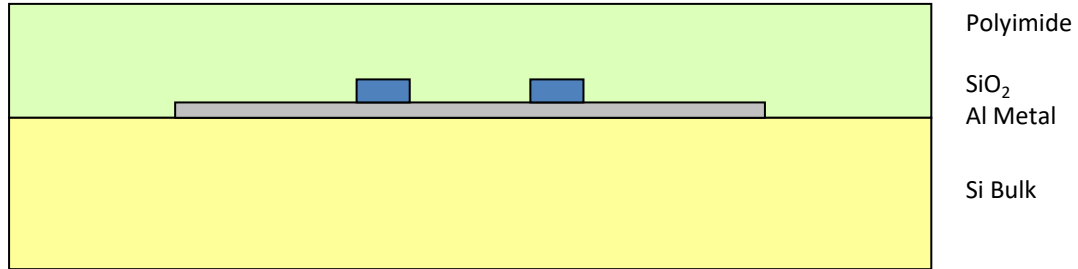
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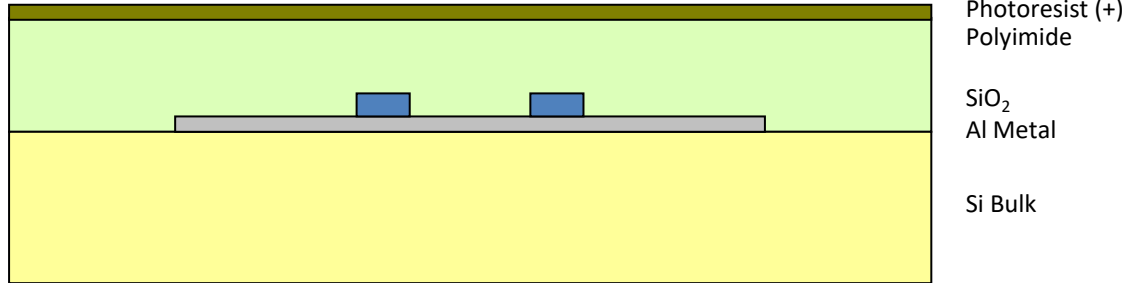
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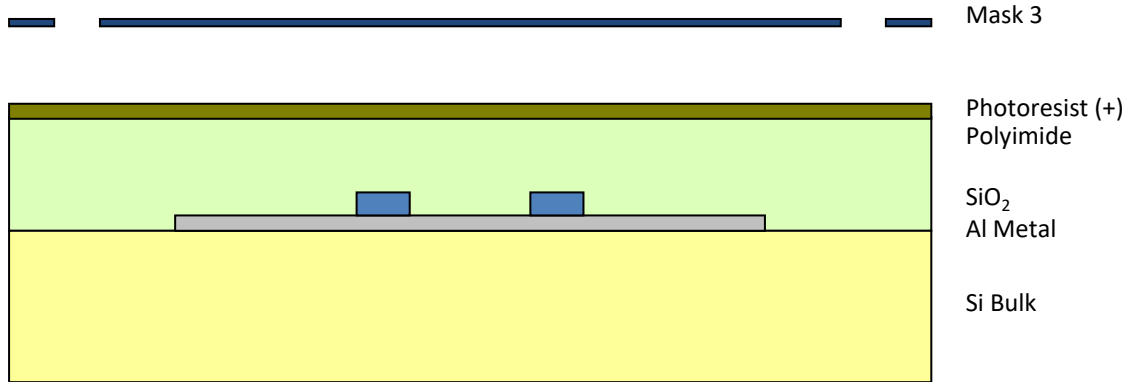
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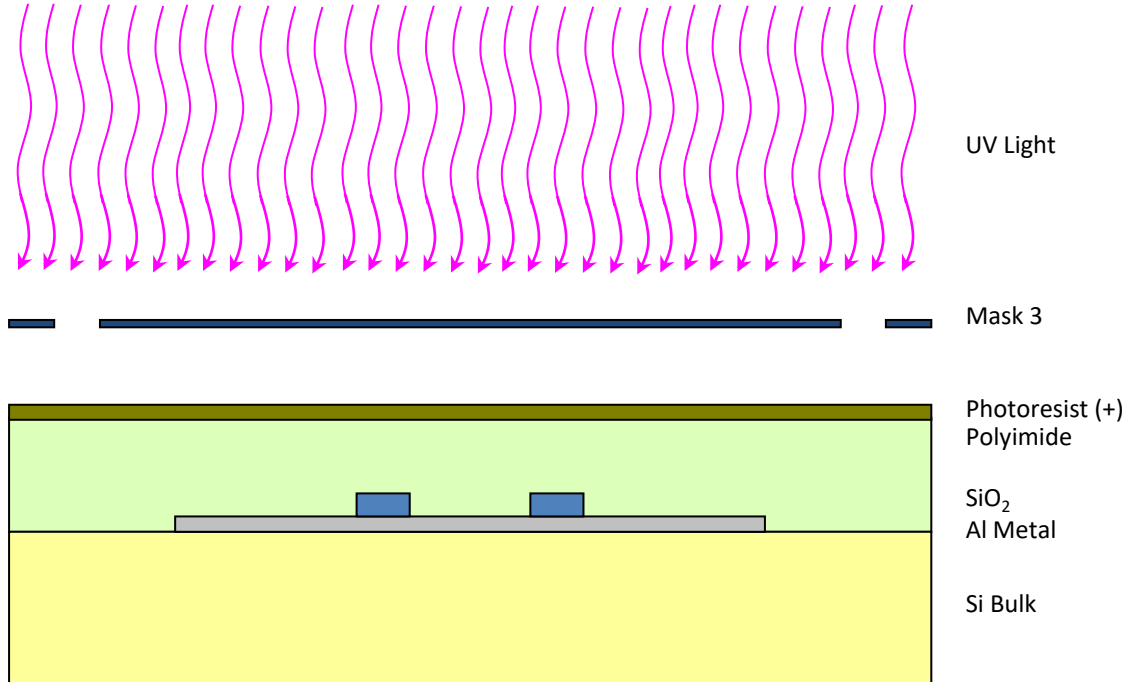
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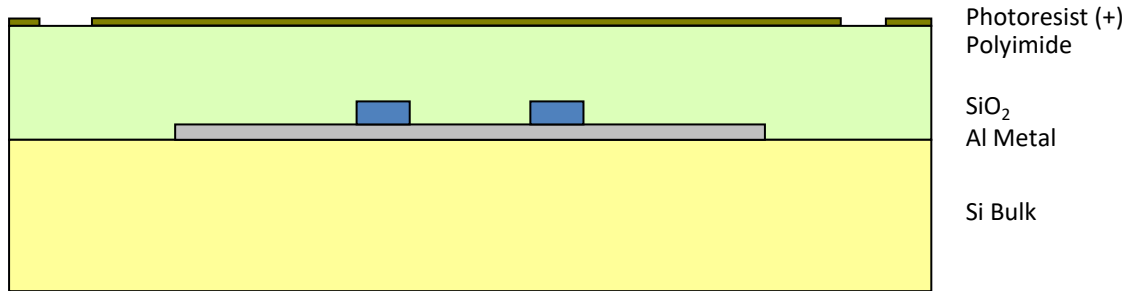
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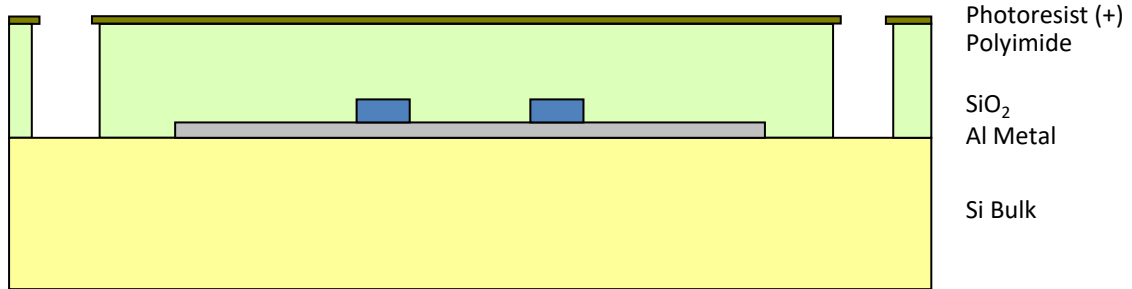
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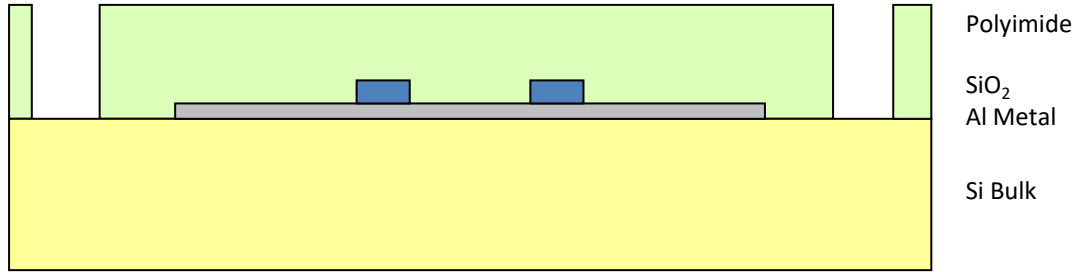
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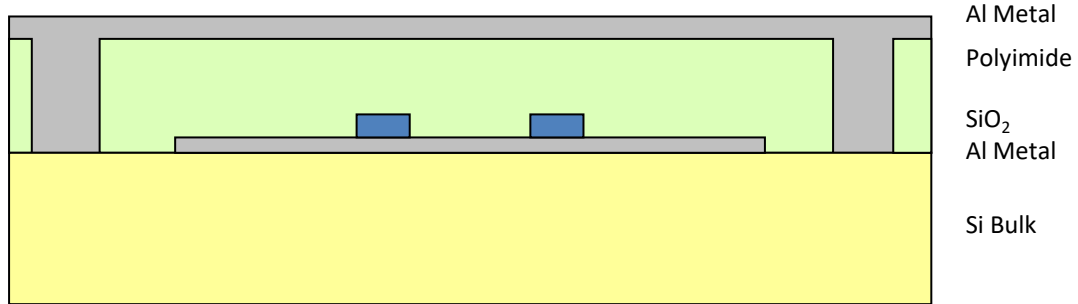
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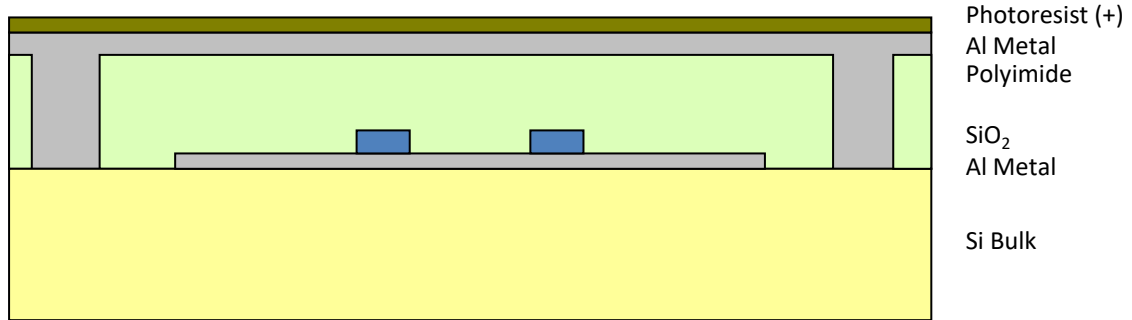
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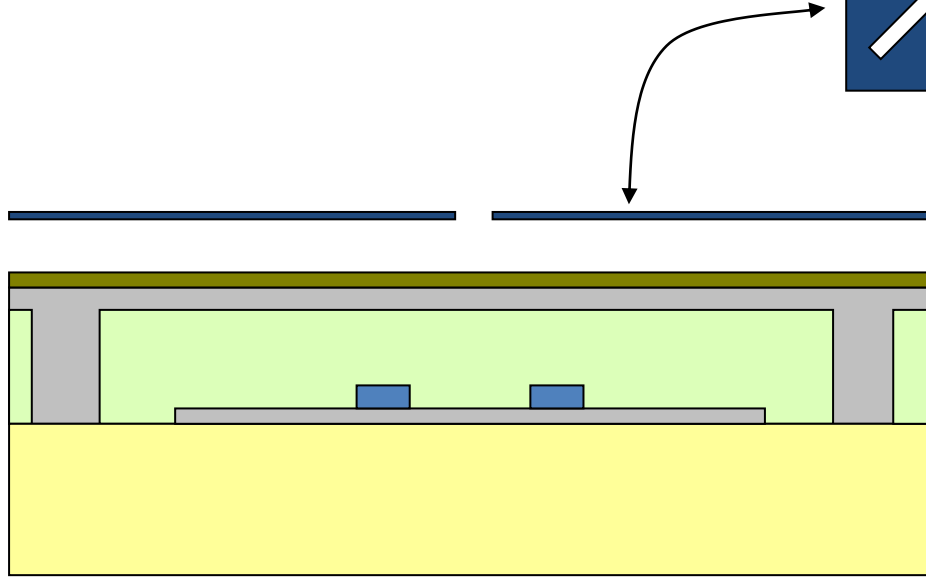
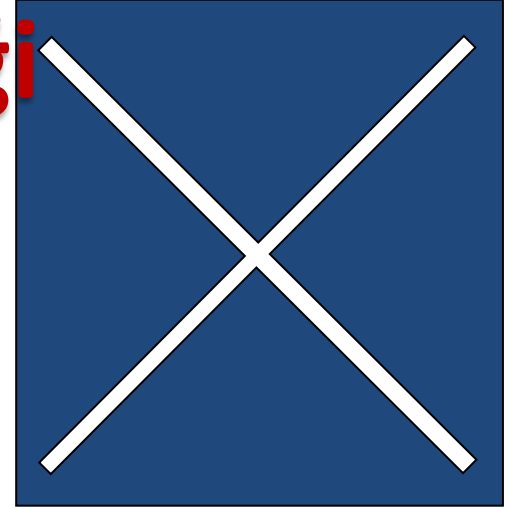
Üretim Örneği



Üretim Örneği



Üretim Örneği



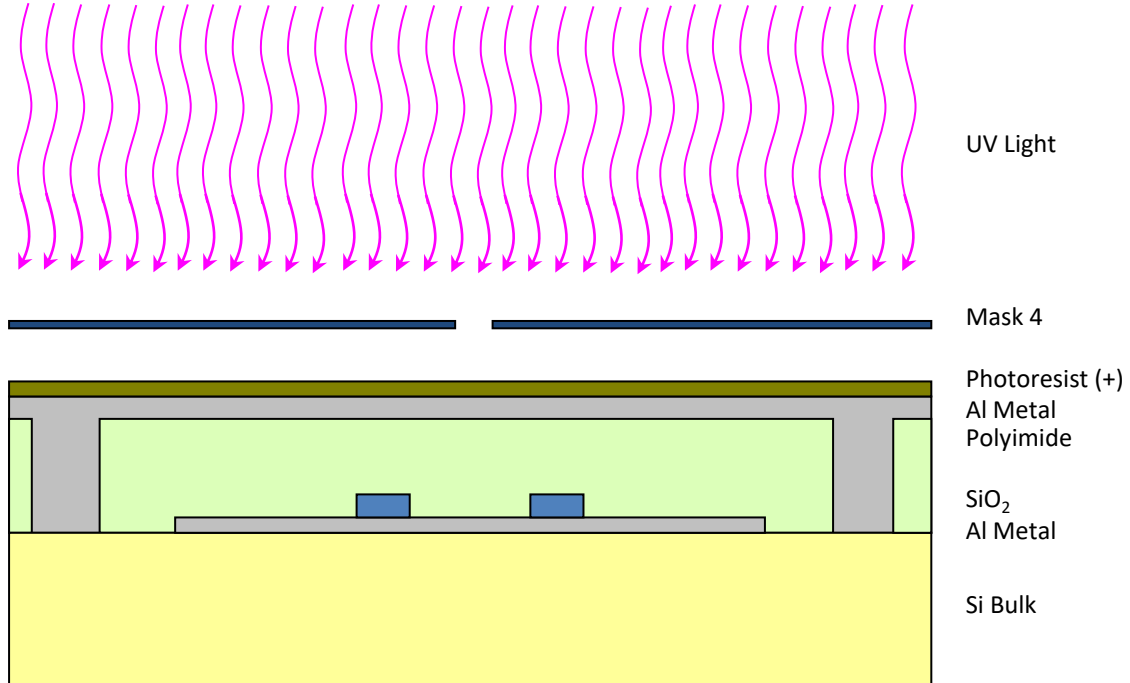
Mask 4

Photoresist (+)
Al Metal
Polyimide

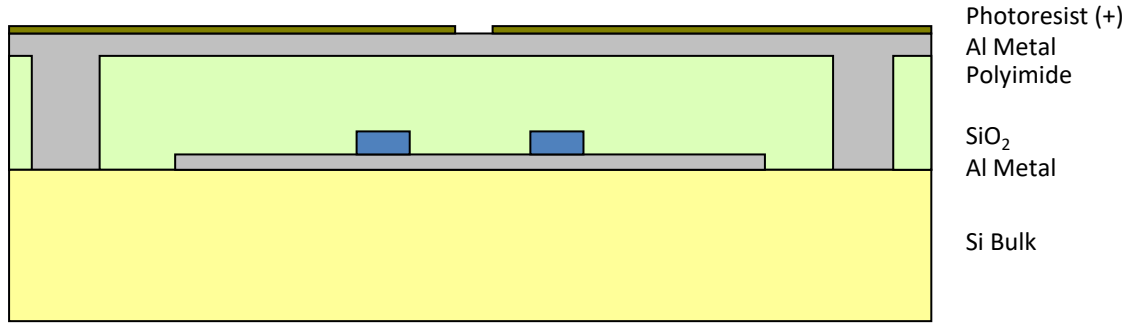
SiO₂
Al Metal

Si Bulk

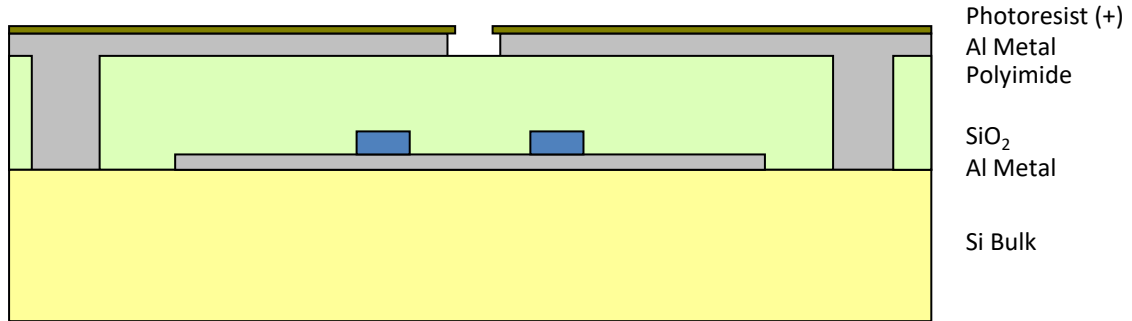
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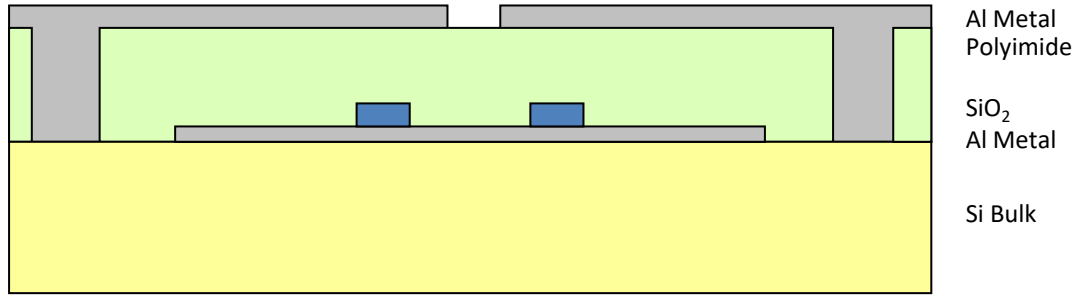
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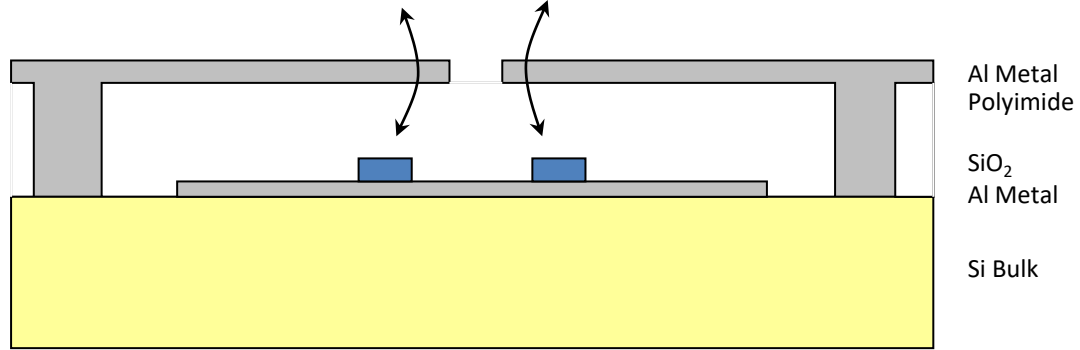
Üretim Örneği



Üretim Örneği



Üretim Örneđi



Şekildeki cisim oluşuyor...

MEMS üretim ve satışları

Technology Area	Typical Devices/ Applications	Companies	Market Baseline (\$Millions)	Market 2003 (Est.) (\$Millions)
Inertial Measurement	Accelerometers, Rate Sensors, Vibration Sensors	TI, Sarcos, Boeing, ADI, EG&G IC Sensors, AMMI, Motorola, Delco, Breed, Systron Donner, Honeywell, Allied Signals	\$350-\$540	\$700-\$1400
Microfluidics and Chemical Testing/ Processing	Gene Chip, Lab on Chip, Chemical Sensors, Flow Controllers, Micronozzles, Microvalves	Battelle, Sarnoff, Microcosm, ISSYS, Berkeley MicroInstruments, Redwood, TINI Alloy, Affymetrix, EG&G IC Sensors, Motorola, Hewlett Packard, TI, Xerox, Canon, Epson	\$400-\$550	\$3000-\$4450
Optical MEMS (MOEMS)	Displays, Optical Switches, Adaptive Optics	Tanner, SDL, GE, Sarnoff, Northrop-Grumman, Westinghouse, Interscience, SRI, CoreTek, Lucent, Iridigm, Silicon Light Machines, TI, MEMS Optical, Honeywell	\$25-\$40	\$450-\$950
Pressure Measurement	Pressure Sensors for Automotive, Medical, and Industrial Applications	Goodyear, Delco, Motorola, Ford, EG&G IC Sensors, Lucas NovaSensor, Siemens, TI	\$390-\$760	\$1100-\$2150
RF Technology	RF switches, Filters, Capacitors, Inductors, Antennas, Phase Shifters, Scanned Apertures	Rockwell, Hughes, ADI, Raytheon, TI, Aether	(Essentially \$0 as of 1998)	\$40-\$120
Other	Actuators, Microrelays, Humidity Sensors, Data Storage, Strain Sensors, Microsatellite Components	Boeing, Exponent, HP, Sarcos, Xerox, Aerospace, SRI, Hughes, AMMI, Lucas Novasensor, Sarnoff, ADI, EG&G IC Sensors, CP Clare, Siemens, ISSYS, Honeywell, Northrop Grumman, IBM, Kionix, TRW	\$510-\$1050	\$1230-\$2470



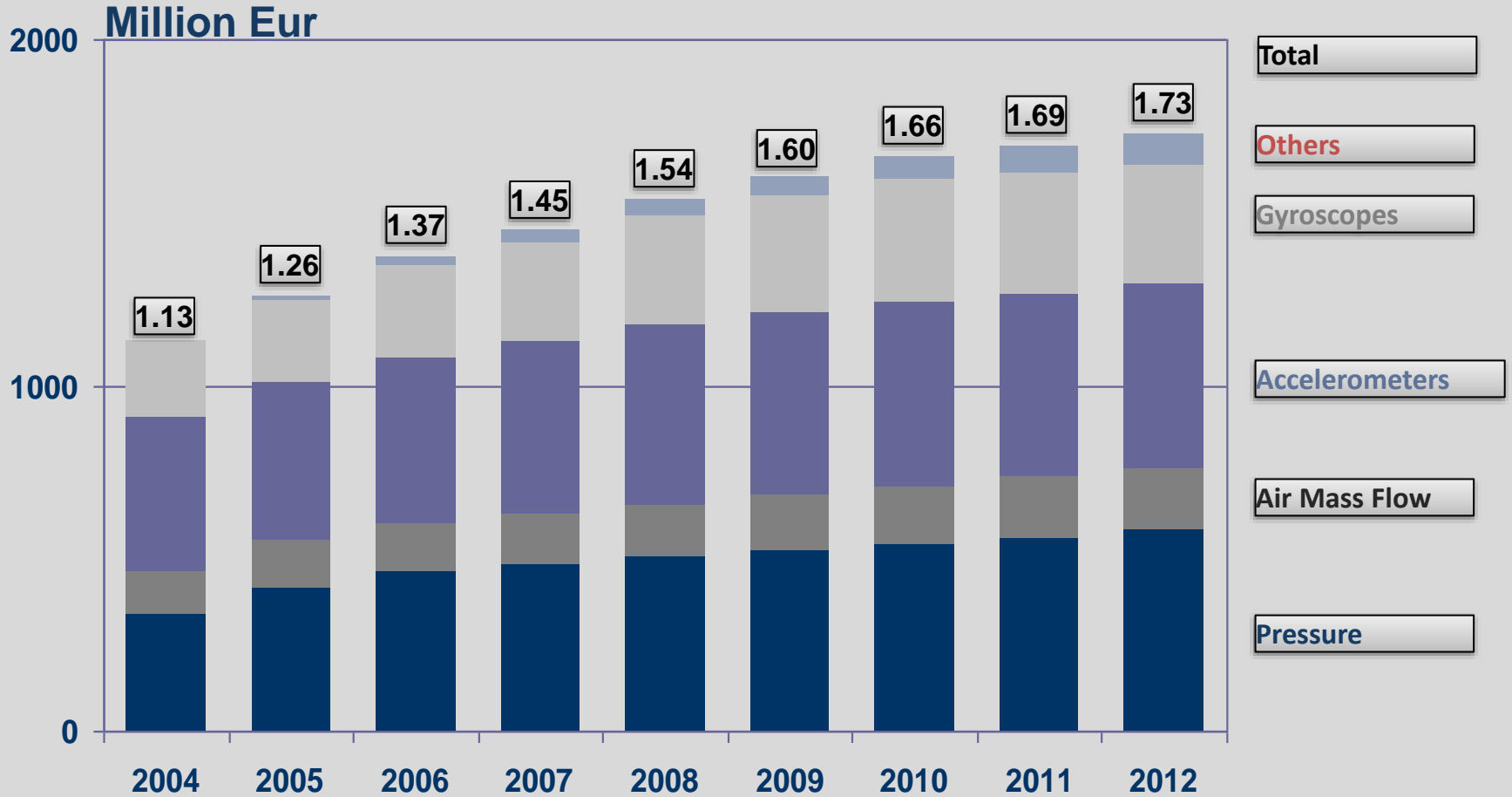
Companies currently under contract.



Companies with past contracts.



Otomotiv alanındaki MEMS satışları

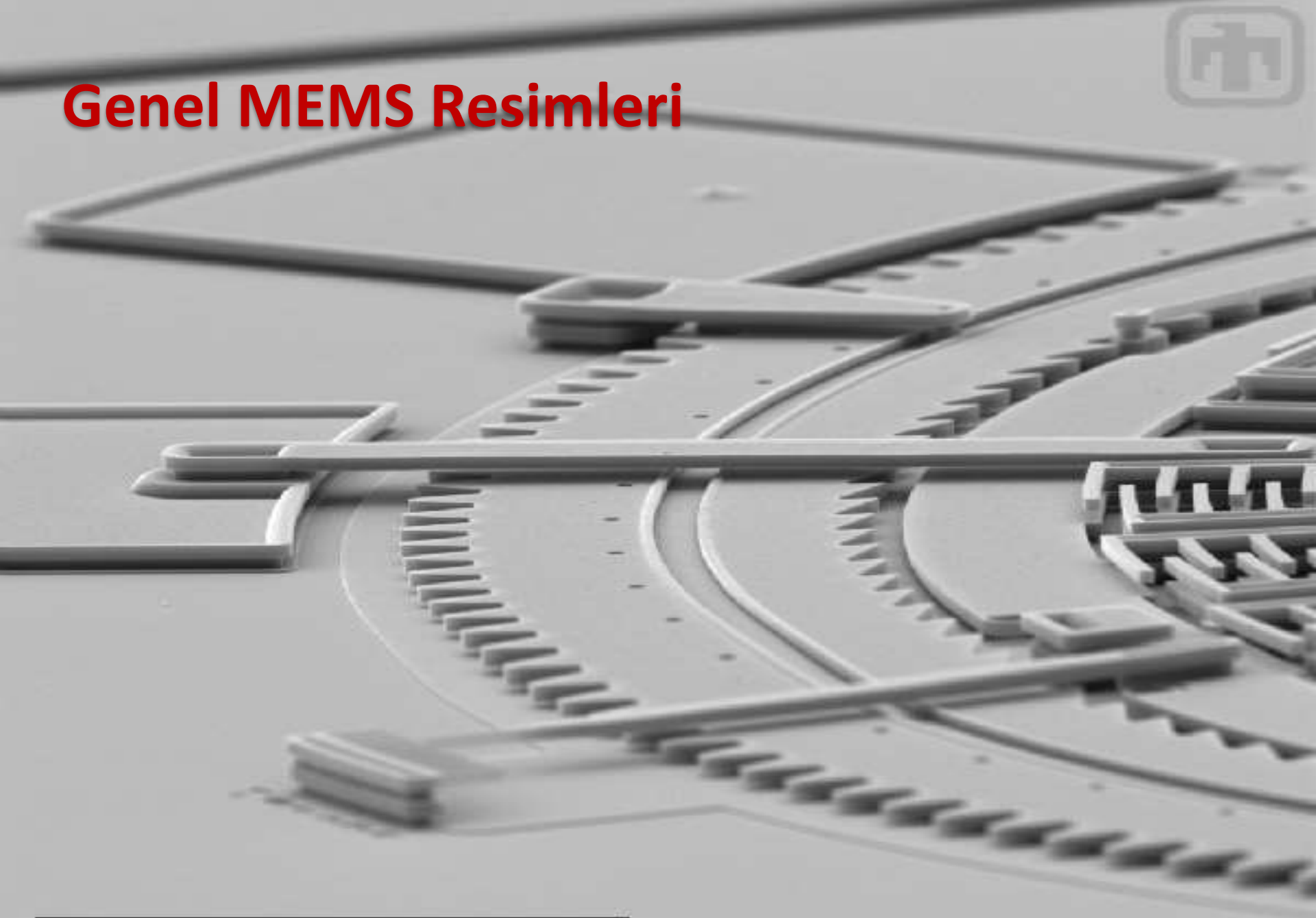


Kaynak: Bosch

Genel MEMS Resimleri

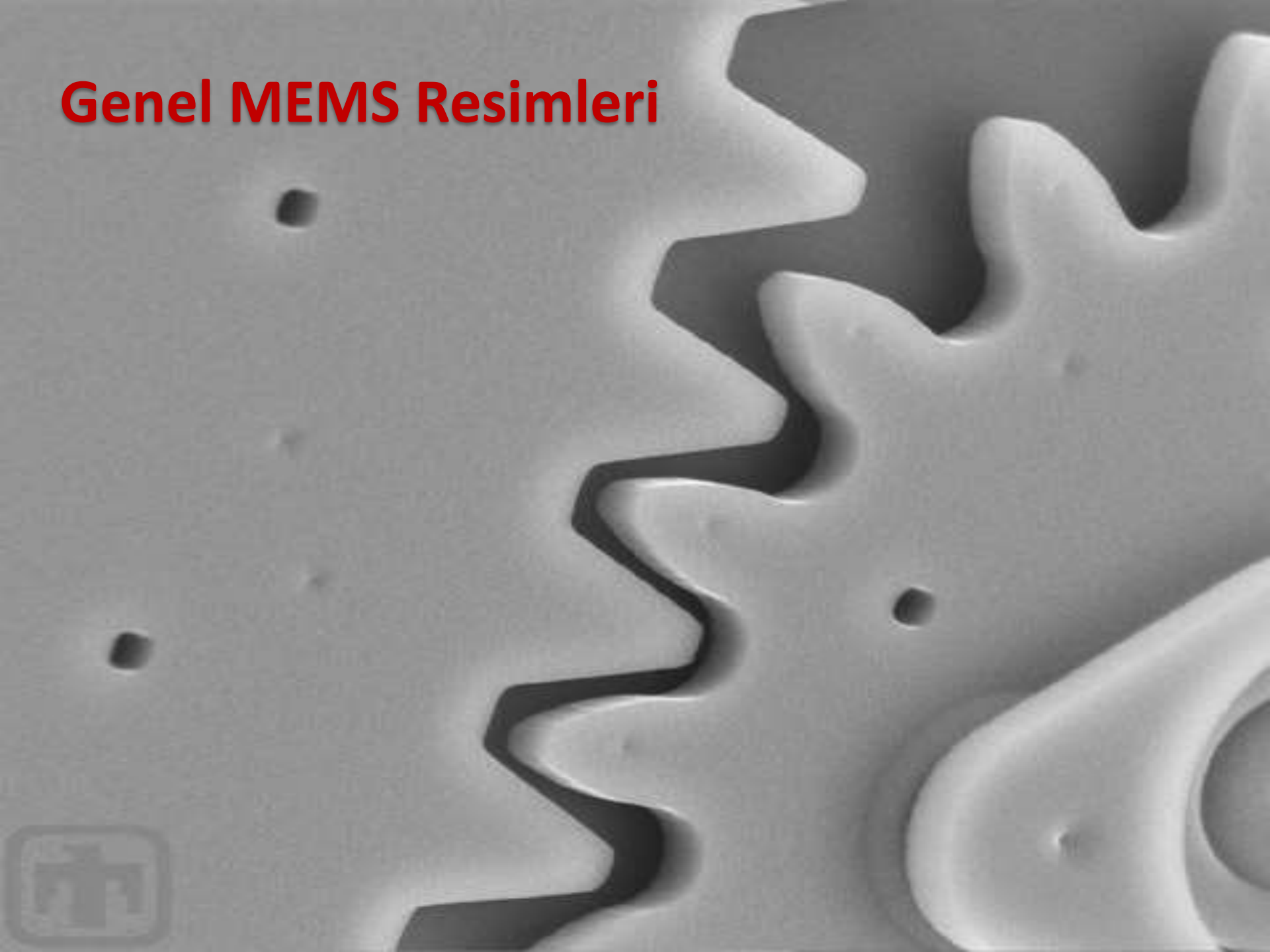


Genel MEMS Resimleri

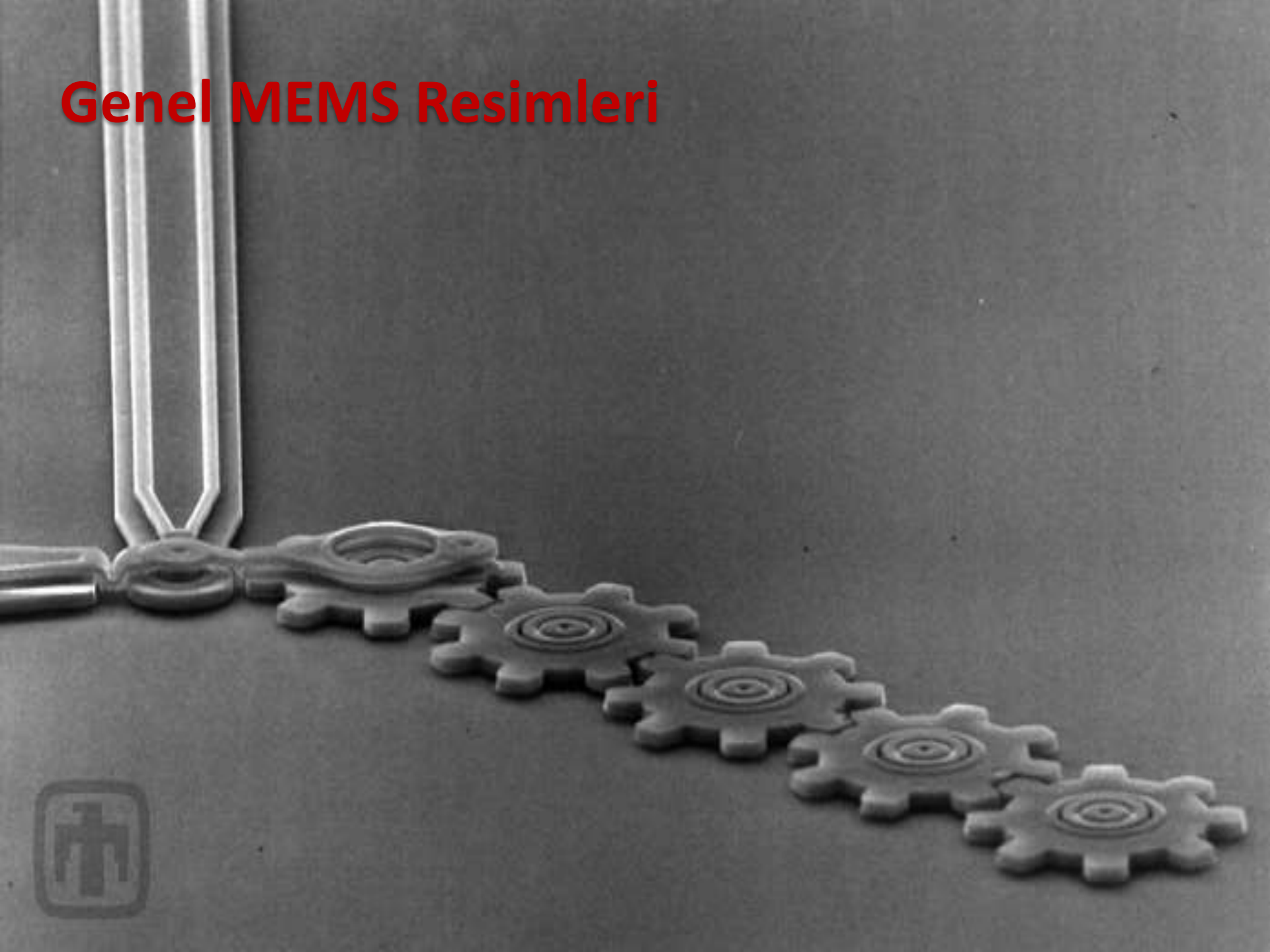


00041 os1949_001 20kV X500 35mm  10µm

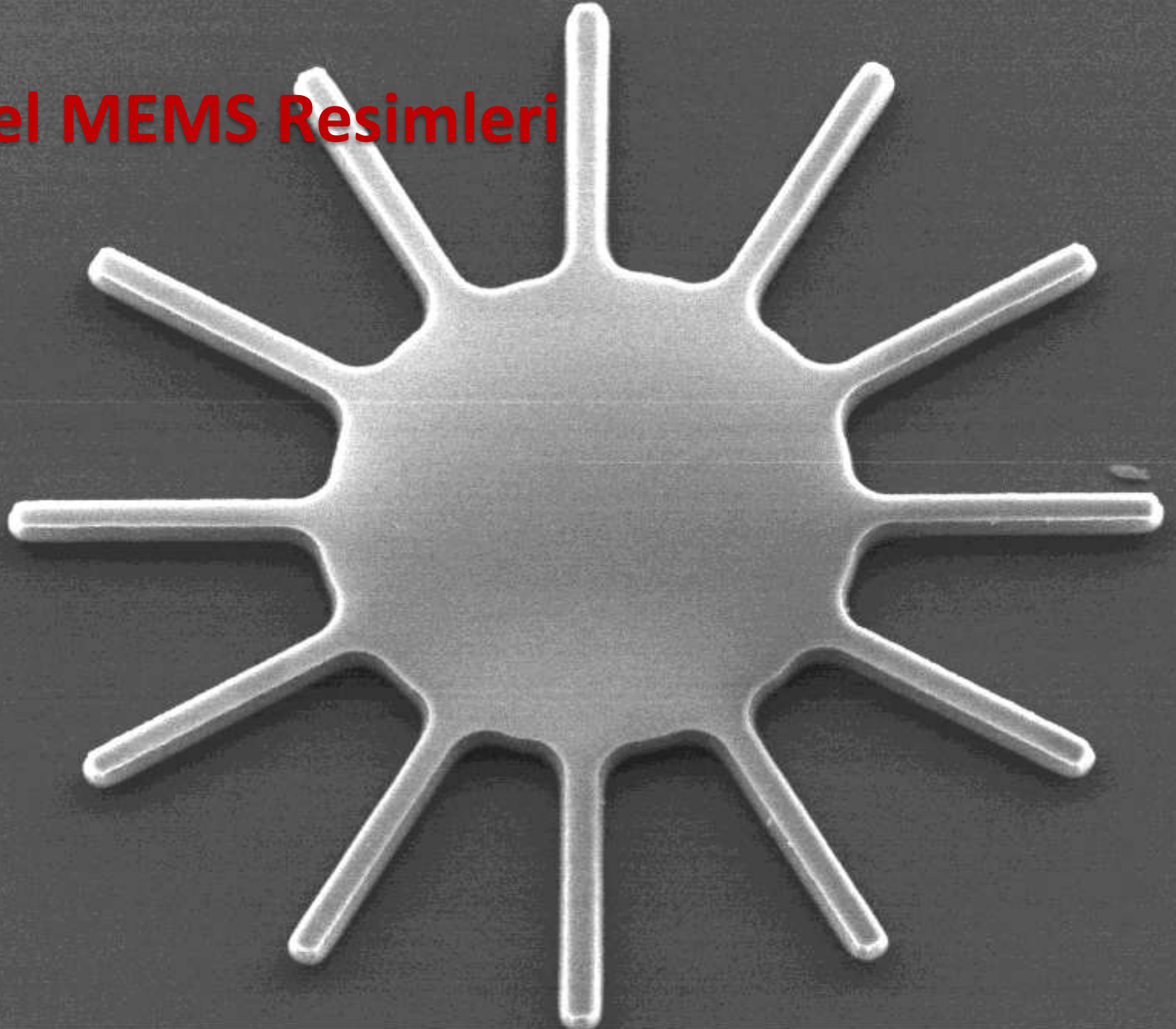
Genel MEMS Resimleri



Genel MEMS Resimleri



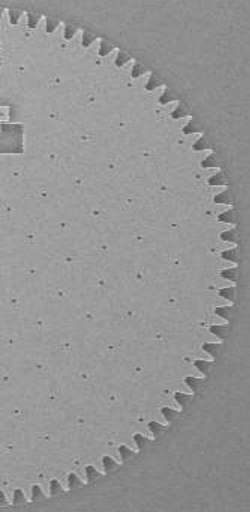
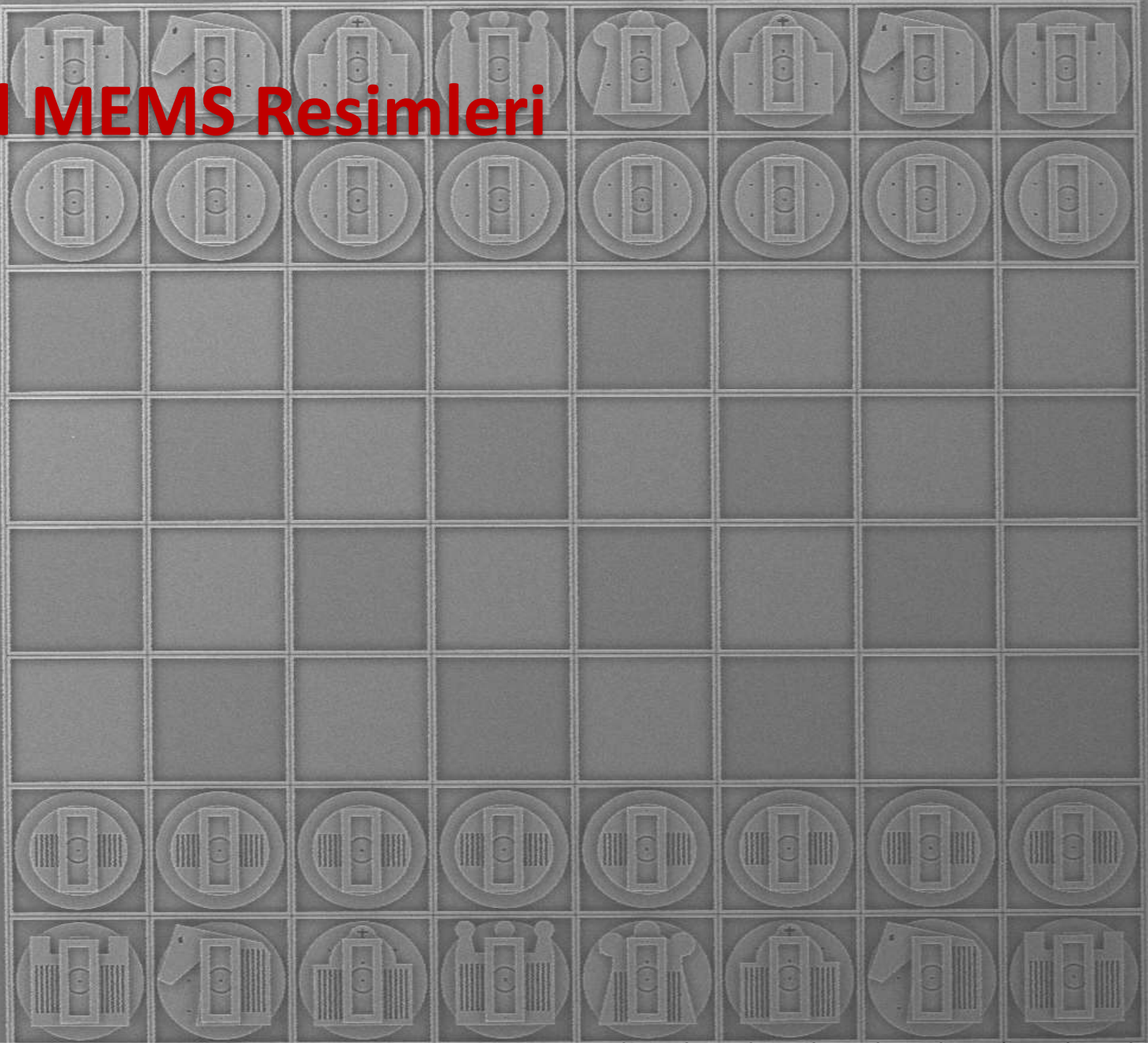
Genel MEMS Resimleri



SPICE



Genel MEMS Resimleri



MEMS



L x180 500 um

MEMS Tanıtım Videosu 1



MEMS Tanıtım Videosu 2



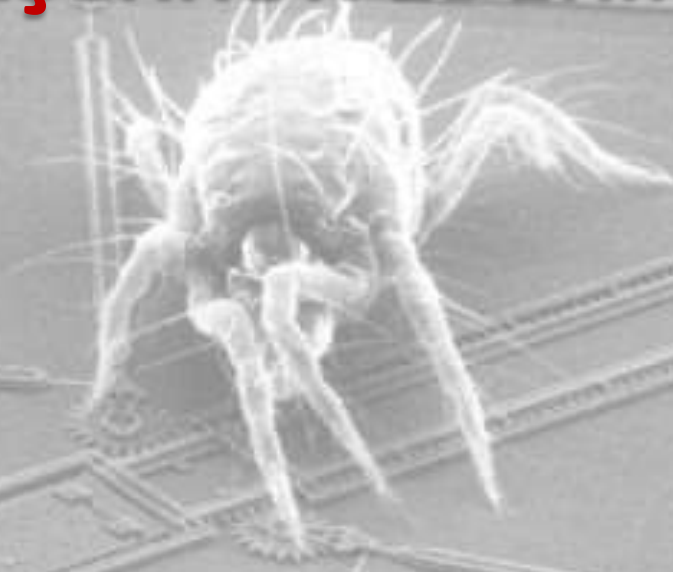
ASI 10.0kV 12.5mm x5.00k SE(M)

10.0um

ODTÜ MEMS Videosu



**SUNUMUMU DİNLEDİĞİNİZ İÇİN
TEŞEKKÜR EDERİM...**



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Kaynaklar



- Prof. Dr. Tayfun AKIN (ODTÜ) - *MEMS Notları (E-Kitap)*
- Doç. Dr. Levent Trabzon (İTÜ) – *Ders Notları (E-Kitap)*
- Prof. Dr. İbrahim YÜKSEL (UÜ) - *MEMS Notları (E-Kitap)*
- DARPA - *The Defense Advanced Research Projects Agency*
- www.odtu.edu.tr - *Ortadoğu Teknik Üniversitesi*
- www.sandia.gov - *Sandia National Laboratories*
- www.ece.cmu.edu - *Carnegie Mellon University*
- www.sfu.ca – *Simon Fraser University*
- www.bosch.com – *The Bosch Group*
- www.memsx.com