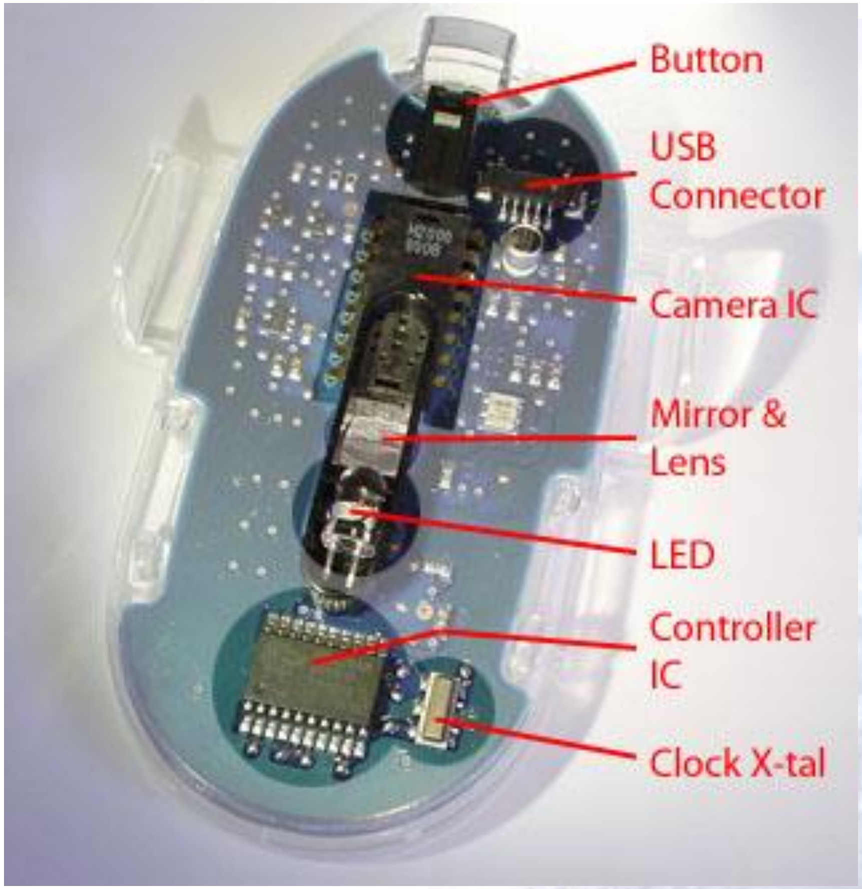
微小光機電的新科技生活



國立彰化師範大學

機電工程學系

沈志雄　副教授

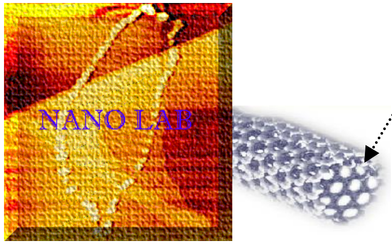
MOEMS

世界是大還是小

科學家借助多種方法對英仙臂進行測量，有的認為有６０００多光年，有的說有１萬多光年，這一精確測量解決了長期爭論。

6000光年
$=5.4\ \ 10^{20}$ 公尺

林肯號 大小：艦長約333 公尺，甲板寬約77 公尺



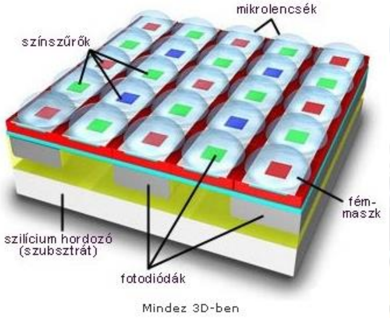
0.3 奈米
$=3\ \ 10^{-10}$ 公尺

金原子的直徑 0.3奈米

MOEMS

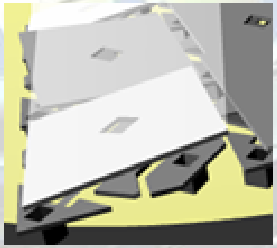
科學家在做些什麼

光機電系統整合



半導體

Process

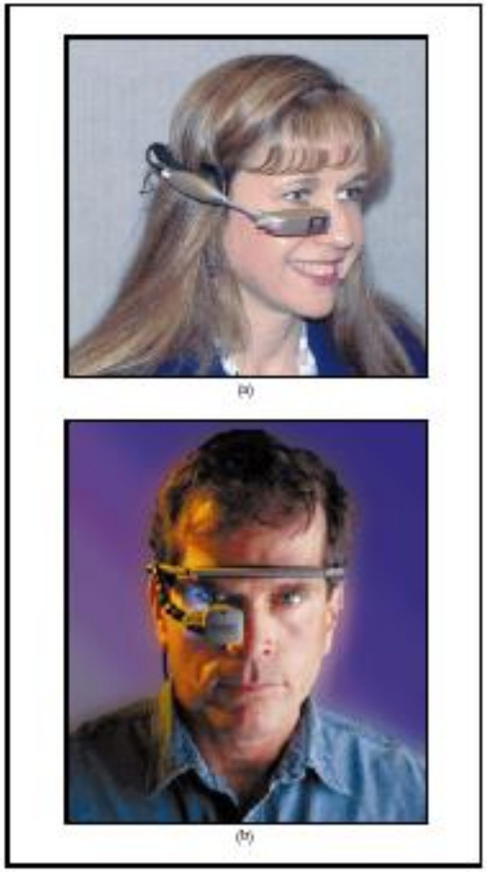


微機電元件

光機

MOEMS

■ Microdisplay



(a)

(b)

Microdisplay

Microdisplay technology for incorporation into the Strike Helmet

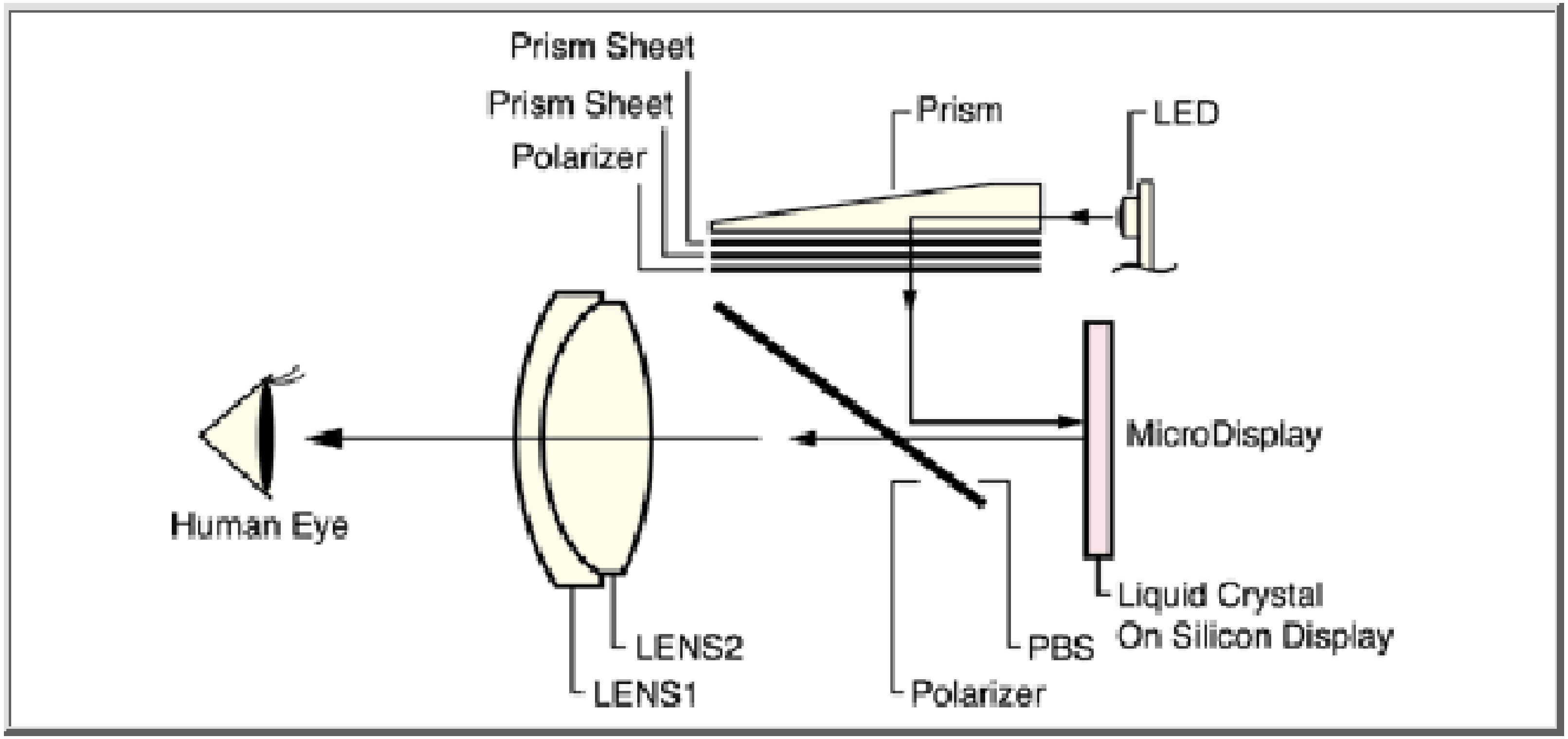
The U.S. Air Force has selected eMagin Corporation's OLED microdisplay technology for incorporation into the Strike Helmet 21 system that uses the Integrated Panoramic Night Vision Goggles in avionics helmets.

The Strike Helmet 21 system is targeted for integration into F-15E aircraft by the 2003-2004 time period.

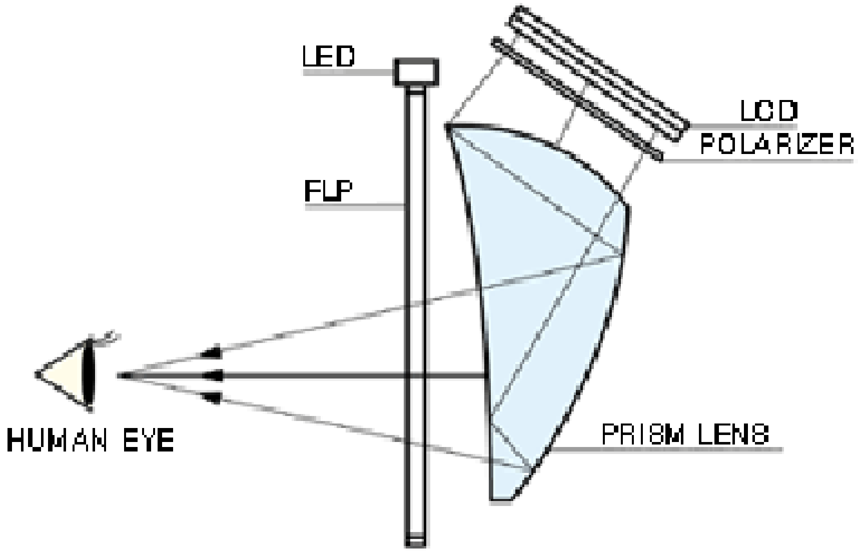
"Now that we have moved beyond the R&D stage for our initial microdisplay products, much of which was supported by US military research contracts, we continue to work closely with military contractors and customers," said Gary Jones, president and CEO of eMagin. "Of the first more than 40 potential customers to whom we have shipped OLED microdisplay evaluation kits or from whom we have received initial production orders, over 17 are evaluating our microdisplay for a variety of military systems."

Flight Helmet Mounted

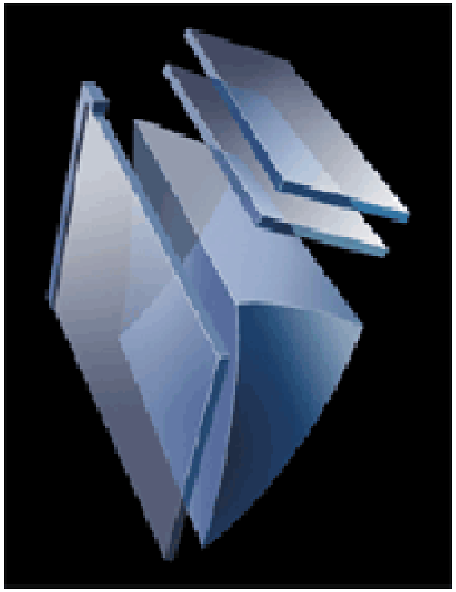
Microdisplay-LCD 1



Microdisplay-LCD 2



[Display Engine]



[Free Curvature Prism Lens]

Type of Microdisplay

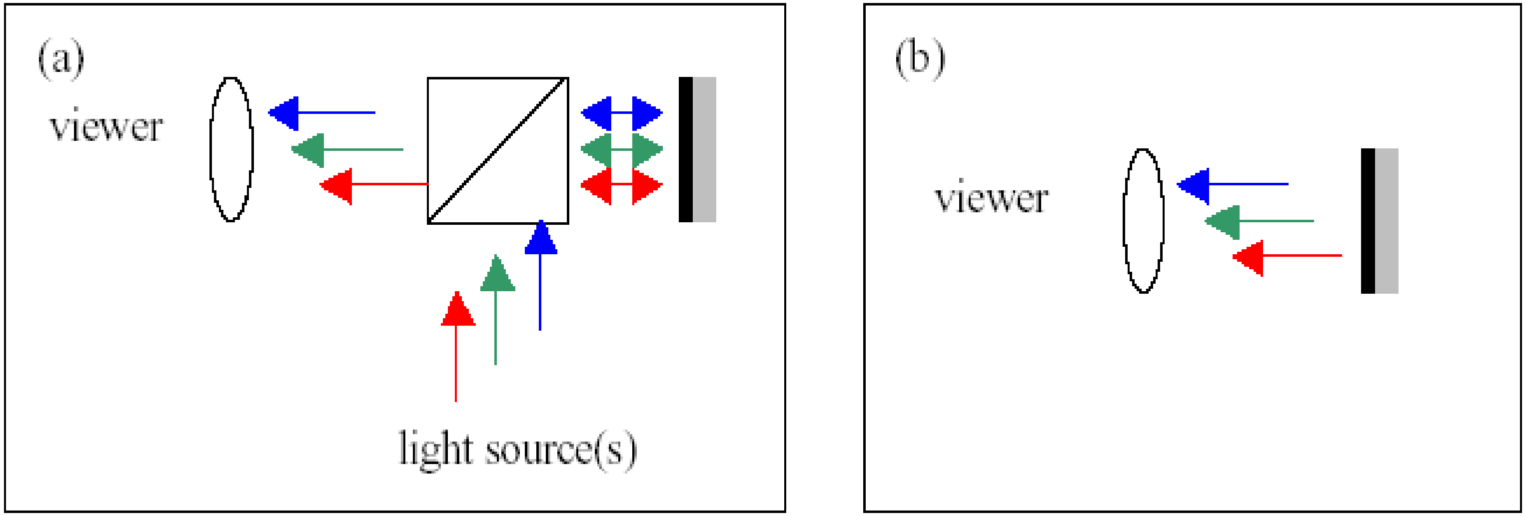
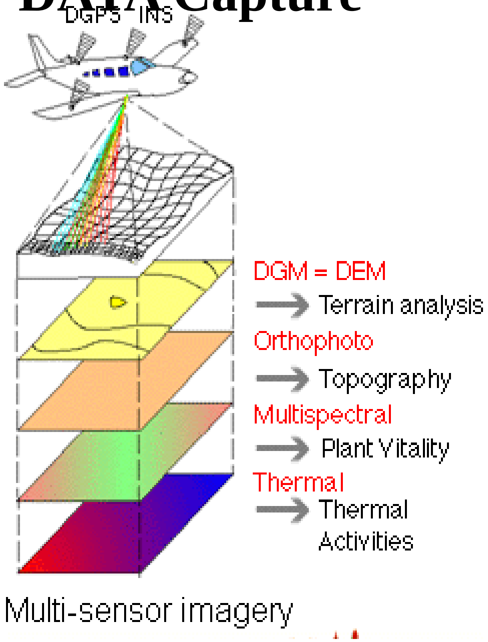


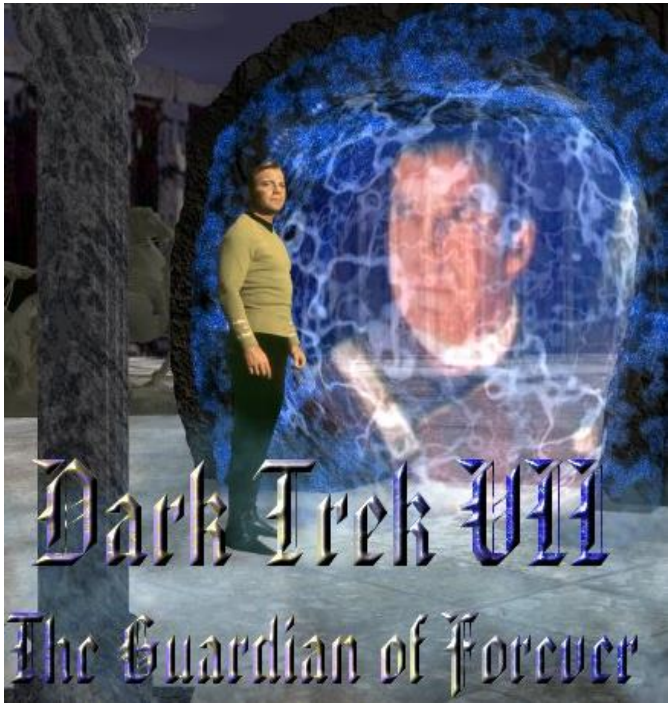
Fig 2.1 Simple system schematic of (a) modulating microdisplay (b) emissive microdisplay

3D Imagery

DATA Capture



DATA Display

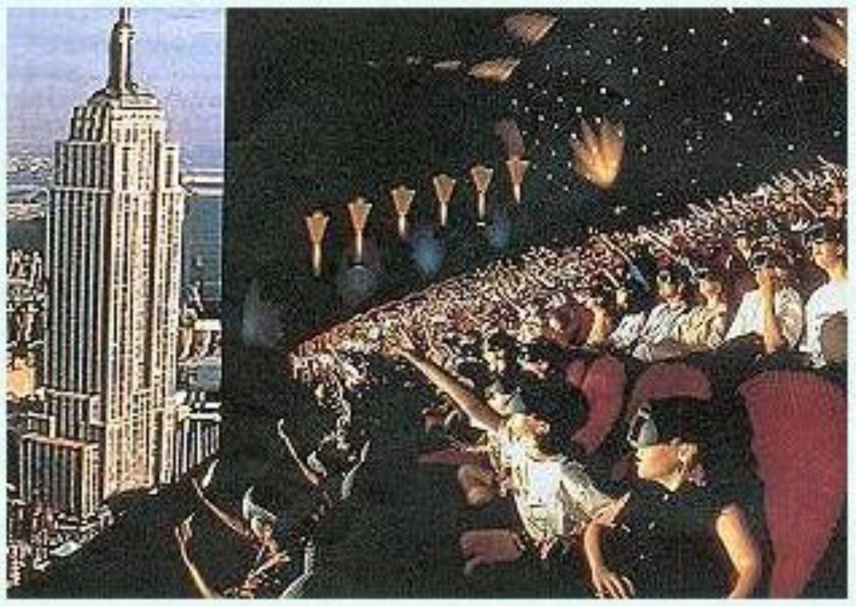


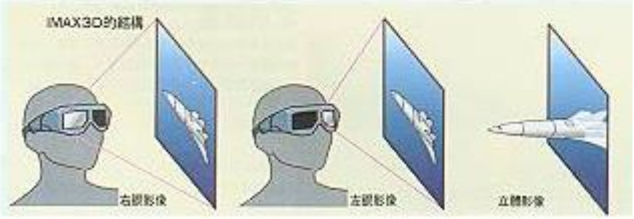
Polarization--可呈現6層樓高巨大畫面的大型立體影像系統

加拿大愛馬克斯公司(lMAX)是著名的立體影像裝置的開發者，該公司係發跡於蒙特婁(Montreal)萬國博覽會，當時該公司曾經將多放影機的方 式(multi—screen)應用於電影上面，產品推出後獲得極高的評價。

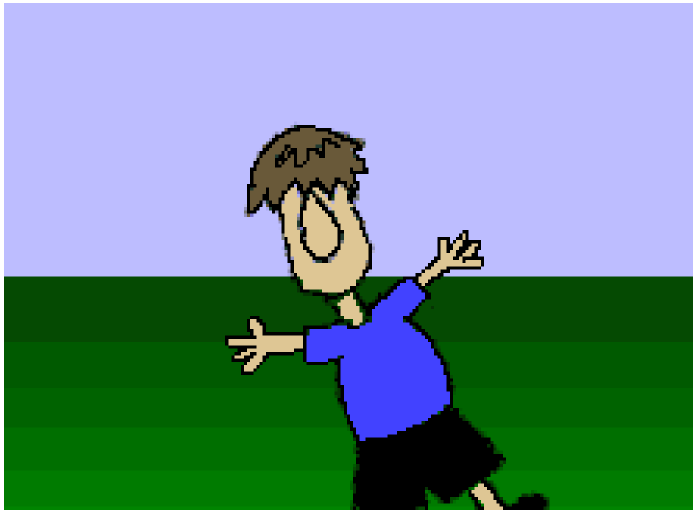
由於電影製作人想避免使用複雜的多放影機方式，於是該公司又開發出以單架強力放影機就能獲得同等效果的裝置，這就是所謂的「IMax影像系統」。

IMAX影像系統於1970年大阪萬國博覽會首次亮相，那個時候是利用極大型的銀幕來展現嶄新的影像。1985年筑波科學博覽會，此項系統則以能提供立體影像的方式露面。

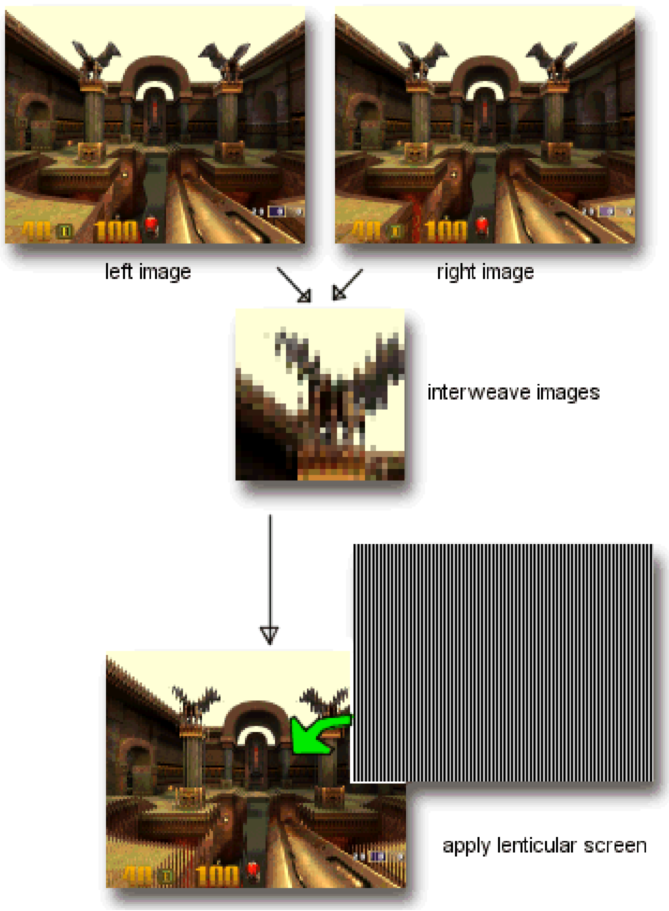




Inter-vision /3D Display Techniques



Principle I.



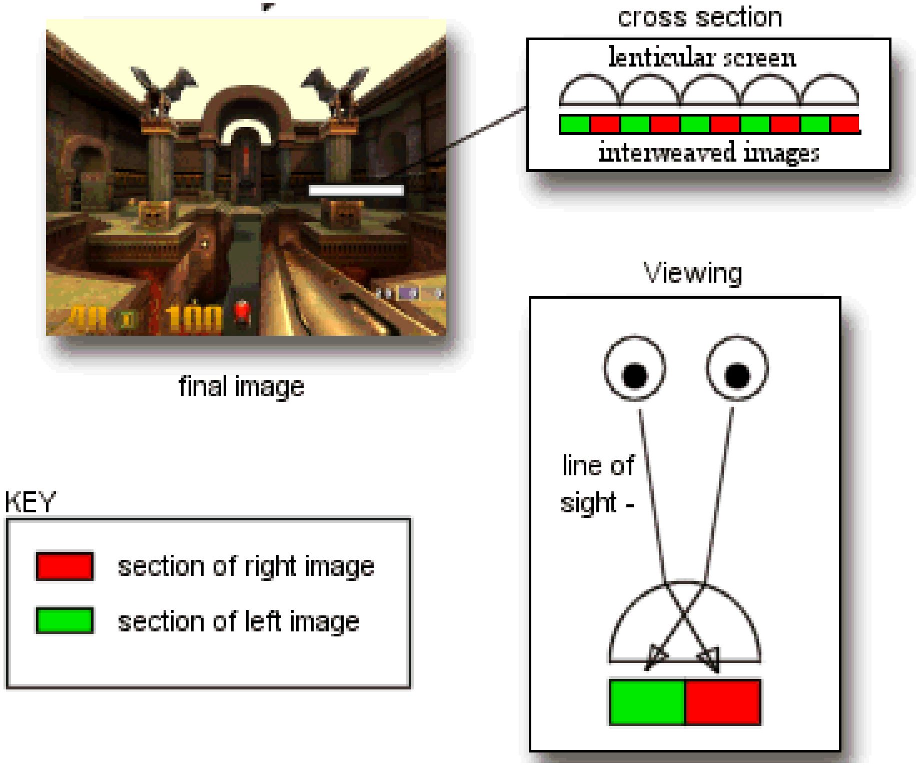
left image

right image

interweave images

apply lenticular screen

Principle II.



cross section

lenticular screen

interweaved images

final image

Viewing

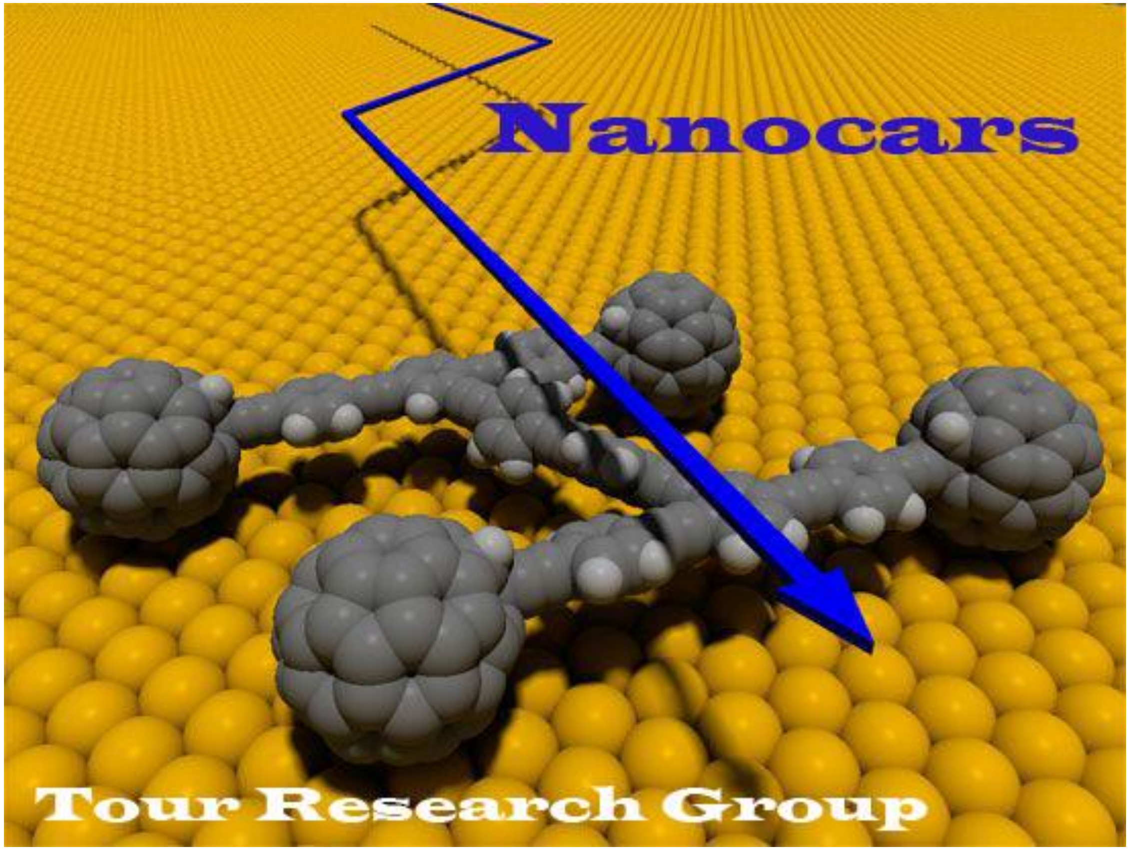
line of sight -

KEY

🟥 section of right image

🟩 section of left image

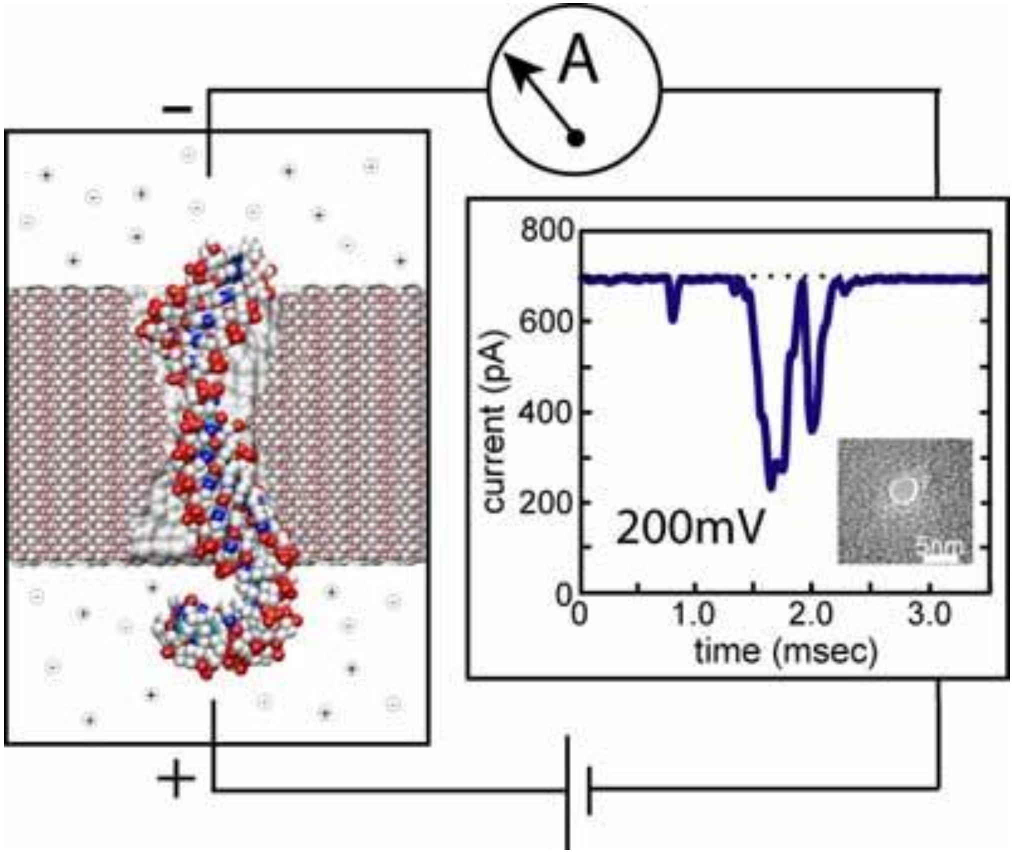
Micro Engineering



T4 病毒入侵細菌動畫

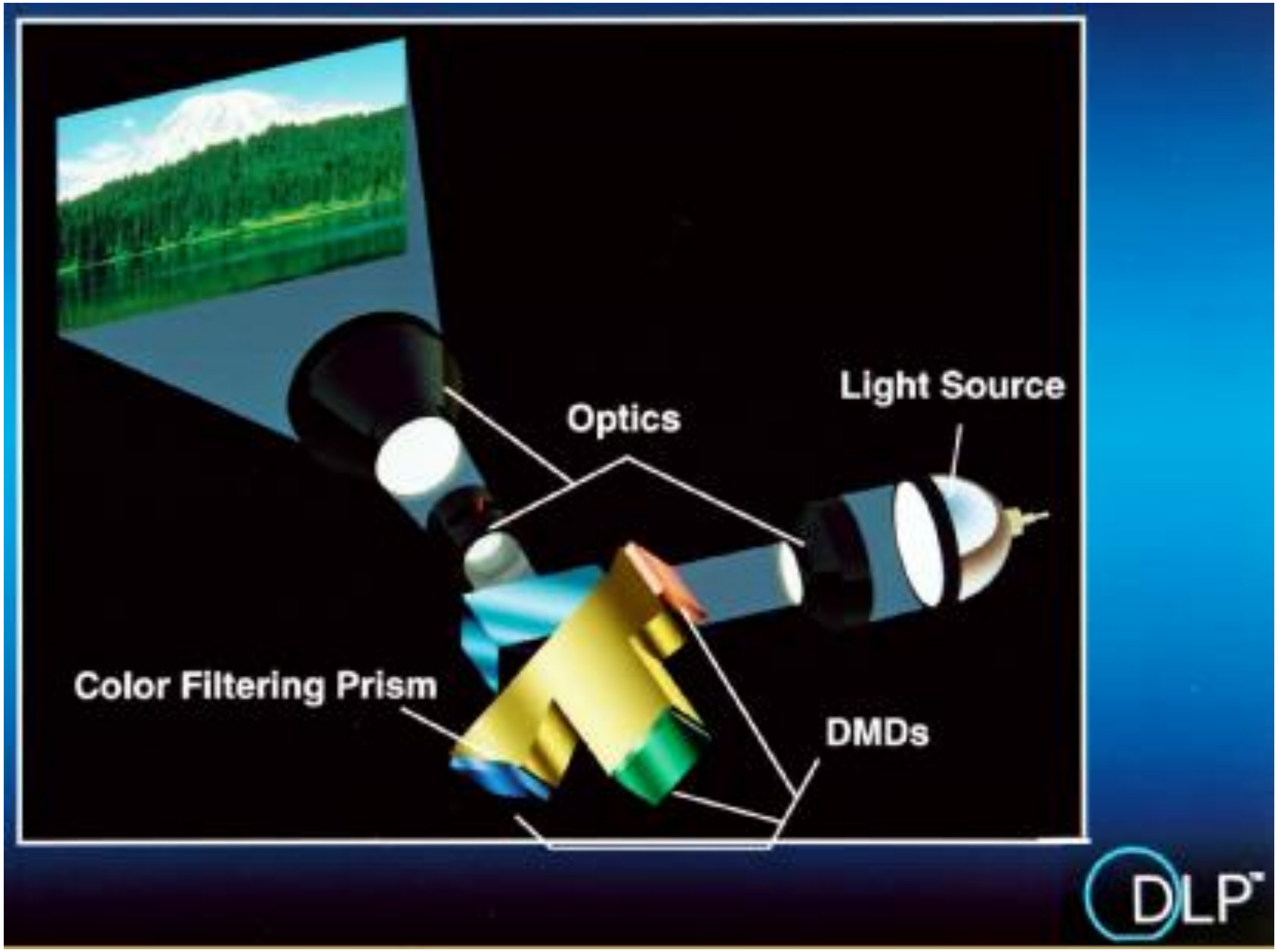
各大科學期刊競相報道的高清晰T4病毒入侵細菌動畫，製作非常精美，美俄日三國科學家共同完成，刊登於04年8月20日出版的《Cell》雜誌上。

Translocation of DNA through Synthetic Nanopores

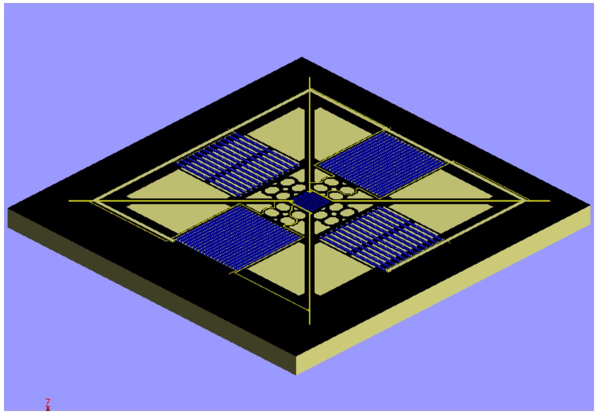


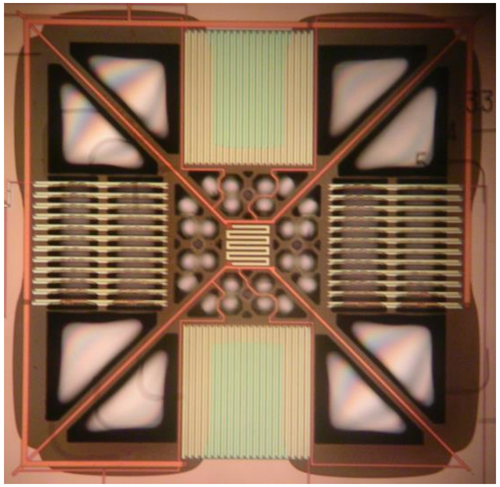
http://www.ks.uiuc.edu/Gallery/Movies/

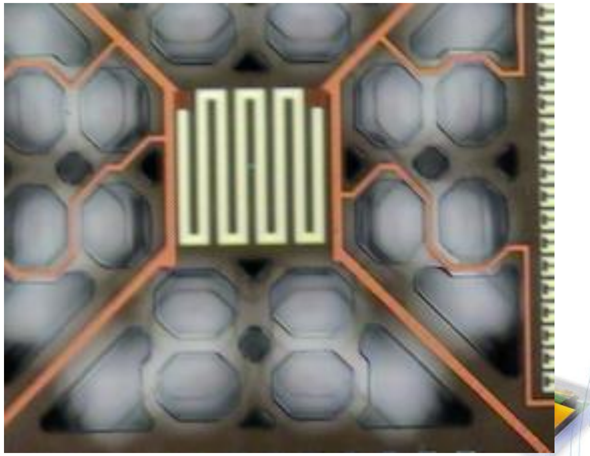
DLP



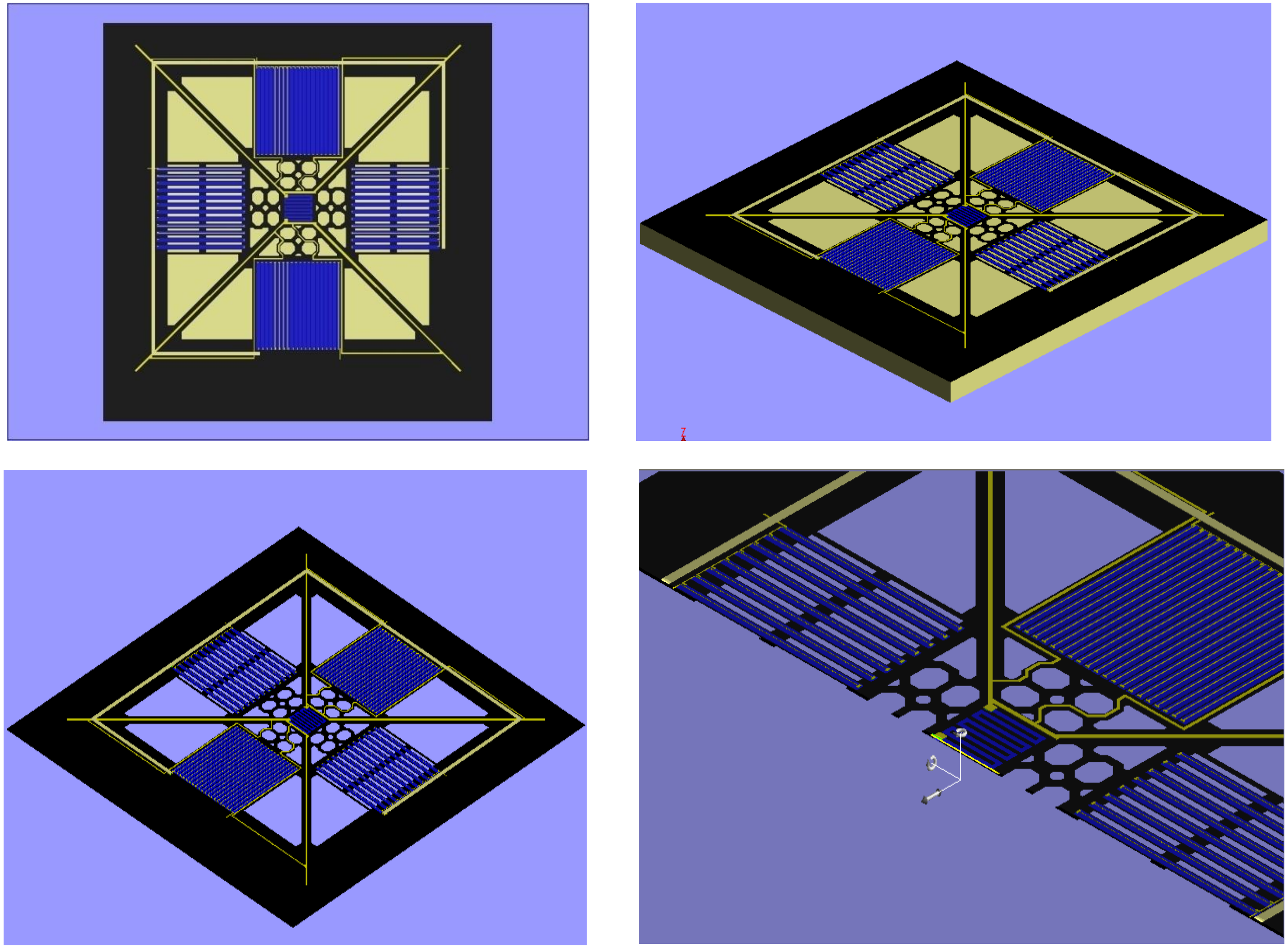
加速計/傾斜計



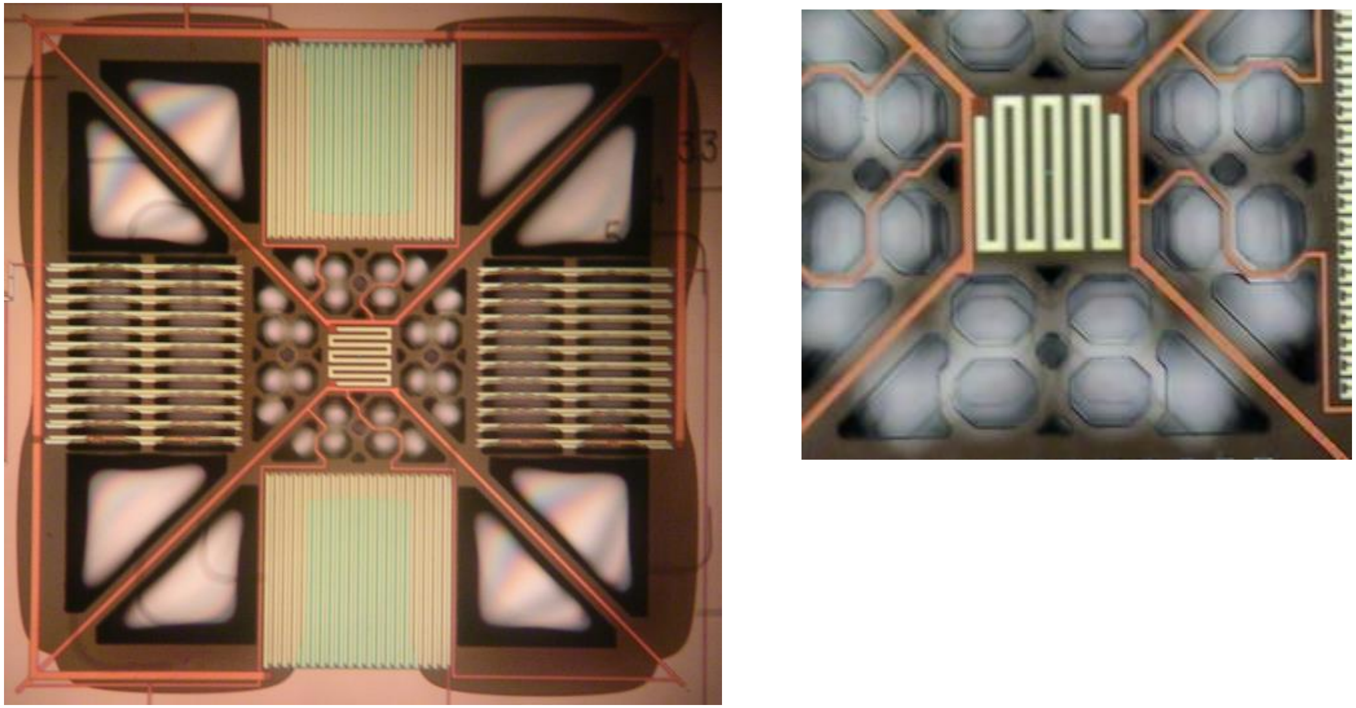




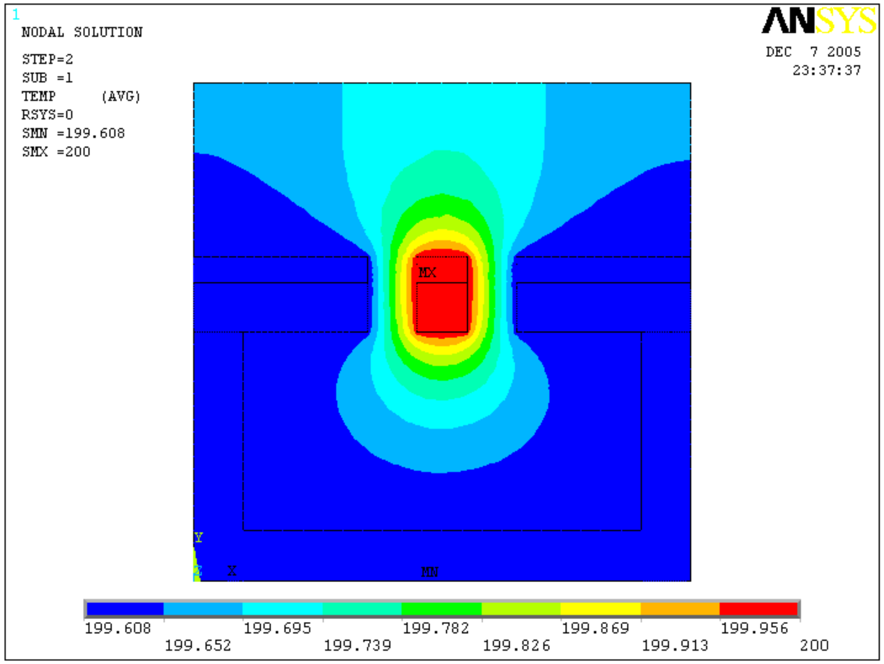
加速計/傾斜計



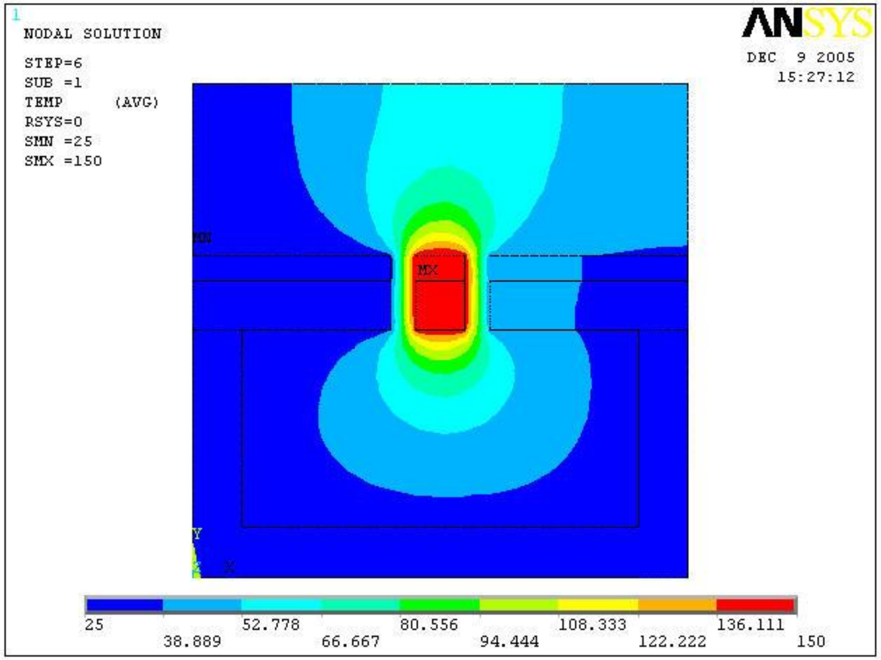
晶片照片



感測原理

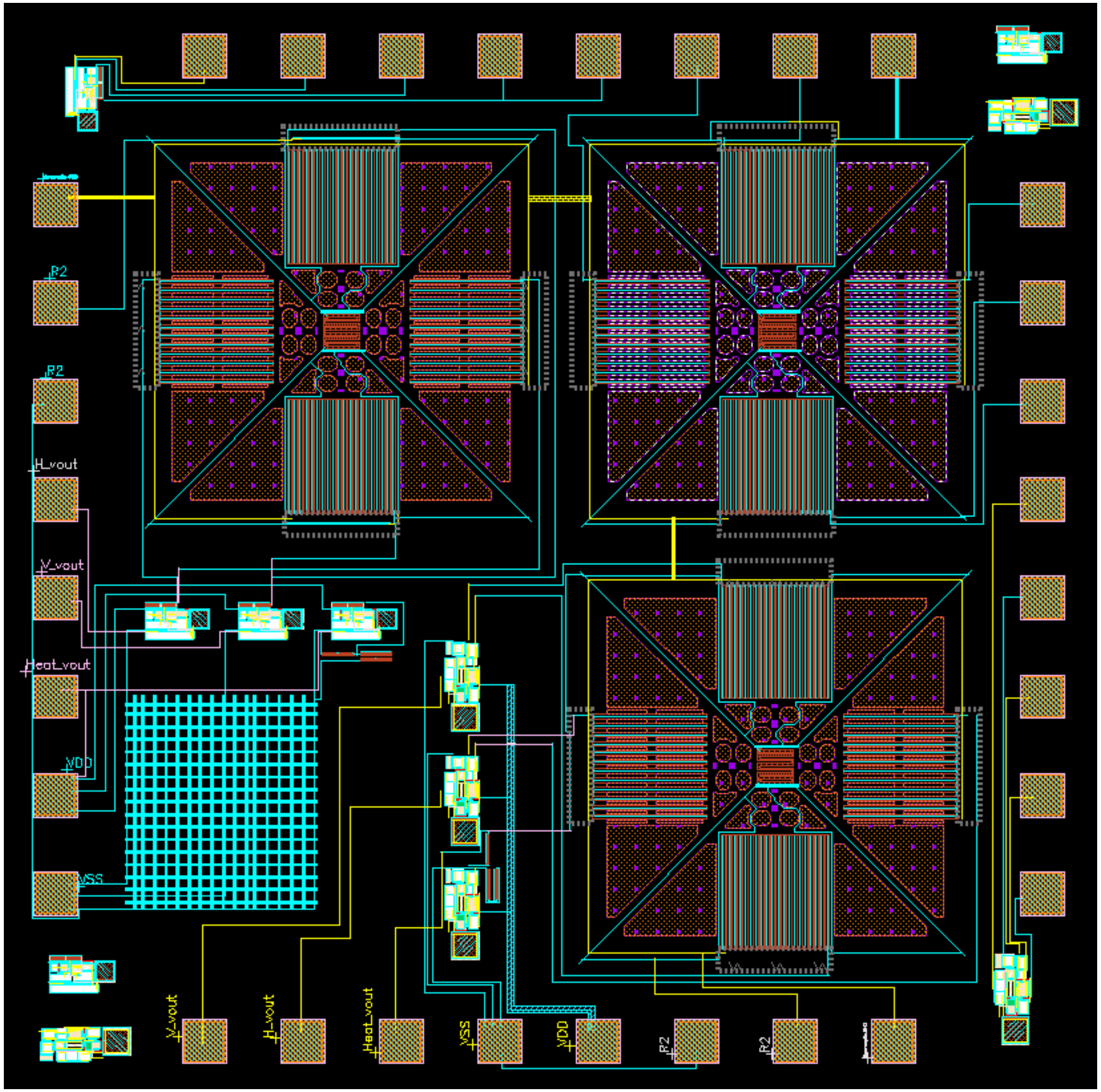


2-D元件模擬~靜止狀態



2-D元件模擬~往__ 運動

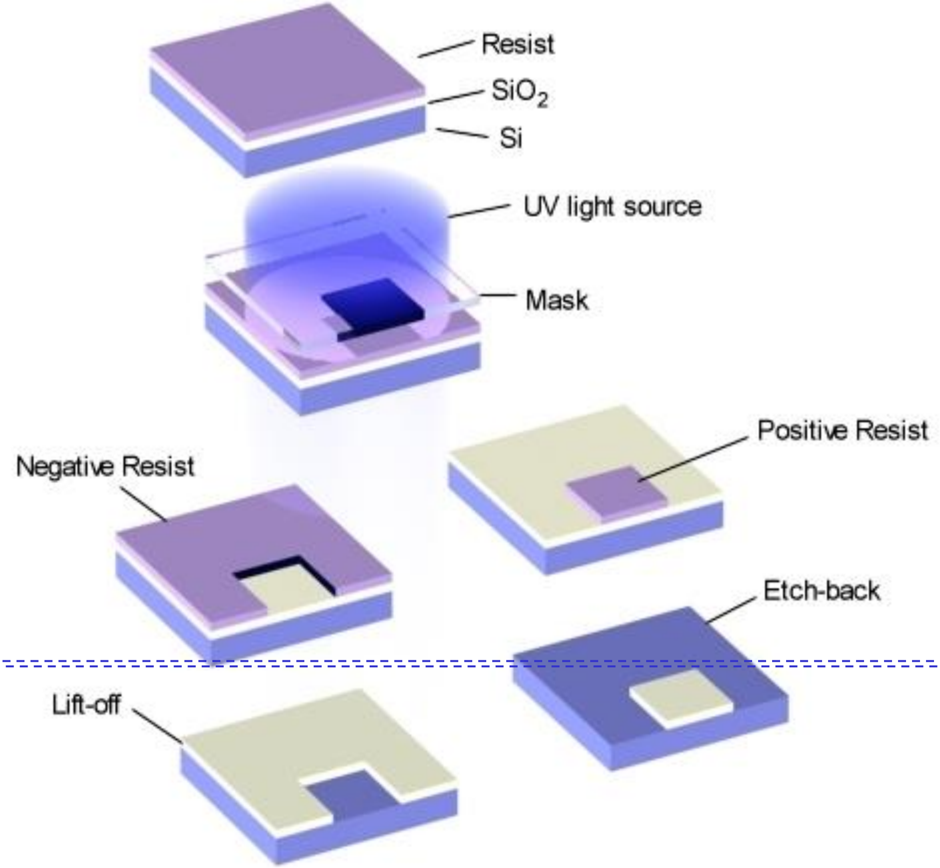
感測器以及電路設計~系統



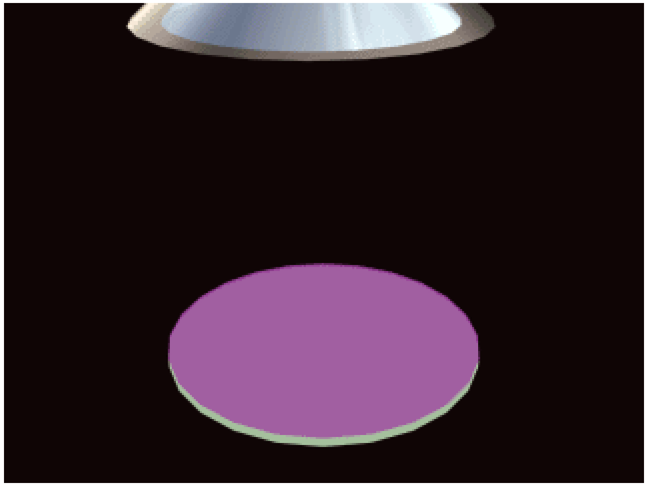
曝光顯影以及蝕刻

曝光顯影

蝕刻



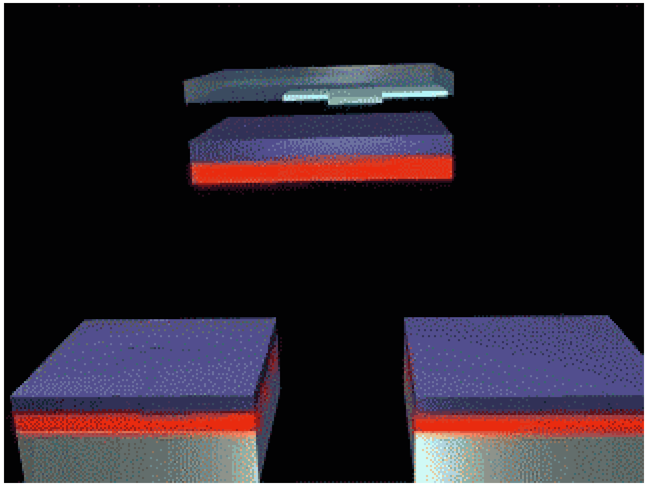
光罩



光罩即是將我們所要之設計電路圖形，利用電子束曝光系統將鉻膜上圖形製作在玻璃或石英上，再利用此光罩上金屬鉻膜擋住光線，而沒有金屬鉻膜的地方，光線就會穿透玻璃到達已塗佈有機光阻的晶圓上，經由光罩上透光與不透光的差別，可在光阻塗層上定義出曝光及不曝光的區域，經由適當的顯影步驟，去除感光的光阻（或去除未感光的光阻），即可用未感光的光阻（或感光的光阻），定義出光罩電路圖形。而目前晶圓上的光阻圖樣一般為光罩圖形的四分之一倍。

光阻

- 光阻介紹
- 光阻的作用是要將積體電路結構圖形印製在晶圓表面上，其功能有些類似底片上的感光劑。光阻主要可分為正光阻及負光阻二種。正光阻就是被光照射的部份可以被顯影液去除掉，而未曝光的光阻則不會被顯影液去除(左邊)。而負光阻則相反，被光照射的部份不會被顯影液去除，而其餘不被光所照射的區域將會被顯影液所去除(右邊)。

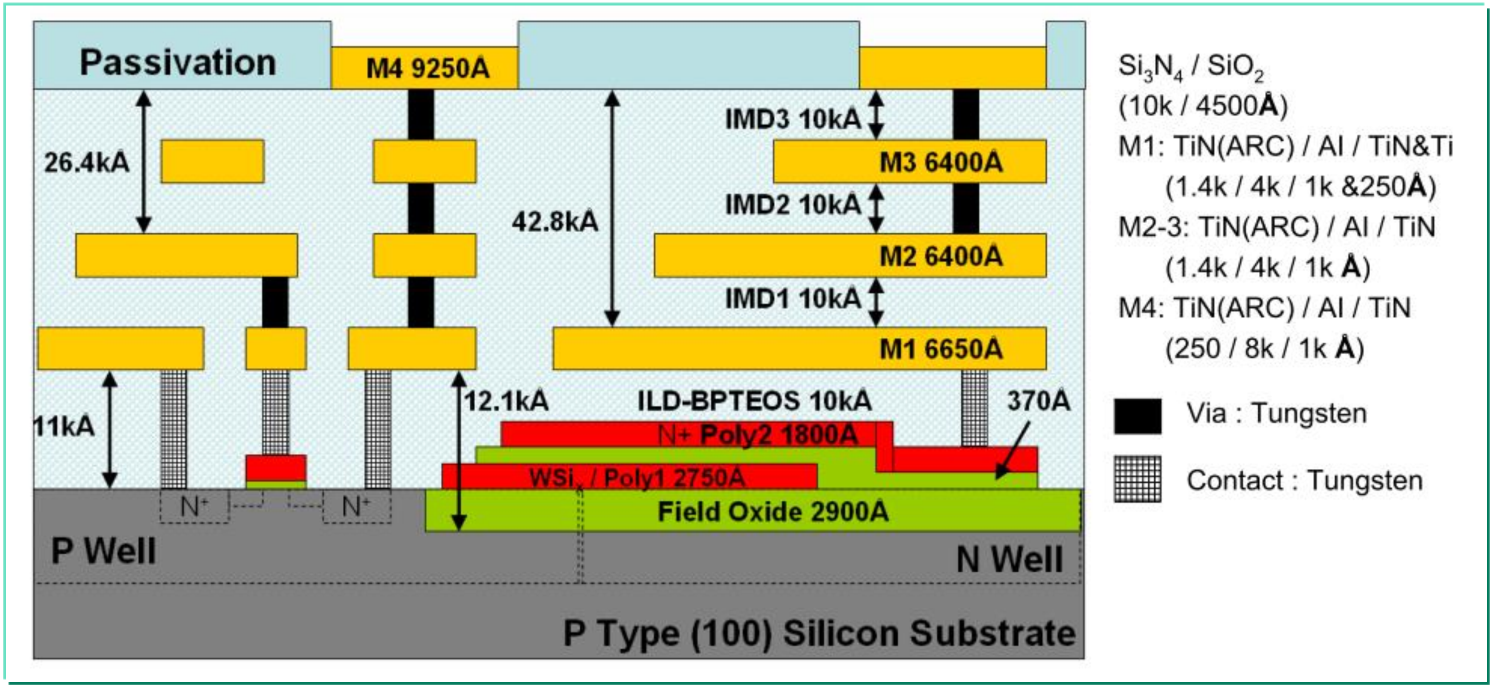


MOEMS

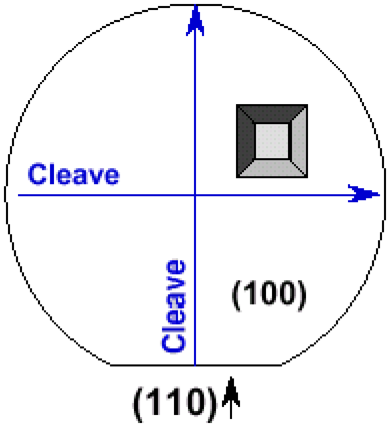
CIC CMOS MEMS Process

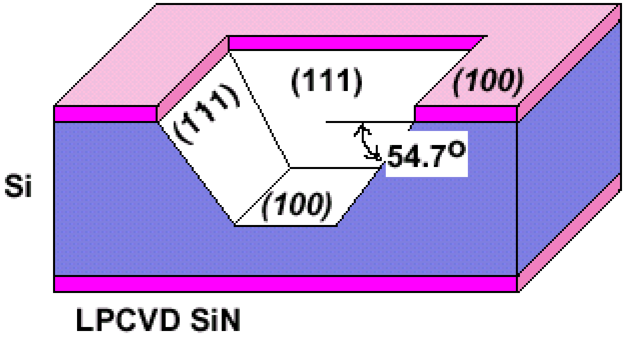
- TSMC 0.35 um 2P4M silicide CMOS process consists of two polysilicon layers and four metal (Alumina) layers.
- Gate poly: $TiSi_2$ / polysilicon
- Metal: Tin / (Al,Cu) alloy / Ti
- ILD: BPSG; others: USG (undoped)
- Passivation: Ni_3N_4 / SiO_2
- Post process
- SiO_2 trench etching
- Isotropic silicon etching

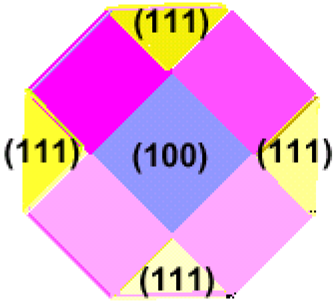
TSMC 2P4M

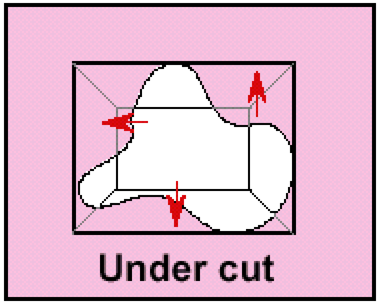

Passivation
M4 9250Å
26.4kÅ
IMD3 10kÅ
M3 6400Å
42.8kÅ
IMD2 10kÅ
M2 6400Å
IMD1 10kÅ
M1 6650Å
11kÅ
12.1kÅ
ILD-BPTEOS 10kÅ
370Å
N+ Poly2 1800Å
WSi_x / Poly1 2750Å
Field Oxide 2900Å
N+
N+
P Well
N Well
P Type (100) Silicon Substrate
Si_3N_4 / SiO_2
(10k / 4500Å)
M1: TiN(ARC) / Al / TiN&Ti
(1.4k / 4k / 1k &250Å)
M2-3: TiN(ARC) / Al / TiN
(1.4k / 4k / 1k Å)
M4: TiN(ARC) / Al / TiN
(250 / 8k / 1k Å)
Via : Tungsten
Contact : Tungsten

Post-Processes of CMOS MEMS



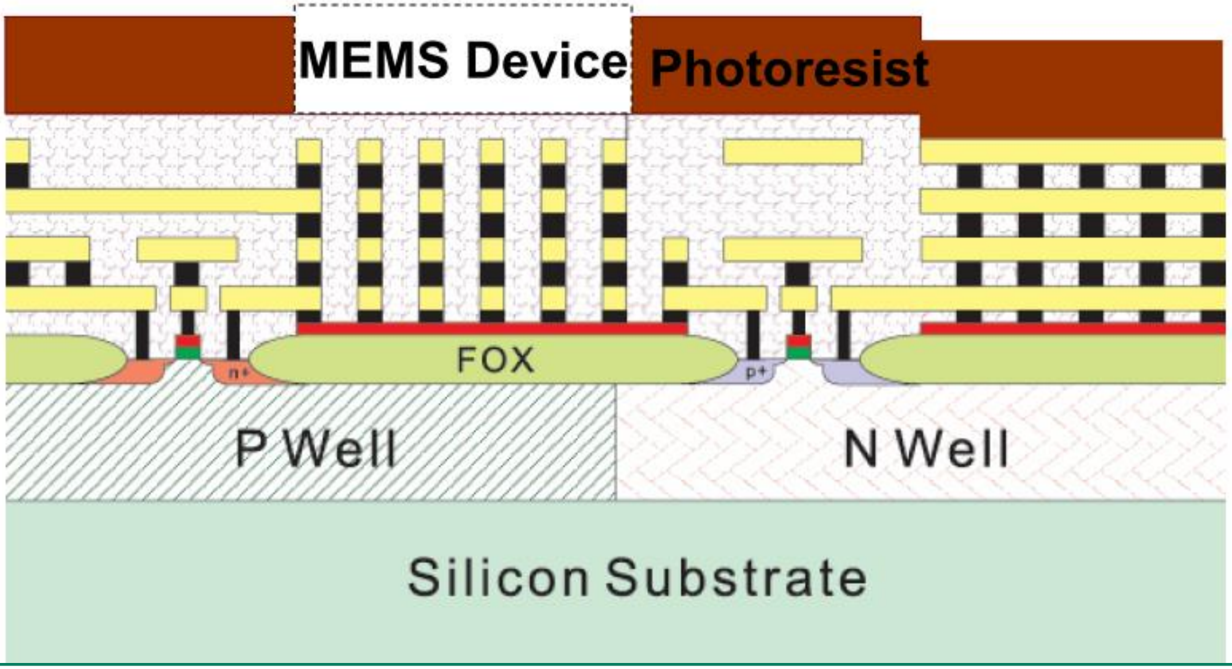




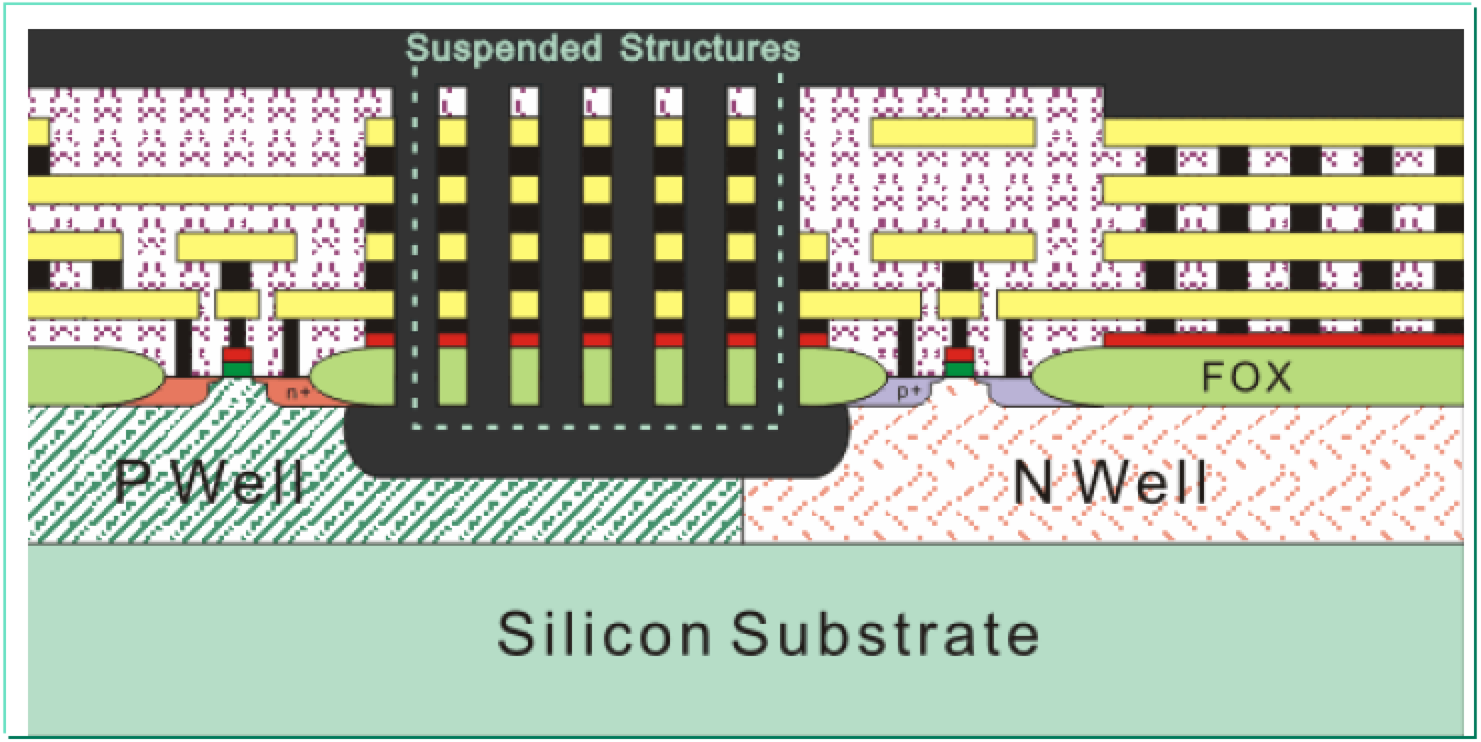


Post-process Design of CIC (1)

MDRC mask : define MEMS device area
RLS mask : define etching area

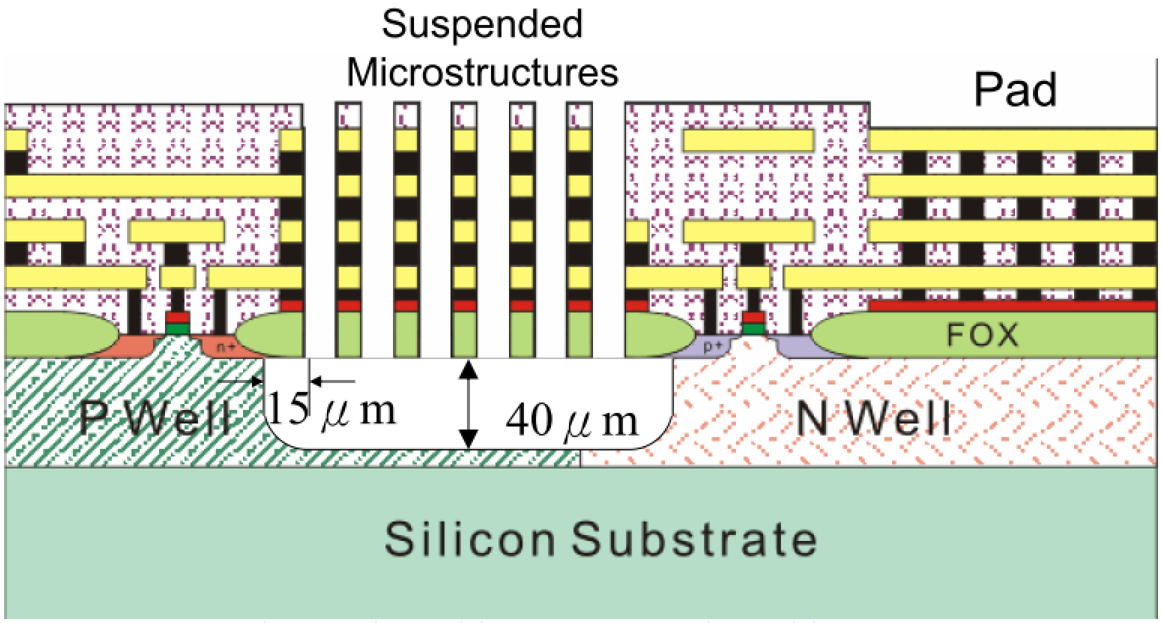


Post-process Design of CIC (2)



Post-process of CIC

SiO_2 trench etching and isotropic silicon etching

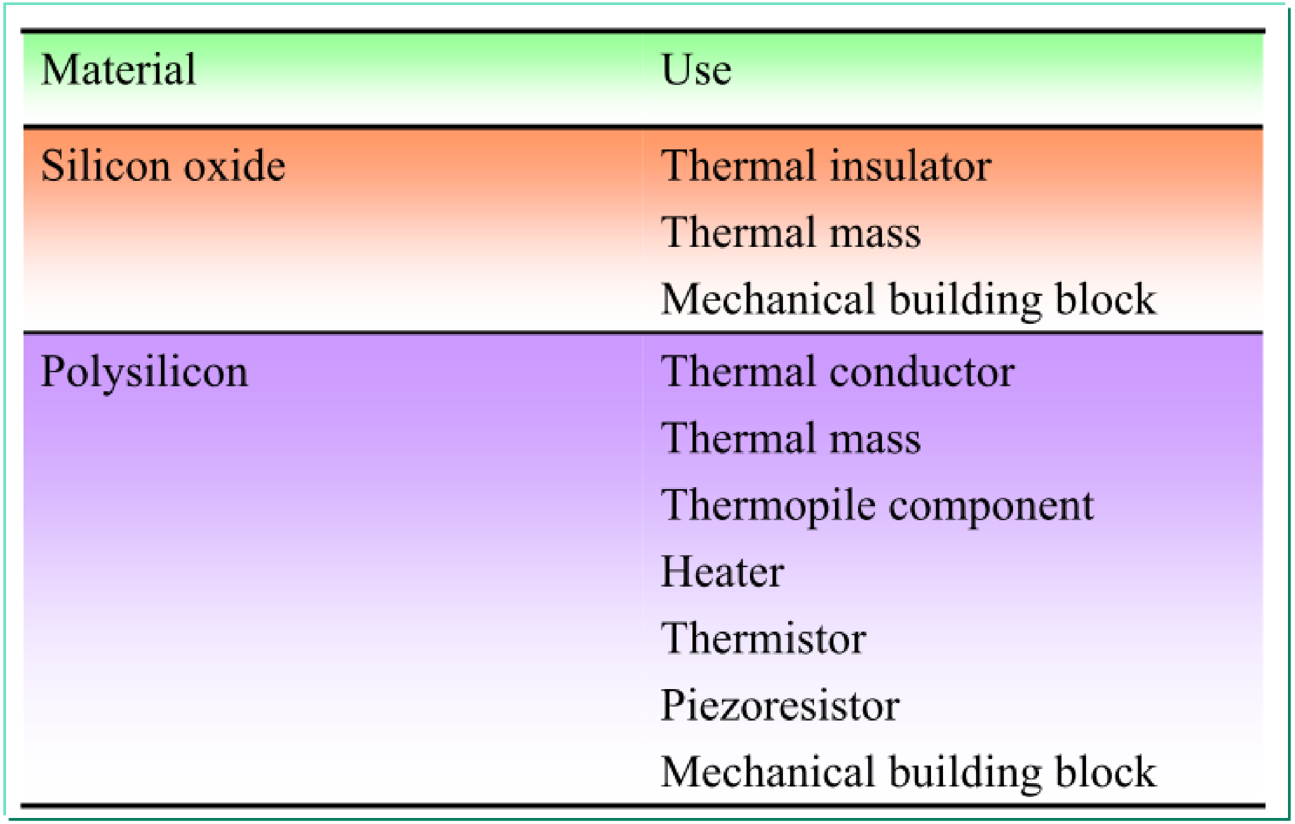


Anisotropic etching + Isotropic etching

- Silicon nitride
- Silicon dioxide
- ~8 μm

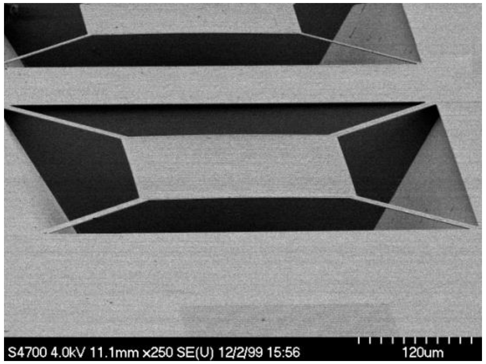
- Silicon substrate
- >15 μm

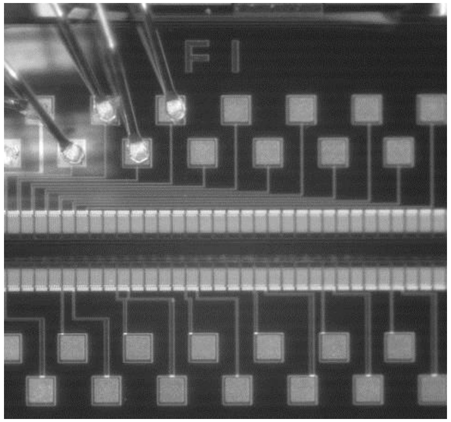
Materials for CMOS MEMS

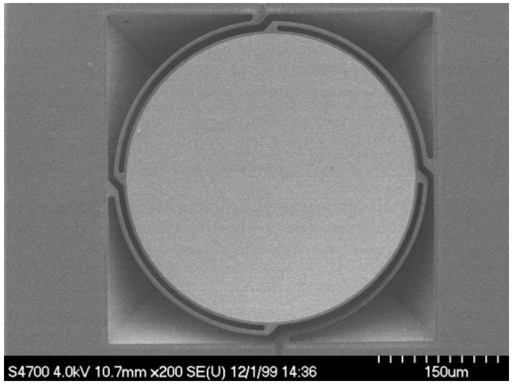


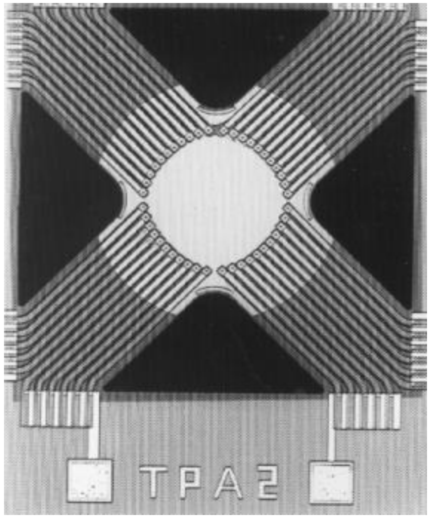
Material	Use
Silicon oxide	Thermal insulator Thermal mass Mechanical building block
Polysilicon	Thermal conductor Thermal mass Thermopile component Heater Thermistor Piezoresistor Mechanical building block

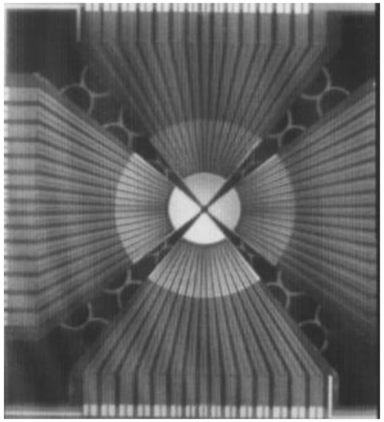
I. MEMS Infrared Sensors



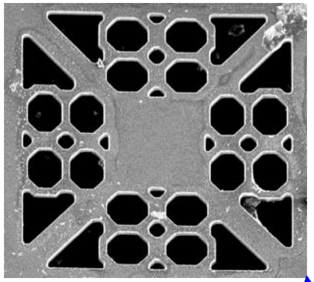




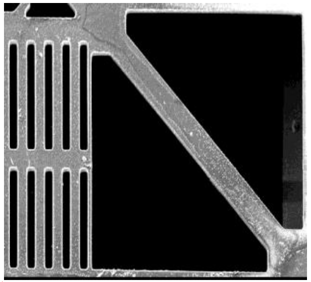




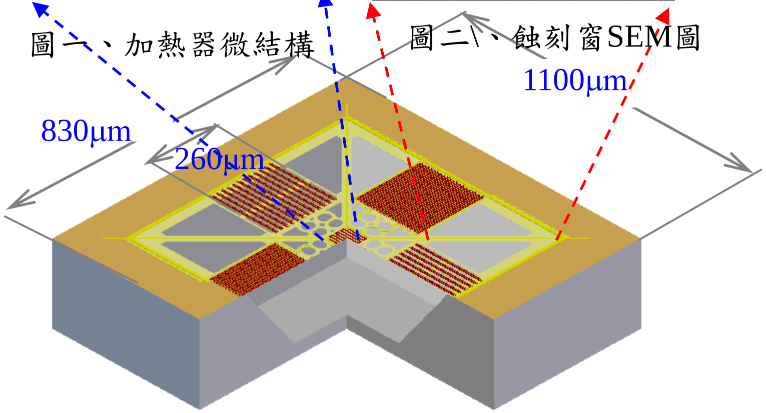
II. 熱型加速計



圖一、加熱器微結構



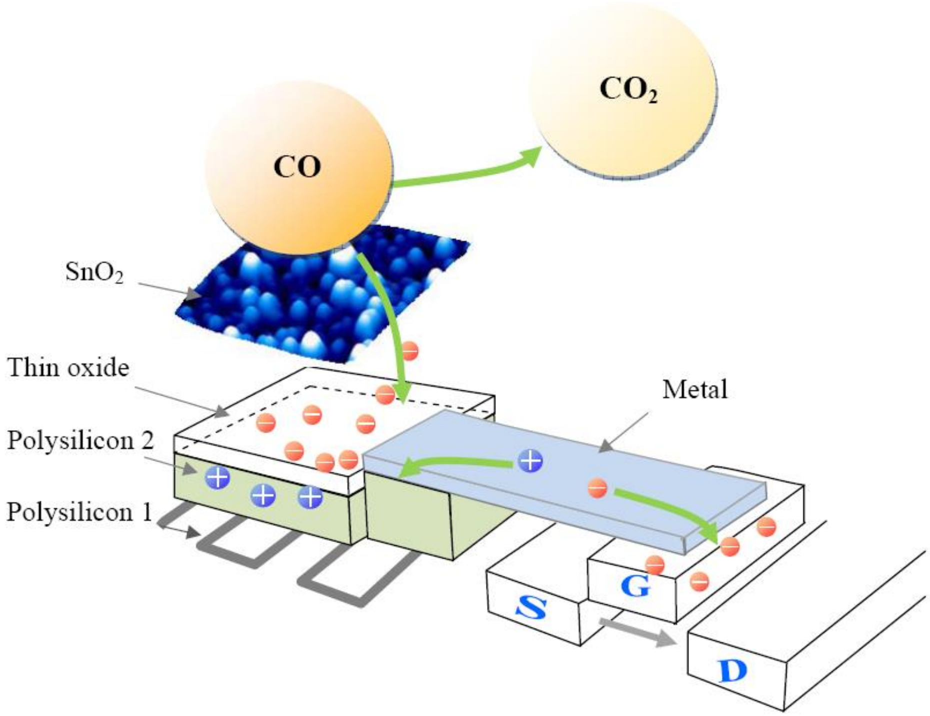
圖二、蝕刻窗SEM圖



圖三、新穎2D的熱型加速計元件尺寸側視圖

- 利用TSMC0.35um CMOS製程中的不同材料來製作出熱電堆的感測元件。
- 熱電堆元件在CMOS製程製作新式熱型加速度計的2-D層次圖。
- 首先在矽基材上長出一層Field Oxide，利用CMOS製程 2P4M的n+ Poly和Al或p+ Poly來製作成熱電偶。

III. 1 CMOS MEMS FET感測晶片



離子感測場效電晶體(ISFET): 一氧化碳氣體感測晶片
- N型多晶矽(N-poly Silicon)當微型加熱器電阻
- P型多晶矽(P-poly Silicon)在感測薄膜上再加熱成長一層薄氧化層,一氧化碳的感測薄膜,
- SnO2溶膠-凝膠法(Sol-Gel)滴附在感測薄膜上偵測CO氣體
-差動放大器電路介面電路技術與設計
-- TSMC 0.35μm之CMOS 2P4M 標準製程以及後製程製作