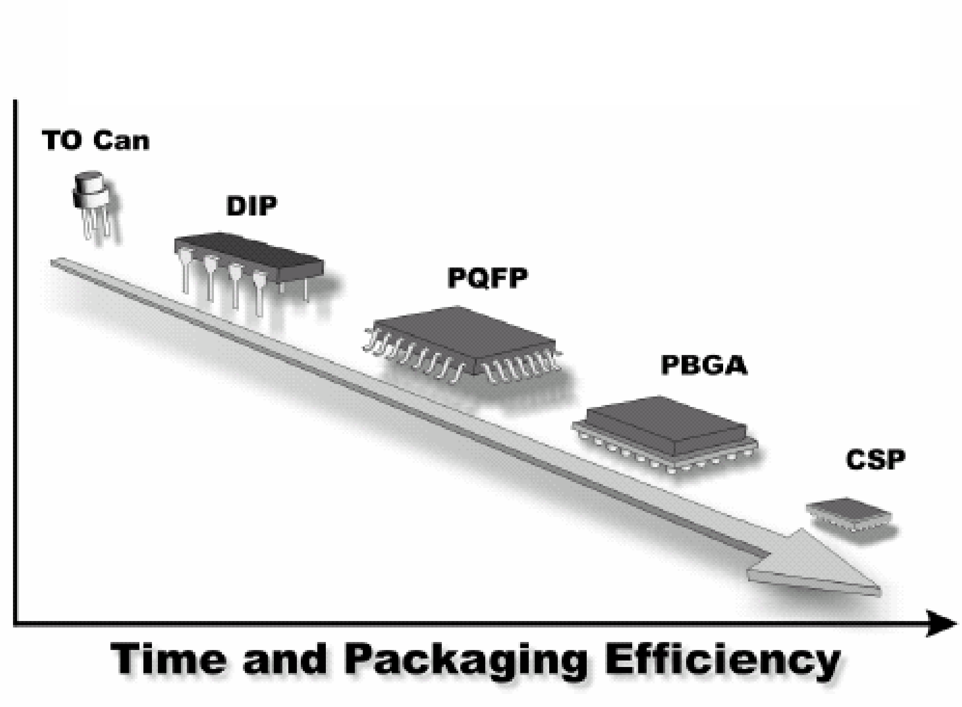
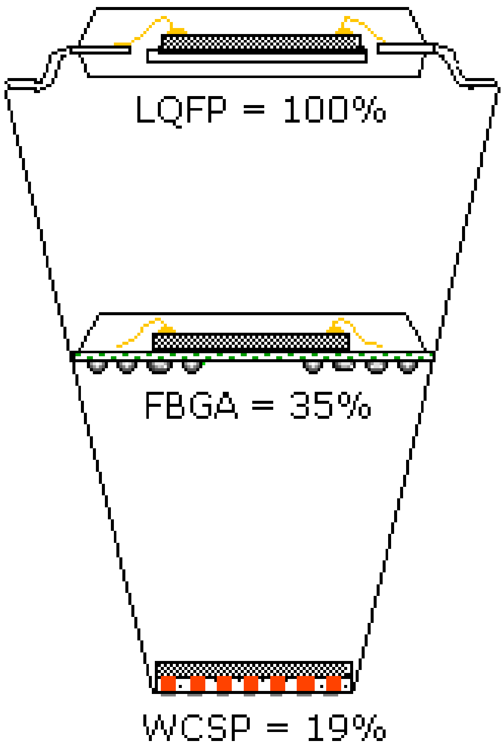
Introduction

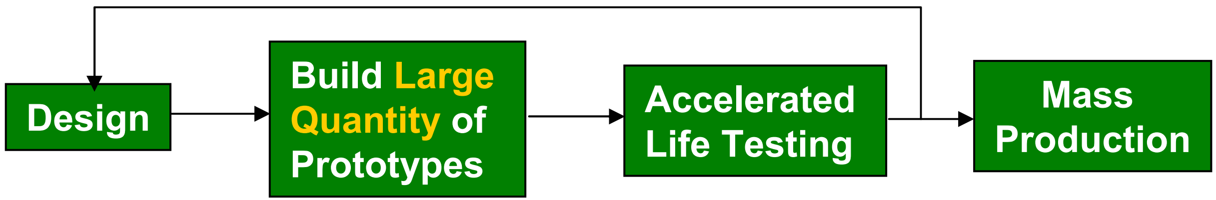
IC Packaging Evolution





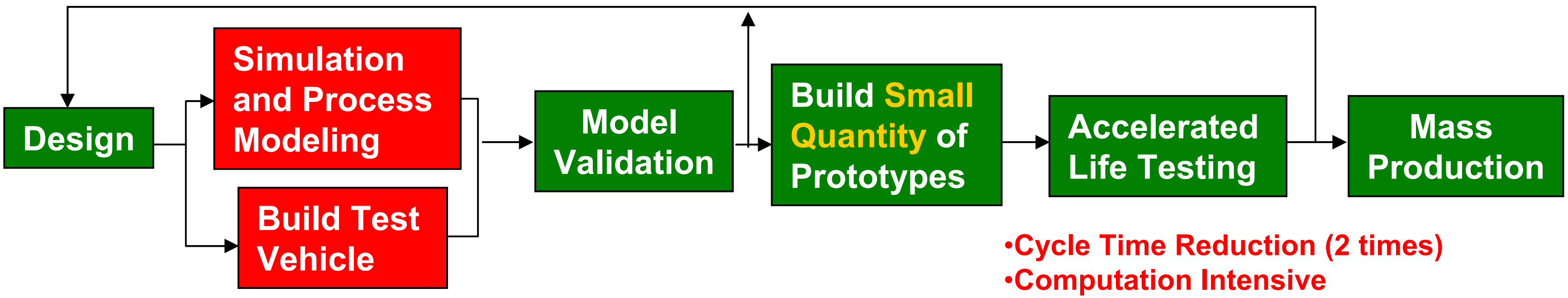
Reliability Modeling vs. Reliability Testing

1. Reliability Testing (Conventional Procedure, DOE)



- Labor Intensive
- Long Cycle Time (e.g. a typical cellular phone requires 4-7 iterations, 4-8 weeks per iteration)
- Lack of Physical Insight

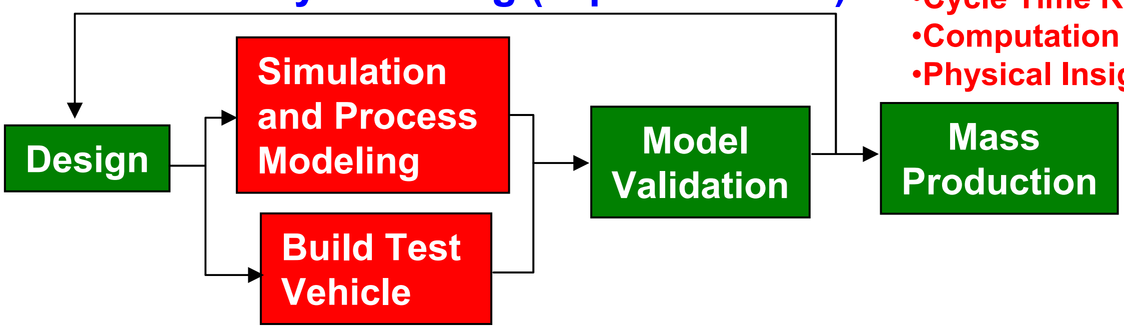
2. Reliability Modeling (Optimized Design Procedure)



- Cycle Time Reduction (2 times)
- Computation Intensive

3. Reliability Modeling (Optimal Goal)

- Cycle Time Reduction (10 times)
- Computation Intensive
- Physical Insight

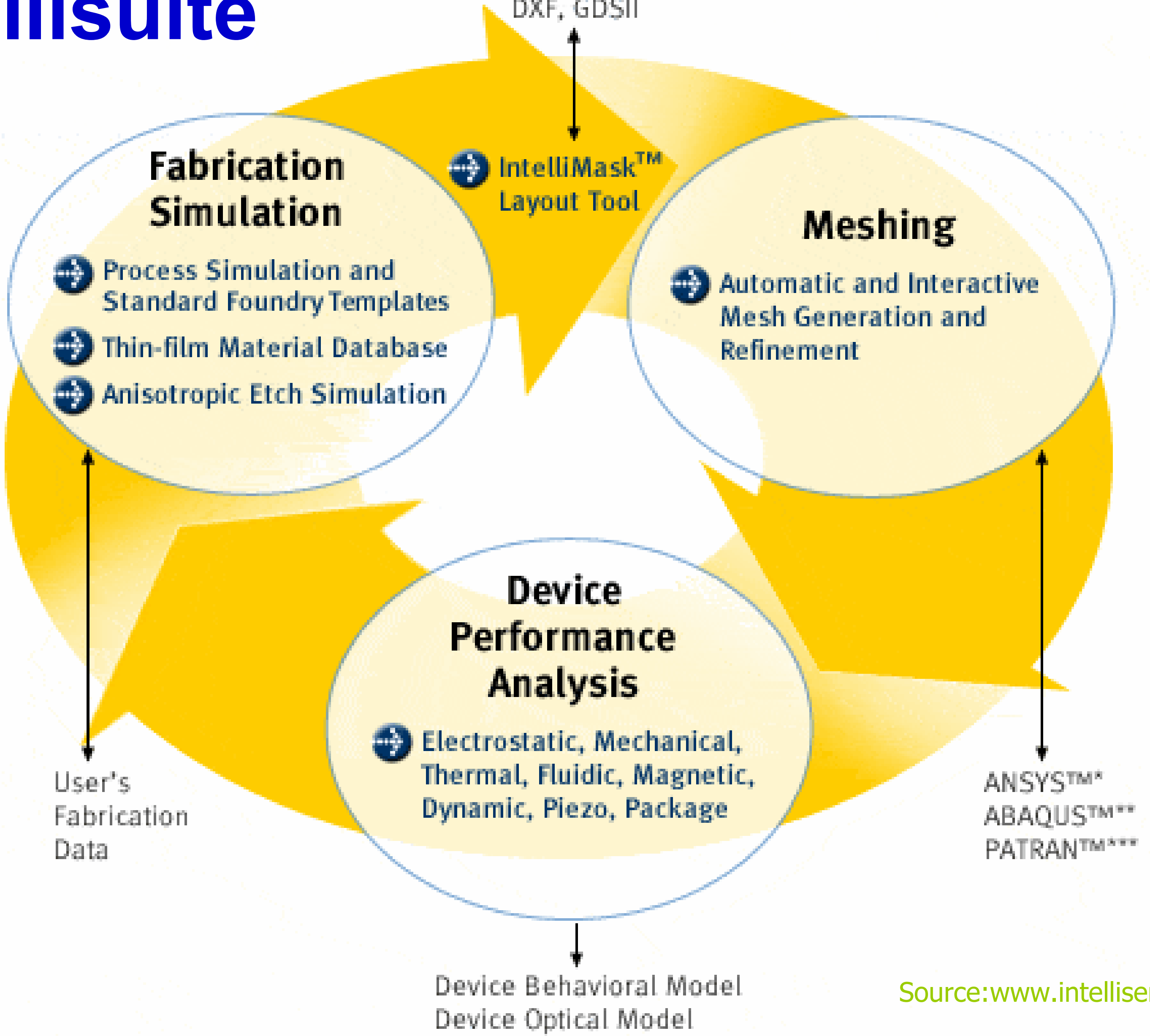


Software Tools for MEMS

- **Layout tools**
  - MEMCAD
  - Intellisuite
  - L-Edit
- **Process Simulation Tools**
  - Avant! TCAD(TSUPREM-4 for semiconductor)
  - Intellisuite
- **Device Simulation Tools**
  - MEMCAD
  - Intellisuite
  - ANSYS
  - NASTRAN
  - ABAQUS

MEMS

Intellisuite

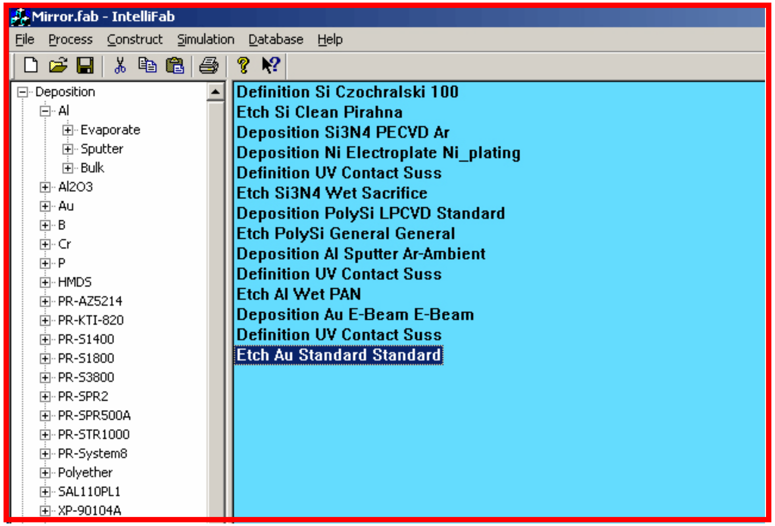


Source:www.intellisense.com

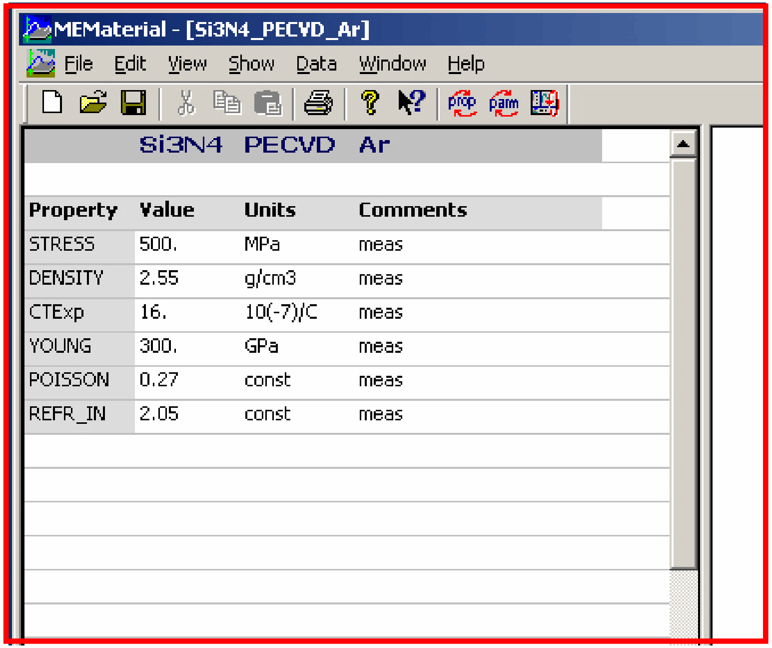
Intellisuite

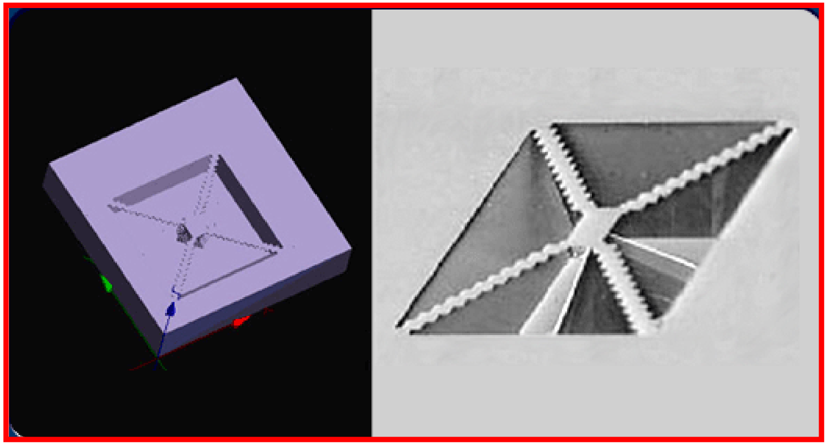
--Fabrication simulation

Process database & table



Thin-film Material Properties

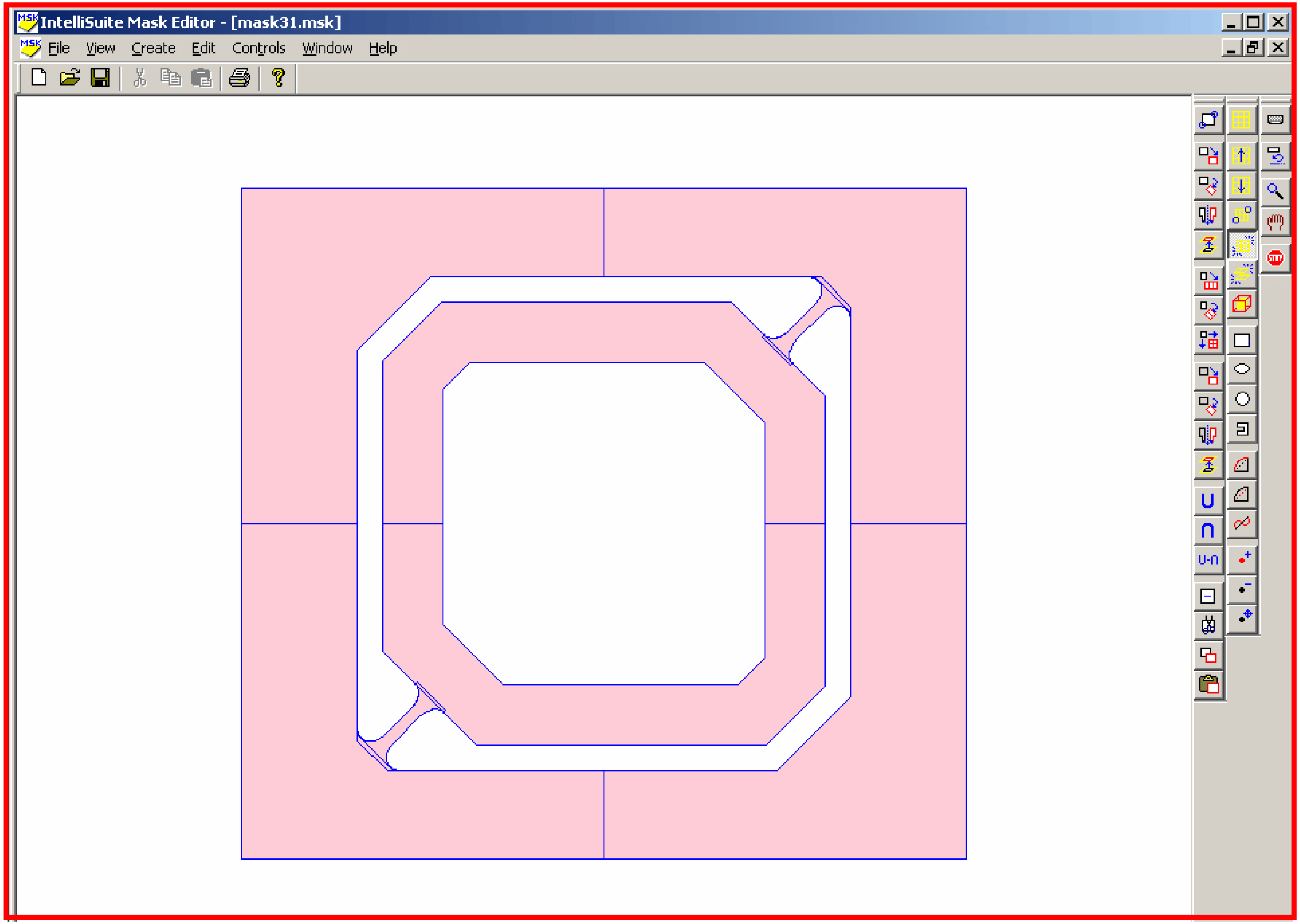




Anisotropic Etch Simulation(AnisE)

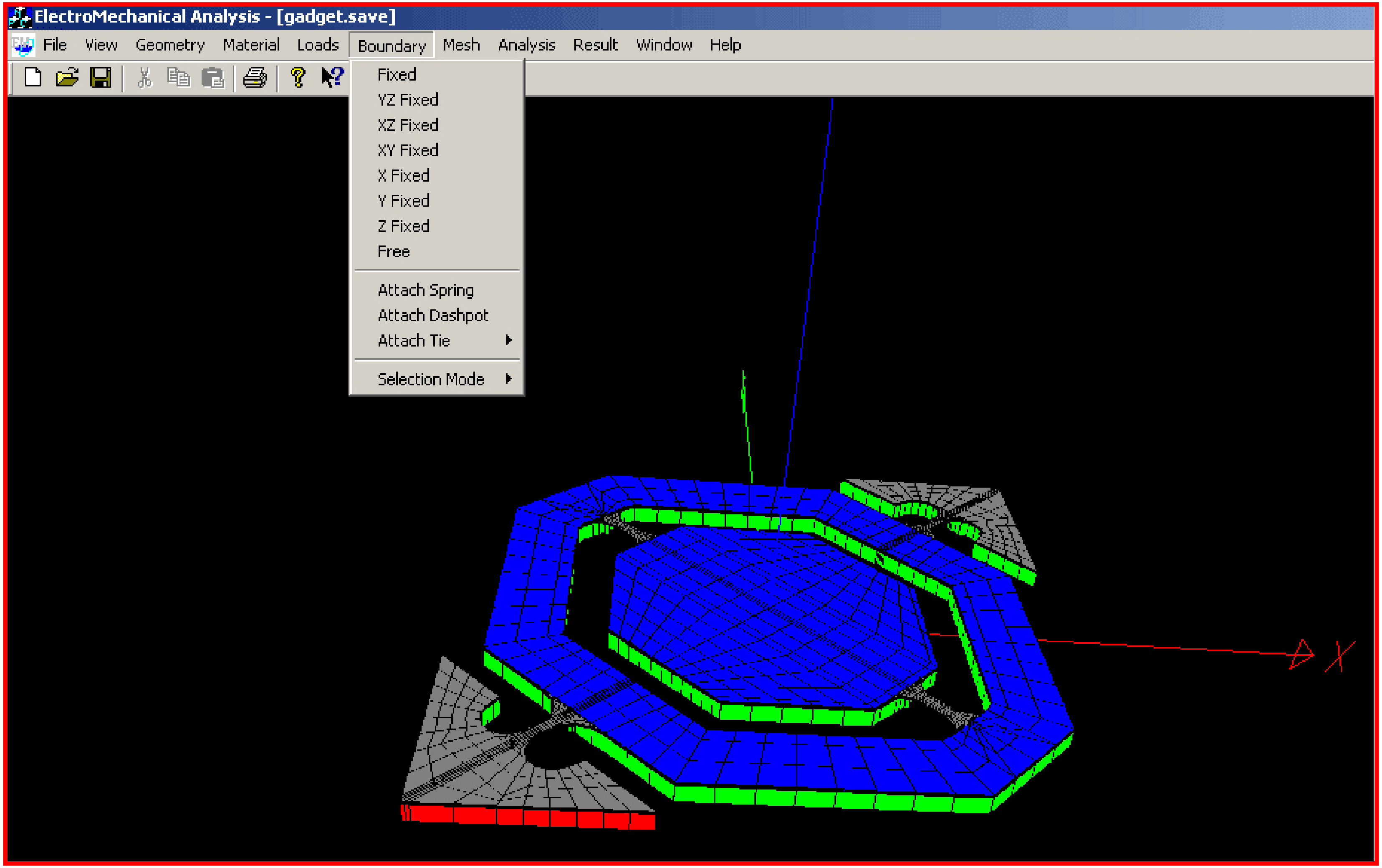
Intellisuite

--Mask Layout



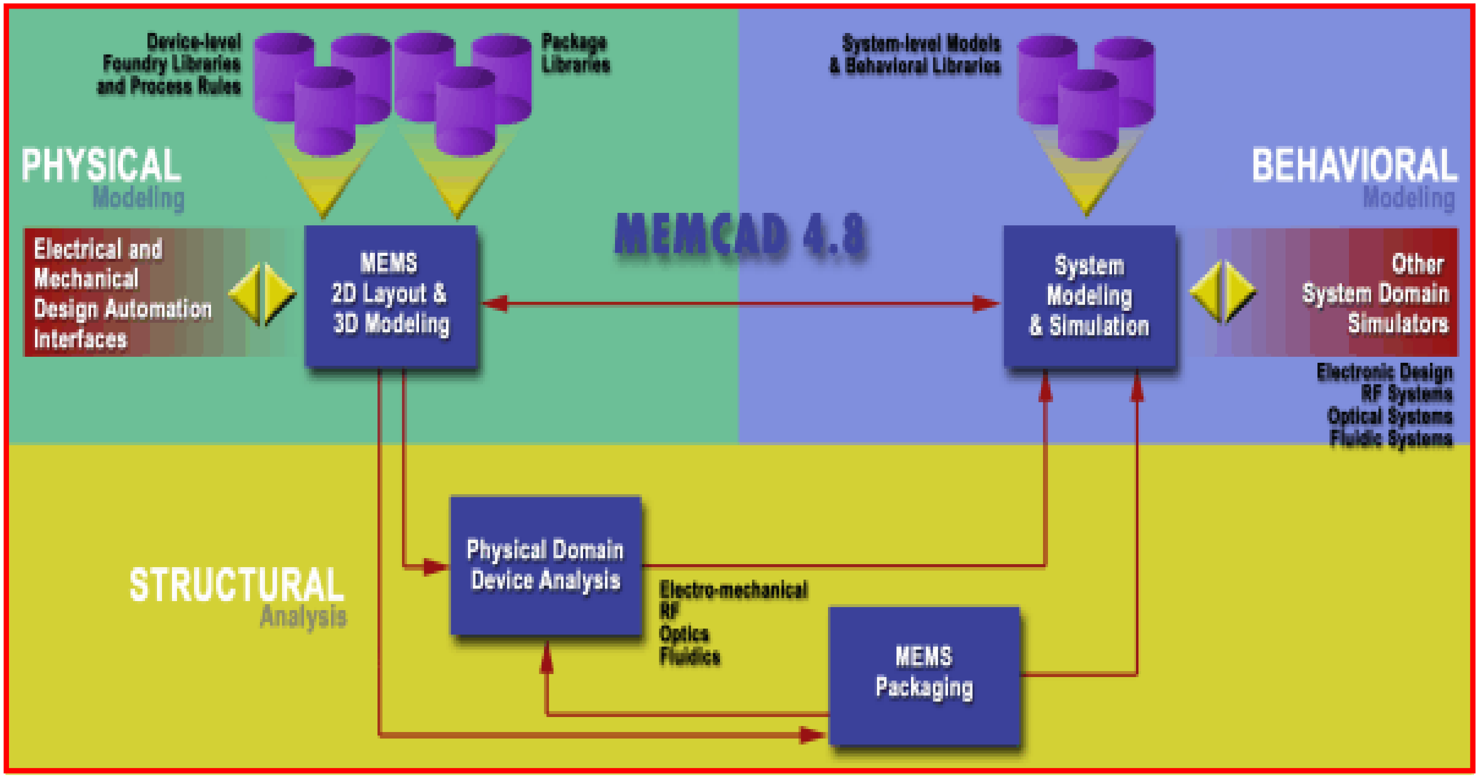
Intellisuite

--Performance Analysis



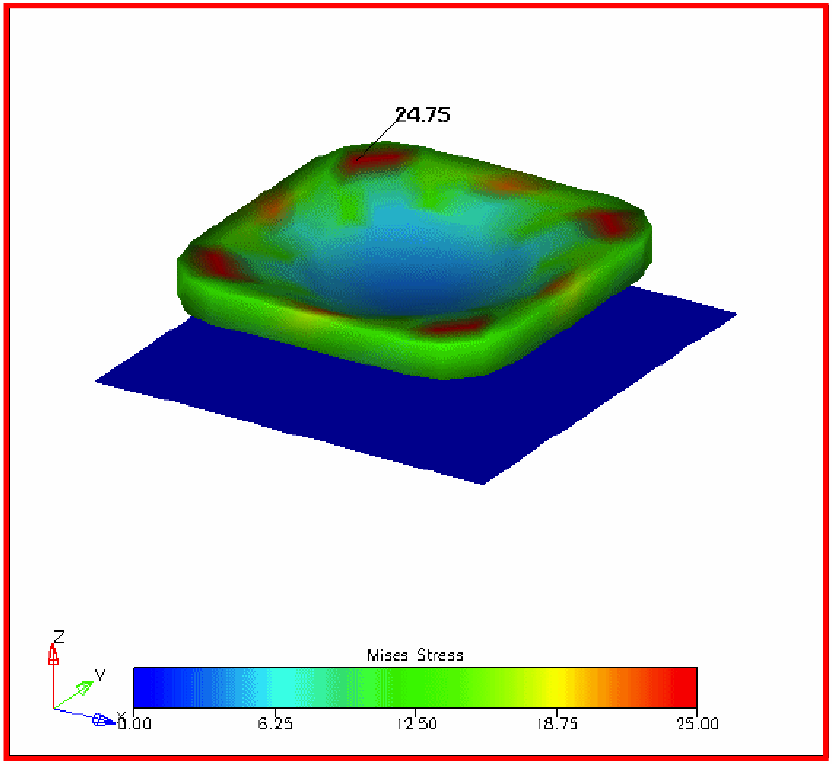
MEMCAD

- Device layout and construction
- Device modeling and simulation
- System modeling and simulation

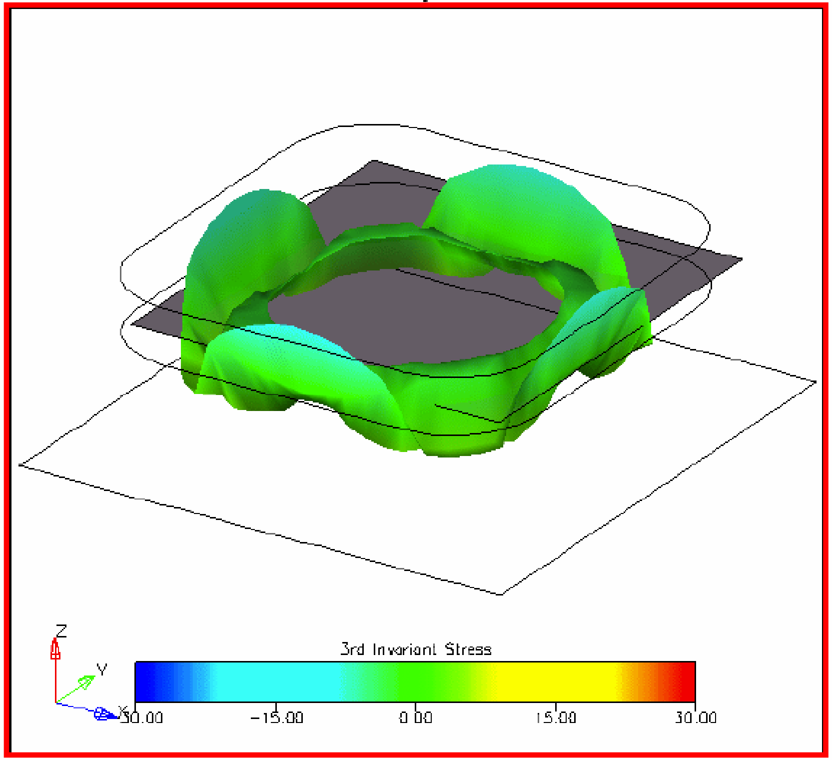


MEMCAD

Visualizer view of a MemMech solution



Pressure sensor slice plane interior stresses



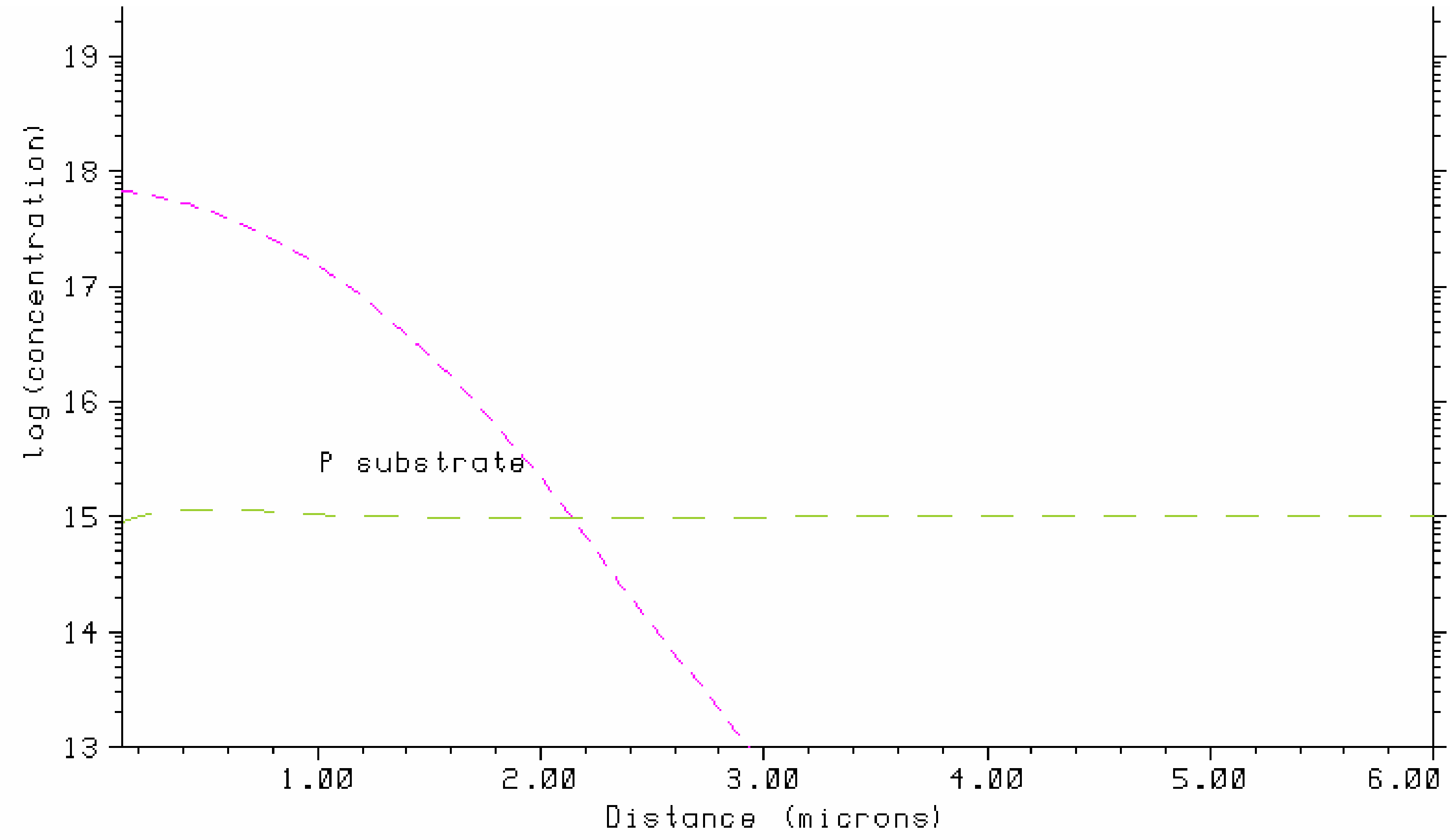
Process Simulation Tool

TSUPREM-4

- **One and two-dimensional process simulation program**
- **Simulation etching, deposition, lithography, implantation, diffusion, epitaxy**
- **Output**
  - ⇨ Boundary of the various layers of material in the structure
  - ⇨ Distribution of impurities within each layer
  - ⇨ Stresses produced by oxidation, thermal cycling, or film deposition

TSUPREM-4

--One Dimension Simulation

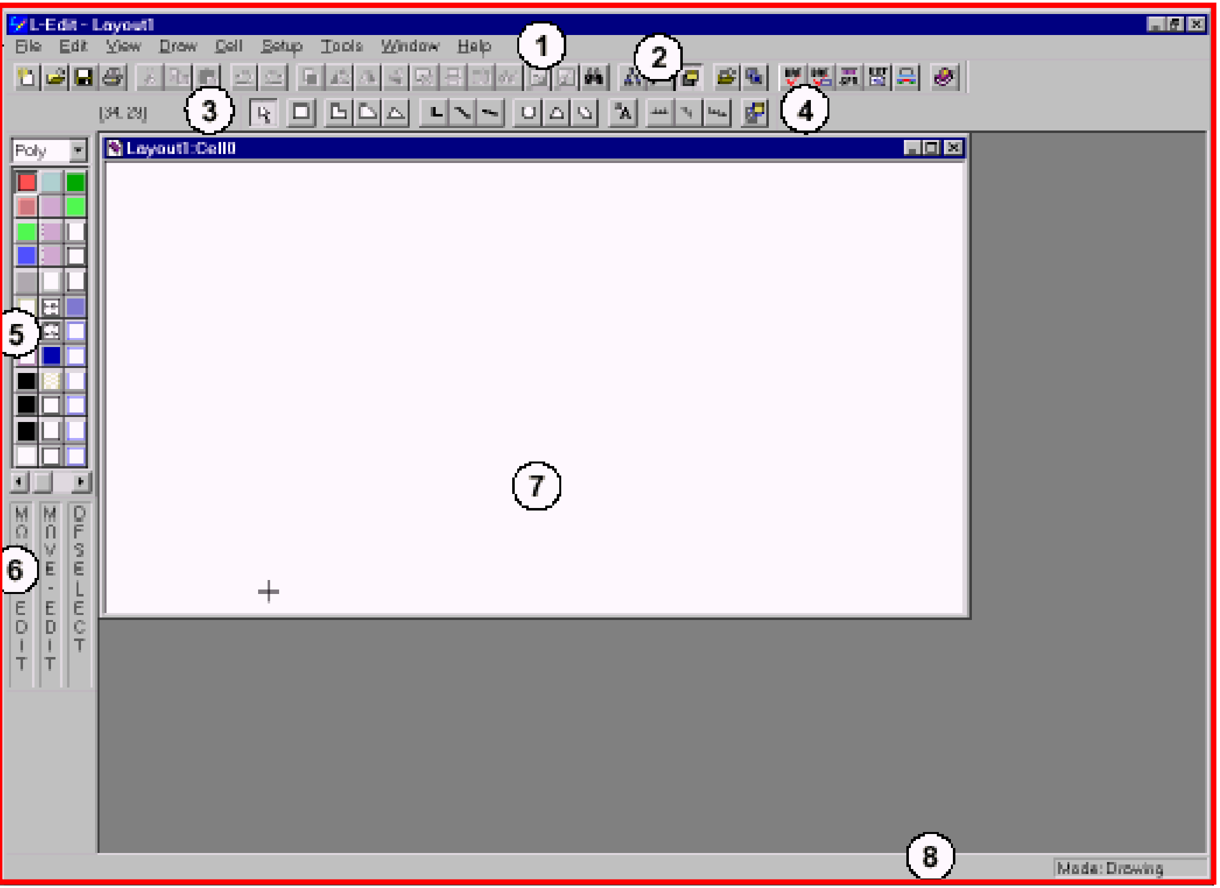


Layout Tool

L-Edit

--Layout Tool

L-Edit is a computer-aided design tool used to create photolithography masks for integrated circuits and MEMS devices



①The Menu bar (adjoined to the Title bar).

②The Standard toolbar.

③The Locator.

④The Drawing toolbar.

⑤The Layer Palette.

⑥The Mouse Buttons bar.

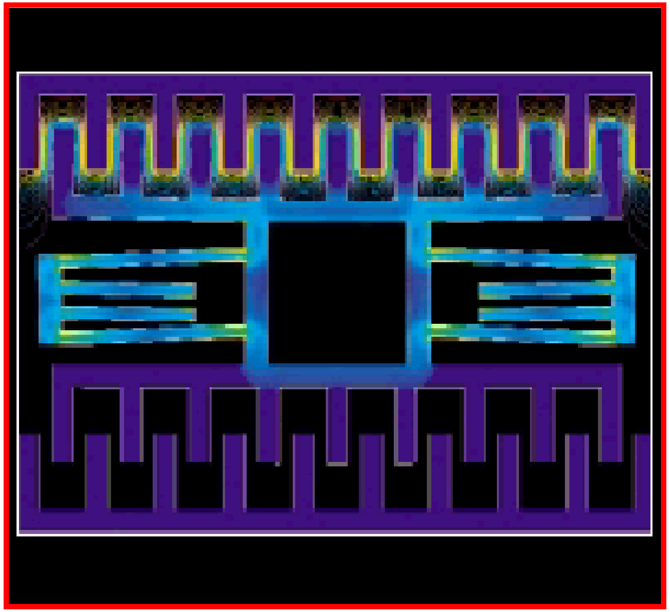
⑦The Layout Window.

⑧The Status bar.

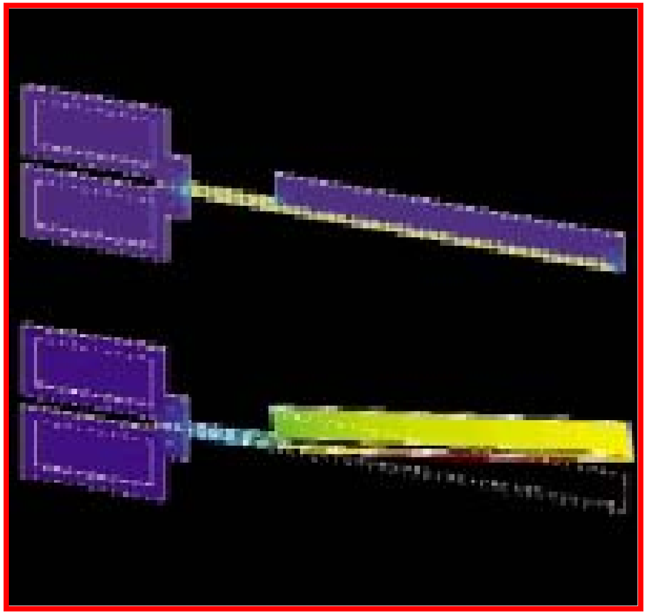
Finite Element Program

ANSYS

- Structure analysis
- Thermal analysis
- Electromagnetics analysis
- CFD analysis
- Acoustic analysis

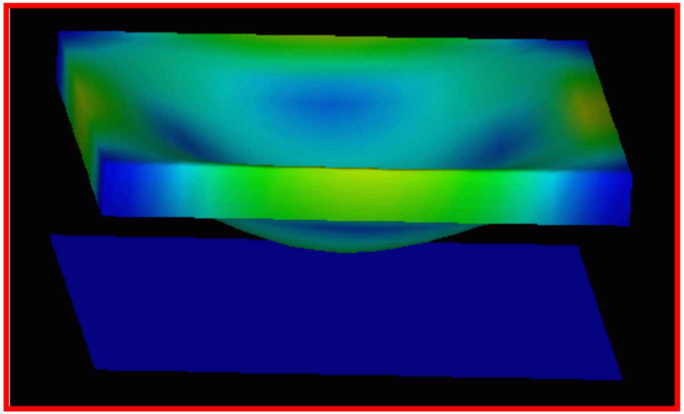


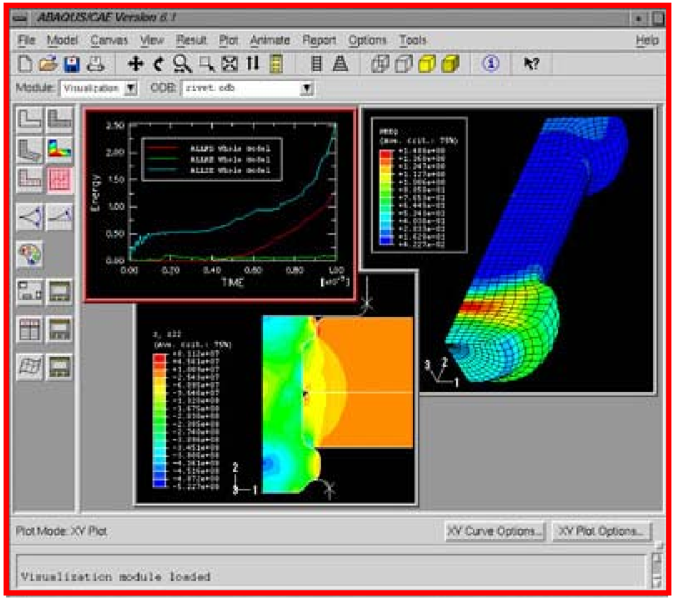
MEMS comb drive has been modeled using electrostatic-structural coupling.



MEMS thermal-mechanical actuator device

ABAQUS





General Analyses

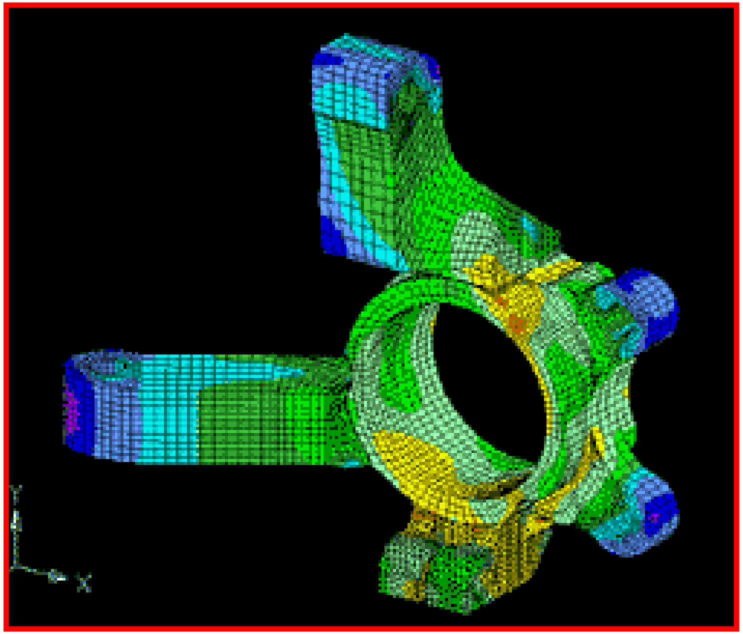
- Static stress/displacement analysis
- Viscoelastic/viscoplastic response
- Transient dynamic stress/displacement analysis
- Transient or steady-state heat transfer analysis

Coupled problems:

- Thermo-mechanical (sequentially or fully coupled)
- Thermo-electrical
- Pore fluid flow-mechanical
- Stress-mass diffusion (sequentially coupled)
- Piezoelectric (linear only)
- Acoustic-mechanical (linear only)

MSN/ANSTRAN

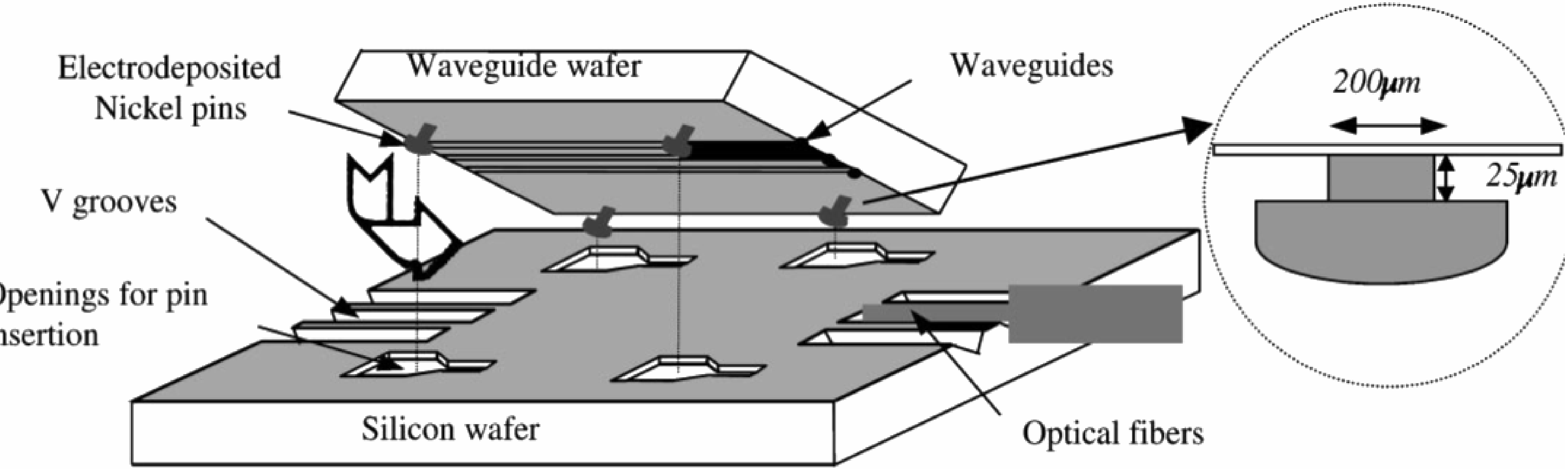
- Linear Static Analysis
- Non-linear Analysis
- Buckling Analysis
- Heat-Transfer Analysis
- Dynamic Analysis
- Optimization Analysis

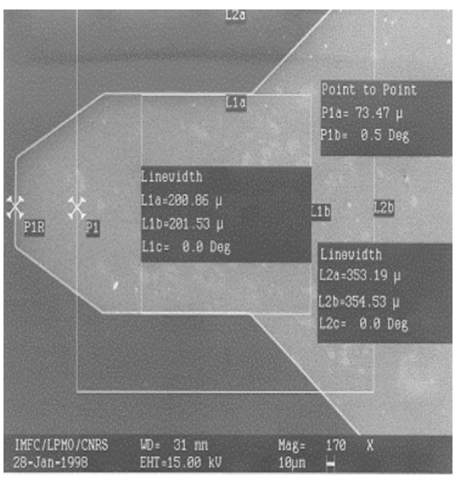


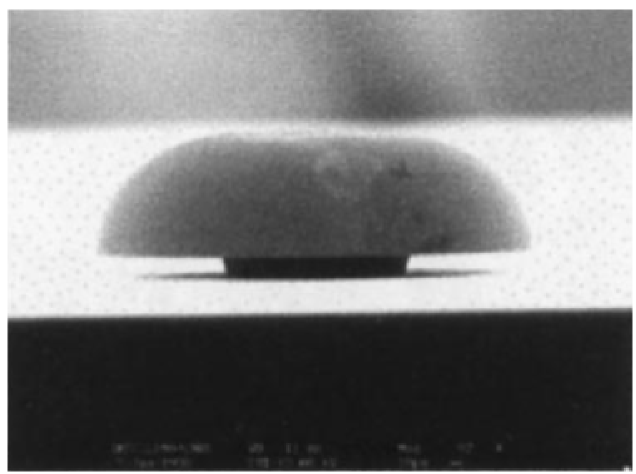
Other Software Tools for MEMS

- **Anisotropic Etch Simulation**
  - ⇨Anisotropic Crystalline Etch Simulation(ACES)
  - ⇨Anisotropic Silicon Etching Program(ASEP)
  - ⇨SEGS
- **Process Simulation**
  - ⇨MEMS Pro
  - ⇨MEMS Xplorer
- **Fluid flow Simulation**
  - ⇨CFD-ACE
  - ⇨Flume CAD

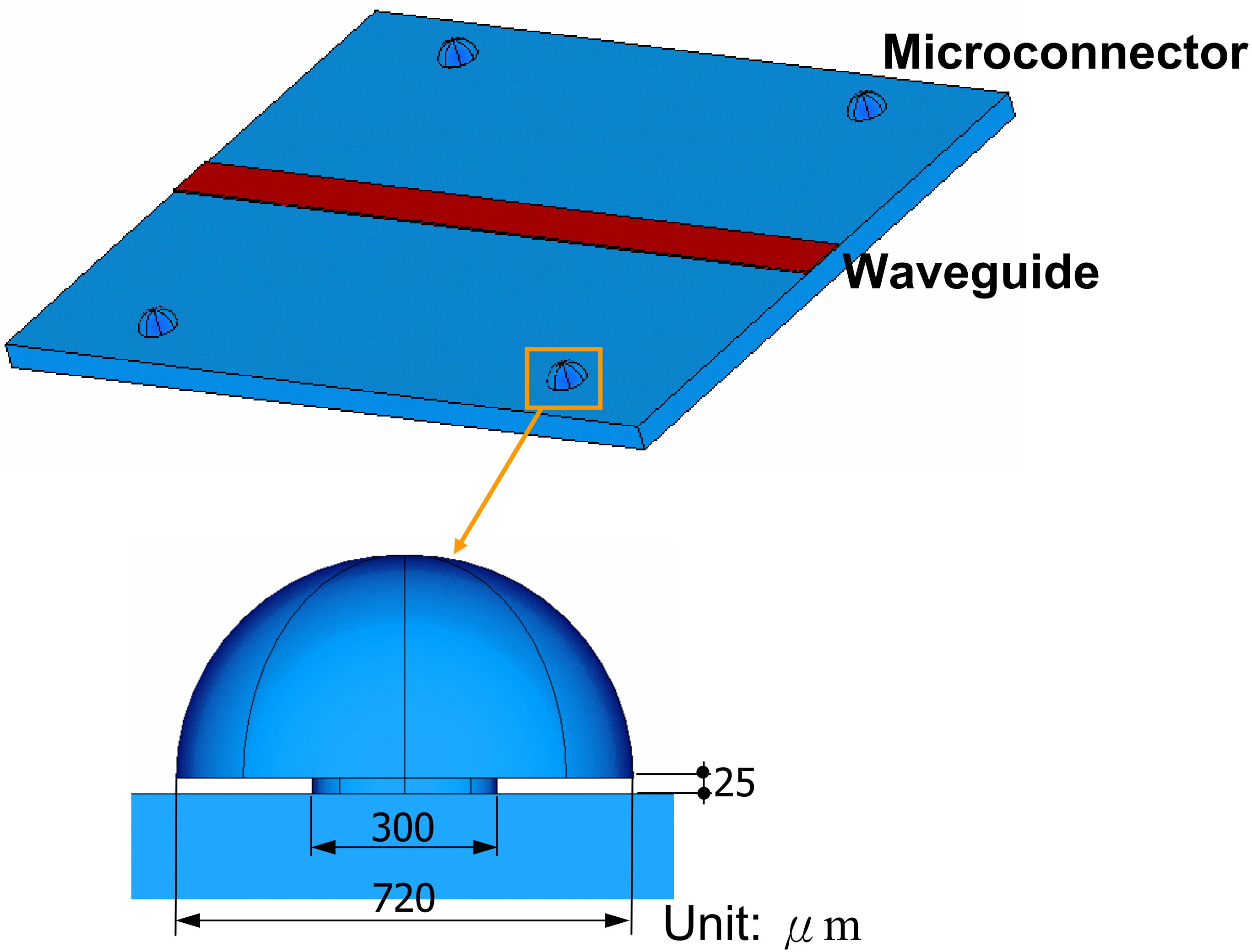
Kaou et al. ,2001



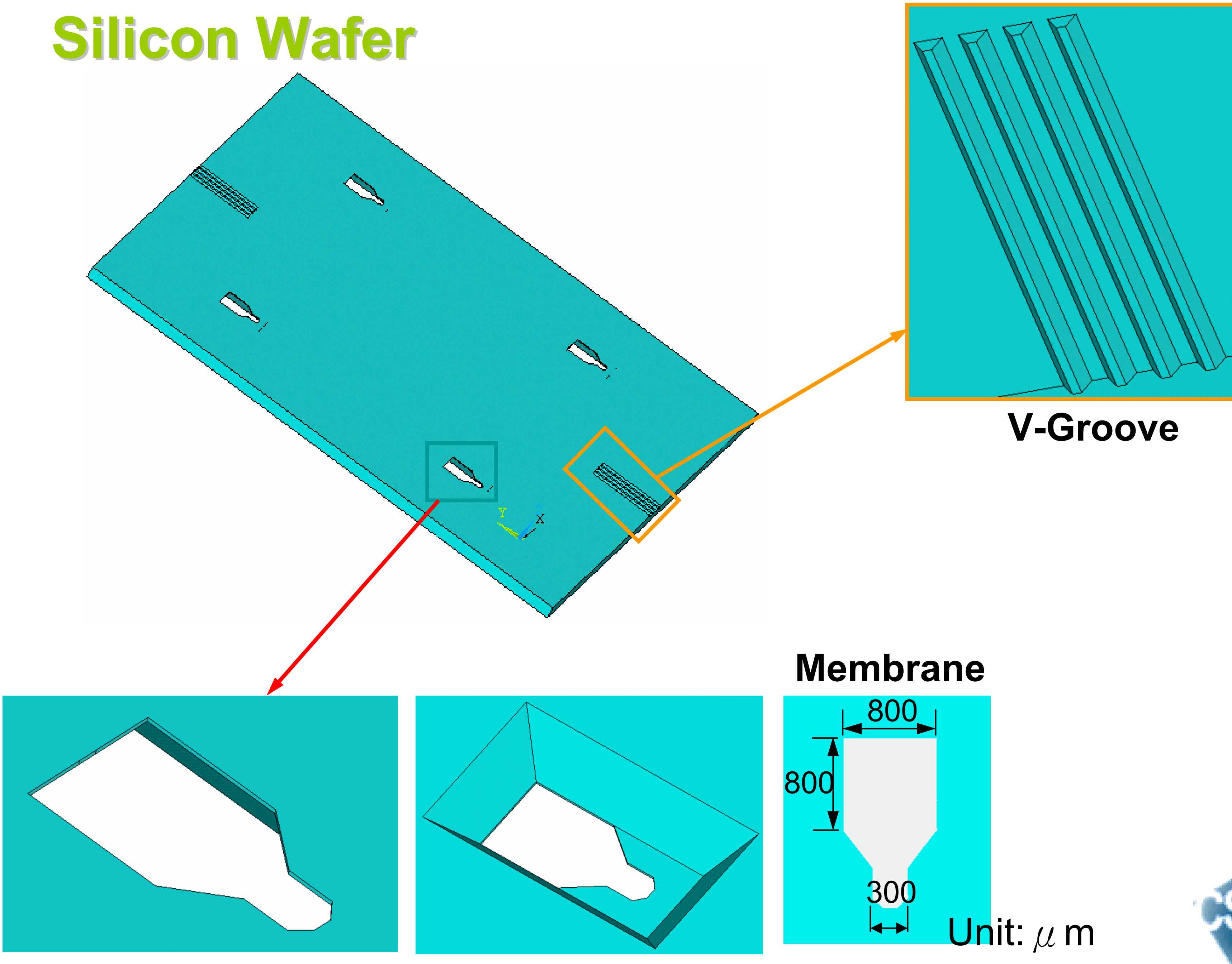




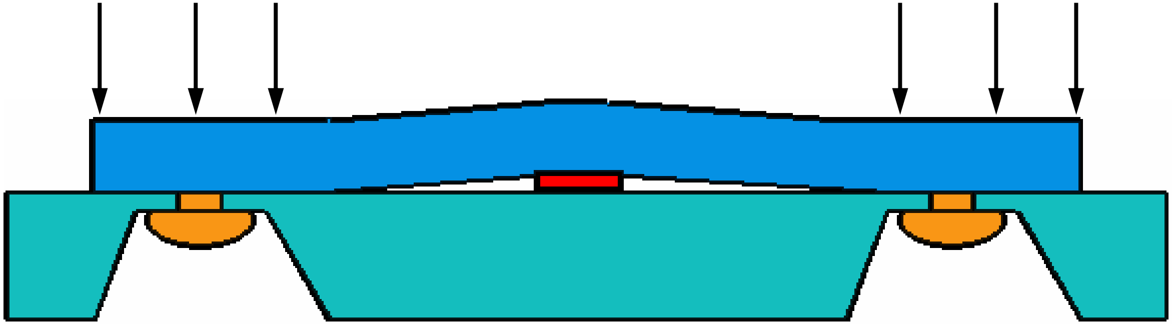
Waveguide Wafer

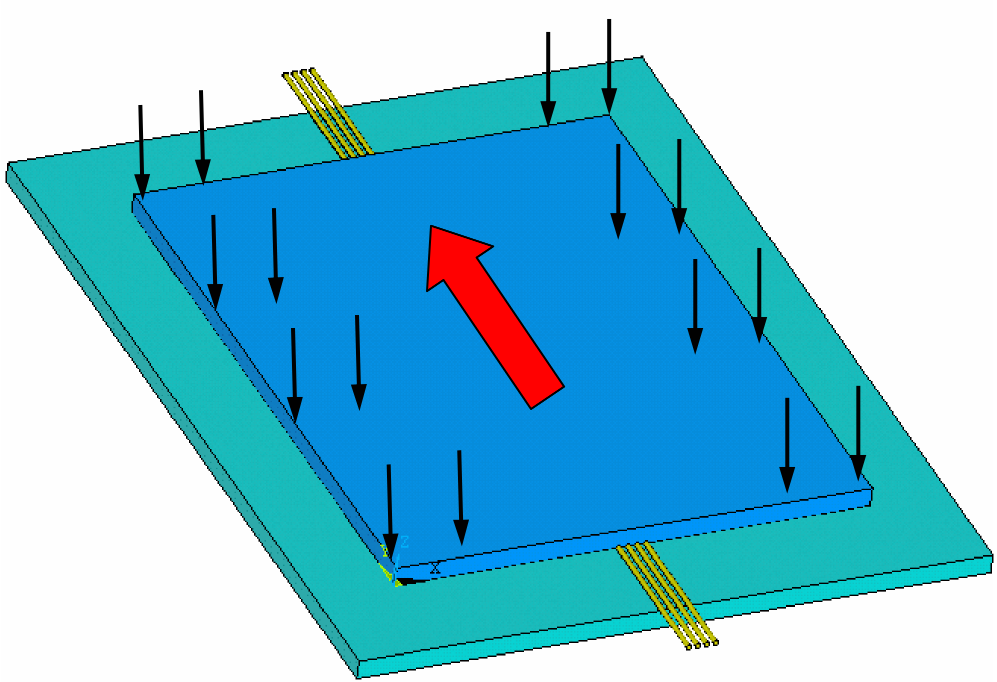


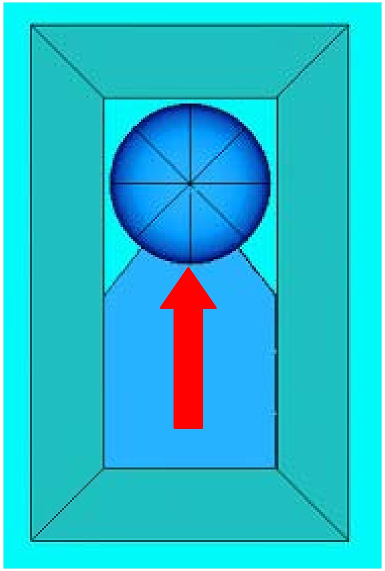
Silicon Wafer



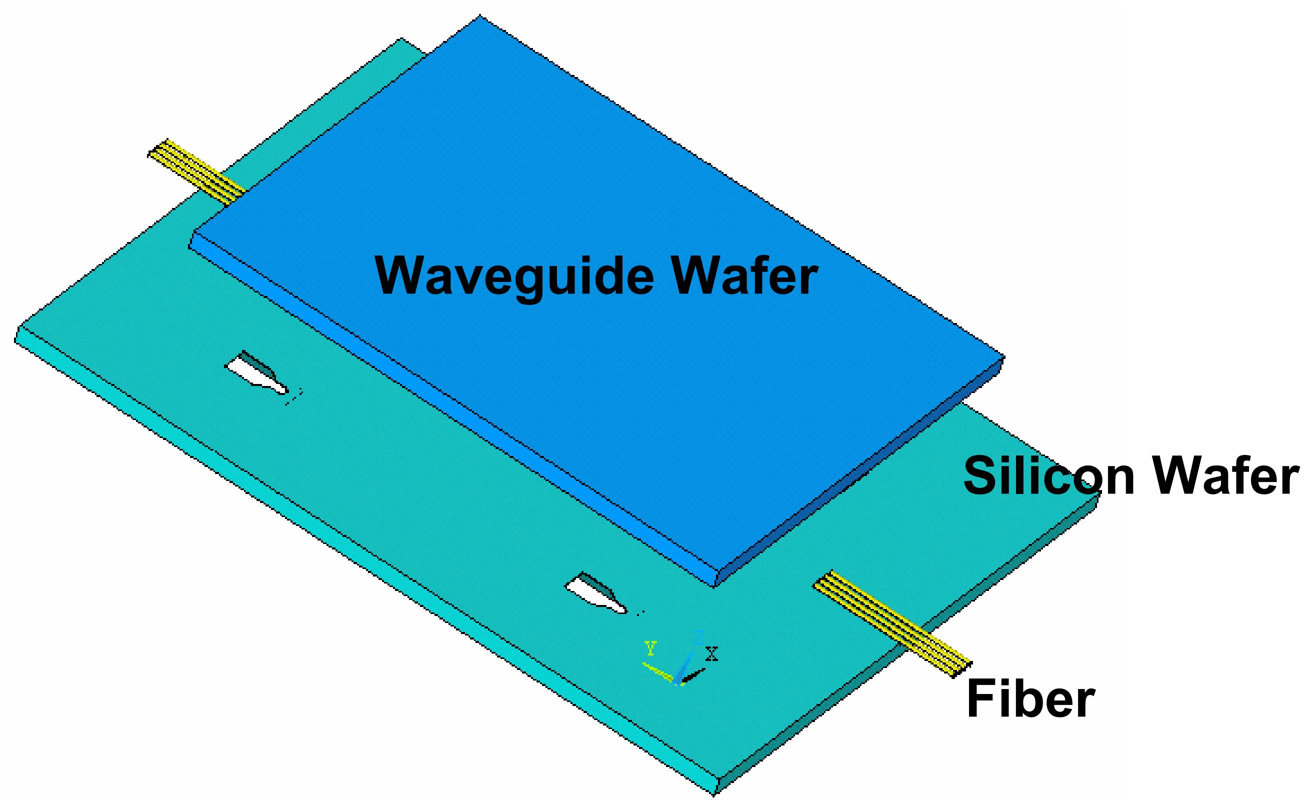
Assembly





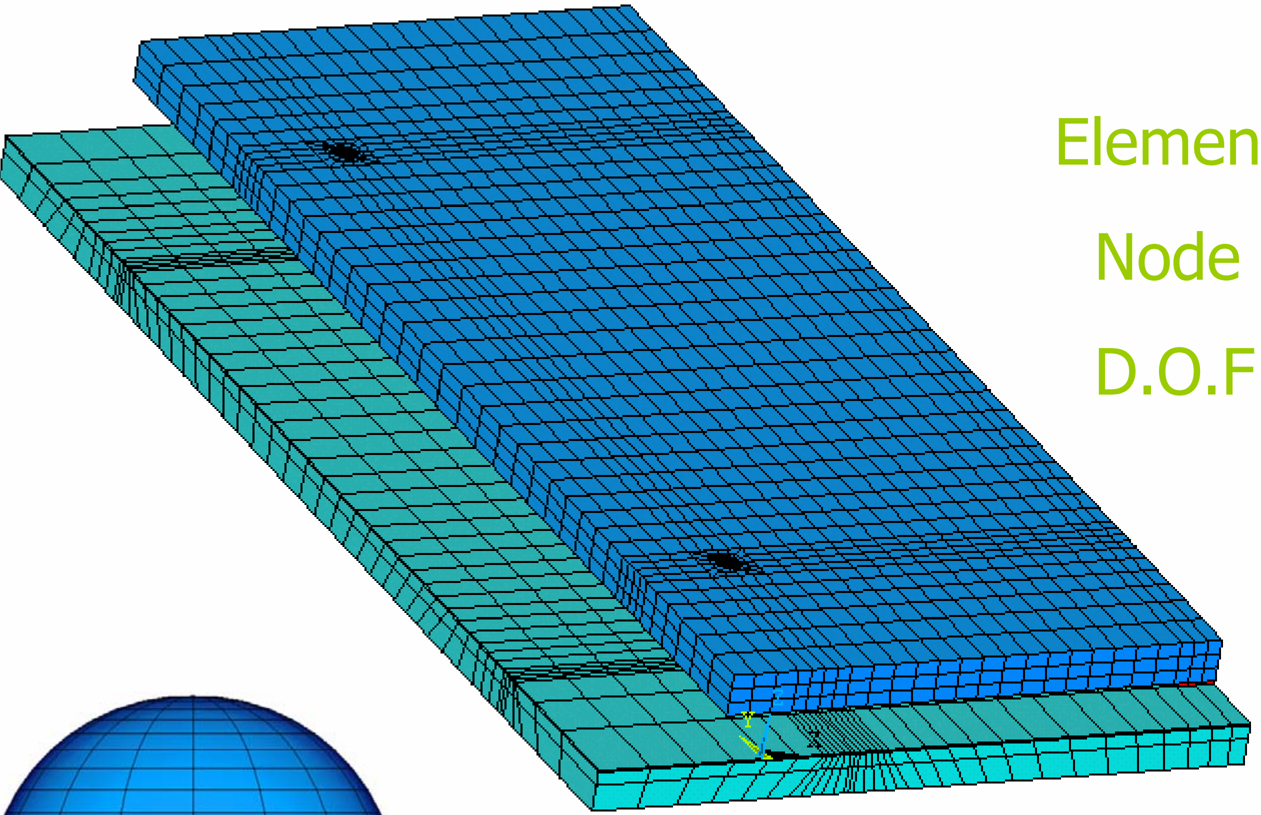


Geometry of Optical Modulus



Finite Element Model

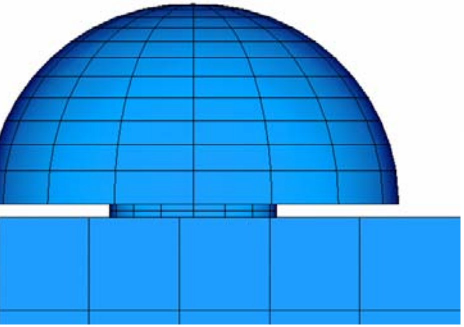
3D Solid Element with one integrated point



Element No : 10,294

Node No : 13,762

D.O.F. : 41,286

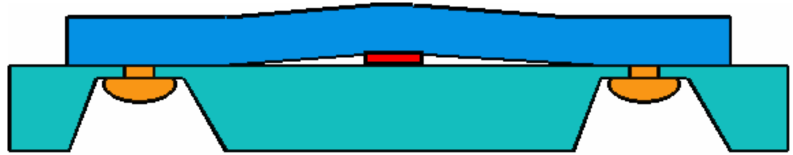


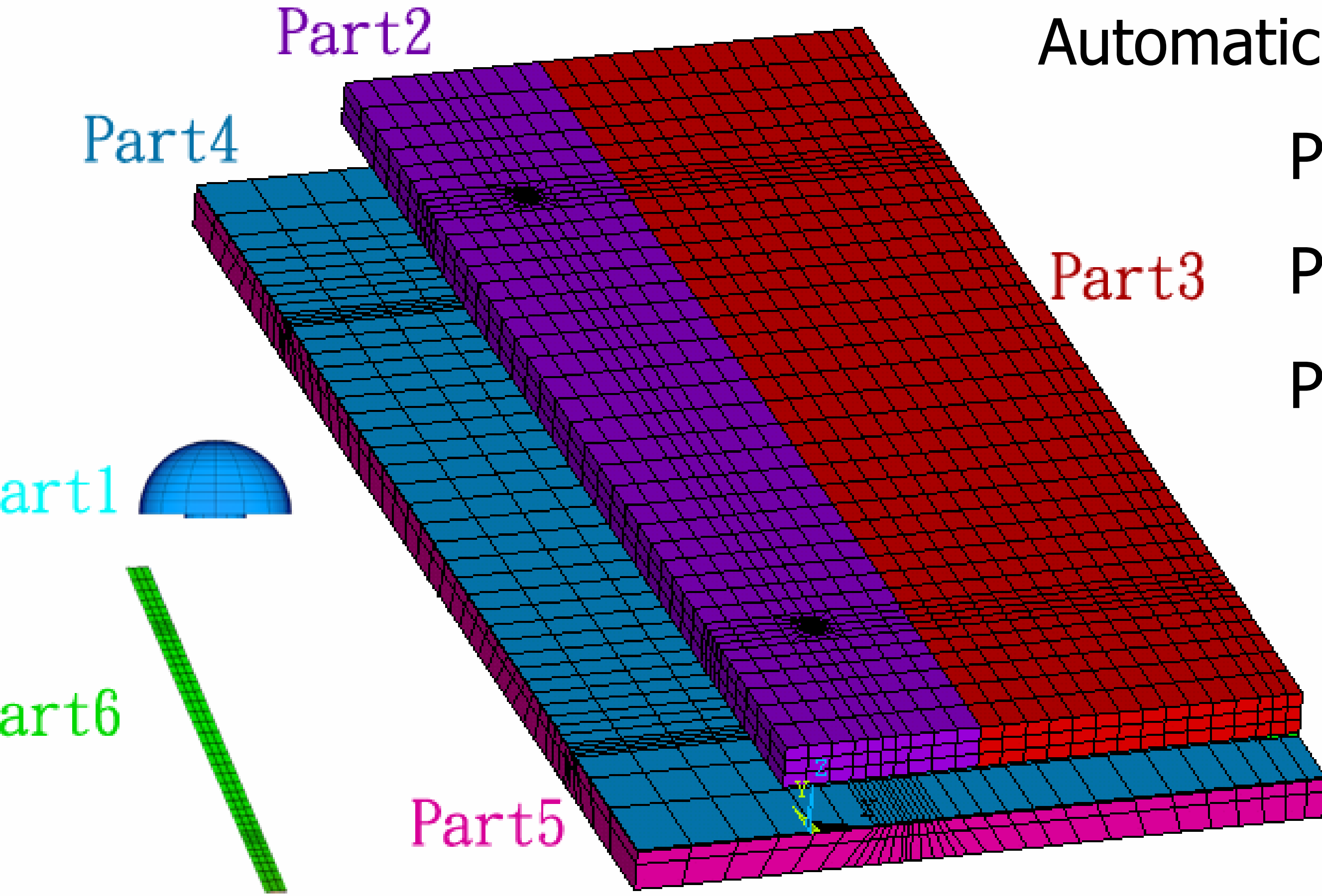
Unit:mm-Kg-Sec

Parameter

Material	Nickel	Silicon
Young's Modulus(GPa)	176.0	112.4
Density(Kg/m^3)	8900	2330
Coefficient of Thermal Expansion(CTE)(ppm)	14	2.62
Possion's Ratio	0.31	0.28

Contact Setting





Automatic Surface to Surfac

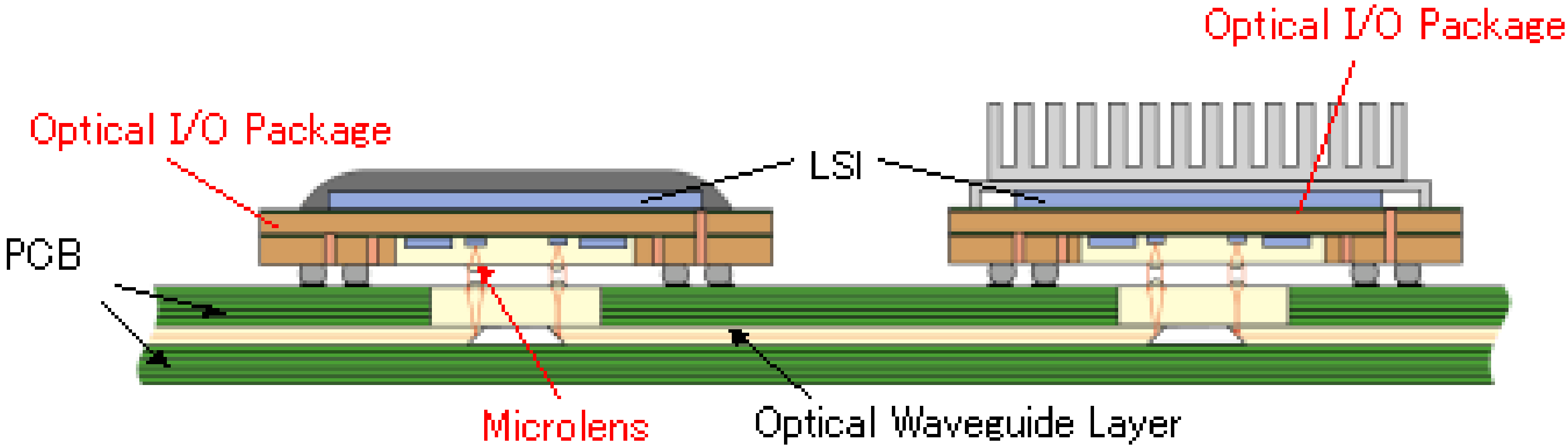
Part1-Part4

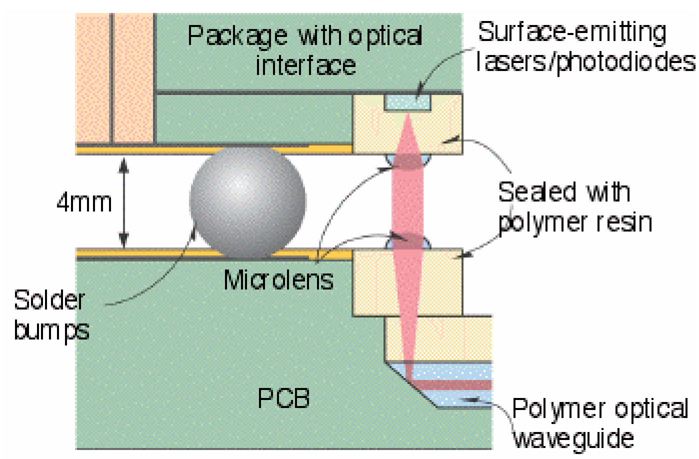
Part2-Part4

Part6-Part4

Introduction

NTT

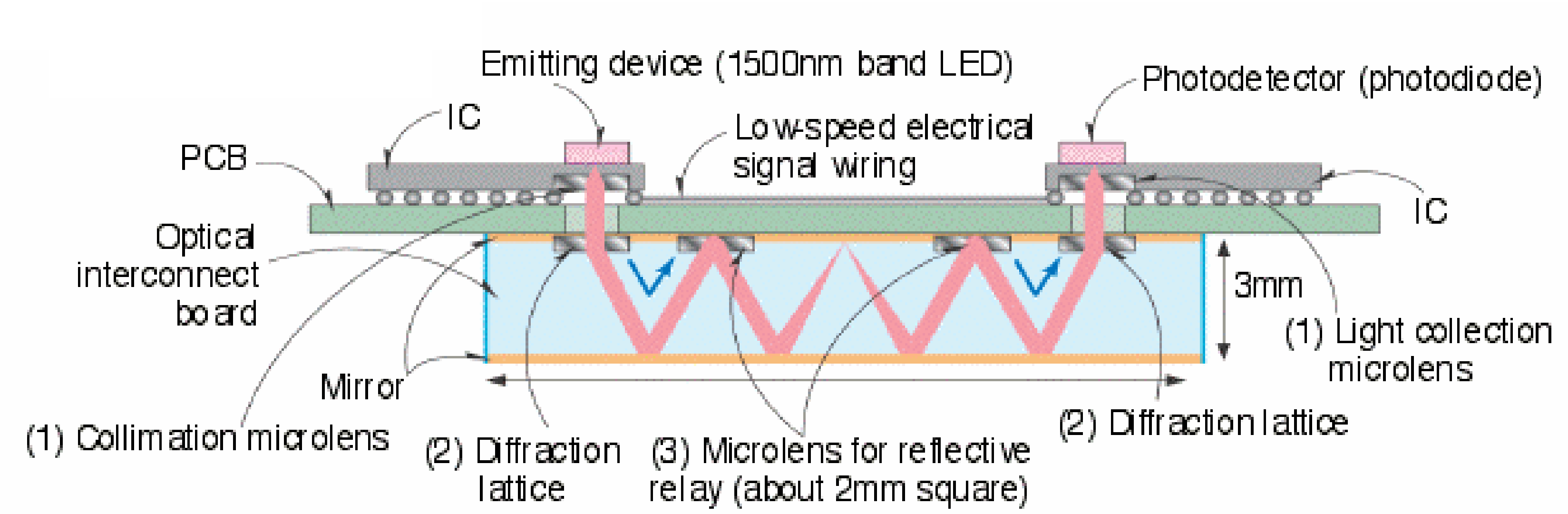




http://www.ntt.co/jp/

Introduction

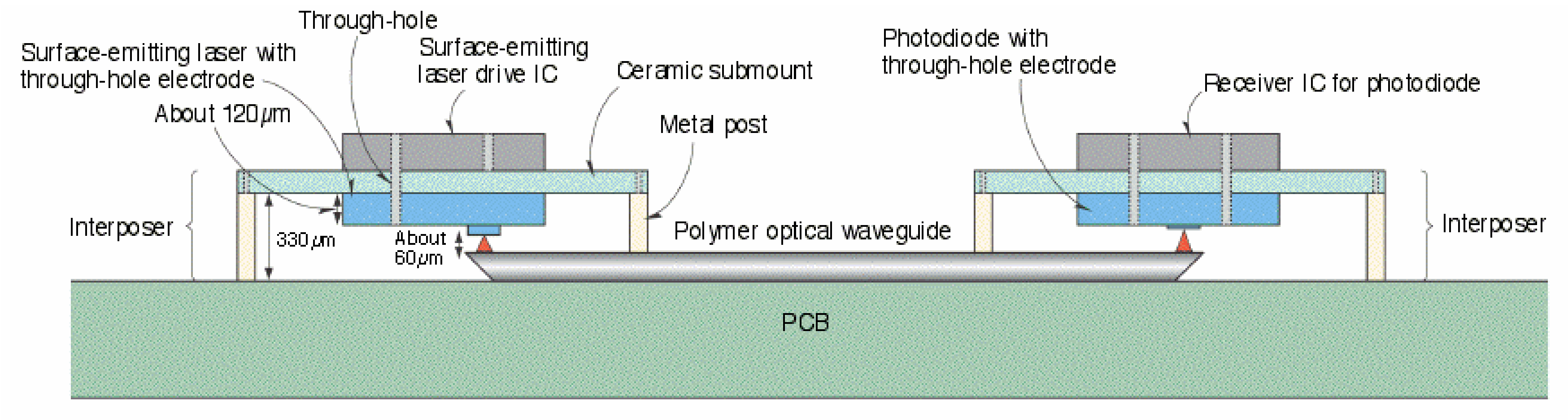
Oki

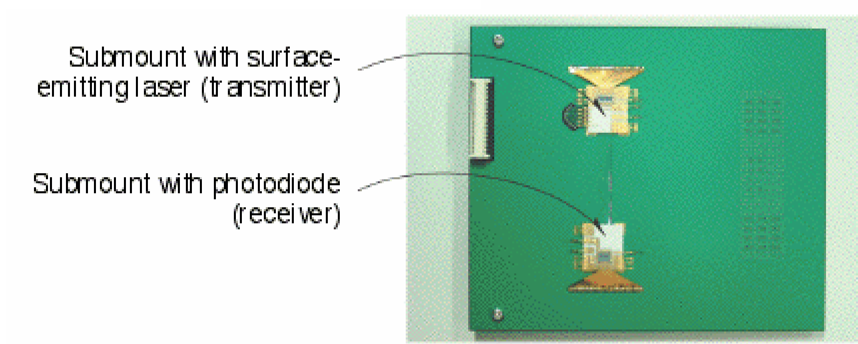


http://www.oki.com/en/

Introduction

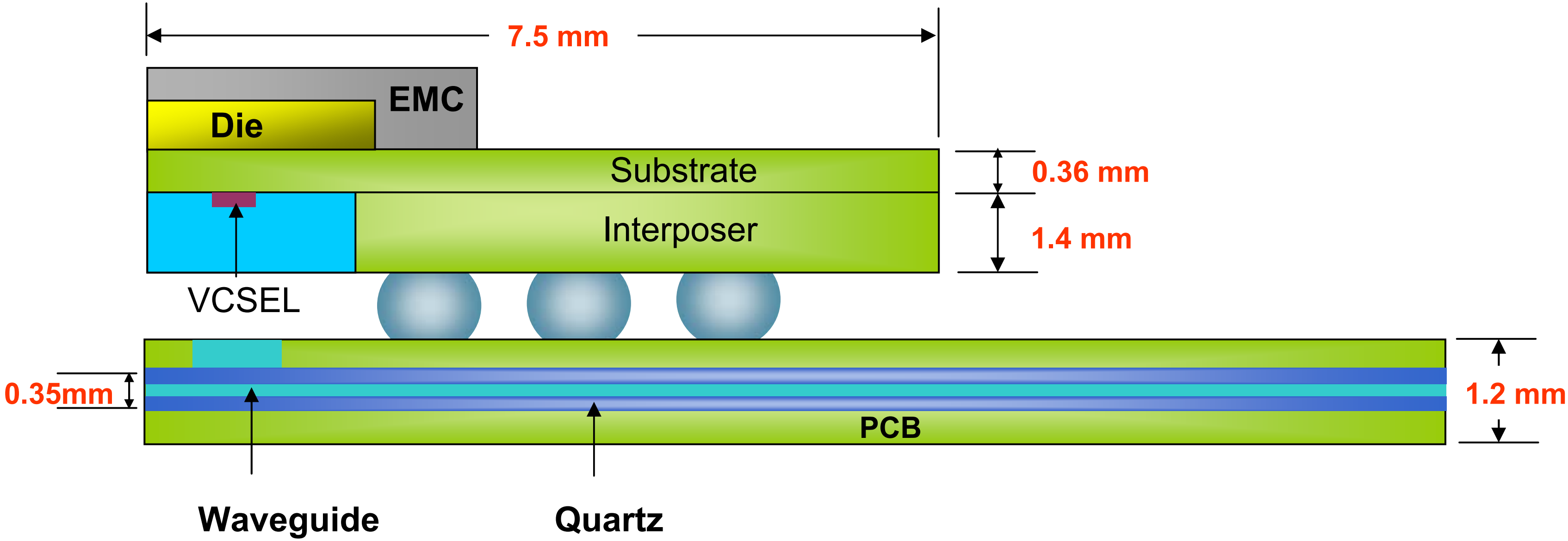
ASET





http://www.aset.or.jp/

Introduction

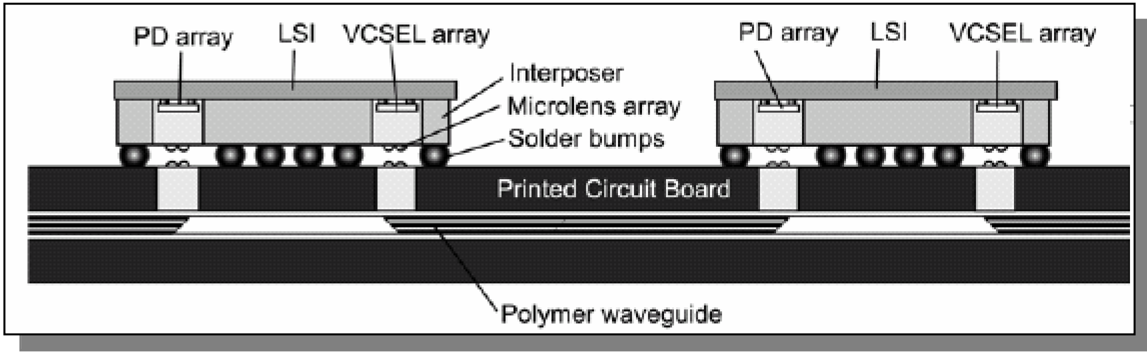


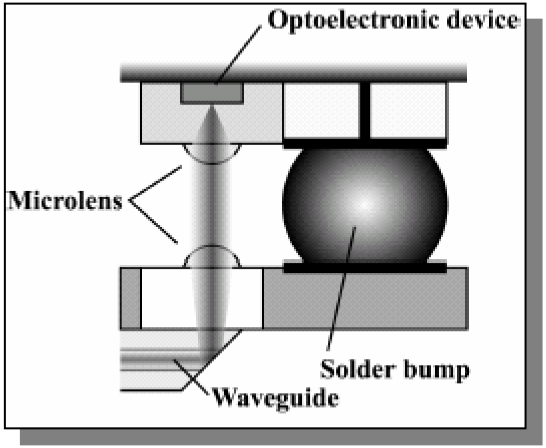
Ball pitch: 1.27 mm

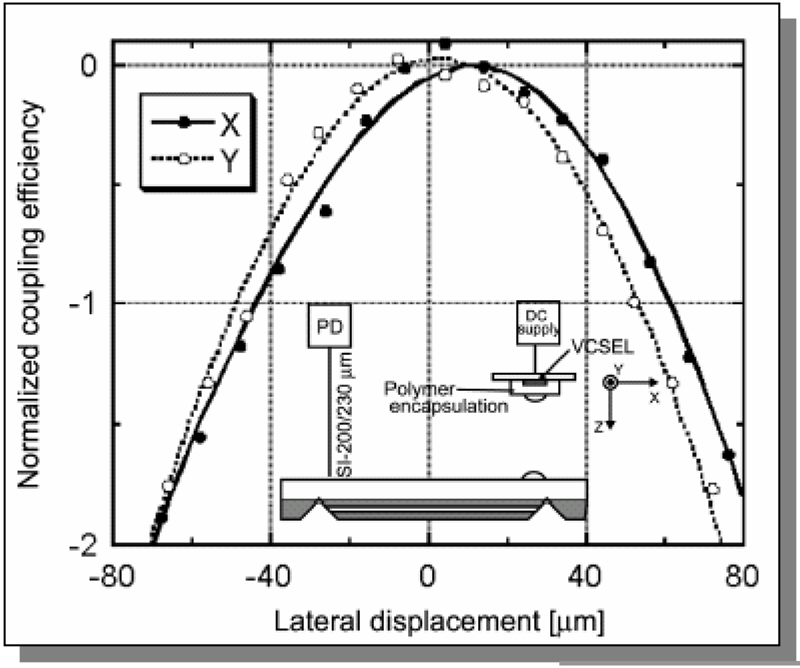
Out of consideration:
- **microlens**
- **reflective mirror**

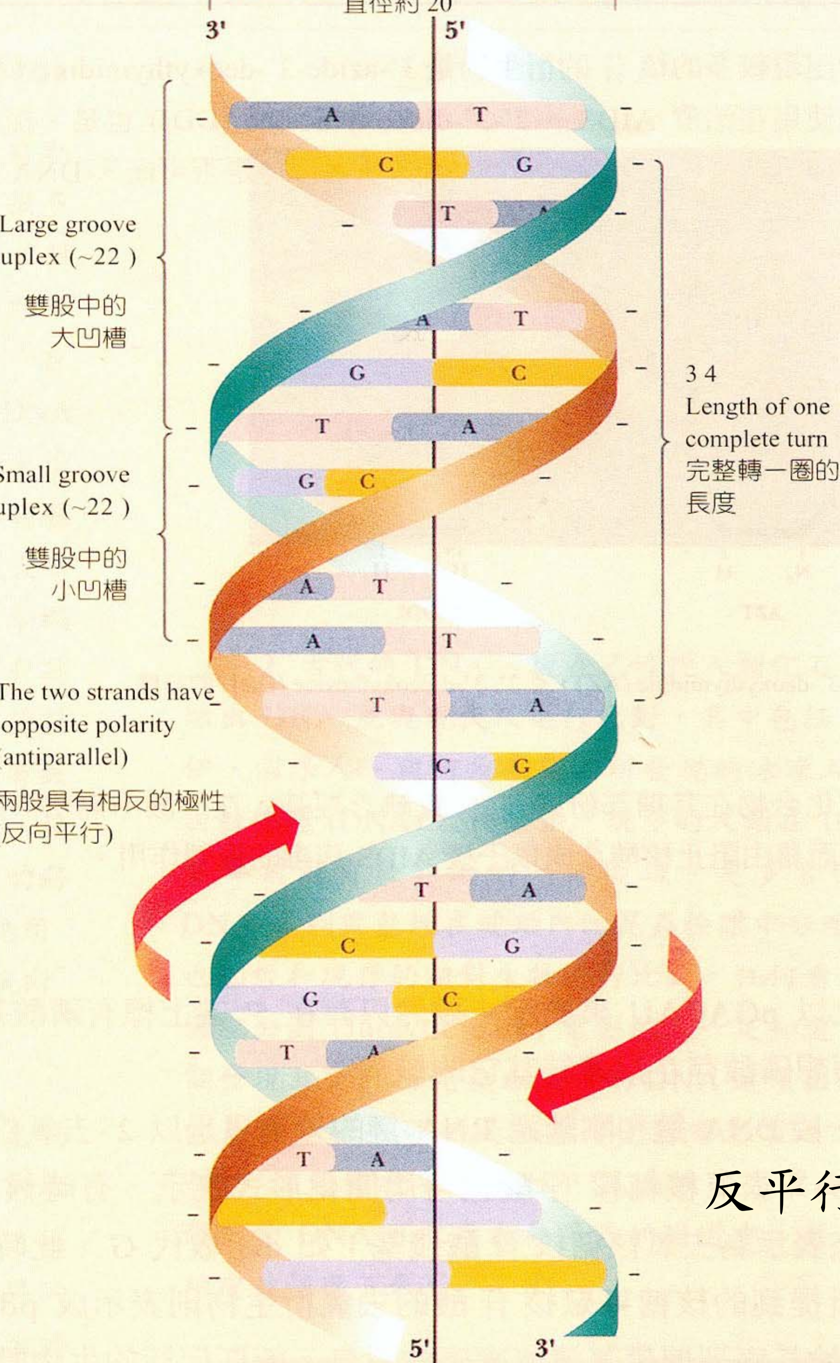
Literature Survey

2001 Ishii

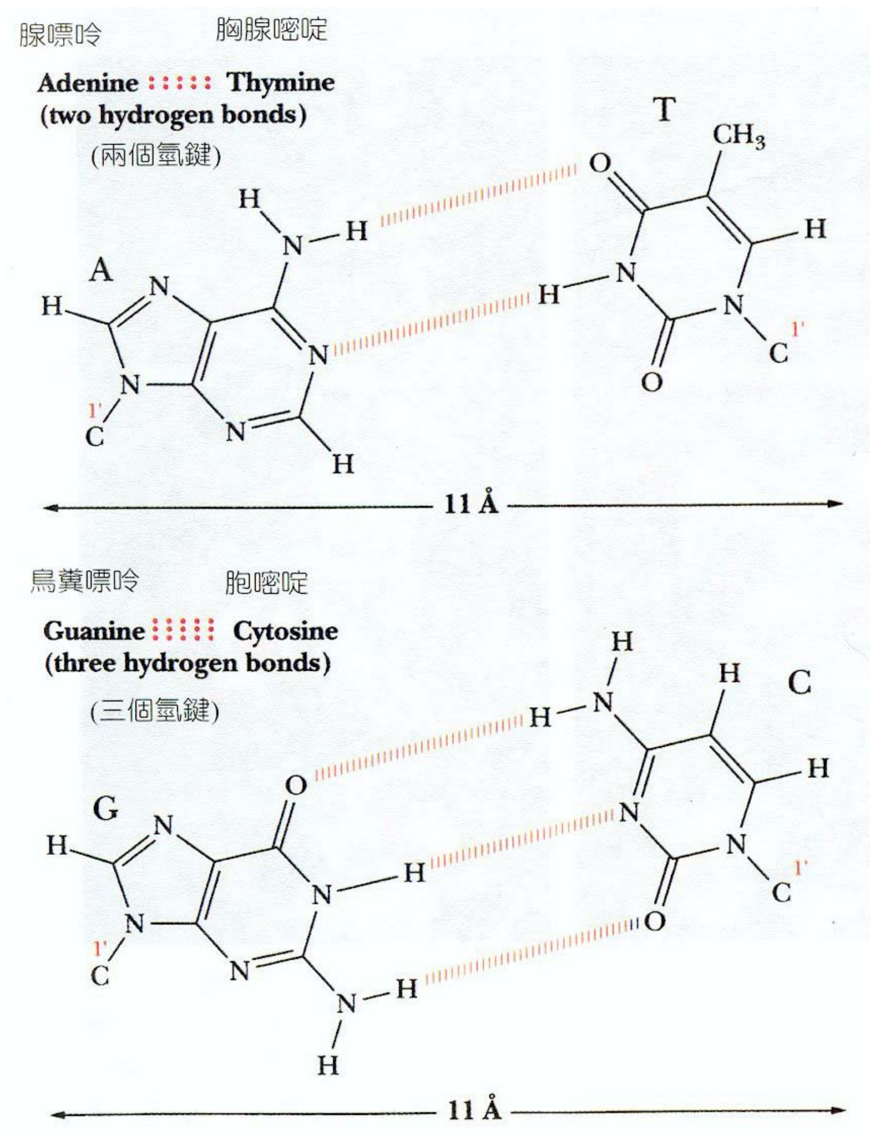




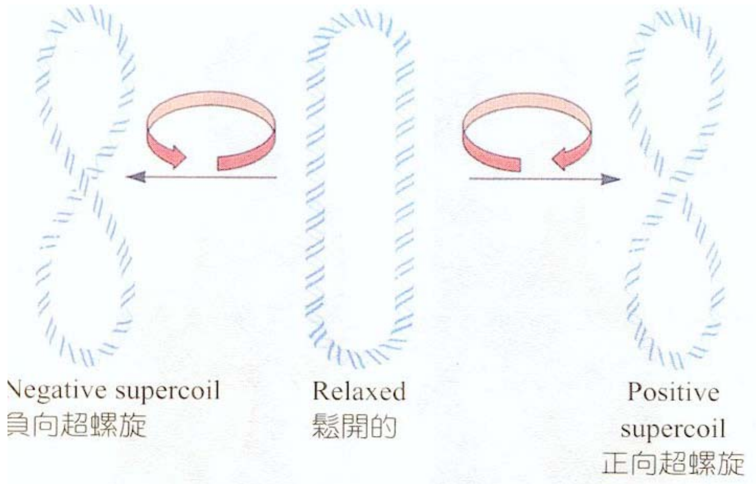


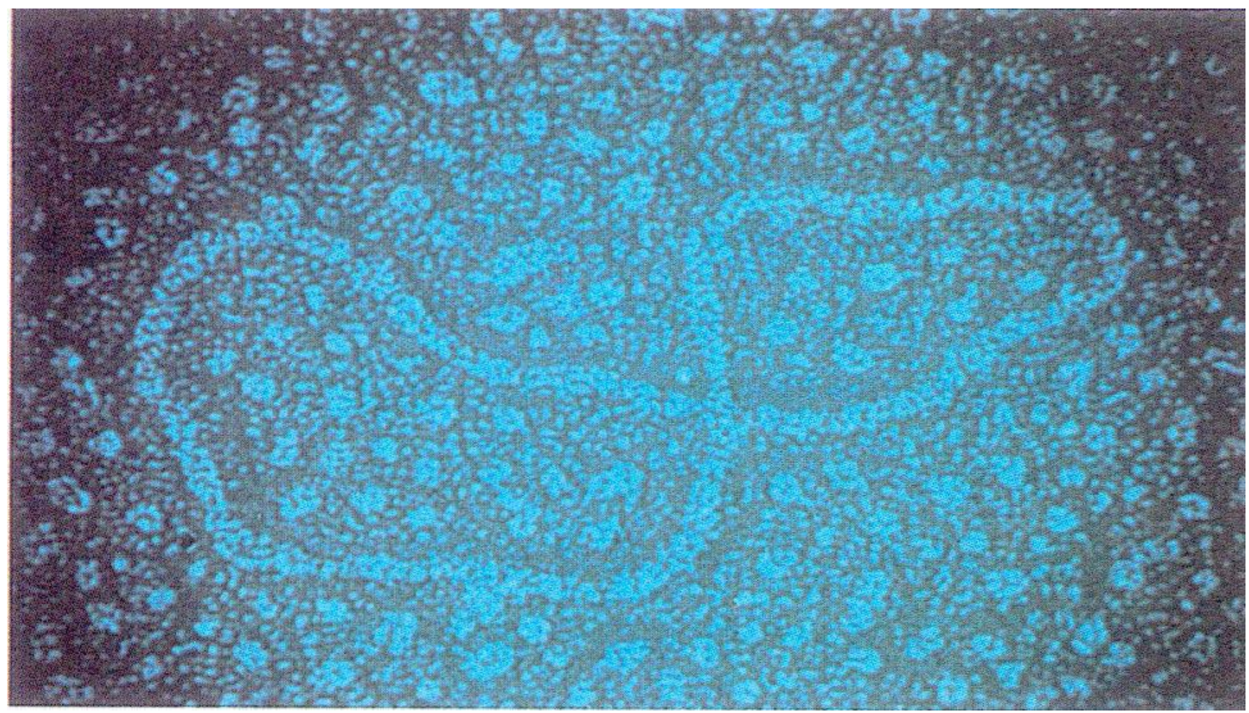

3'
5'
Large groove
uplex (~22)
雙股中的
大凹槽
Small groove
uplex (~22)
雙股中的
小凹槽
3 4
Length of one
complete turn
完整轉一圈的
長度
The two strands have
opposite polarity
(antiparallel)
兩股具有相反的極性
(反向平行)
5'
3'

反平行

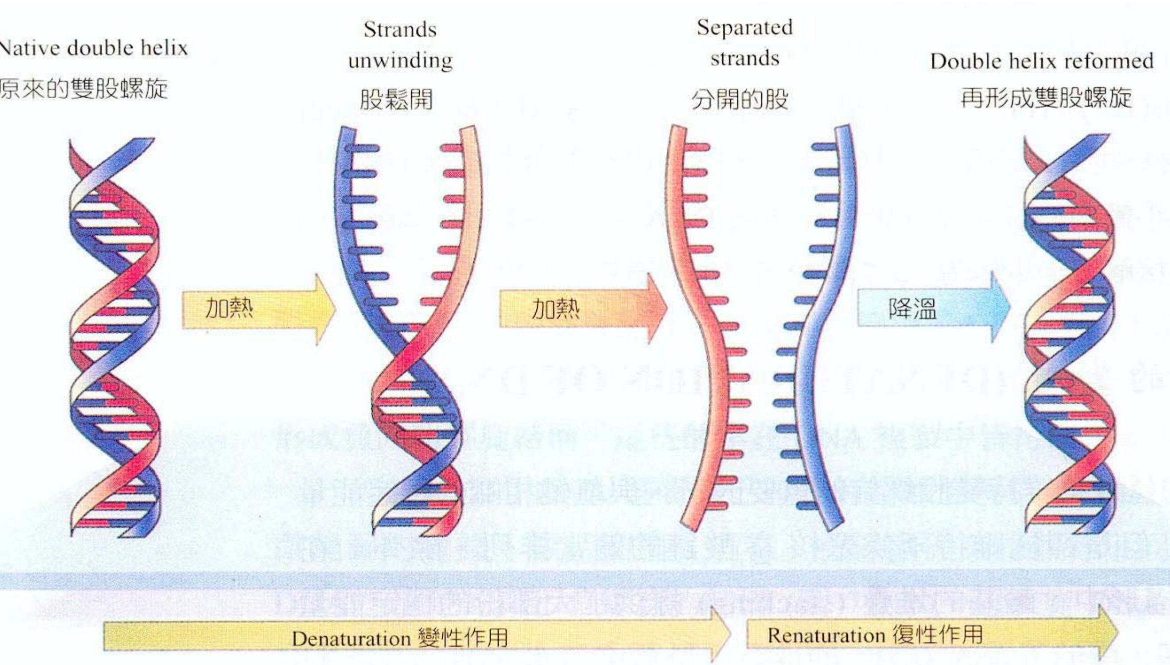

腺嘌呤
胸腺嘧啶
Adenine Thymine
(two hydrogen bonds)
(兩個氫鍵)
A
T
CH3
11 Å
鳥糞嘌呤
胞嘧啶
Guanine Cytosine
(three hydrogen bonds)
(三個氫鍵)
G
C
11 Å

原核生物DNA的超螺旋結構

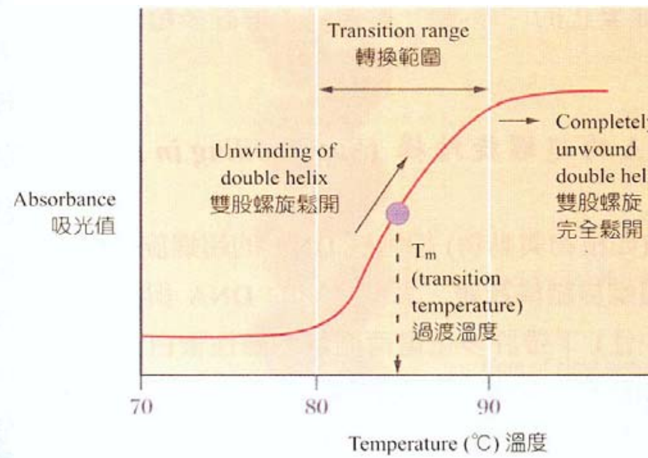




DNA變性(Denaturation)

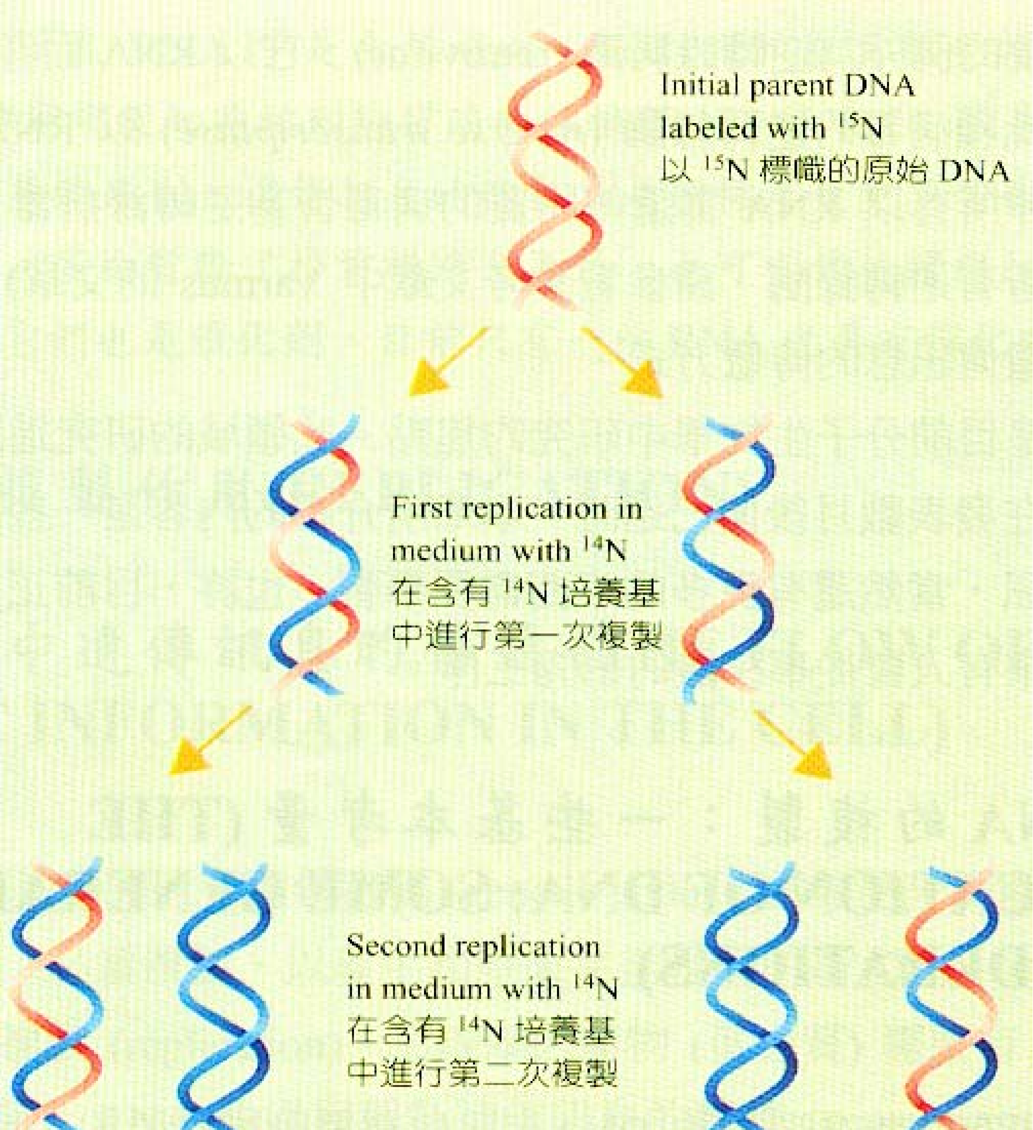


增色效應



λ =260nm

半保留複製



1950年代

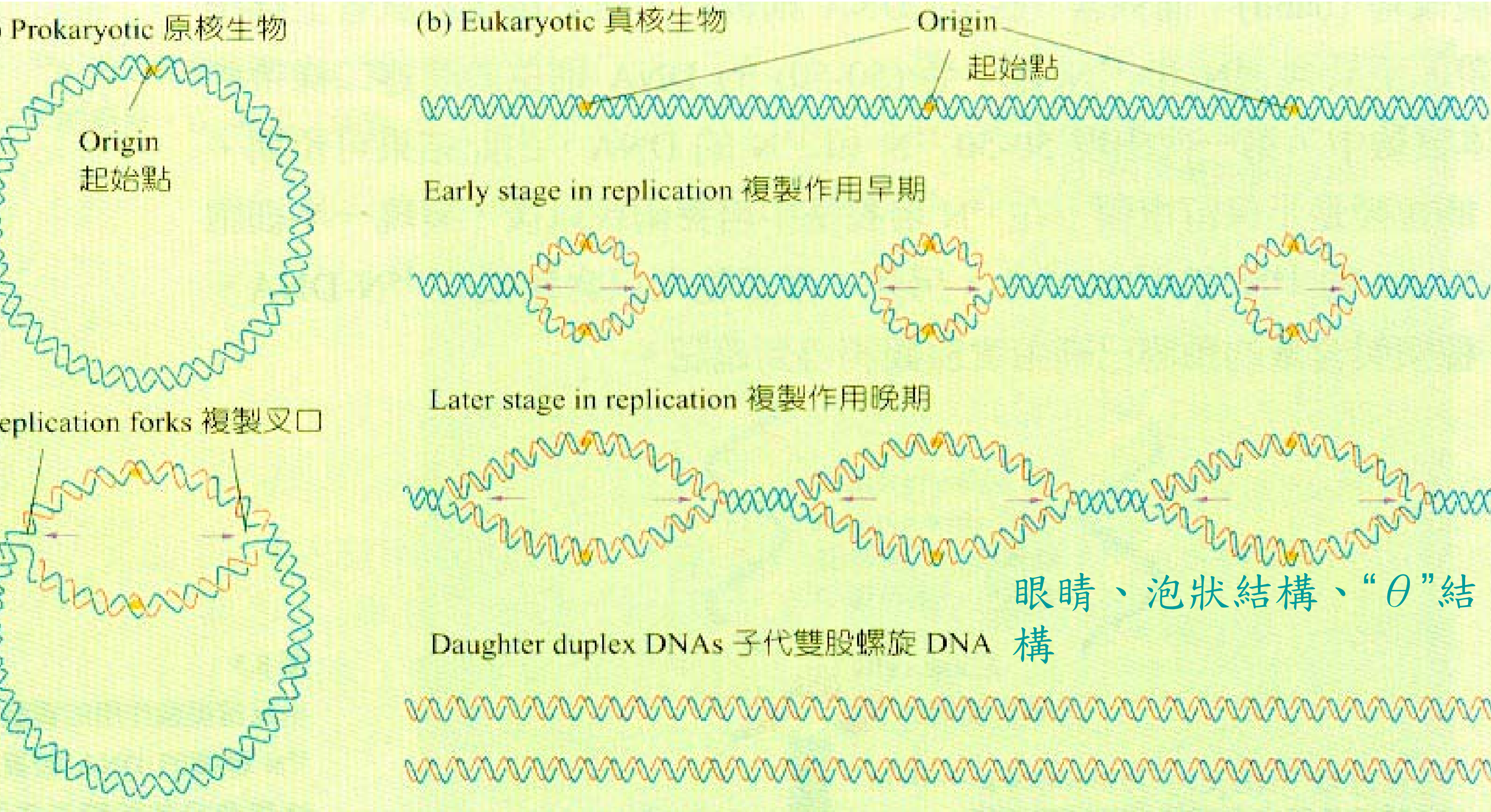
Meselson和Stahl

實驗證明。

密度 - 梯度離心法

CSML

雙向複製



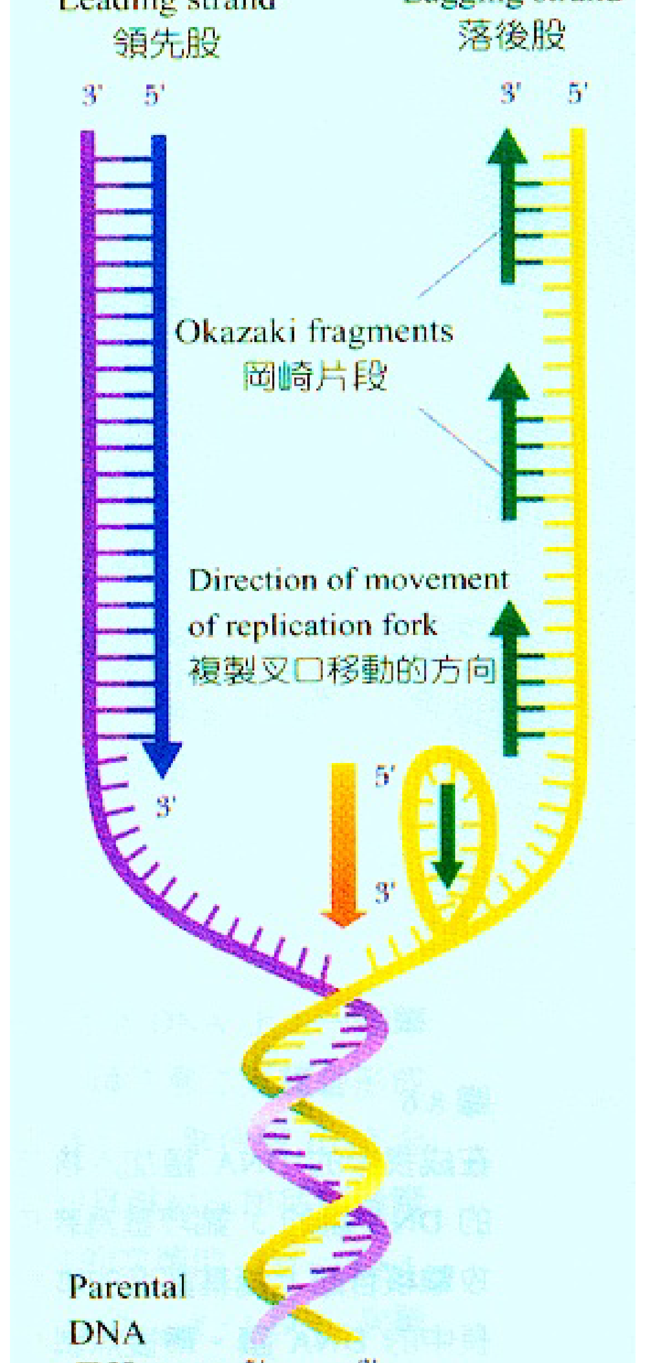
眼睛、泡狀結構、“θ”結構

複製過程

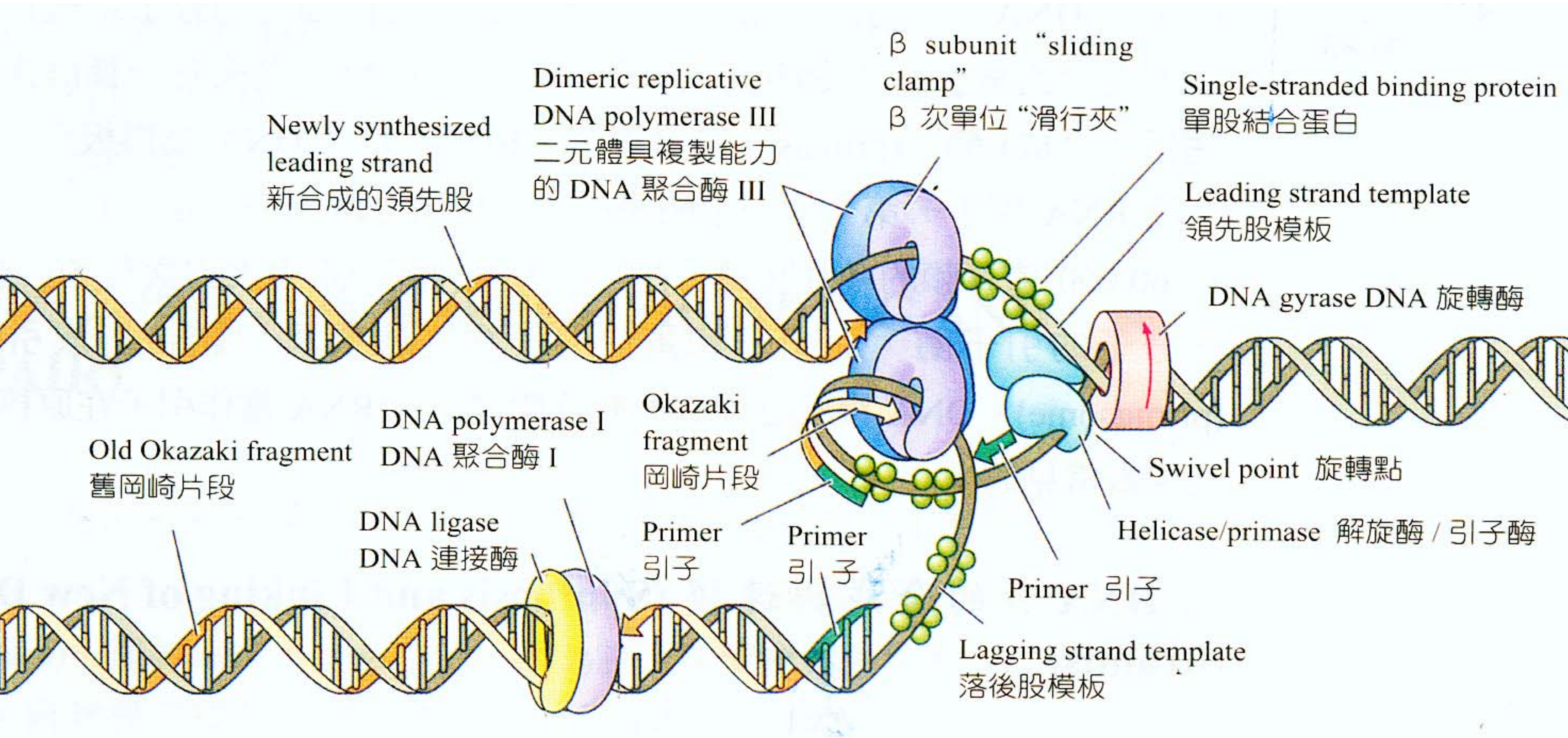
DNA的合成必須由5‘→3’

落後股(Lagging strand)由岡崎片段(1000-2000核苷酸長度)組成。

岡崎片段(Okazaki fragments)最後由DNA連接酶(DNA ligase)的酵素作用而連結起來。



DNA複製需要的酵



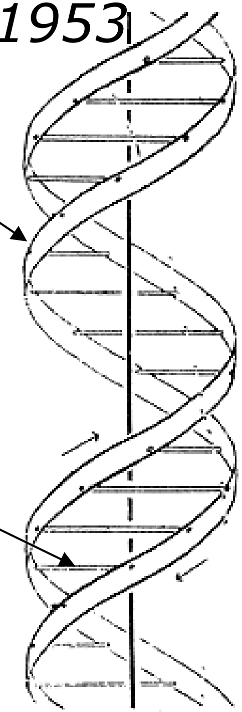
β subunit "sliding clamp"
β 次單位 "滑行夾"
Dimeric replicative DNA polymerase III
二元體具複製能力的 DNA 聚合酶 III
Newly synthesized leading strand
新合成的領先股
Single-stranded binding protein
單股結合蛋白
Leading strand template
領先股模板
DNA gyrase DNA 旋轉酶
Okazaki fragment
岡崎片段
DNA polymerase I
DNA 聚合酶 I
Old Okazaki fragment
舊岡崎片段
Swivel point 旋轉點
Helicase/primase 解旋酶 / 引子酶
DNA ligase
DNA 連接酶
Primer
引子
Primer
引子
Primer 引子
Lagging strand template
落後股模板

DNA Structure

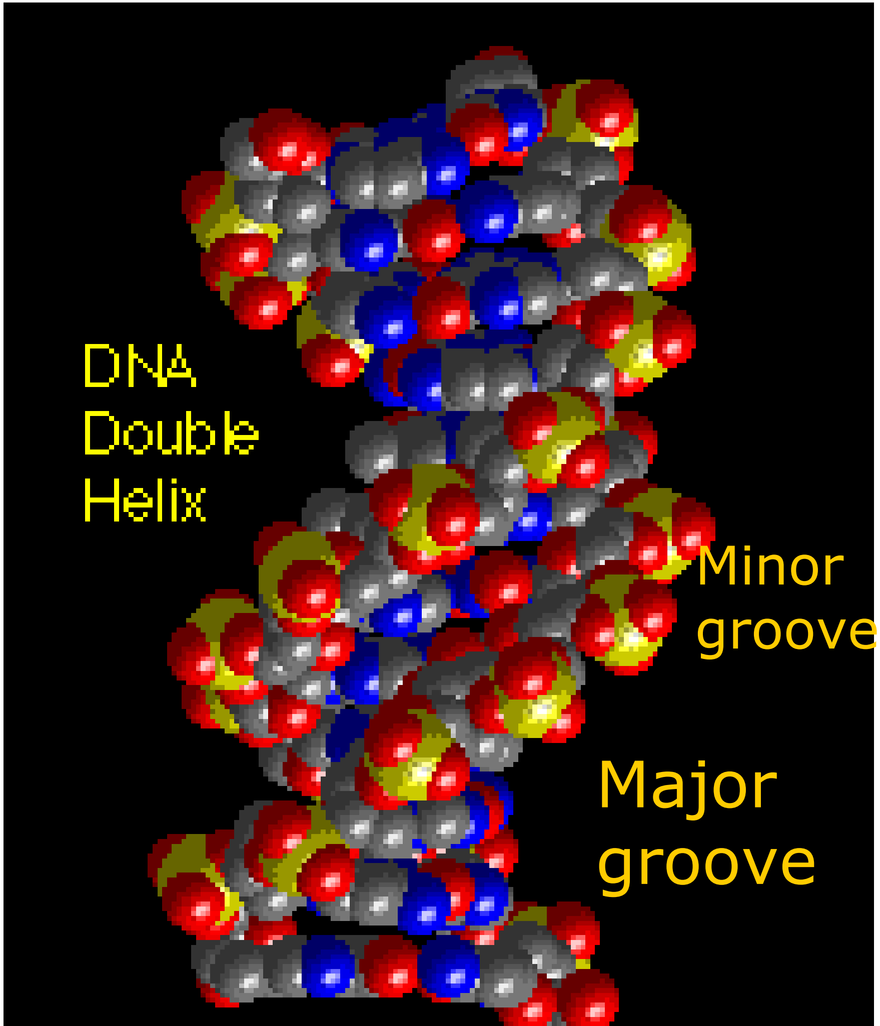
Watson & Crick's double helix DNA proposed on *Nature, vol 171, pp737,1953*

backbone

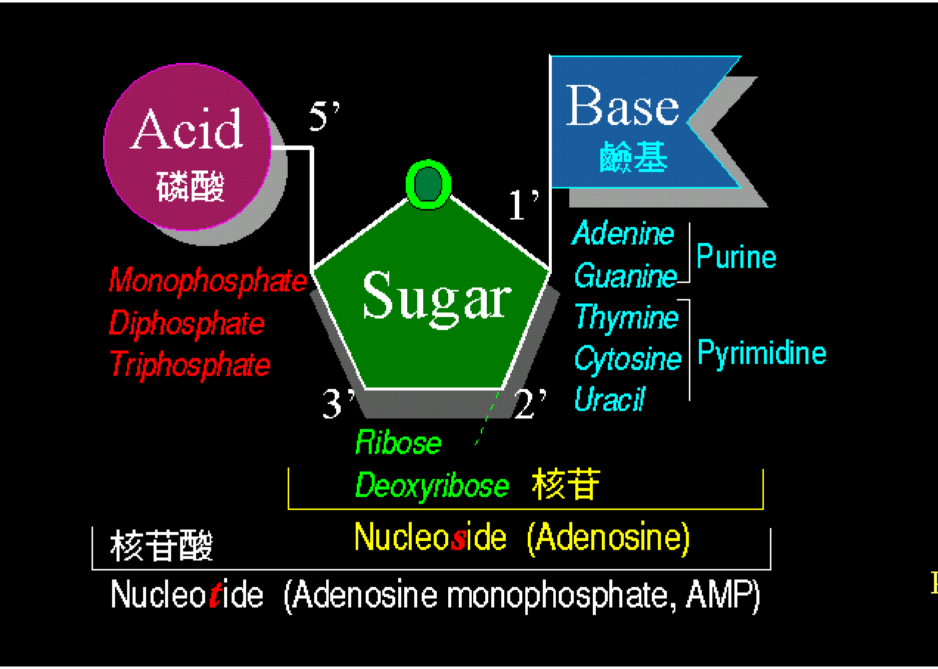
Base-pair

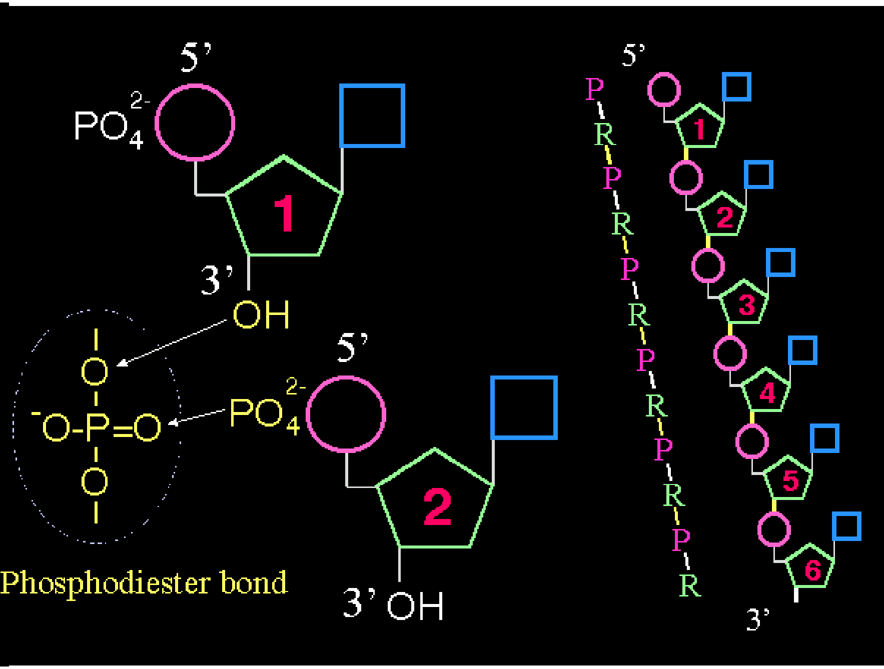


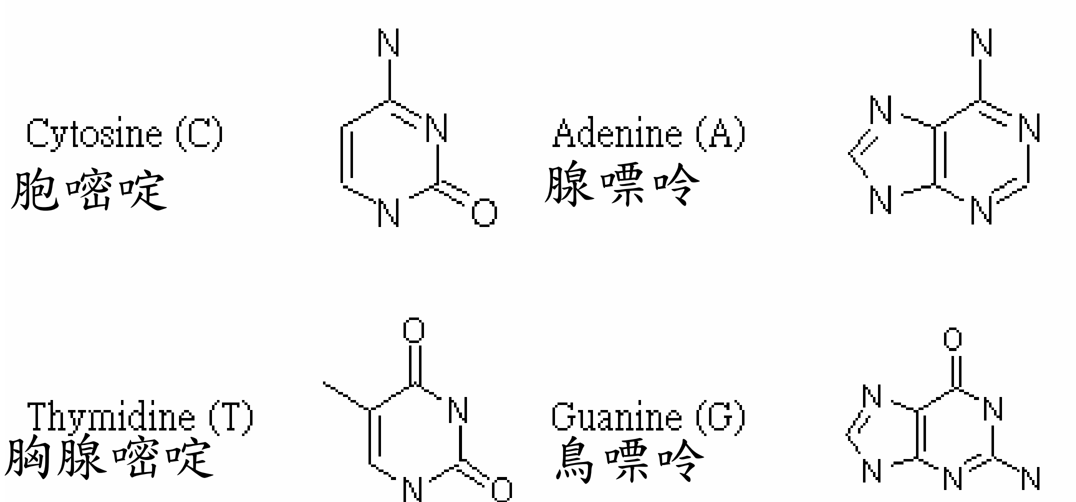
This figure is purely diagrammatic. The two ribbons symbolize the two phosphate—sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical

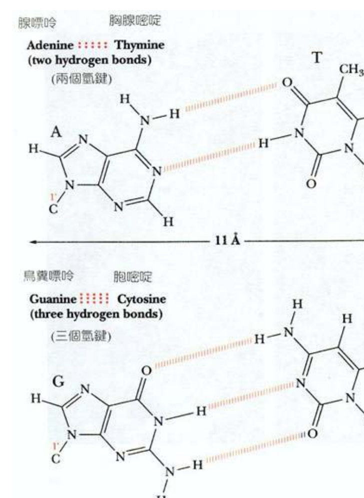


Chemical Composition of DNA

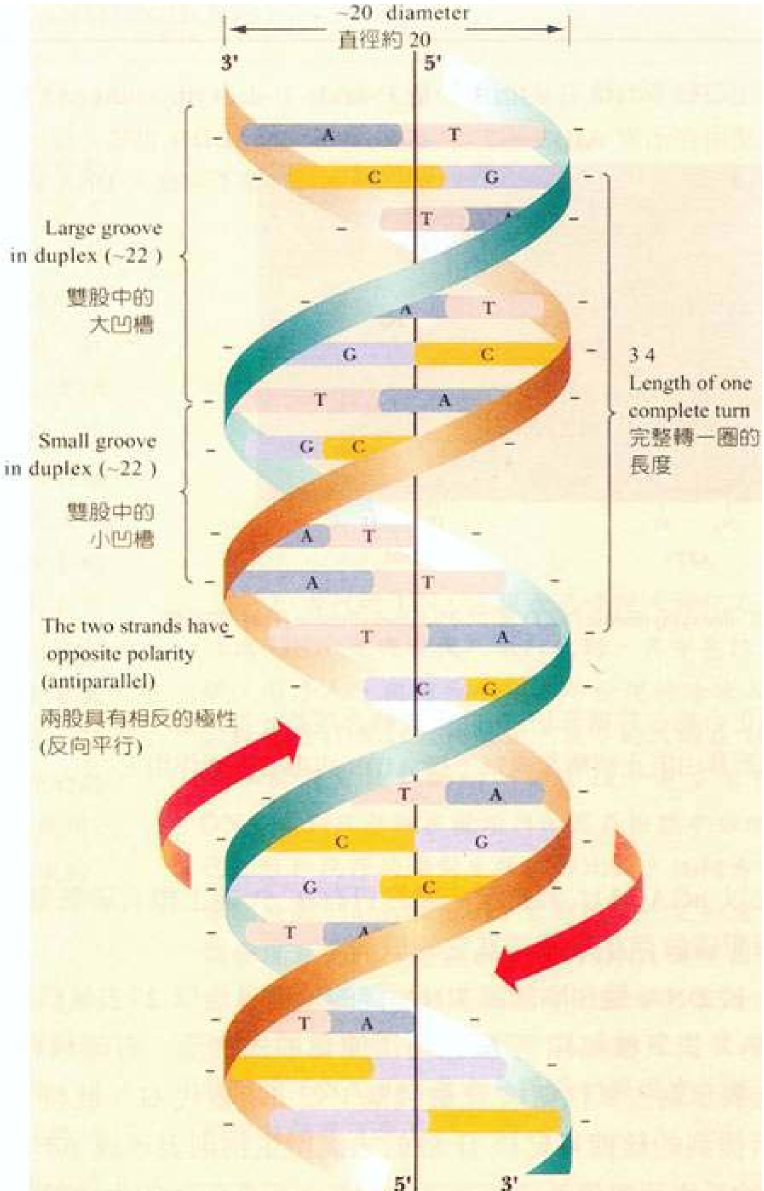


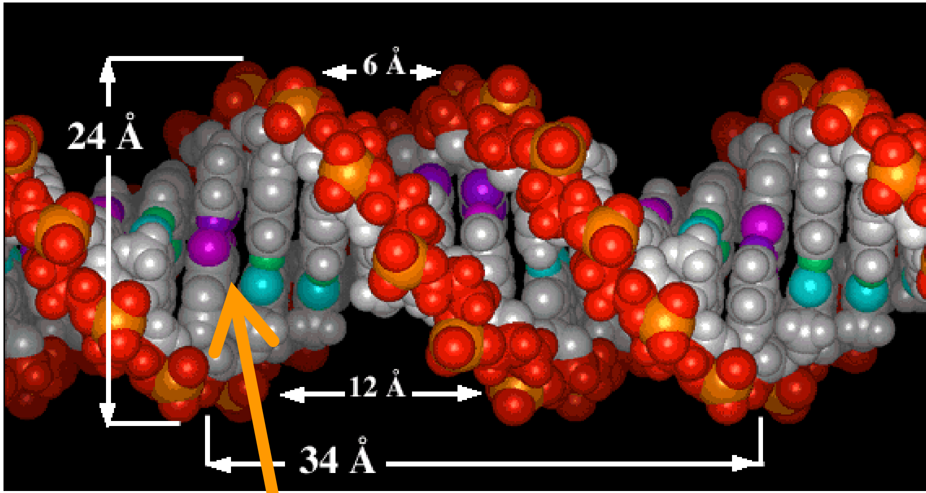






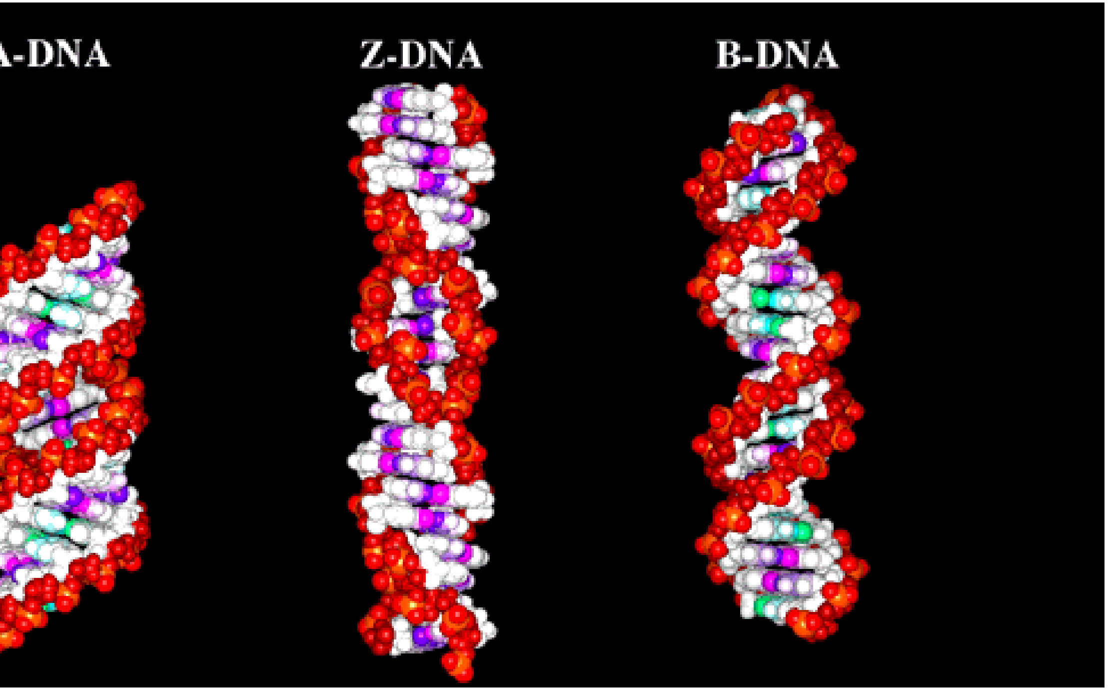
Geometry of DNA



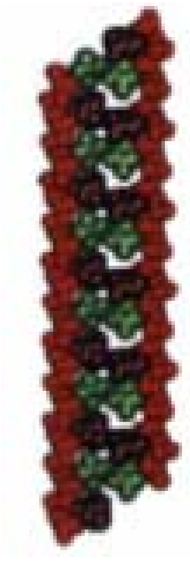


Twist for each two bps, 36°(B-Type)

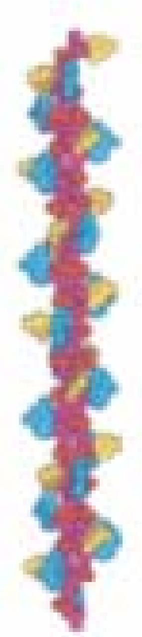
DNA conformation



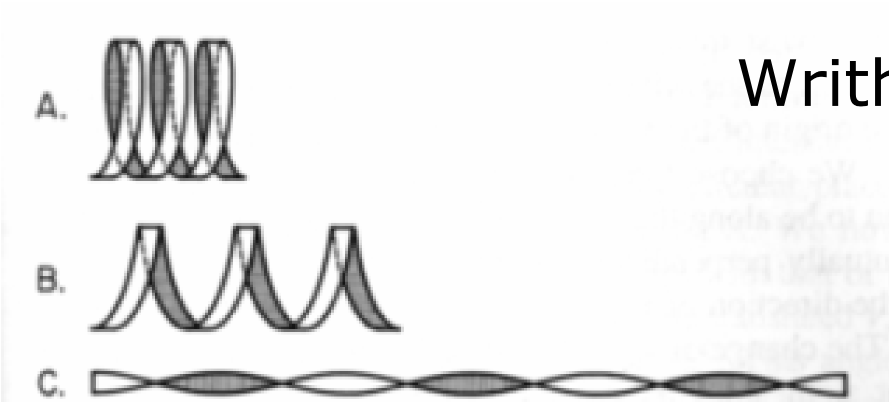
S-DNA



P-DNA



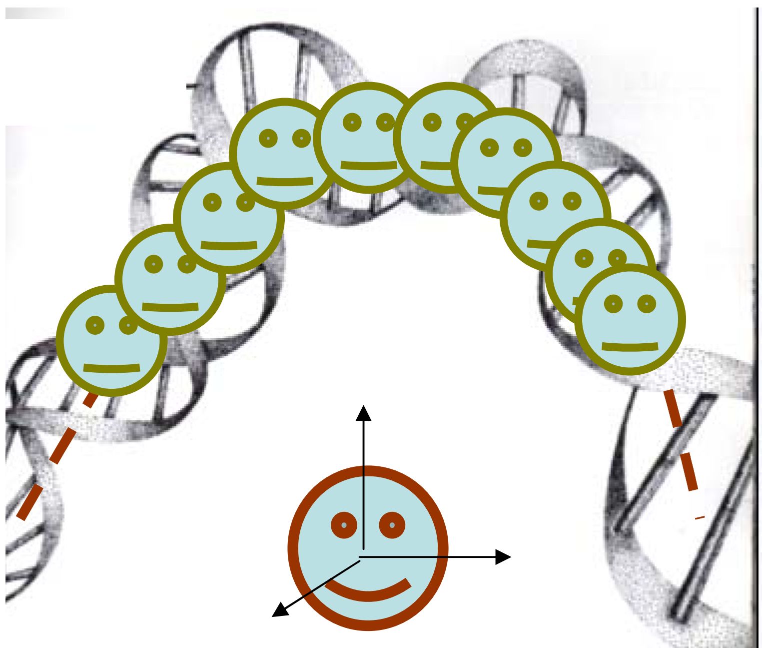
The linking Number-- Definition



Writhe=3, Twist=0

↓

Writhe=0, Twist=3



$$Tw$$

$$Wr$$

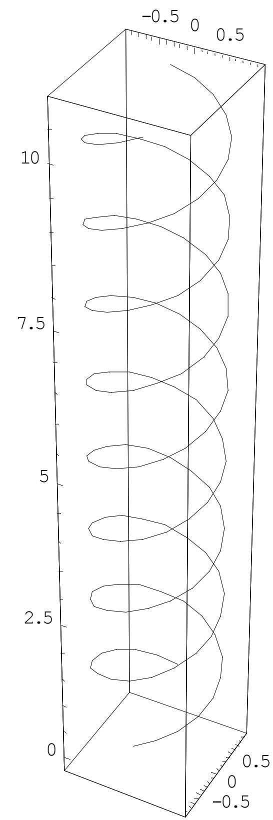
$$L_k = Tw + Wr$$

Degree of Supercoiling (超螺旋度)

$$\sigma = \frac{L_k - L_{k0}}{L_{k0}}, \quad L_{k0} \approx \frac{N_{bp}}{10.5}$$

$\sigma : Degree\ of\ Supercoiling$

$N_{bp} : Total\ Number\ of\ base-pairs$

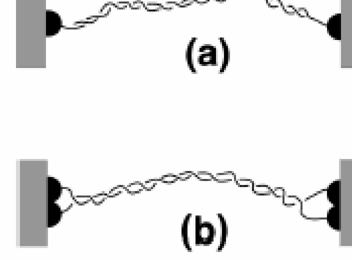


if

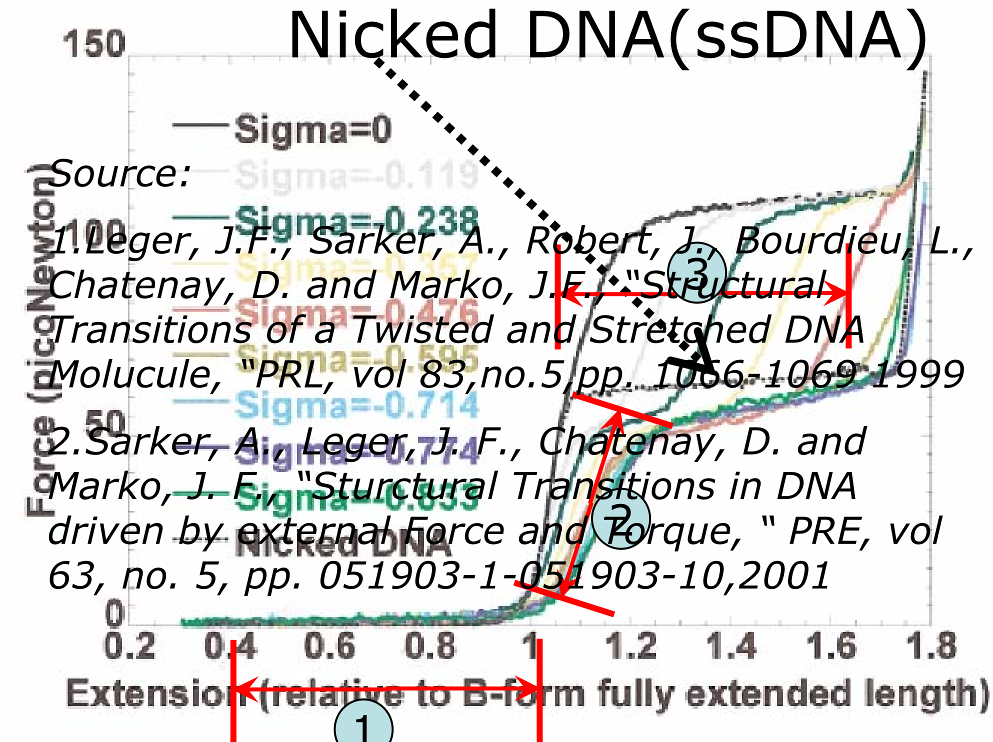
$\sigma > 0, overtwisted$

$\sigma < 0, undertwisted$

$usually,\ B-type\ DNA\ \sigma \approx -0.05\ (in\ vivo)$



DNA Strength Diagram



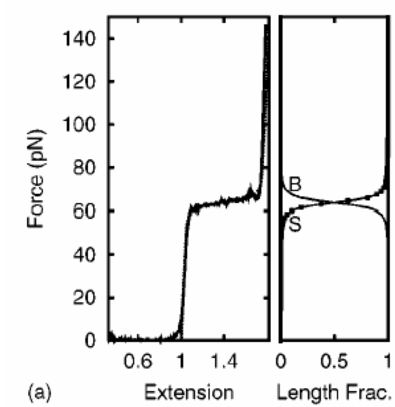
Source:

1.Leger, J.F., Sarker, A., Robert, J., Bourdieu, L., Chatenay, D. and Marko, J.F., "Structural Transitions of a Twisted and Stretched DNA Molucule, "PRL, vol 83,no.5,pp. 1066-1069 1999

2.Sarker, A., Leger, J. F., Chatenay, D. and Marko, J. F., "Sturctural Transitions in DNA driven by external Force and Torque, " PRE, vol 63, no. 5, pp. 051903-1-051903-10,2001

Sample:

dsDNA, 44kb ～ 14.96 μ m, $L_{ko}=T_{w0}$～ 4200 (44kb/10.5～4190



①:0~10pN, to remove bending from random coil

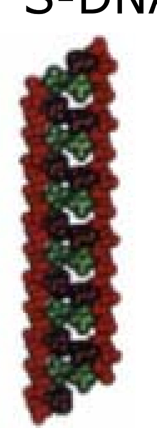
②:10~65pN, Almost linear stretching elastic constant

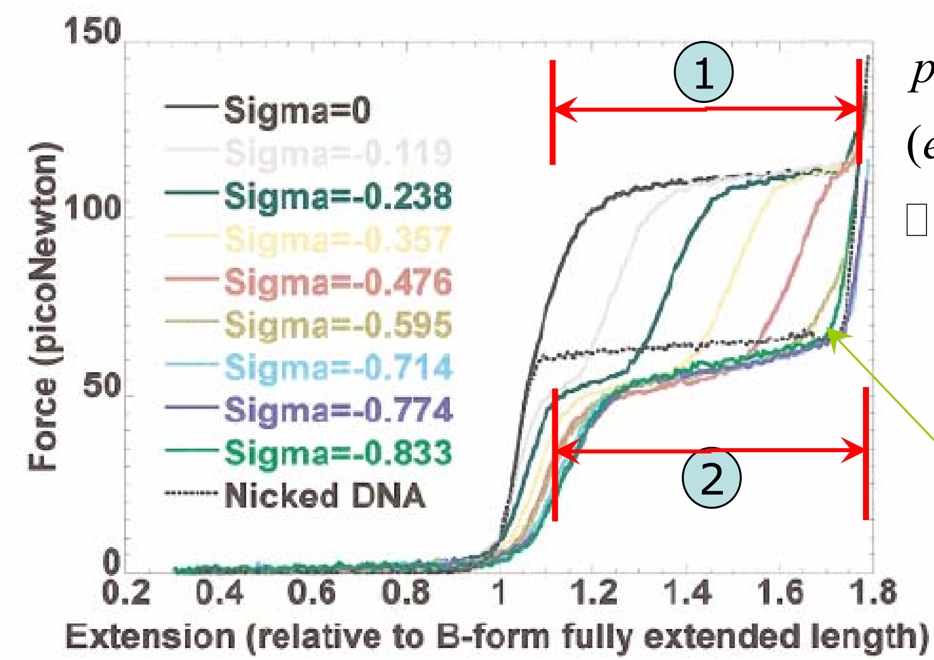
③:S-DNA, 65pN plateau, 1.7 times longer than B-DNA

Under twisted

$$from\ \sigma = \frac{L_k - L_{k0}}{L_{k0}}, L_{k0} = N_{bp}/10.5$$

$$bps/turn = \frac{10.5}{1+\sigma} \approx 37.5$$

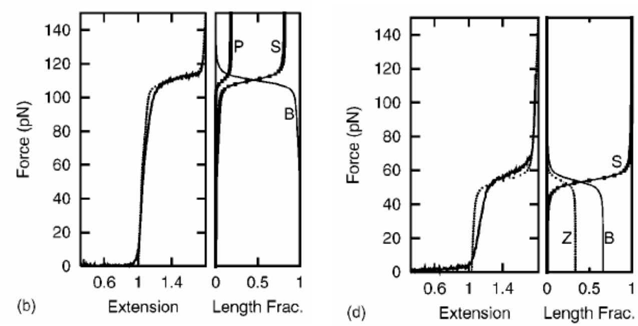




pitch per turn:

$$(extension)*(0.34nm)*(37.5)$$

$$\approx 21.675nm$$



σ =0 σ =-0.714

1: σ =0, unnicked DNA, 110pN plateau appears(S+P Type)

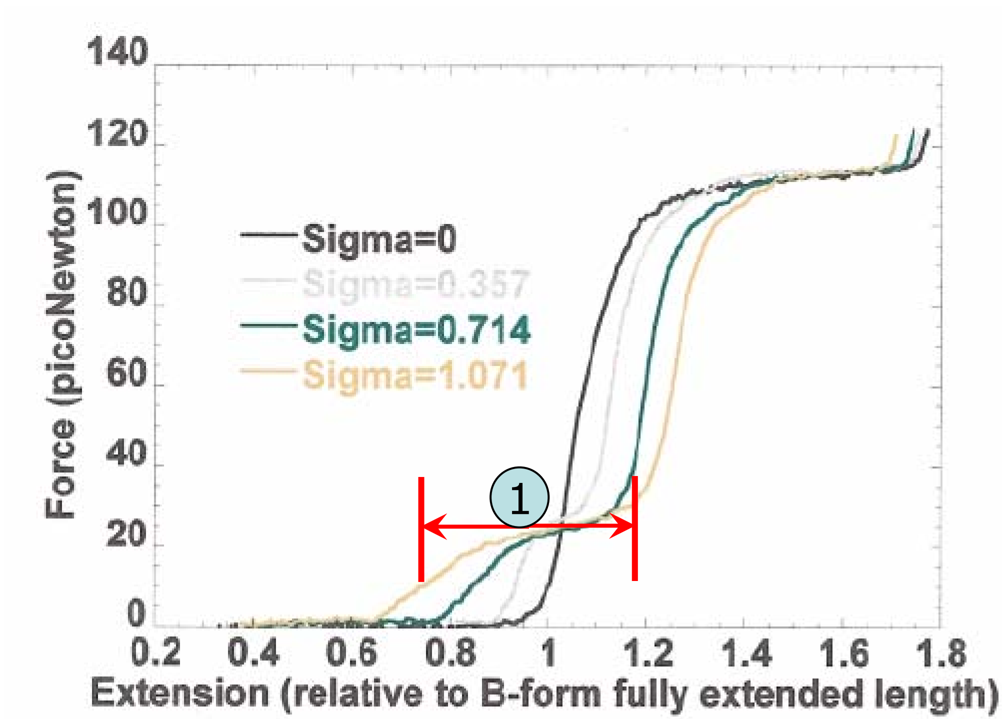
2: at σ =-0.1, ~50pN plateau appears

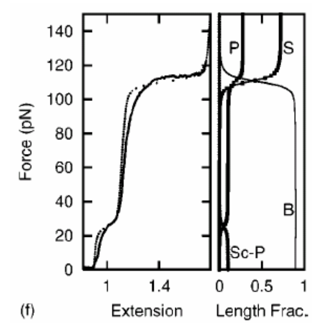
3: at σ =-0.72±0.05, the 110pN plateau disappear.

Def. S-DNA, pitch per turn~22nm, 37.5 bps/turn

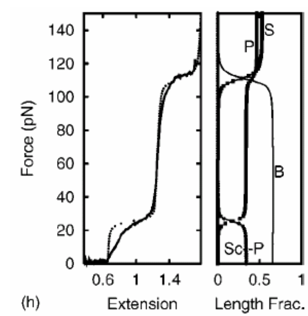
P-DN

Over Twisted





$\sigma = 0.357$

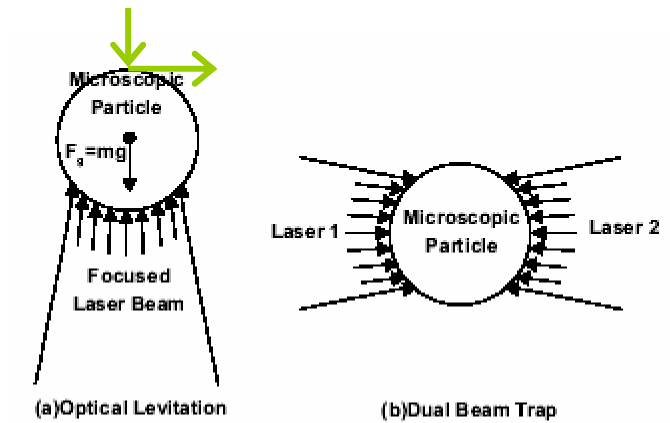


$\sigma = 1.071$

1 :A new plateau at 25 pN

Principle of Optical Trap

- We could apply force on micro-particle by optical pressure, and trap and control the micro-particle.



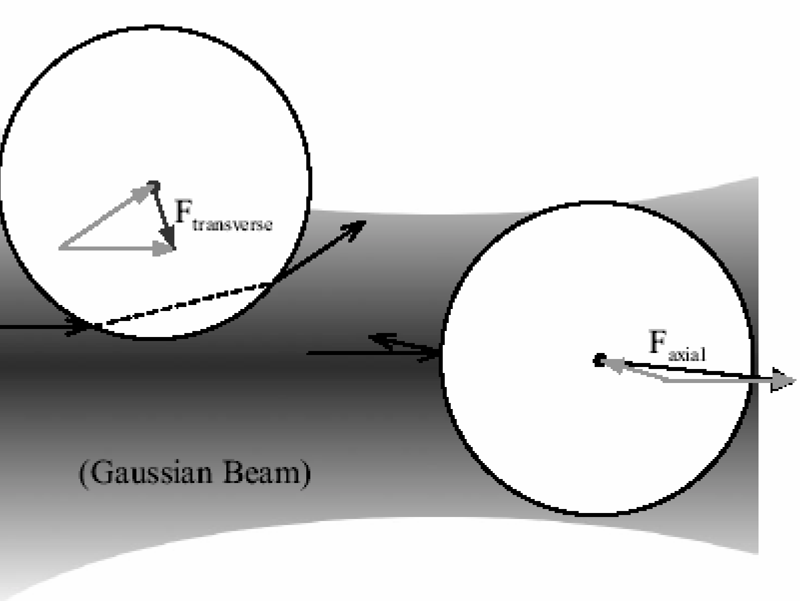
- Single Beam, Highly focus, large solid angle → single beam optical trap
- Gradient Force: orthogonal to light ; Scattering Force: parallel to light

Brief History of Optical Trap

- A. Einstein: Photon Model
- A. Ashkin(1969): Optical Pressure experiment
- A. Ashkin(1970-1980): first laser trap (Ar Laser)
- A. Ashkin & S. Chu (1986): Single Beam Optical Tweezers
- A. Ashkin (1987): manipulate cell by YAG laser (1064nm)
- S. Chu (1997): Nobel prize: laser cooling

Preliminary Theory Study: RO Model

- RO (Ray-Optics Model)
- Describe optical trap by geometric optic and momentum change of photon
- micro-particle diameter larger than wave length

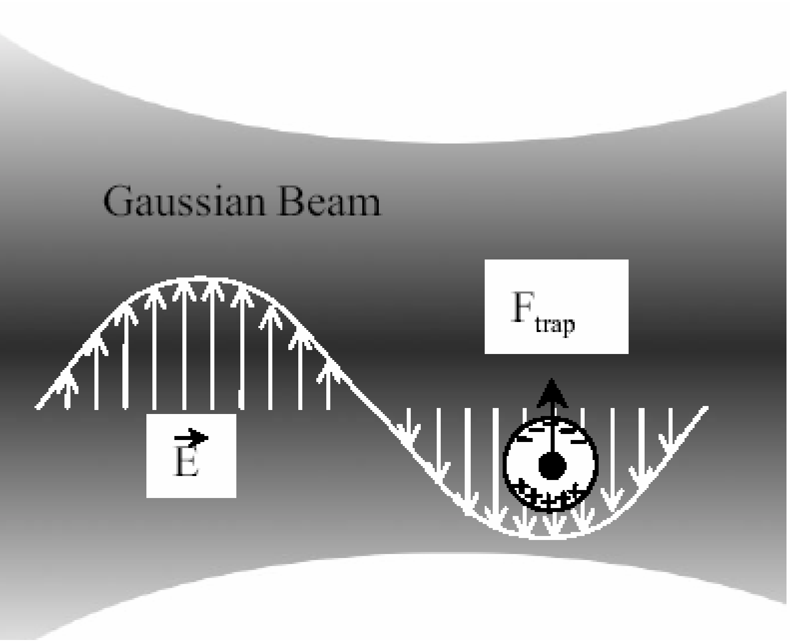


Gradient force:
refract photon while laser enter micro-particle, which cause momentum change of photon. Base on Newton Mechanics, there are force ac on microparticle

Scattering Force:
Part of photon reflex upon micro-particle, which cause axial force

Preliminary Theory Study: EM Model

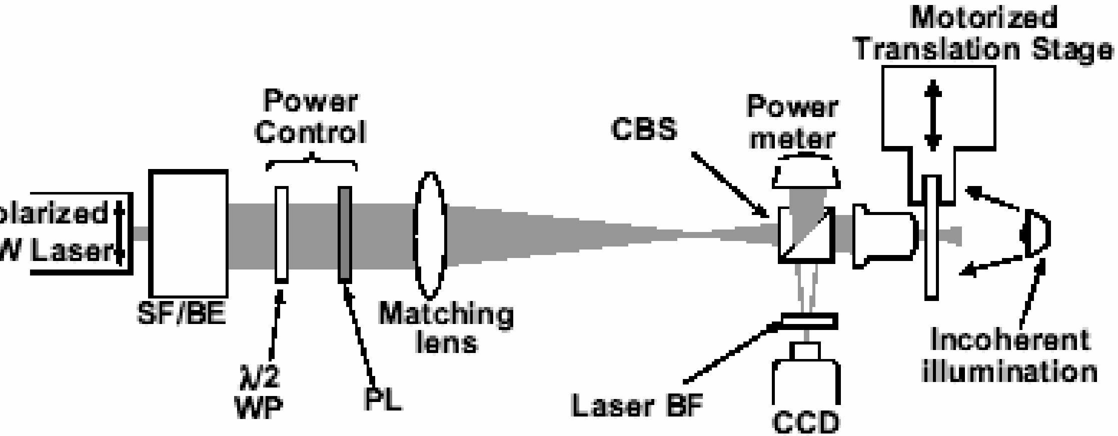
- EM model: Electromagnetics model
- Base on the EM theory and micro-particle being polarize
- micro-particle diameter smaller than wave length



Gradient force:
As the laser polarizes the object, the object experiences a force in the gradient of the electric field

Scattering Force:
Light being reflected or absorbed by the particle
The scattering force is proportional to the optica
intensity.

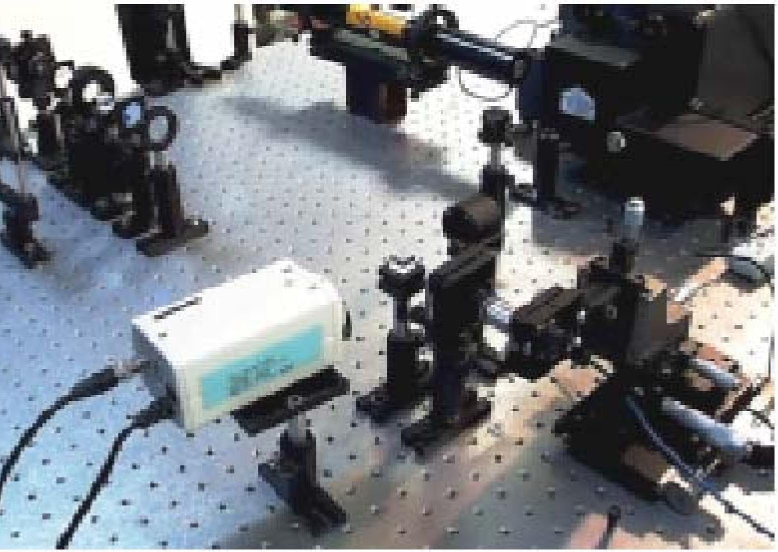
Basic Optical Trap Instrument

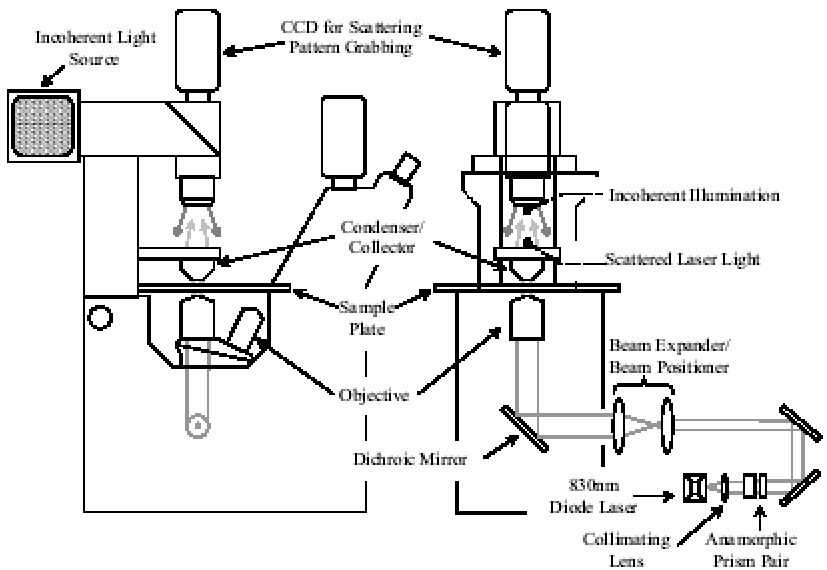


Optical tweezers typically use light at wavelengths of 0.7~1.06 um and 25 to 500 mW

- CW laser
- SF(Spatial Filtering) 濾波
- BE(Beam Expending 擴束
- WP: Half Wave Plate
- PL: Polarizer
- Laser BF: Laser Blocking Filtering

Optical Trap Instrument around TW Univ.

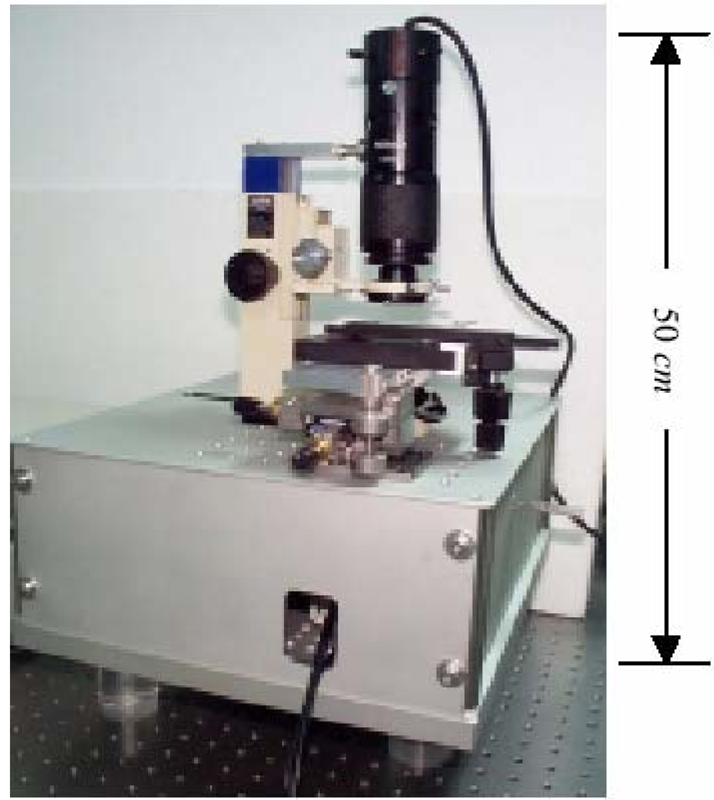




東華大學、電機系、邱爾德教授　陽明大學、微免所、林奇宏教授

Optical Trap Instrument around TW Univ.

交通大學、電物系、徐琅教授

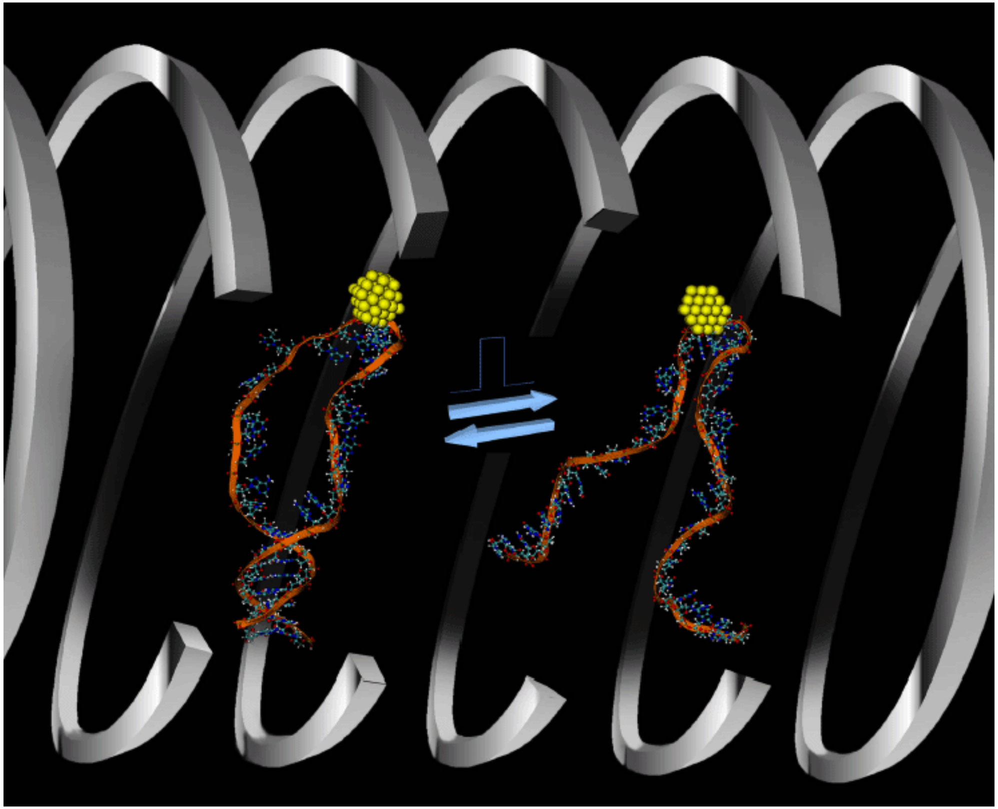


Remote electronic control of DNA hybridization through inductive coupling to an attached metal nanocrystal antennas

Author: Hamod,K, Schwartz,J.J., Santos, A.T., Zhang, S. and Jacobson, J.M.
(MIT Media Lab,US)

Journal: Nature, vol415, pp. 152-155
Date: 10-Jan-02’

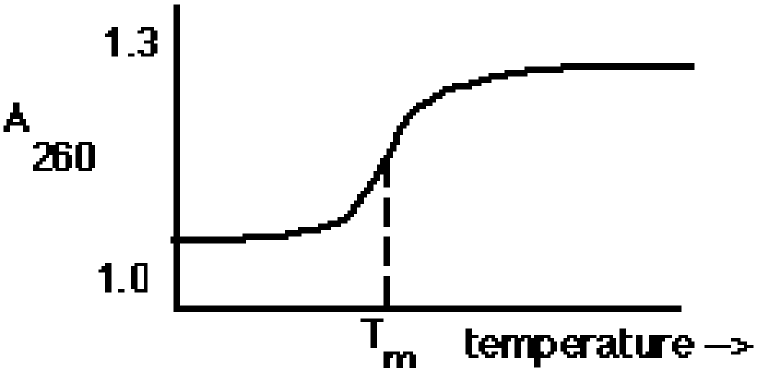
Hybridization by Antenna/Heat

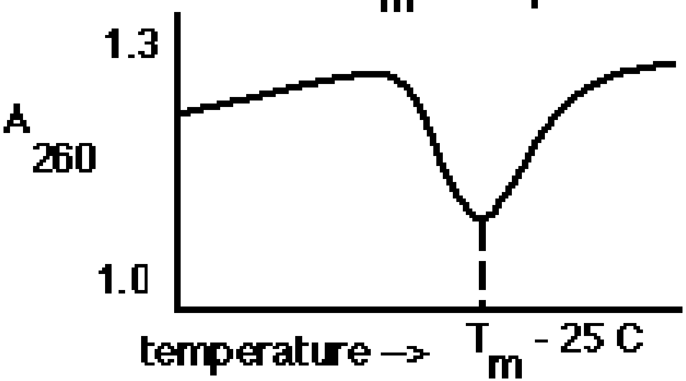


Inductive coupling of a RFMF to metal convalenty link to DNA.

Inductive coupling to the nanocrystal increase the local temperature of the bound DNA.

Hyperchromicity/DNA optically absorbance

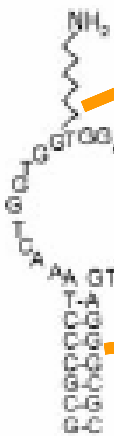




The absorbance of DNA at 260 nm (the absorption maximum) was followed as the DNA was slowly heated.

The hypochromicity was maximal about 25 C below the Tm.

“Antenna” Design

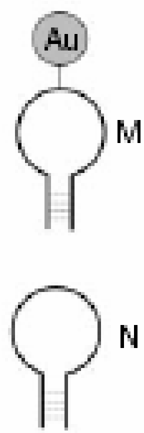


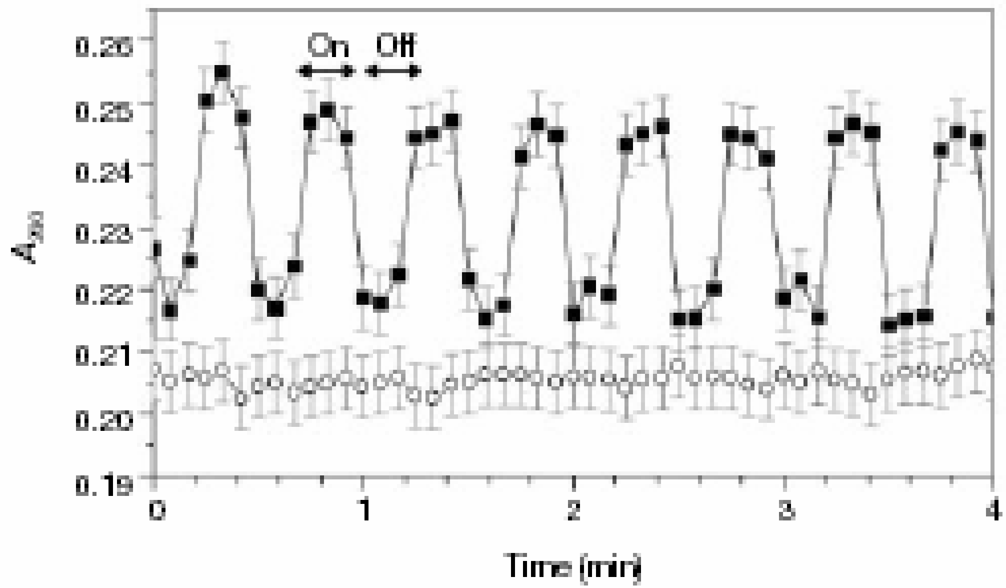
1.4nm, Gold

On Thymine: C6

24 nucleotide

14 nucleotide(7bps)

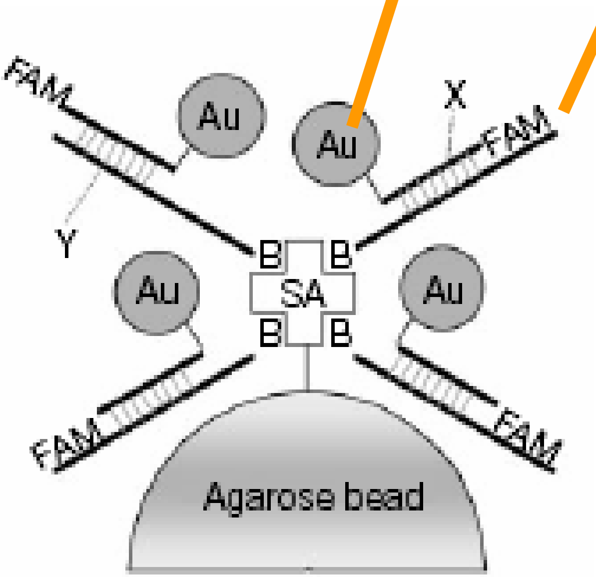


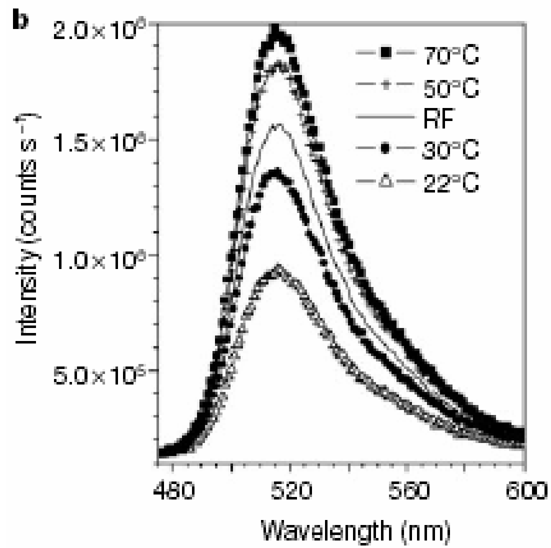


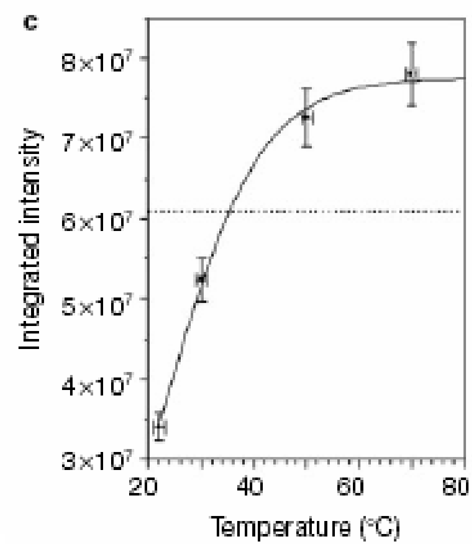
Effective Temp.

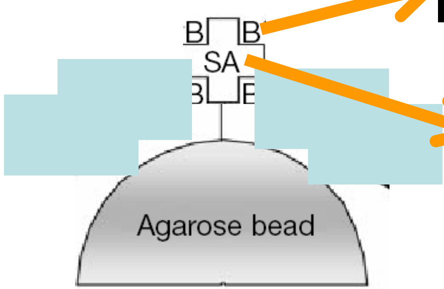
3′ end,Au nanoparticle

5′ end,FAM:fluorophore λ=516nm









Biotin(維生素H)

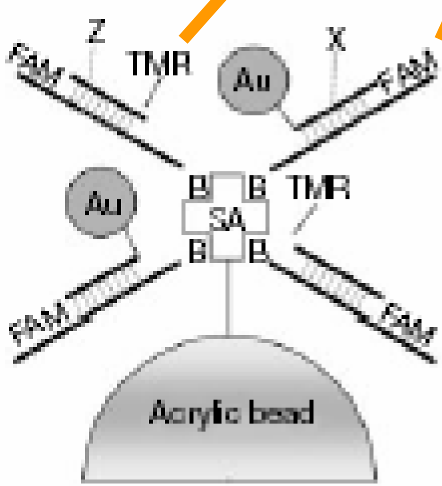
streptavidin(鏈狀卵白素)

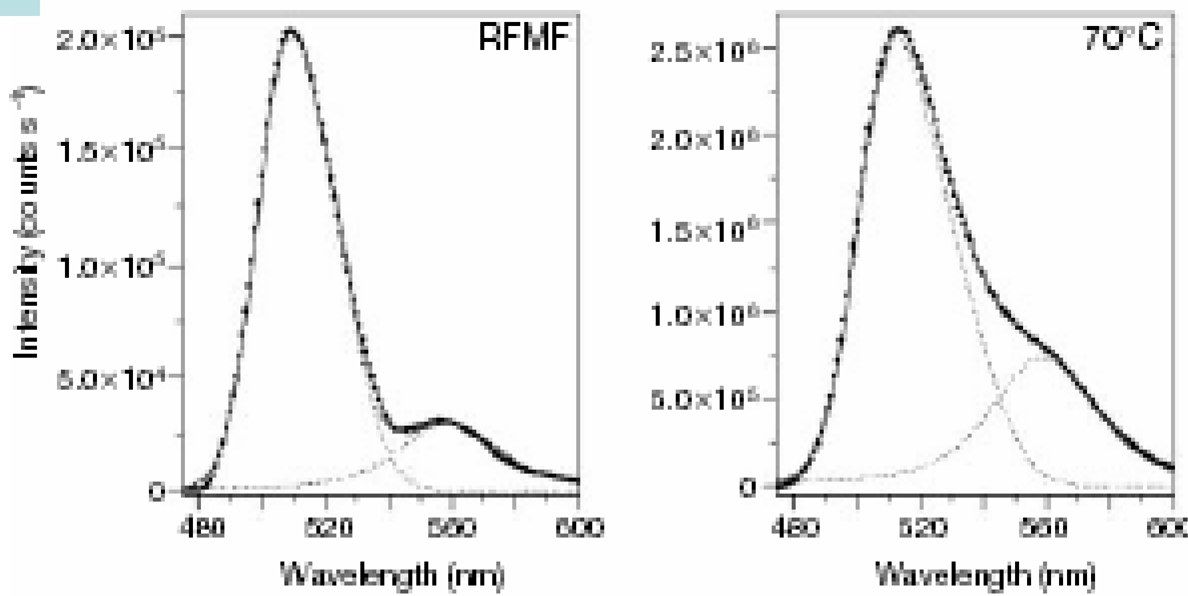
T_{eff}=35℃

Selectivity

3′ end, TAM, NHS-teteramethylrhodamine, λ =563n

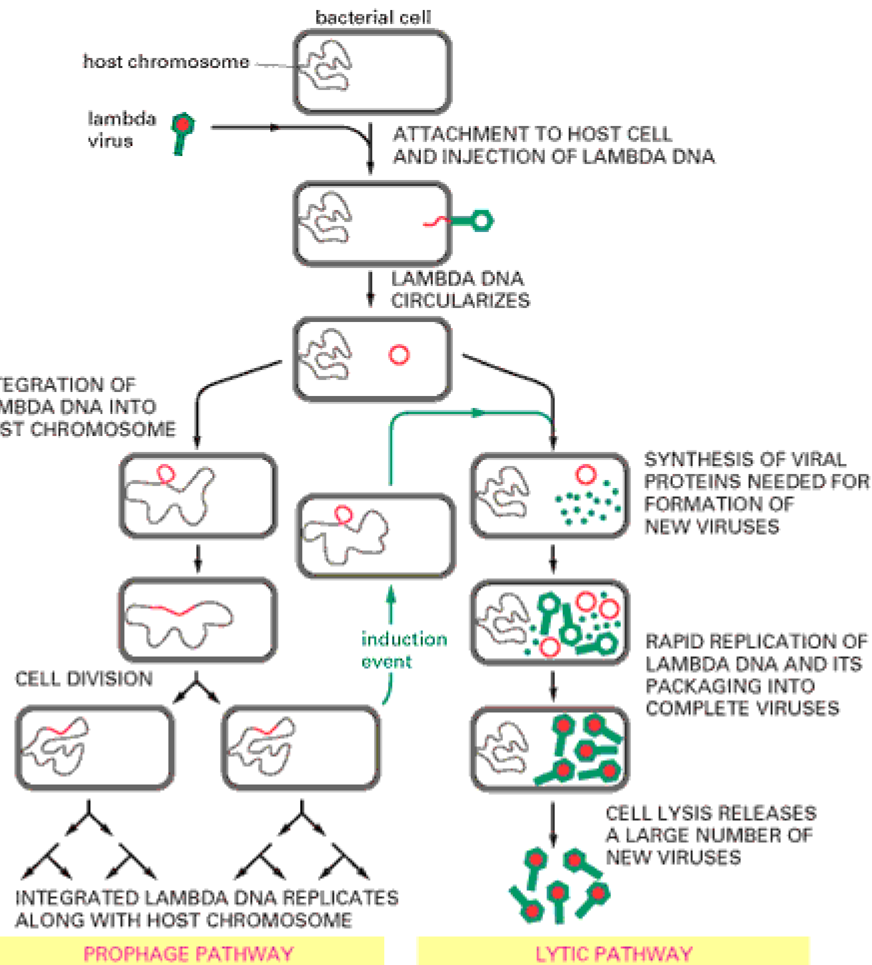
5′ end,FAM:fluorophore λ =516nm

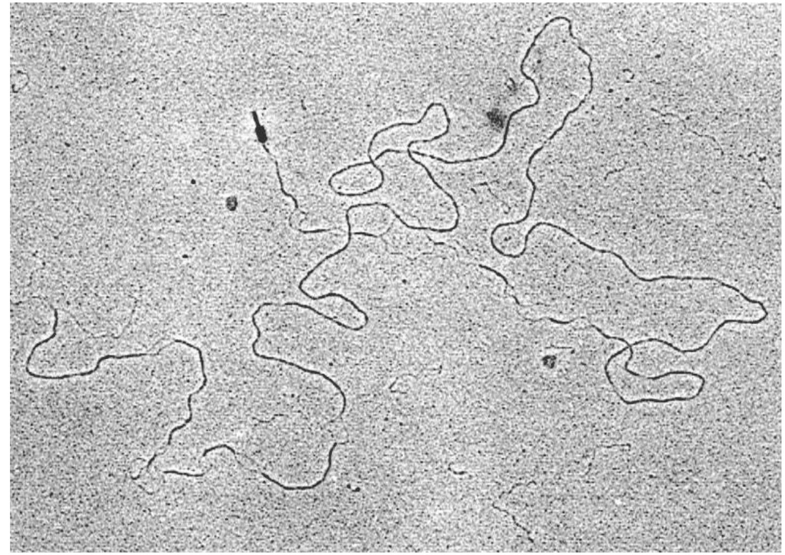


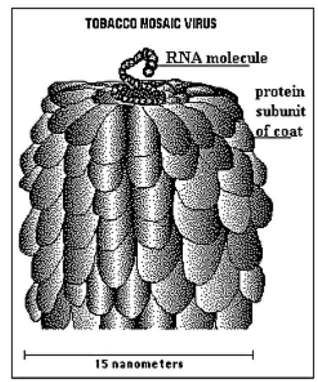


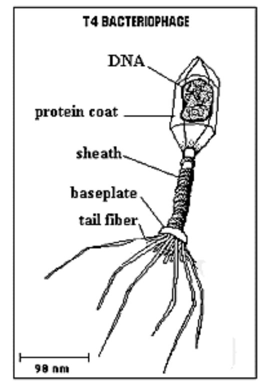
DNA Paper Review: DNA Packaged by Phage

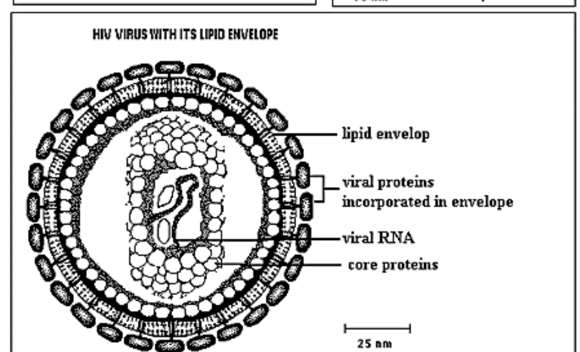
Phage &


bacterial cell
host chromosome
lambda virus
ATTACHMENT TO HOST CELL AND INJECTION OF LAMBDA DNA
LAMBDA DNA CIRCULARIZES
EGRATION OF MBDA DNA INTO ST CHROMOSOME
SYNTHESIS OF VIRAL PROTEINS NEEDED FOR FORMATION OF NEW VIRUSES
induction event
RAPID REPLICATION OF LAMBDA DNA AND ITS PACKAGING INTO COMPLETE VIRUSES
CELL DIVISION
CELL LYSIS RELEASES A LARGE NUMBER OF NEW VIRUSES
INTEGRATED LAMBDA DNA REPLICATES ALONG WITH HOST CHROMOSOME
PROPHAGE PATHWAY
LYTIC PATHWAY




TOBACCO MOSAIC VIRUS
RNA molecule
protein subunit of coat
15 nanometers

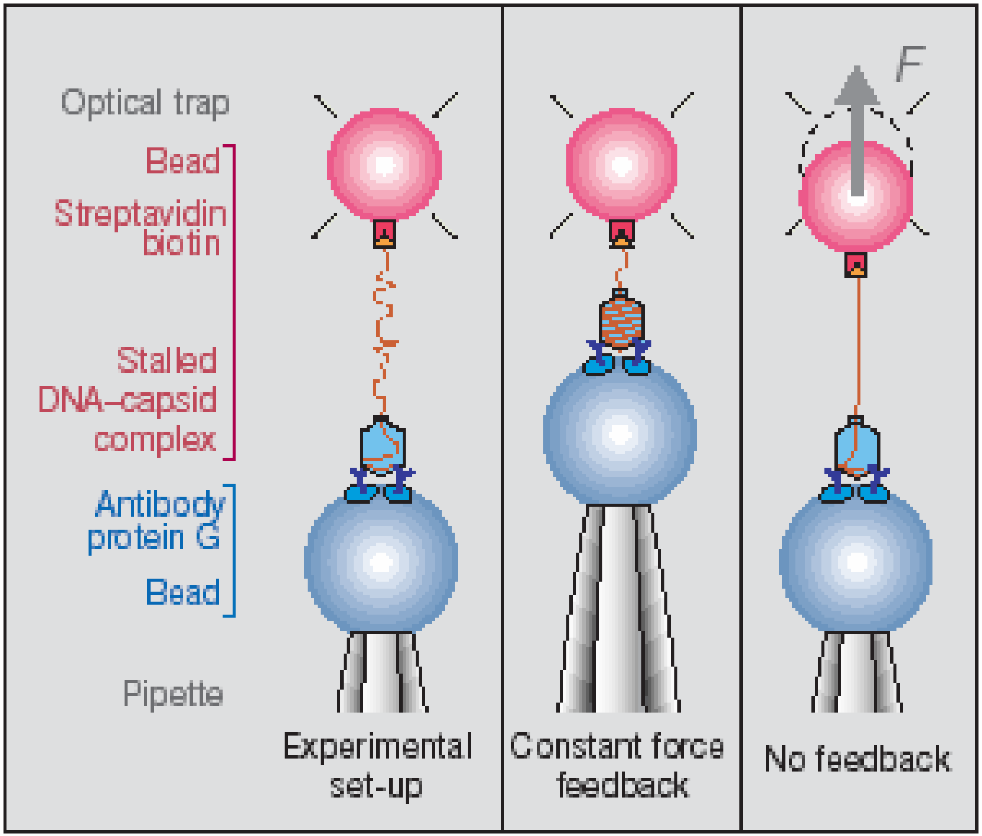

T4 BACTERIOPHAGE
DNA
protein coat
sheath
baseplate
tail fiber
98 nm


HIV VIRUS WITH ITS LIPID ENVELOPE
lipid envelop
viral proteins incorporated in envelope
viral RNA
core proteins
25 nm

Bateriophage ϕ29 study

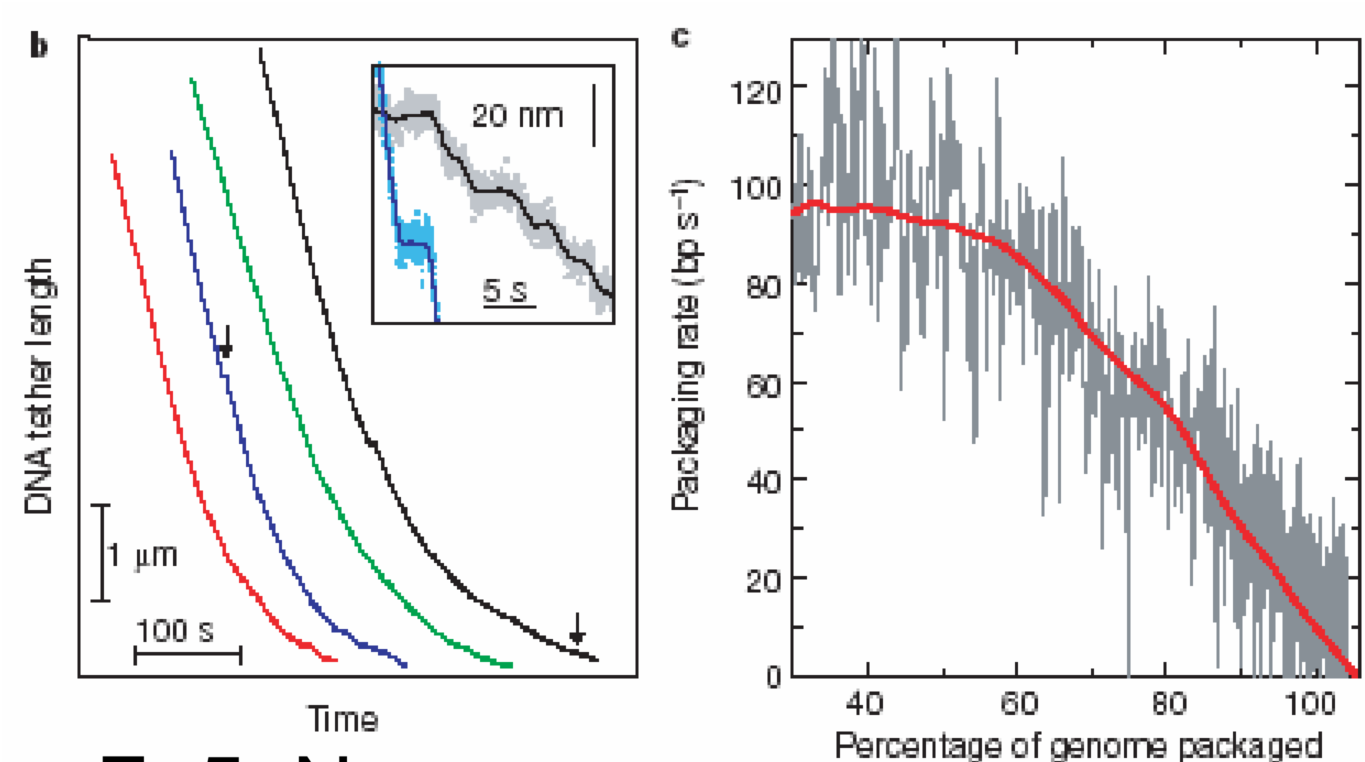
- **Title:** *The bateriophage ϕ29 portal motor can package DNA against a large internal force*
- Authors: D.S. Smith, S.J. Tans, S.B. Smith, S.Grimes, D.L. Anderson and C. Bustamante
- ***Nature***, vol. 413, 18-Oct-02, pp. 748-752

Experiment Setup



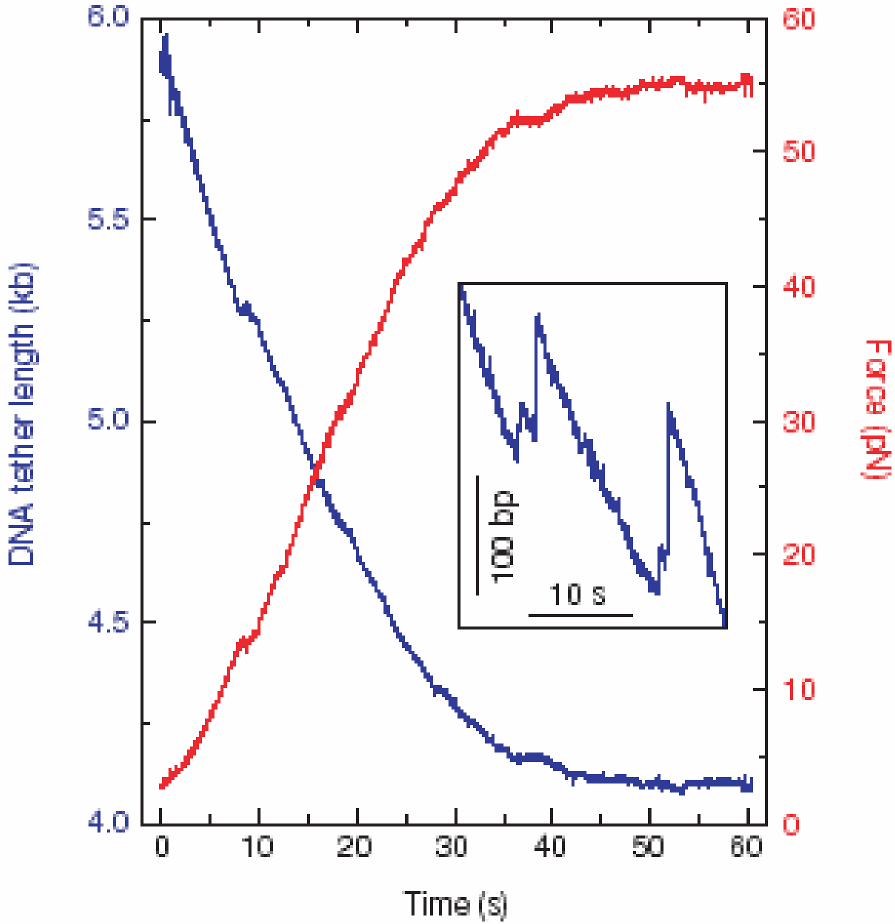
- Capsid: 42x54 nm
- Phage can package its 6.6 μm
- DNA sample: longer than 1.8 times original phage ϕ29

Constant Force Feed Back Mode



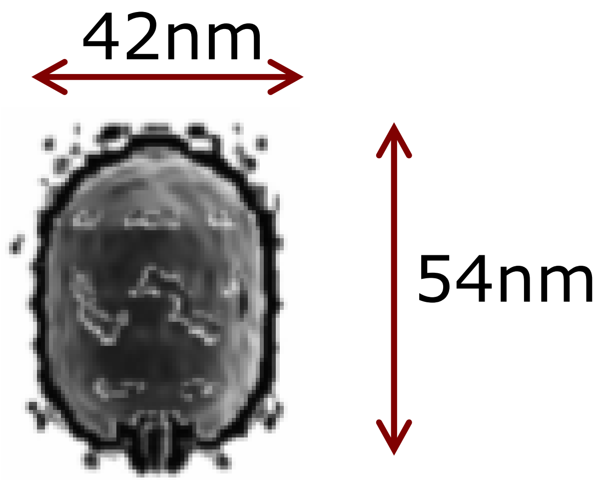
- F~5pN
- Using 34.4 kb ϕ29- λ DNA

No Feed-Back Mode

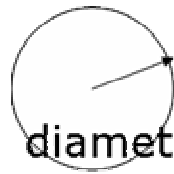


- The force is measured from the laser tweezers
- The stall force is 57pN in avg. and distance moved per ATP is 0.68nm. Assuming ATP in buffer is 120 pN-nm, the efficiency of the motor is **30%**
- The pressure in the capsid is known as 6 MPa, and the thickness of the capsid is 1.6 nm
- The tensile stress of the capsid wall is ~100 MPa

Estimate the Bateriophage $\phi 29$ Capsid while the DNA is fully packaged



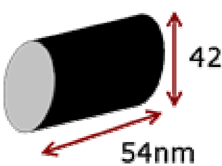
Assume the capsid is sphere:



$$\sigma = \frac{pr}{2t} = \frac{6 * \left(\left(\frac{54+42}{2} \right) / 2 \right)}{2 * 1.6} \approx 45 MPa$$

Assume the capsid is vessels:

$$\sigma = \frac{pr}{t} = \frac{6 * \left(\frac{42}{2} \right)}{2 * 1.6} \approx 78.75 MPa$$



Introduction to DNA Chip

Chang Ann Yuan
H.S. Ku

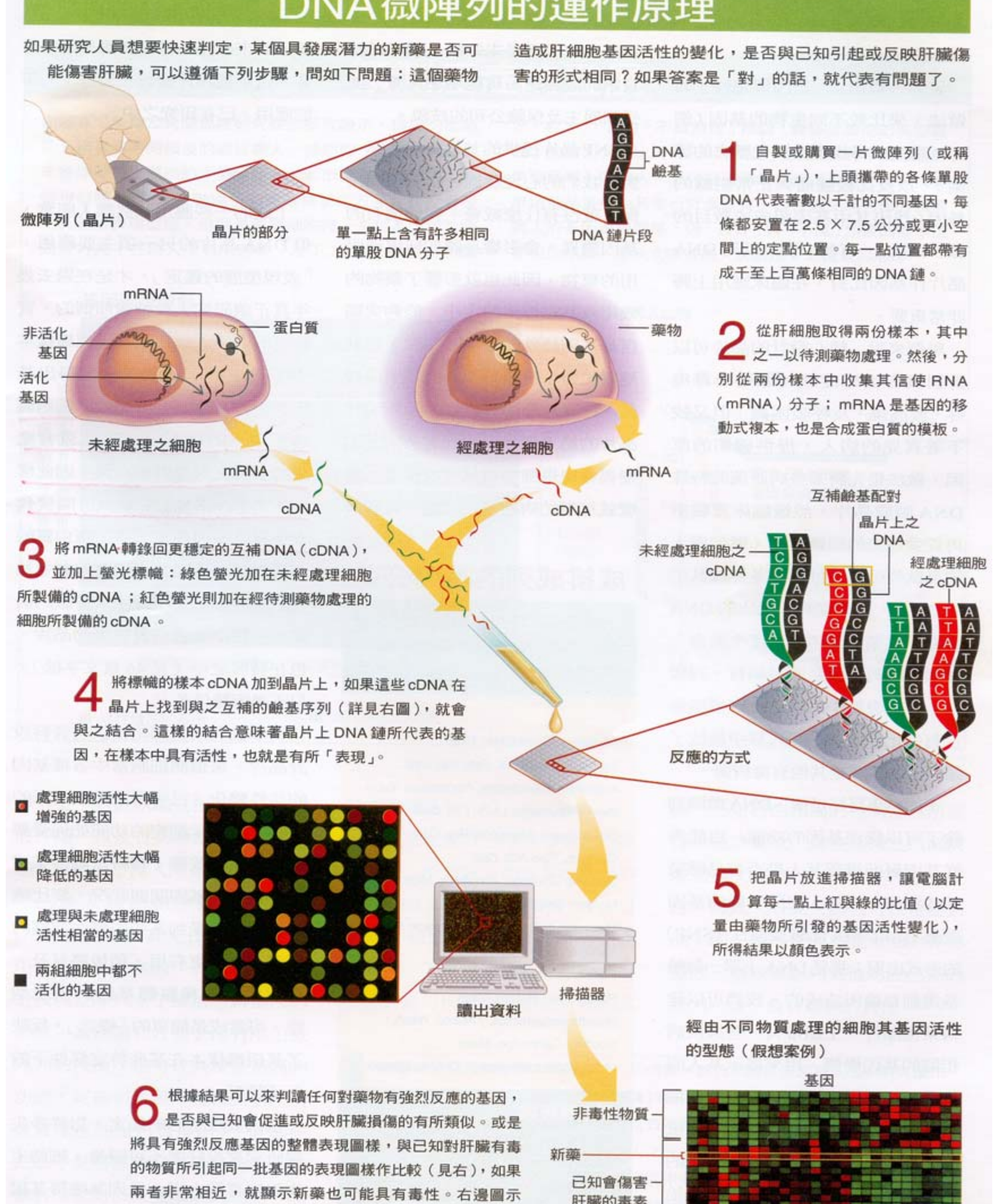
Advisor: Dr. K.N.Chiang

03-Sep-02’

Outline

- DNA Chip Principle
- DNA Chip Type
- DNA Chip Product: Nanogen
- DNA Chip & EP/MEMS Packaging
- New Idea: Reusable DNA Chip

DNA Chip Principle



DNA Chip Type

- Probe

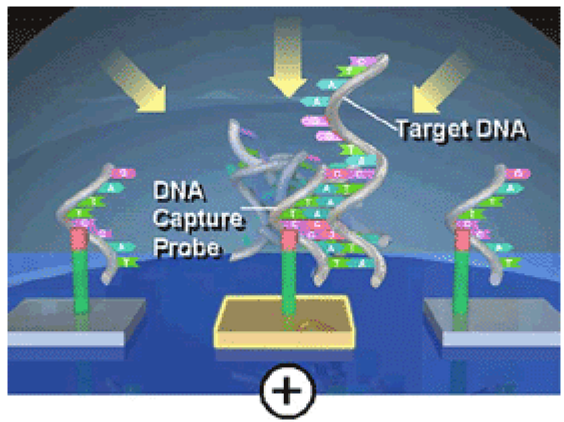
✓ Oligonucleotides or Pepide nucleo acids (PNA)
✓ DNA Segments

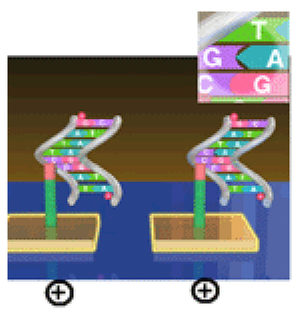
- Manufacture

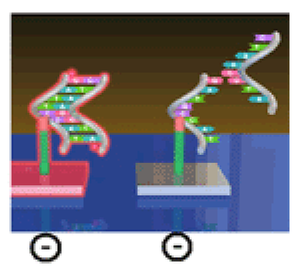
✓ Photolithography
✓ Mechanical microspotting
✓ Ink jet

Note:the hybrid time: 10-15 hrs

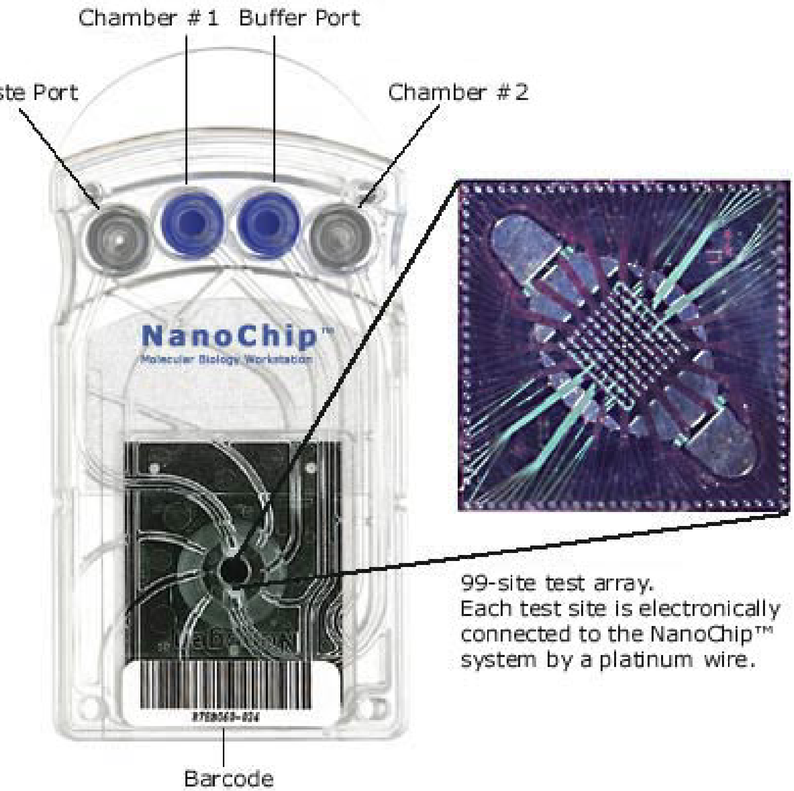
DNA Chip Product: Nanogen

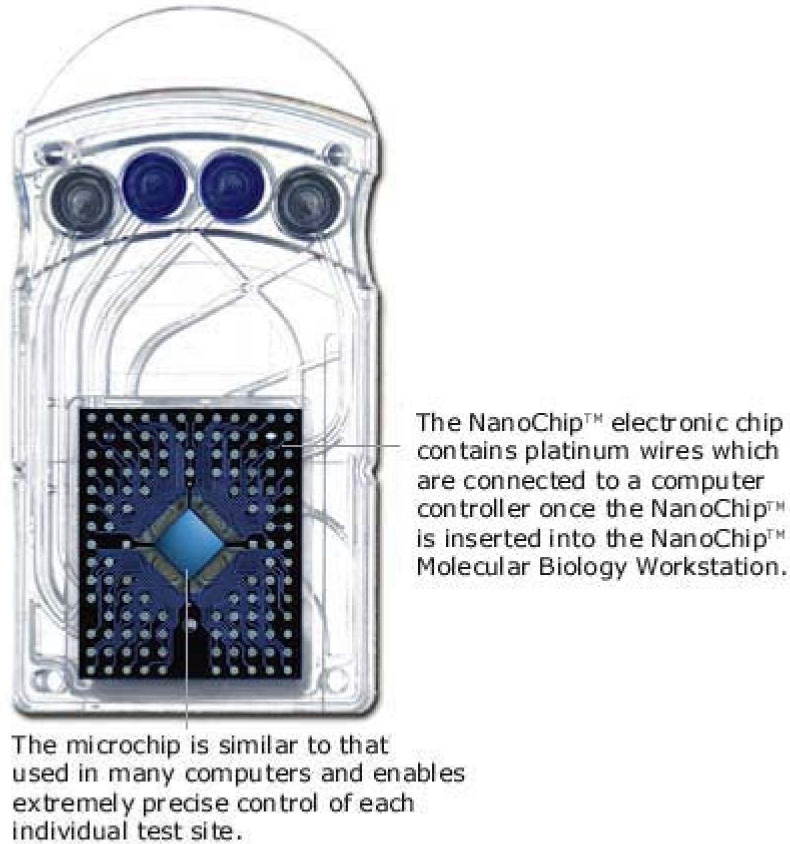




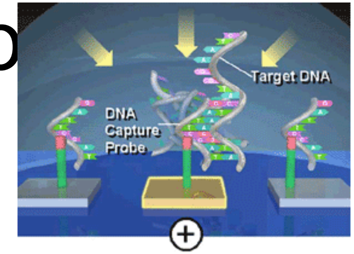


DNA Chip & EP/MEMS Packaging





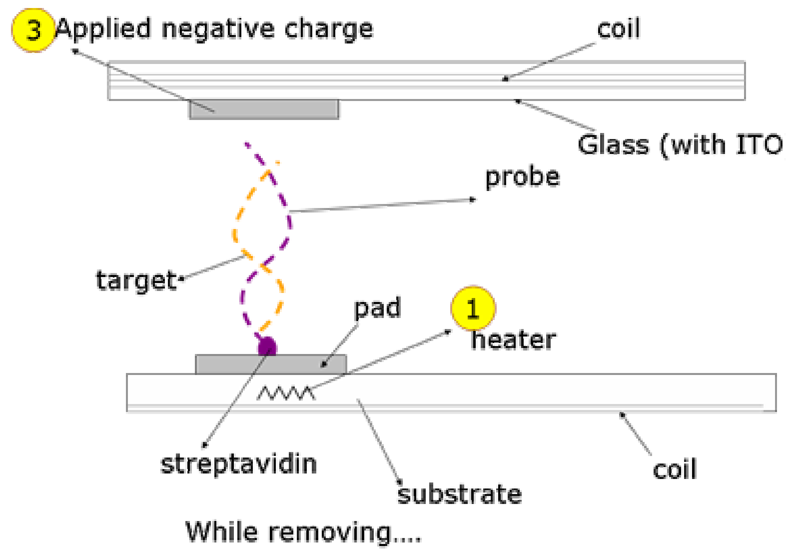
New Idea of Reusable DNA Chip

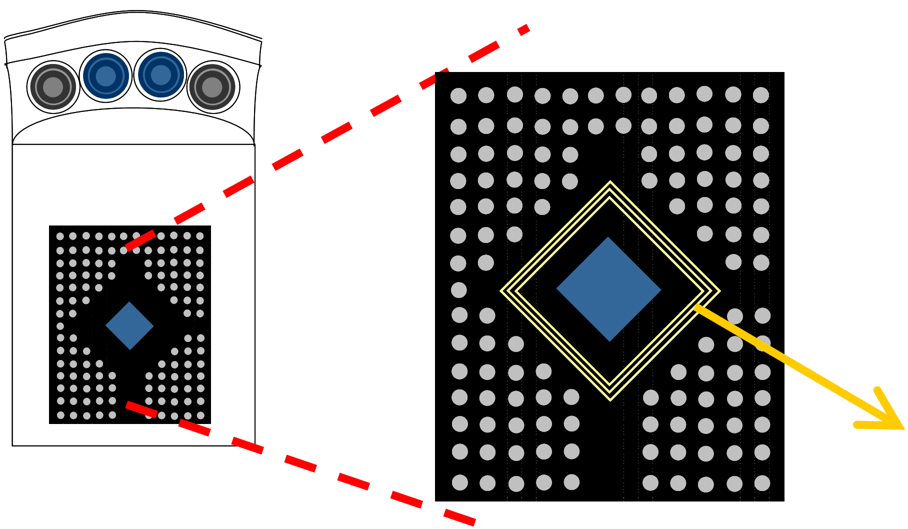


Physical phenomenon

-to remove target DNA segment after testing

- ✓ RFMF
- ✓ TM(rising the temperature)
- ✓ Negative charge





Coil + heater