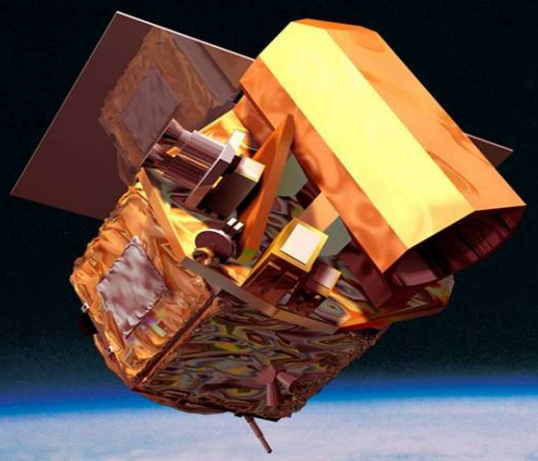
# *The Evolution and Challenges to the Innovation System in Taiwan*



**Maw-Kuen Wu**
**Institute of Physics**
**Academia Sinica**

**1 August 2006**

行政院國家科學委員會
National Science Council

# Taiwan's Leading Product

## Consumer Product-Materials, Chemicals, Parts, etc.

- ABS resin
- Glass fiber
- PVC
- PU leather
- Textiles
- Chip resistors
- Copper foils
- Hand tools
- Screws-bolts
- Bicycles

## Computer & Peripheral Devices

- Notebook PC
- LCD Monitor
- Mother Board
- Digital Camera
- COMBO Drive
- CD/DVD Drivers
- CD/DVD Disks
- Small&Medium Size TFT-LCD module
- Large Size TFT-LCD Panel
- TN/STN LCD module
- Plasma Display

## IC

- Foundry
- Mask ROM
- IC Packaging
- IC Design
- DRAM

## Network Products

- Network Interface Card
- SOHO Router
- Hub
- Wireless LAN
- ADSL/ Cable / Analog Modem
- Lan Switch

From Dr. H.S. Chu, VP-ITRI

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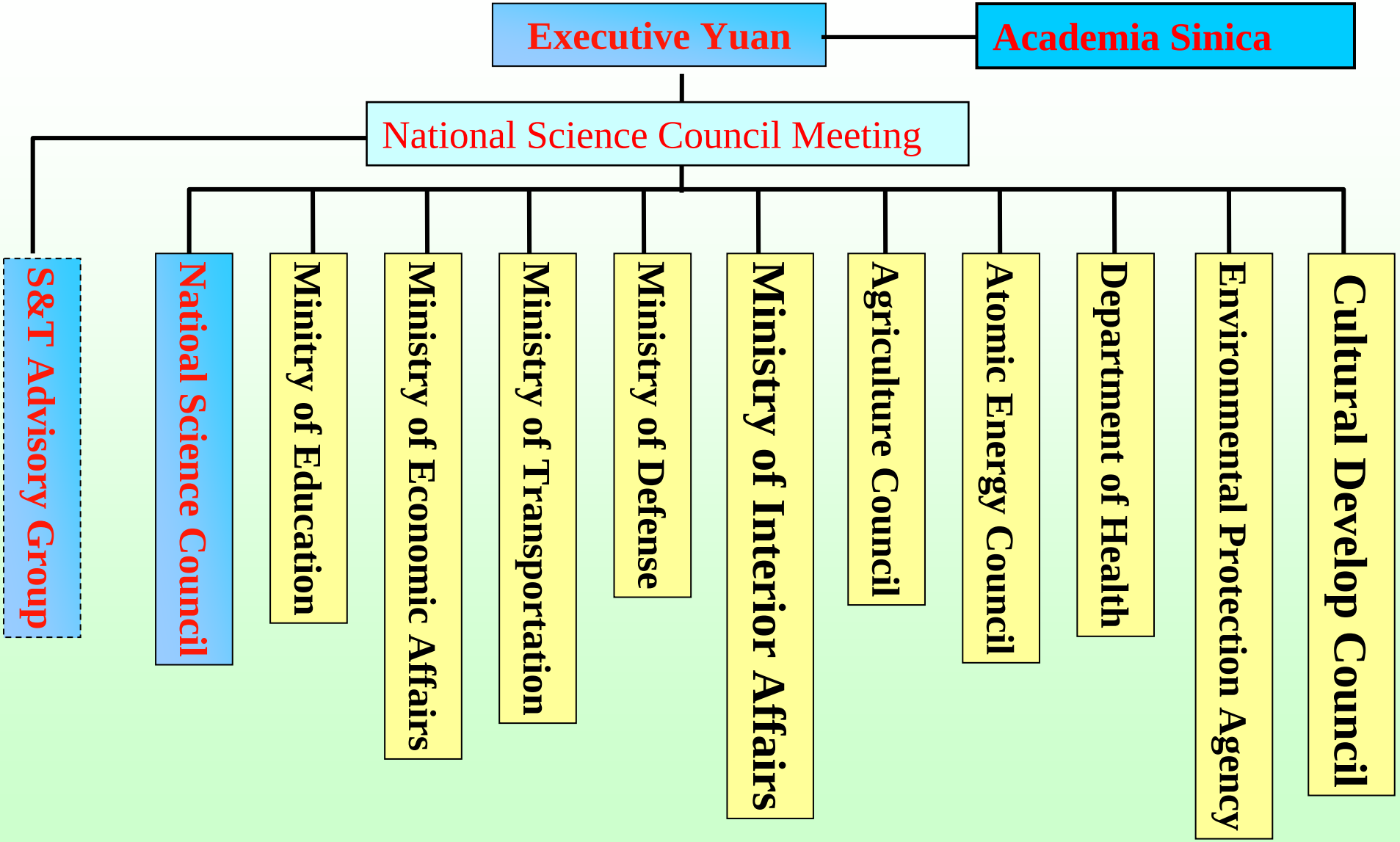
# Government R&D Organizations



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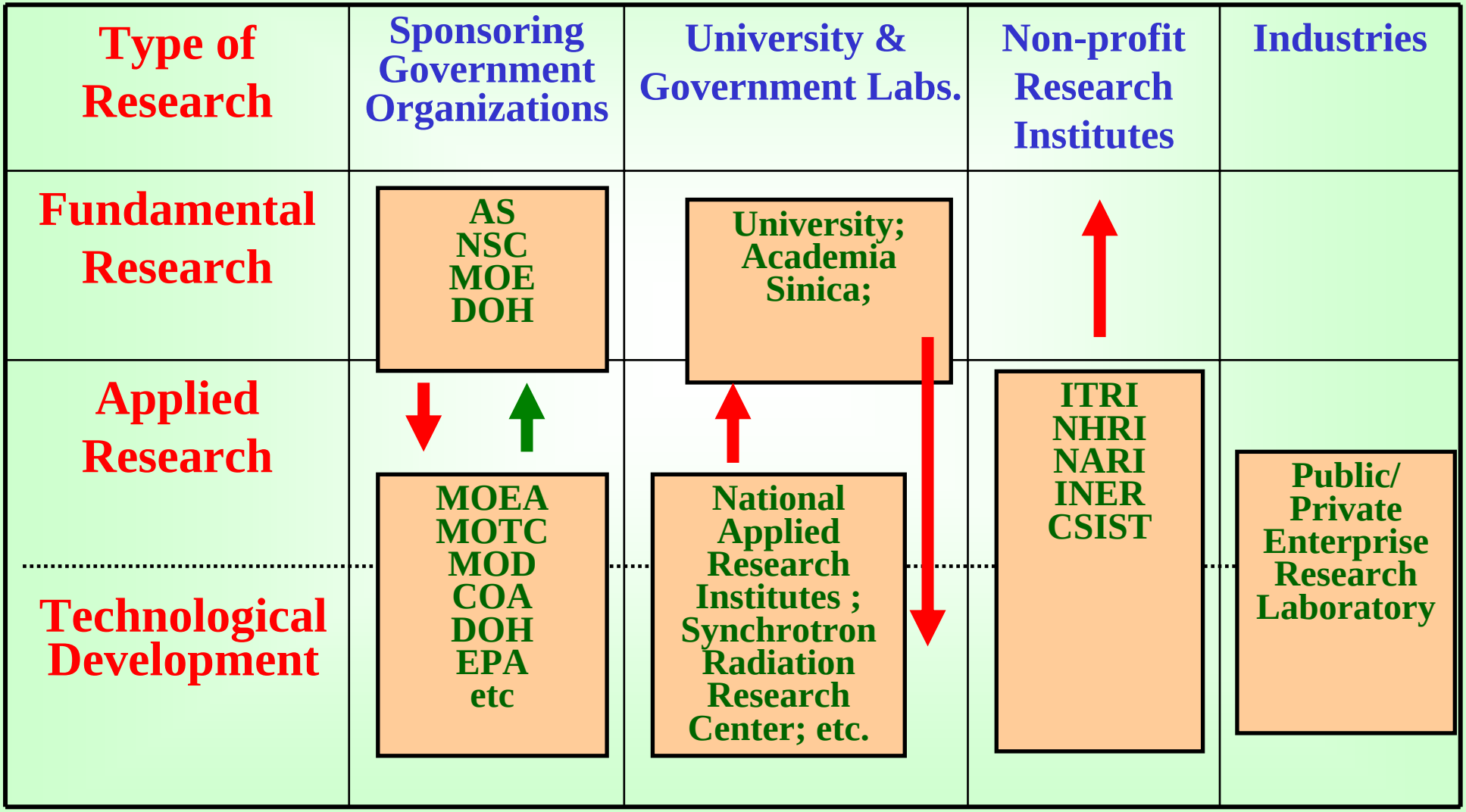
# Research Organizations/Research Types



# NSC Missions

- **Promote National S&T Development**
  - Plan and coordinate national S&T affairs
  - Formulate mid- and long-range S&T plans
  - Review, control, and evaluate government S&T programs
  - Survey national R&D activities
- **Support Academic Research**
  - Sponsor research projects
  - Cultivate, recruit, and reward S&T personnel
  - Promote S&T interchange and cooperation
- **Develop Science-based Industrial Parks**

行政院國家科學委員會
National Science Council

# Promote Science and Technology Development

**Assumption: GDP increase rate 5.0%，Gov/Private Ratio38:62**
**Government spending increase 15% in years 2005~2006**

Unit: 100M NT

| Year | GDP | R&D in GDP% | R&D Fund | Gov. Invest | Private Invest | | |
|---|---|---|---|---|---|---|---|
| | | | | | +11% | +8% | deficit with 8% |
| 2002 | 97,488 | 2.30% | 2,244 | 854 | 1,390 | 1,390 | 0 |
| 2003 | 98,476 | 2.47% | 2,434 | 967 | 1,547 | 1,501 | - |
| 2004 | 103,399 | 2.60% | 2,688 | 1,029 | 1,722 | 1,621 | 38 |
| 2005 | 108,569 | 2.80% | 3,040 | 1,148 | 1,916 | 1,751 | 141 |
| 2006 | 113,998 | 3.00% | 3,420 | 1,287 | 2,133 | 1,891 | 242 |
| | | | | | | Total | 421 |

***R&D expenditure reaches 3% GDP by 2006***

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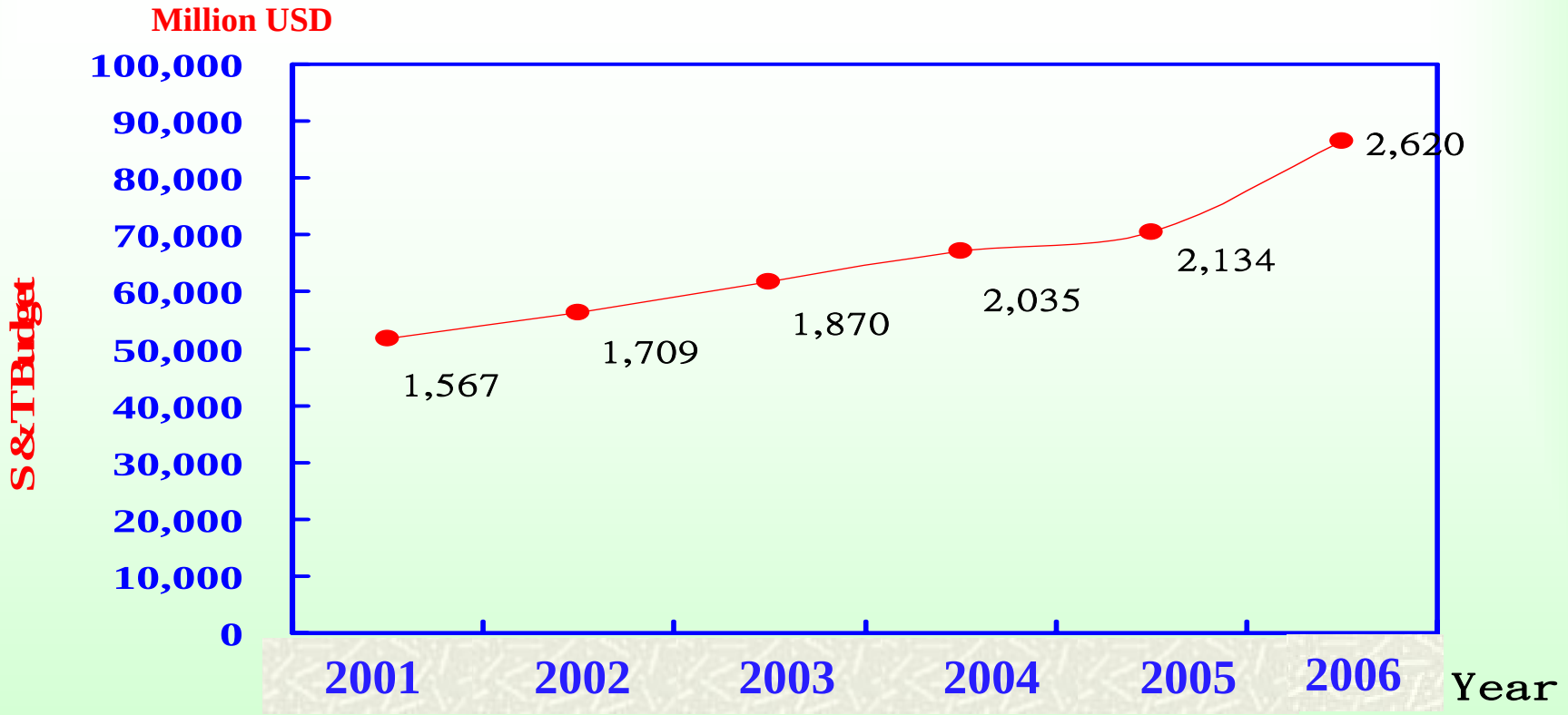
National Science Council

# Taiwan Government Spending on Science and Technology Research



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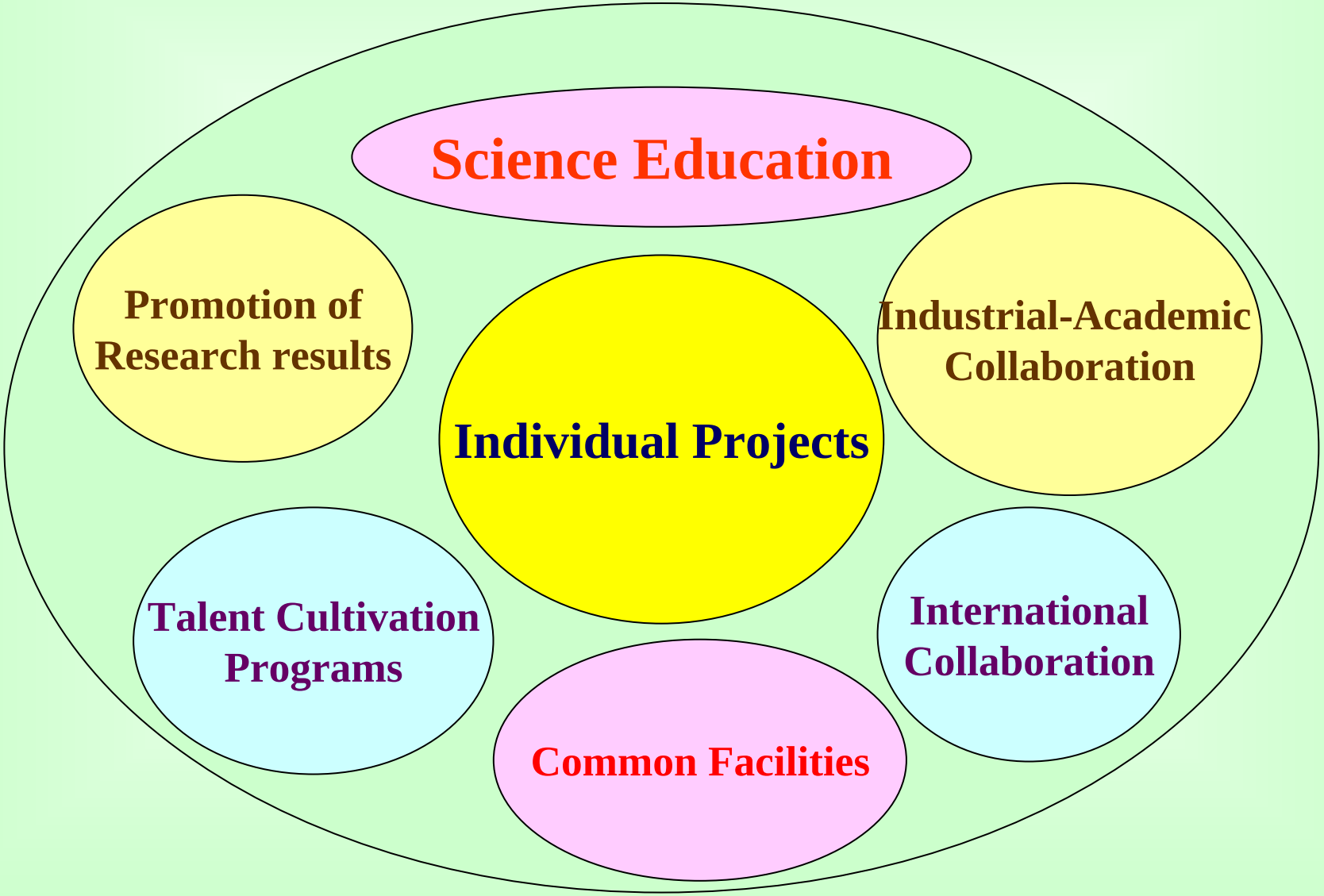
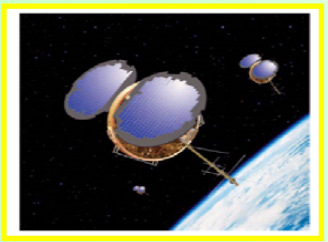
# Support Academic Research



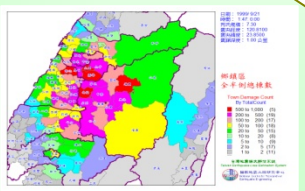
# National Laboratories—NARL and NSRRC

NSRRC-SC Cavity

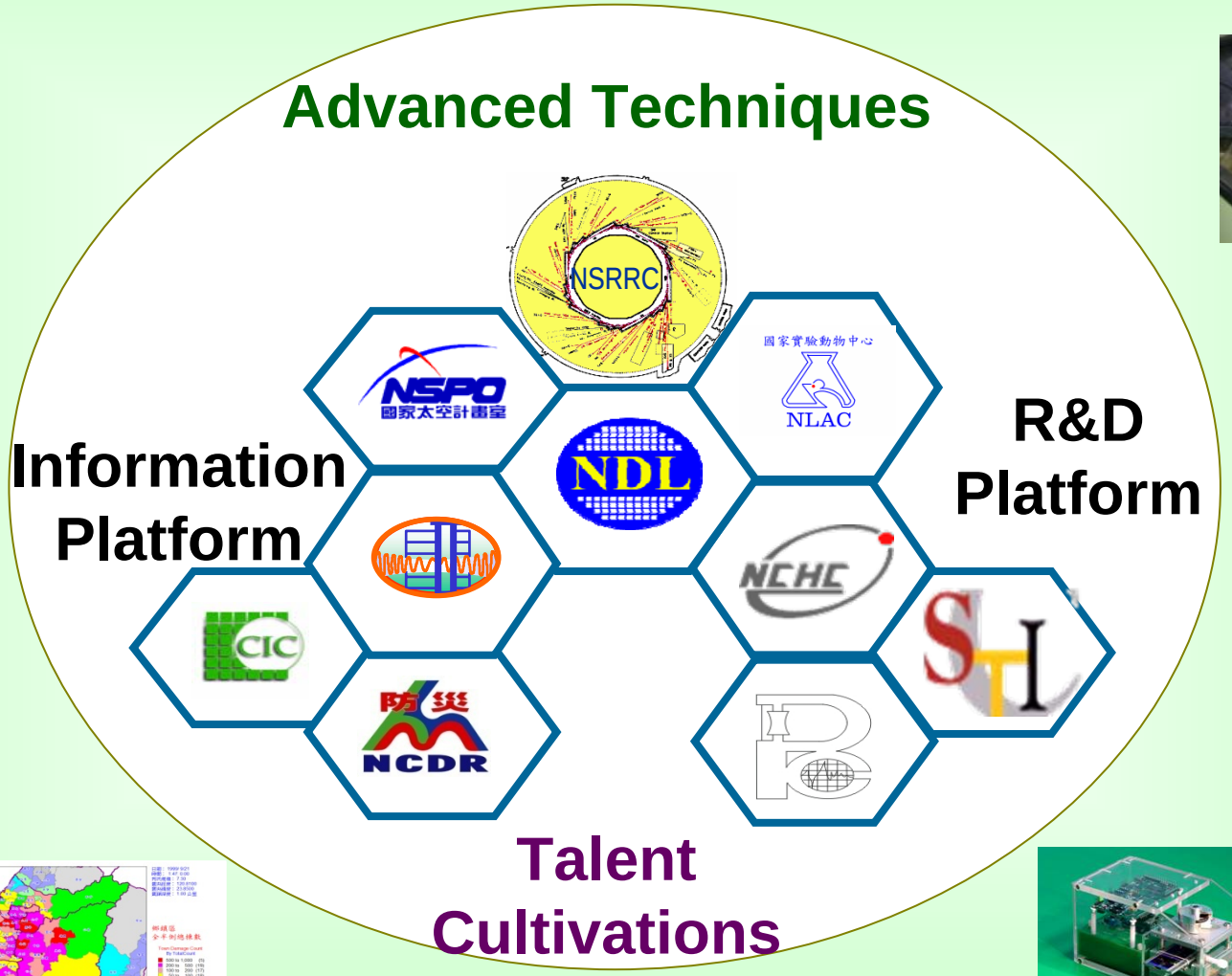


Cosmics-Formasat-III

SOC Testing Platform

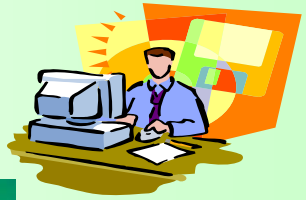


Earthquake monitoring




Animal Breeding Center

Taiwan Research Network



Data Center



Micro-biochips

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National Science Council

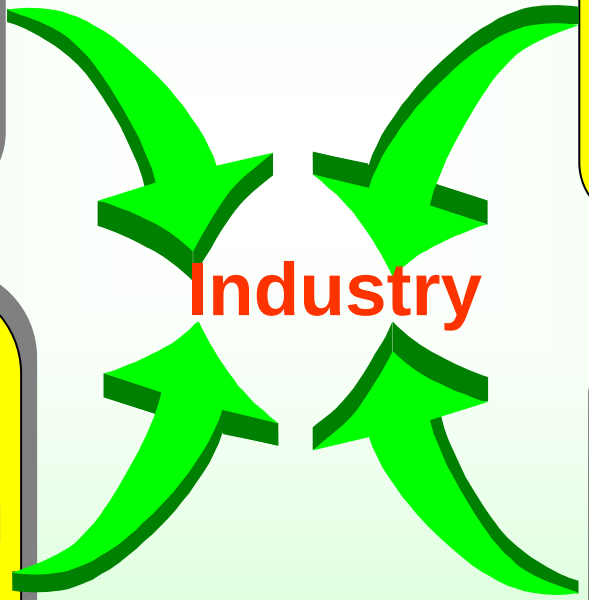
# Governmental Strategies for Industrial Development

**Technology**

- Establish R&D Systems
- Invest in R&D
- Promote international cooperation & strategic alliance

**Human Resource**

- Revamp education systems
- Expand on-the-job training
- Promote academia-industry cooperative program
- Recruit overseas




**Infrastructure**

- Build water, power and transportation networks
- Establish SBIP(Science-based Industrial Parks)
- Found Incubation centers
- Develop Information System platform

**Finance**

- Offer tax incentives
- Encourage VC (Venture Capital) investment
- Fund government-lead Investment
- Provide low-interest loans

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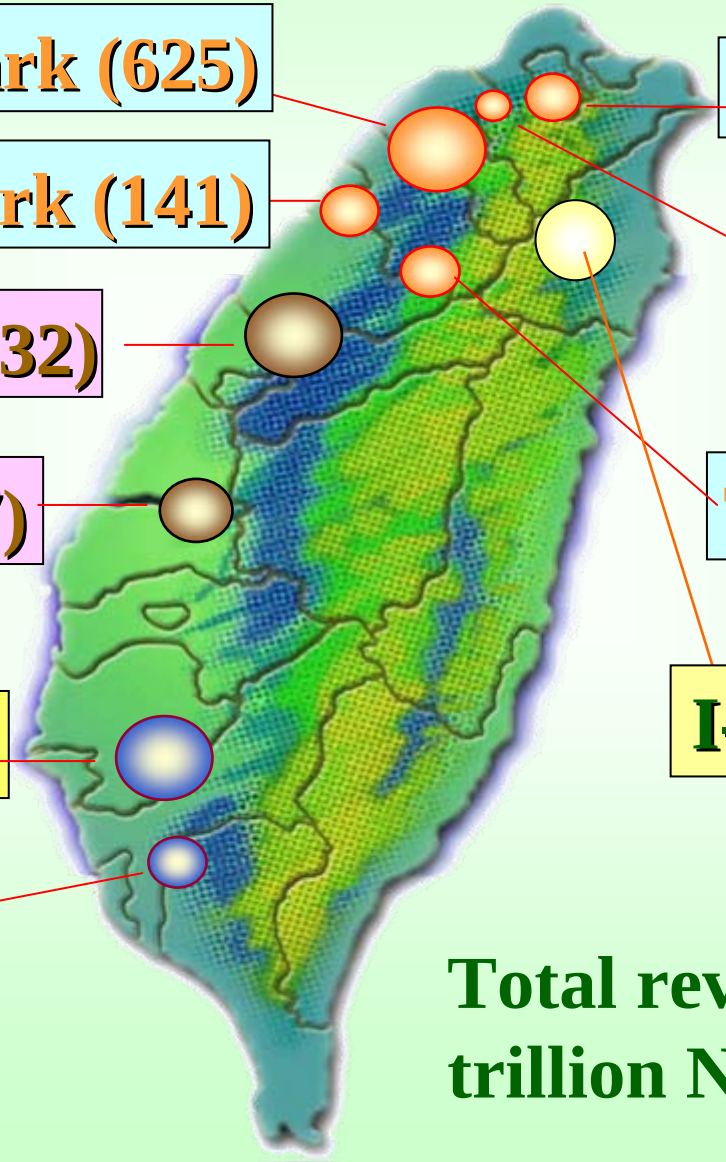
National Science Council

# Sites of Science Parks

(hectares)



Hsinchu Park (625)

Chu-nan Park (141)

Taichung Park (332)

Hu-wei Park (97)

Tainan Park (1038)

Lu-chu Park(571)

Long-tan Park (198)

Hsinchu bio-medical Park (38)

Tung-lo Park (350)

I-lan Park (890)

**Total revenues in 2005 ~ 1.3 trillion NT (~12% GDP)**

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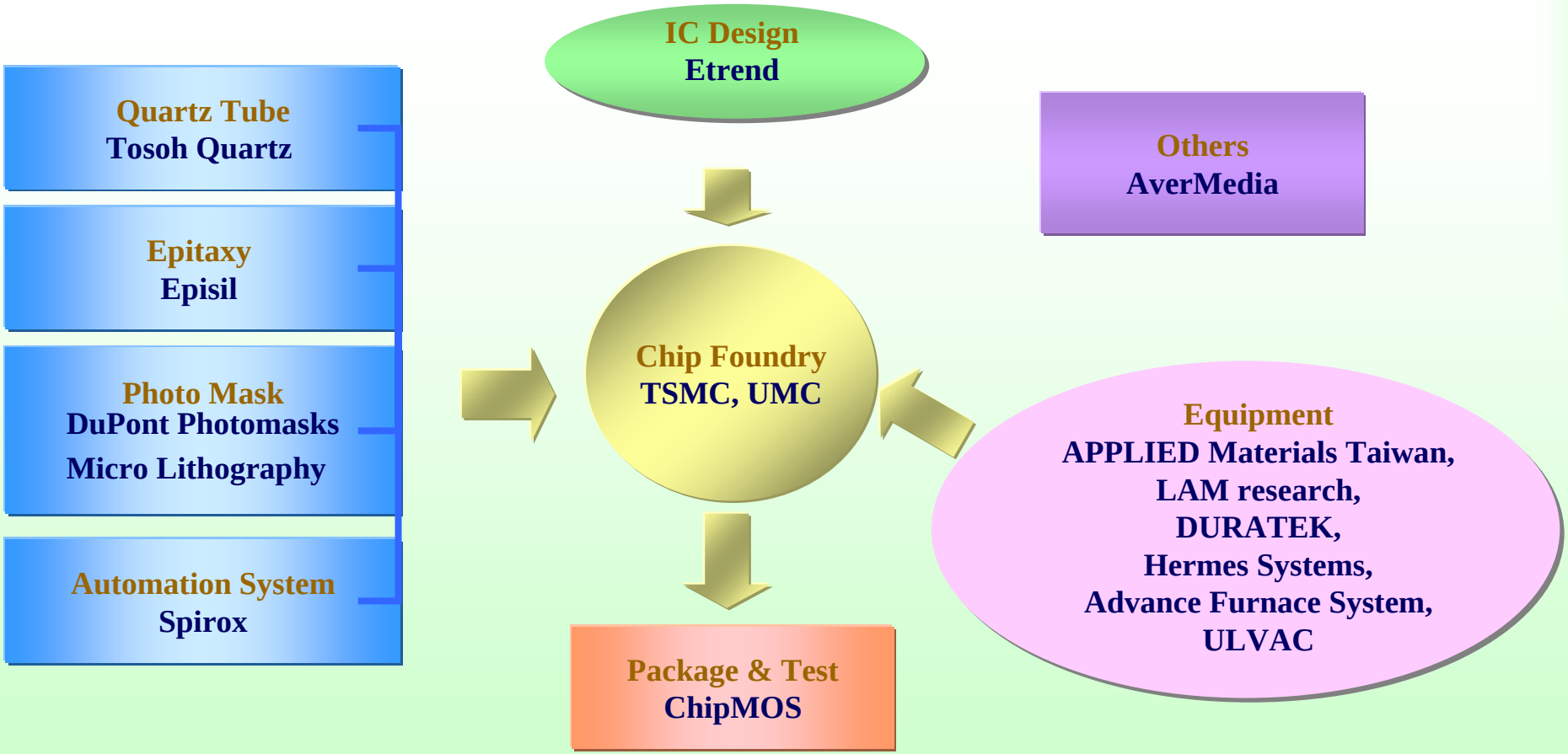
# One-Stop Service System

| Service Items | Government | Service Department | Backup Org. |
|---|---|---|---|
| -Investment application<br>-Business registration<br>-R&D encouragement<br>-Construction inspection<br>-Labor administration<br>-Security and safety management<br>-International trade service<br>-Building management<br>-Educational Institutes | -Ministry of Economic<br>-Labor Committee<br>-Ministry of Finance<br>-Ministry of Interior<br>-Ministry of Education | -Customs<br>-Bank outlet<br>-Post Office<br>-Medical Clinic<br>-Storage & Shipping | -Water & Electricity<br>-Building Security<br>-Environment Protection<br>-Transportation Committee & Working Group |

# Industrial Clusters

## *Semiconductors* (Southern Taiwan Science Park)

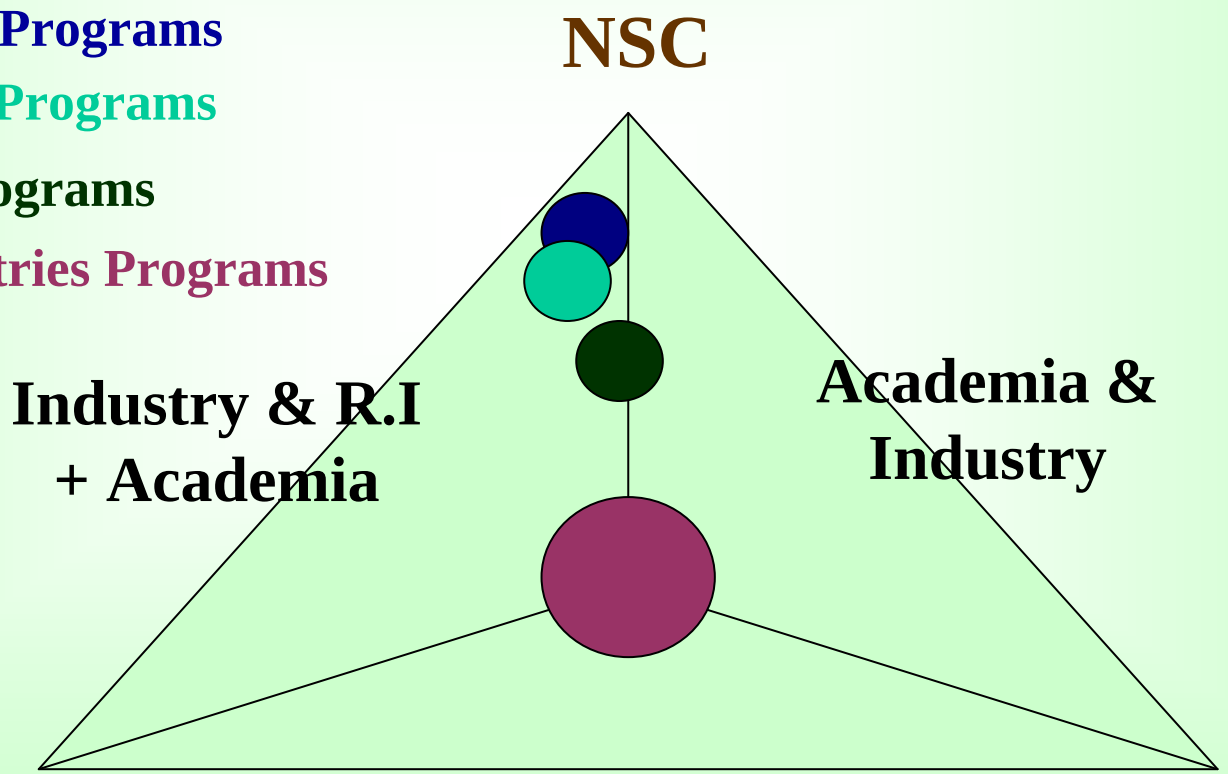



**- 22 companies have been approved by June, 2005.**

# Industrial-Academic Collaborations

**Establish cross-ministerial collaborative efforts to promote the academia + research institutes & industrial research programs**

- Large Scale Programs
- Small Scale Programs
- National Programs
- Cross-Ministries Programs



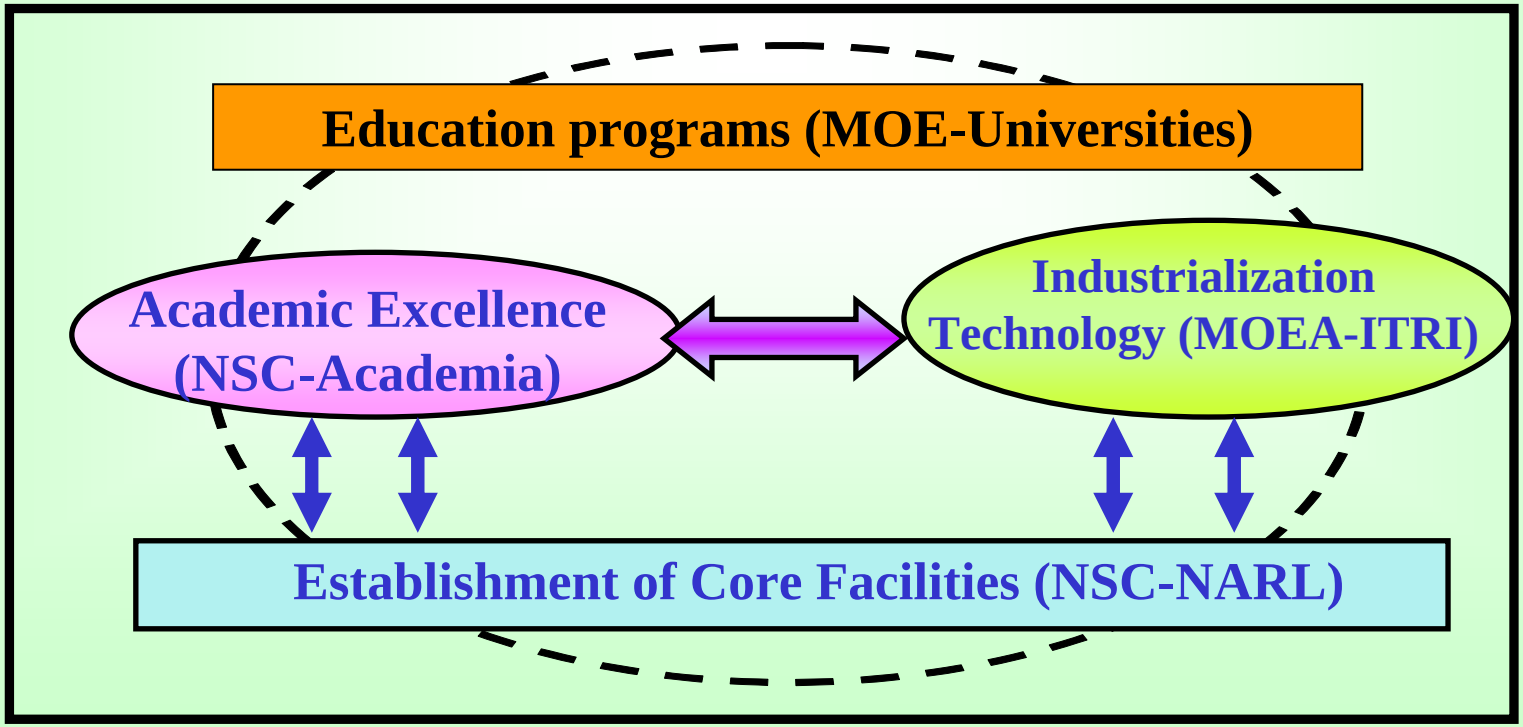
# National Science and Technology Programs

**National Science and Technology Programs to address major social, economic problems in Taiwan were established since 1997. Currently, there are three categories with nine programs in total: (cap with 20% of S&T fund)**

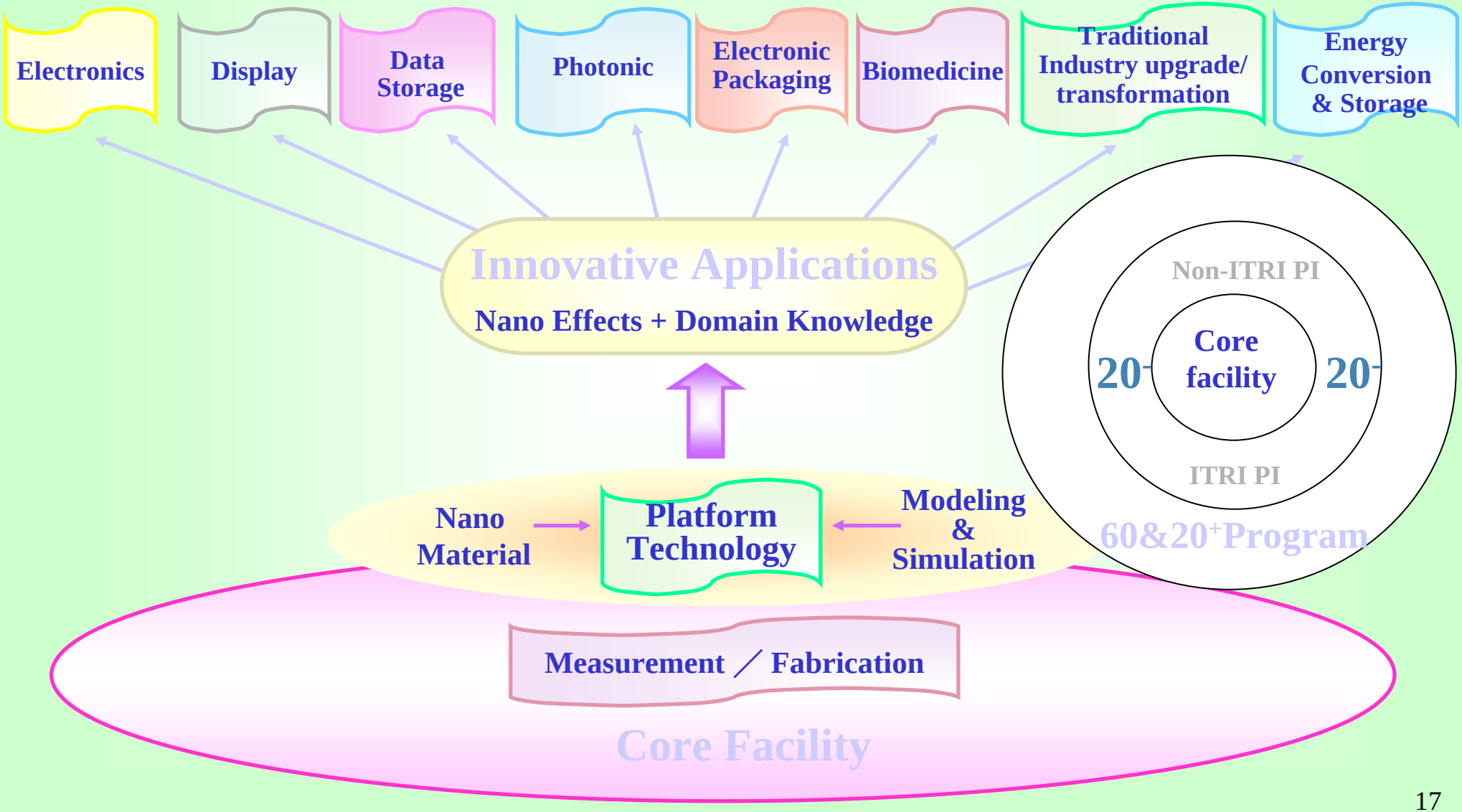
- **Promote economic growth and develop new technologies**
  - Telecommunications, System-on-Chip, Nanoscience & Nanotechnolgy
- **Promote environmental safety and develop digital learning**
  - Digital Archives—e-Learning
- **Promote innovative bio-technologies**
  - Agricultural Biotechnology, Biotechnology and Pharmaceuticals, Genomic Medicine

# Structure of Government Sponsored Research

**Through the establishment of common core facilities and education programs to achieve academic excellence in basic research, to create innovative industrial applications and to speed up the commercialization of industrial technology.**



# Industrialization Technology Program (Nanotechnology as an example)

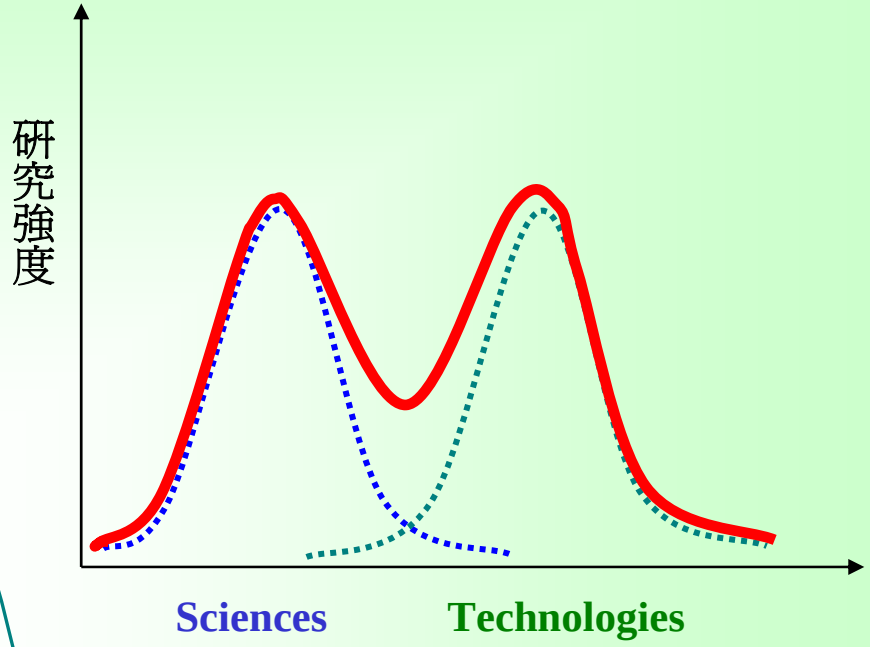


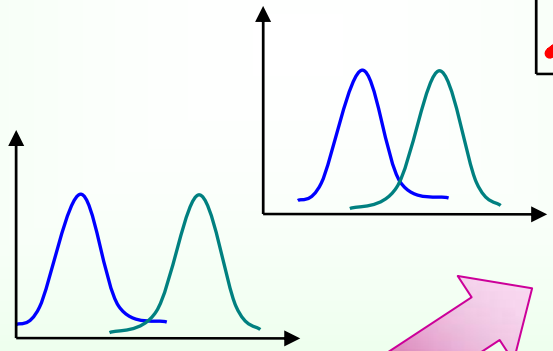
# *What Are Our Opportunities in the Future?*

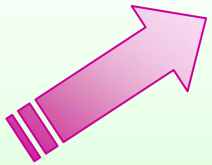
# Correlation between Science and Technology

## The Role of NSC

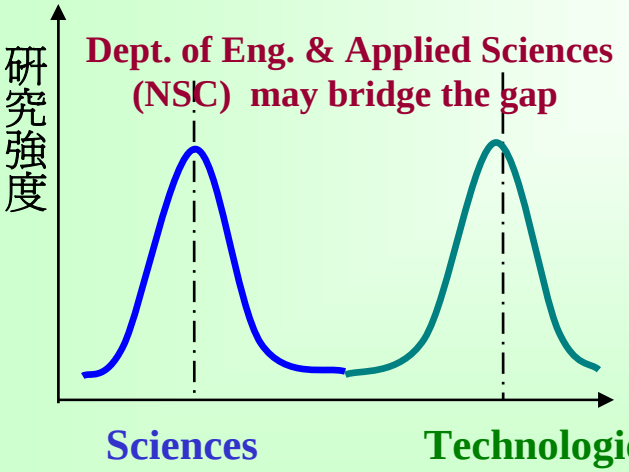
- Bridging between Basic Sciences and Industrialization technology
- Equal weight between Sciences, Applied Sciences and Engineering





Time Evolution




(from Dr. C.K.Lee of NSC)

# Opportunities: Diversity
# Unique Characteristics of Taiwan

台灣住民性格特徵

台灣文化與藝術—鑽石台灣

Cultural Diversity

Time

Industrial Diversity

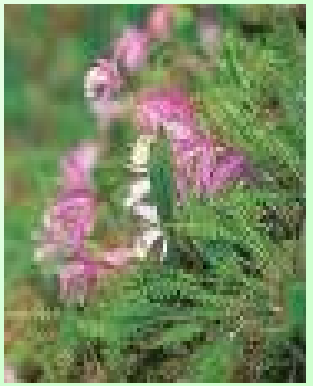
Recognize, Respect, Enjoy, and Cherish

Bio-diversity

Geo-diversity

生物巨量-滅絕-復育的變遷史

Space

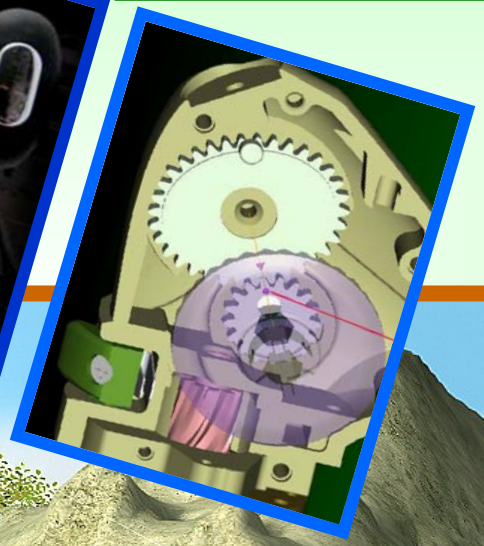


植物生態系的變遷

行政院國家科
National Scienc

# 從基礎到產業應用：
# 非圓形齒輪不是夢

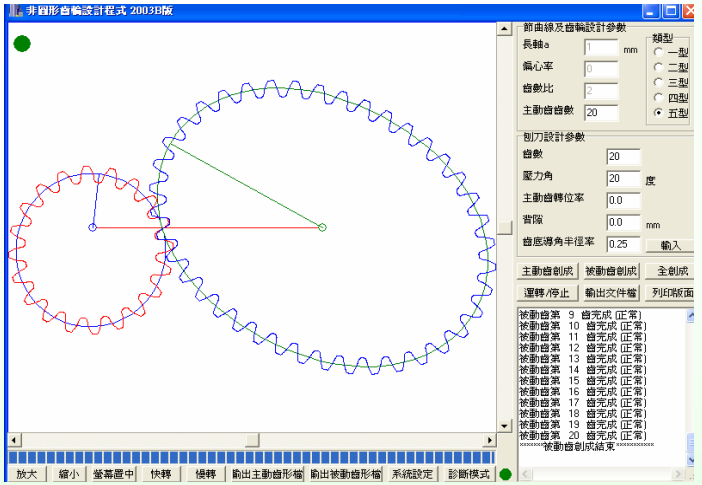


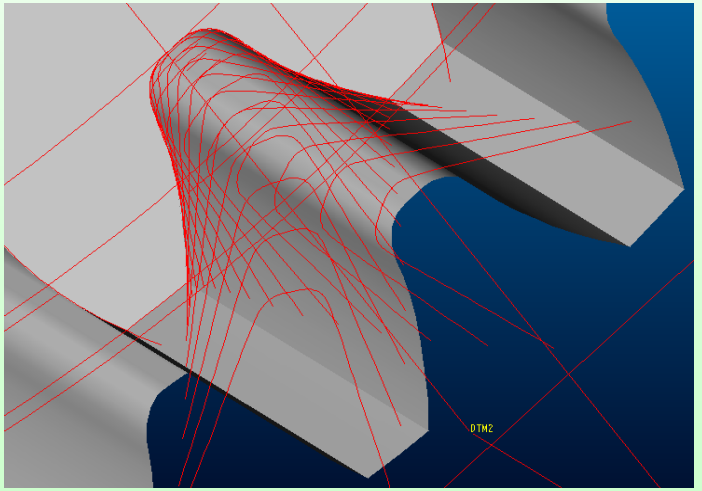


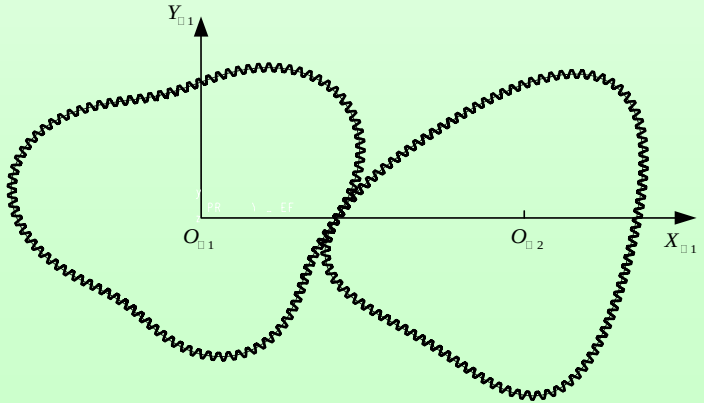
科技研究照亮夢想
放長線才能釣大魚

# Project to Develop Non-spherical Gears

- 計畫期間85年8月1日至87年7月31日
- 技術開發成果
  - 電腦輔助非圓形齒輪齒形創成技術開發
  - 電腦輔助非圓形齒輪製造
  - 電腦輔助非圓形齒輪強度分析
  - 非圓形齒輪傳動系統設計
  - 最佳橢圓齒輪函數模式
  - 最佳捲線器繞線函數設計
- 技術推廣廠商
  - 寶熊漁具(OKUMA)之紡車式捲線器



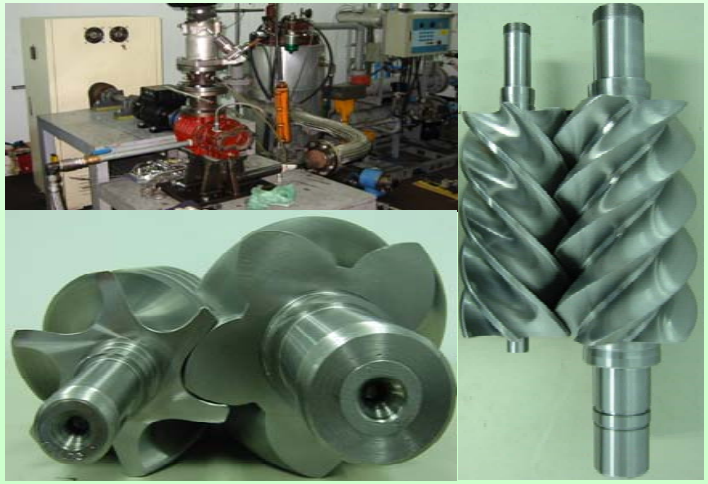



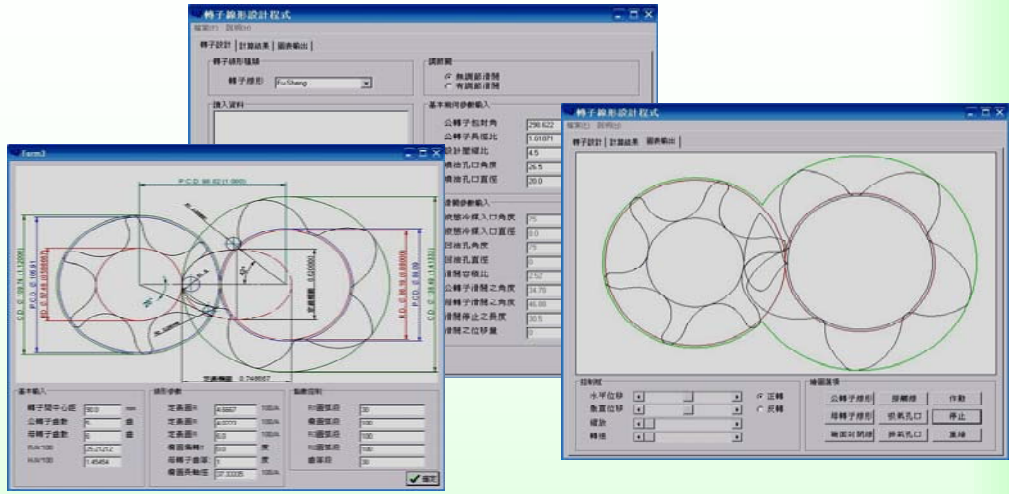
# The Value of the Okuma Fishing Gears

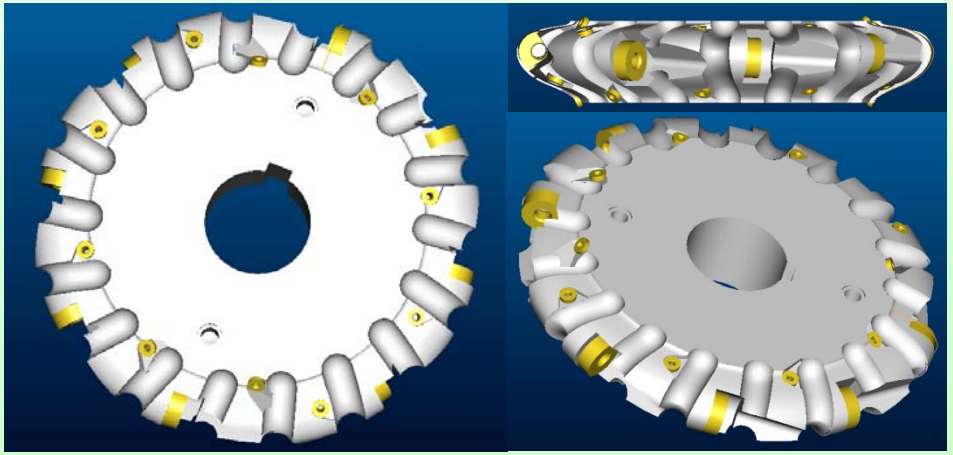
- The new EOS elliptical fishing gears technically surpass the products of Shimano, which is world No.1 fishing gear provider
- The product value increases from 80 USD/each to 150 USD/each
- Company's standing:
  - 台製捲線器第一品牌 (No.1 in Taiwan)
  - 中國大陸捲線器第一品牌 (No.1 in China)
  - 美加地區捲線器第三品牌 (No. 3 in North America)
  - 全世界紡車式捲線器第四品牌 (No. 4 in the World)

# 變齒深螺旋式真空泵浦轉子之齒形研究

- 計畫期間90年8月1日至93年7月31日
- 技術開發成果
  - 轉子齒面間隙分析
  - 轉子線形最佳化設計
  - 轉子專用刀具設計製造
  - 轉子與刀具設計以及熱流、受力分析、檢測之整合性軟體開發
- 技術推廣廠商
  - 漢鐘精機之雙螺旋乾式真空幫浦
  - 復盛工業之雙螺旋空壓機與冷媒壓縮機





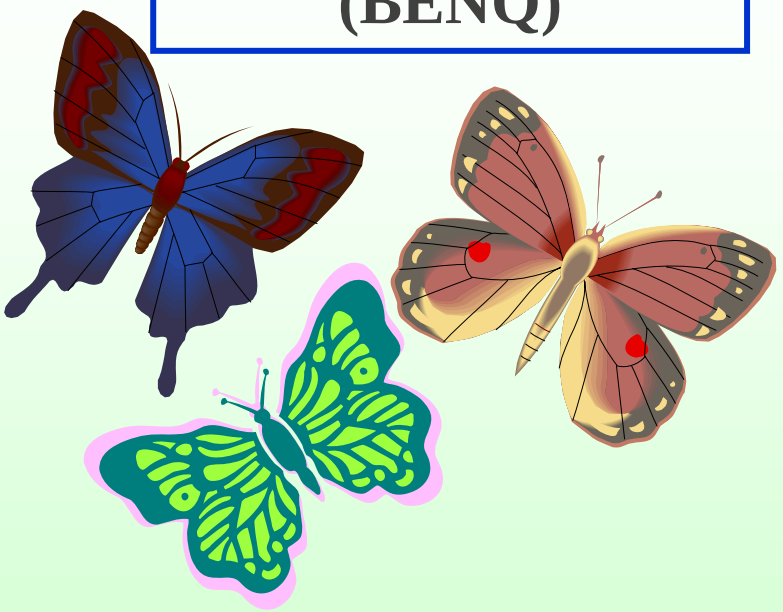


「科技與藝文的結合，才能創造最高的附加價值」

產品功能訴求之外，與消費者的互動「必須透過文化修養使之真切貼近人群，」這就是品牌的「軟性價值」。

---明基董事長李焜耀

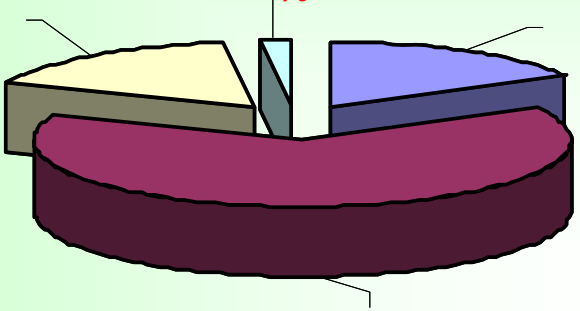

**Design Metaphor: Butterfly (BENQ)**



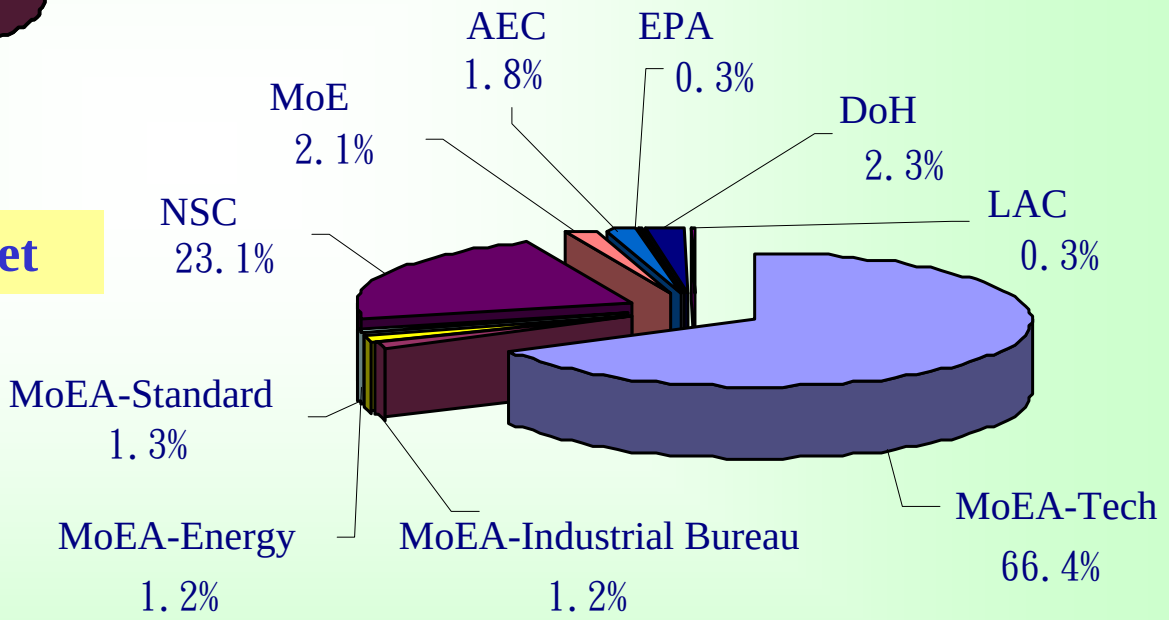
**BenQ FP783液晶顯示器以獨特的蝶翼腳座造型設計，勇奪美國「工業產品傑出設計獎」高科技產品銅牌獎，並躍登七月份美國商業周刊( Business Week )國際版的封面主角**


25

# Phase I of Natioanl Nano-Progam Total Budget (USD 605 Millions)




**Distributions of Budget**




**Appropriations from Ministries**

NSC—National Science Council
MoE—Ministry of Education
DoH—Department of Health
AEC—Atomic Energy Council
LAC—Labor Affair Counci
EPA—Environmental Protection Agency
MoEA—Ministry of Economic Affair

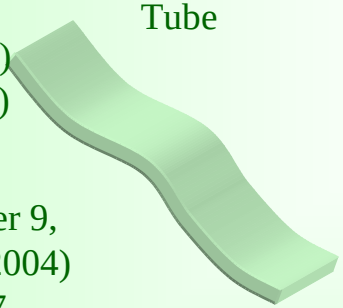
# 1-D Functionalized Integrated Systems

*Appl. Phys. Lett.* **81**, 22 (2002)
*JACS* **123**, 2791 (2001)
*JACS* **127**, 2820 (2005)

Wire/Rod

*APL* .**79**, 3179 (2001)
*Adv. Func. Mate.* **12**, 687, (2002)
*APL* **81**, 4189 (2002)
*APL* **86**, 203119 (2005)
*JACS* **128**, 8368 (2006)

Tube

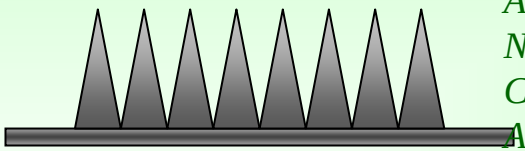


Z.L. Wang Ed., Chapter 9, pp.259-309, Kluwer (2004)
*Adv. Fun. Mat.* **16**, 537 (2006)

Belt

*Adv. Mater.* **14**, 1847 (2002)
*Nature Mater.* **5,** 102 (2006)

Peapod

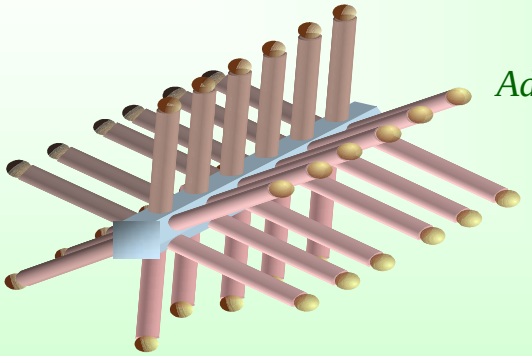


*APL.* **83**, 1420 (2003)
*Nano. Lett.* **4**, *471* (2004)
*Chem. Mater.* **17**, 553 (2005)
*Adv. Func. Mat.* ***15***, 783 (2005)
*APL* ***86***, *203119 (2005)*
US Patent 6,960,528,B2
*APL* (2006)

Nanotip

Core-shell

*APL.* **81**, 1312 (2002)
*Nano. Lett.* **3**, *537* (2003)

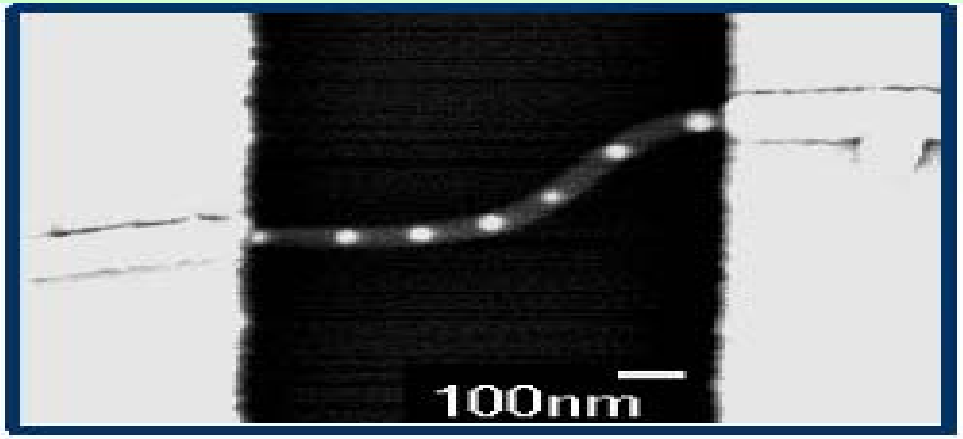


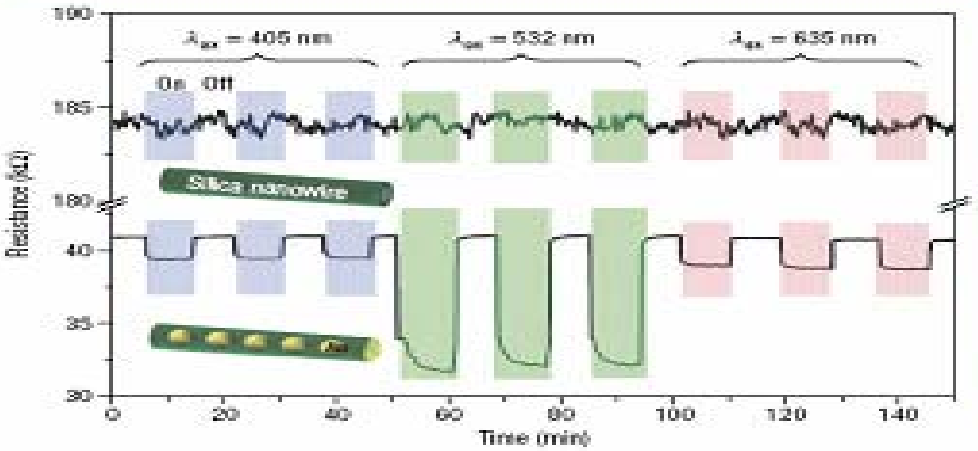
Brush

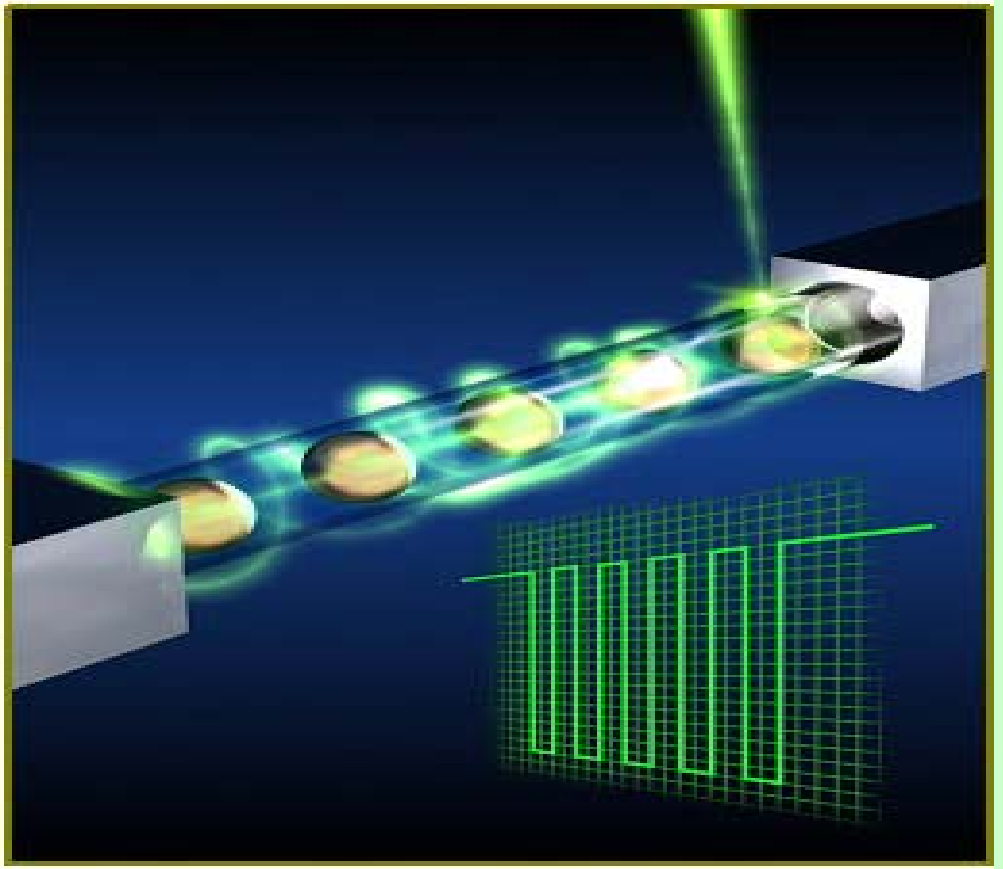
*Adv. Func. Mater.* **14**, 233 (2004)

**Other Thin Films:**
*DRM* **14**, 1010 (2005)
APL **86**, 21911 (2005)
*APL* **86**, 83104 (2005)
*APL* **86**, 161901 (2005)
*APL* **87**, 261915 (2005)
*JVST* B **24**, 87 (2006)
*APL* **88**, 73515 (2006)

# 1D: Au Peapodded in $SiO_2$ NW



$SiO_2$ nano-rod with Au-nanoparticle filled inside to form Nano-peapod. The impedance of the Nanopeapod varies with an external excitation. Green region is excited by 532 nm light; while the pink region shows the result by exciting with 635 nm light. (From L.C. Chen et al, IAMS, Academia Sinica, Taiwan)

*Nature Mater.* **5**, 102 (2006)

# Terahertz Imaging

With 10nm QDs in head

316GHz MMW images of seahorse

From C.K. Sun et al., EE, NTU, Taiwan







## Research Highlights

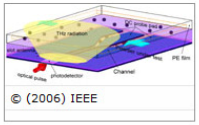
*Nature Photonics* Published online: 2 November 2006 | doi:10.1038/nphoton.2006.34

**Subject Categories:** Terahertz optics | Optoelectronic devices and components | Imaging and sensing

### Terahertz detective: Drugs can run, but they can't hide

Amber Jenkins

**Terahertz microchip offers a sensitive nose to sniff out drugs**



© (2006) IEEE

Detecting trace amounts of substances is important for many biosensing applications, where the target can range from DNA to illegal drugs. For really precise detection, the compound under study must not be modified, but existing techniques often involve adding labelling markers that change the molecular environment. Now a team of Taiwanese researchers have developed a terahertz microchip that can detect minute concentrations of drugs and other substances in a non-invasive way[1].

Biomolecules can be distinguished according to their terahertz 'fingerprints' – the unique region of the spectrum in which they absorb terahertz light. But for a truly practical terahertz sensor, the radiation source would ideally be incorporated into existing lab-on-a-chip technology. Unfortunately, such devices typically contain glass substrates, which absorb terahertz waves very easily.

Ja-Yu Lu and colleagues, reporting in *Photonics Technology Letters*, have overcome this hurdle with a biosensor that successfully couples a cell having a glass substrate to a terahertz transmitter. The compound under study sits in microchannels within a sample cell, where edge coupling between the glass substrate and terahertz-radiation source enables light to be directly and completely transmitted to the sample. Because the sample lies inside the near field of the source — where the radiation is up to 150 μm shorter than the terahertz wavelength – it experiences intense, localized radiation. The result is a highly sensitive probe that requires less than five milliwatts of optical power.

Absorption spectra were collected for different trace white powders: cocaine, amphetamine, potato starch, lactose and flour. The microchip was shown to distinguish each compound and could detect drug powders with weights of just ten nanograms. This sensitivity matches that of current forensic techniques used to detect drugs, yet preserves the native state of the sample. By incorporating microfluidic channels into the device, water-based molecular sensing could become possible and improved sensitivity could open up detailed studies of molecular dynamics.

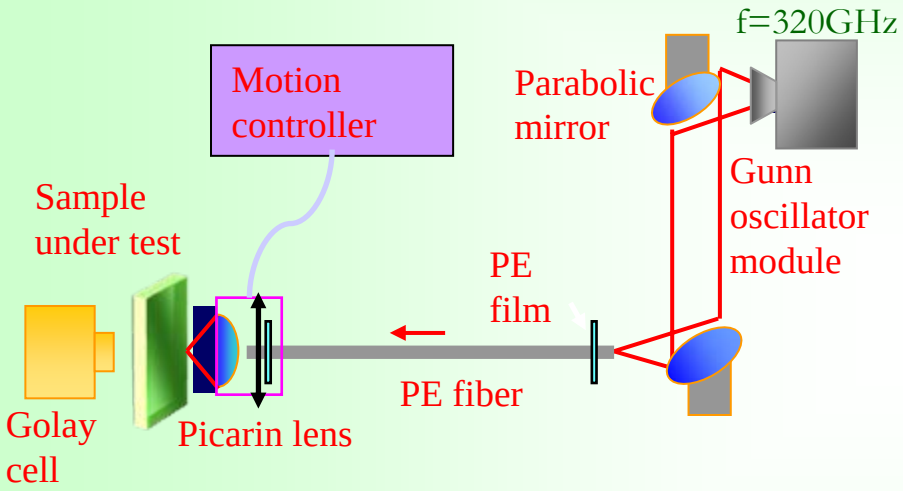
**REFERENCES** top

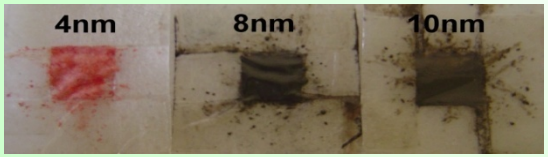
1. Lu, J.-Y. *et al.* Terahertz microchip for illicit drug detection. *Photon. Technol. Lett.* (2006). doi: 10.1109/LPT.2006.883285 Published online 01 November 2006 | Article |

# Type II Nanoparticles as Contrast Agent of THz Imaging

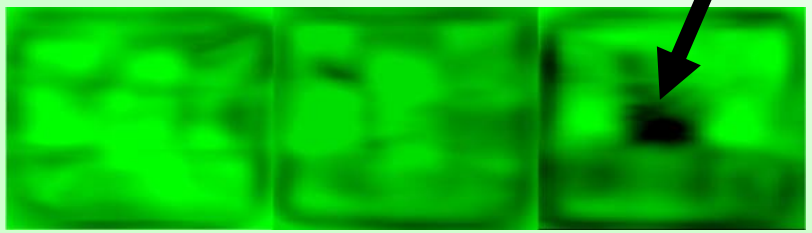
- Low absorption contrast for bio-tissue in the THz frequency range

THz imaging system



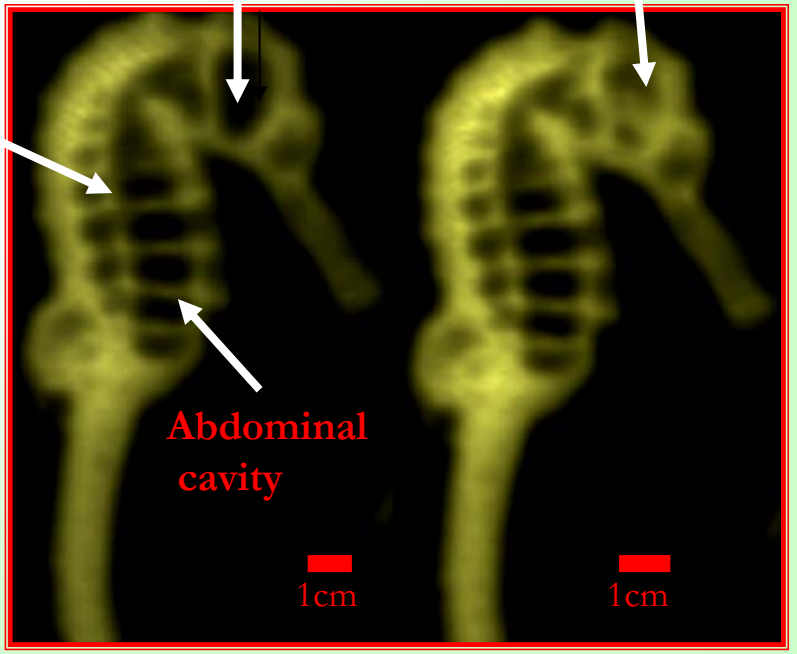




Resonant absorption

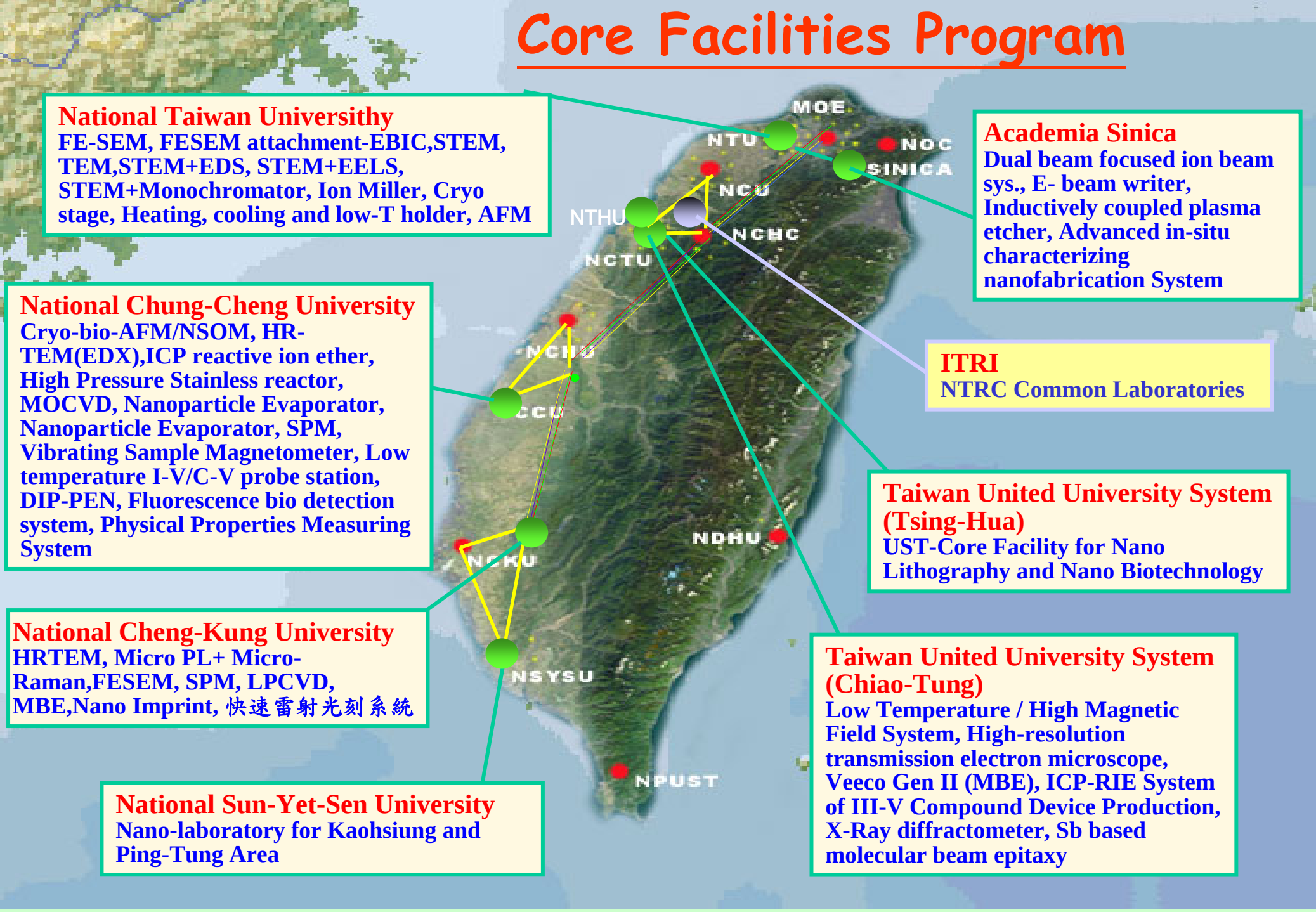


4.4nm CdSe  8 nm CdSe/CdTe  10.4 nm CdSe/CdTe

Dry seahorse



# Core Facilities Program




**National Taiwan Universithy**
FE-SEM, FESEM attachment-EBIC,STEM, TEM,STEM+EDS, STEM+EELS, STEM+Monochromator, Ion Miller, Cryo stage, Heating, cooling and low-T holder, AFM

**Academia Sinica**
Dual beam focused ion beam sys., E- beam writer, Inductively coupled plasma etcher, Advanced in-situ characterizing nanofabrication System

**National Chung-Cheng University**
Cryo-bio-AFM/NSOM, HR-TEM(EDX),ICP reactive ion ether, High Pressure Stainless reactor, MOCVD, Nanoparticle Evaporator, Nanoparticle Evaporator, SPM, Vibrating Sample Magnetometer, Low temperature I-V/C-V probe station, DIP-PEN, Fluorescence bio detection system, Physical Properties Measuring System

**ITRI**
NTRC Common Laboratories

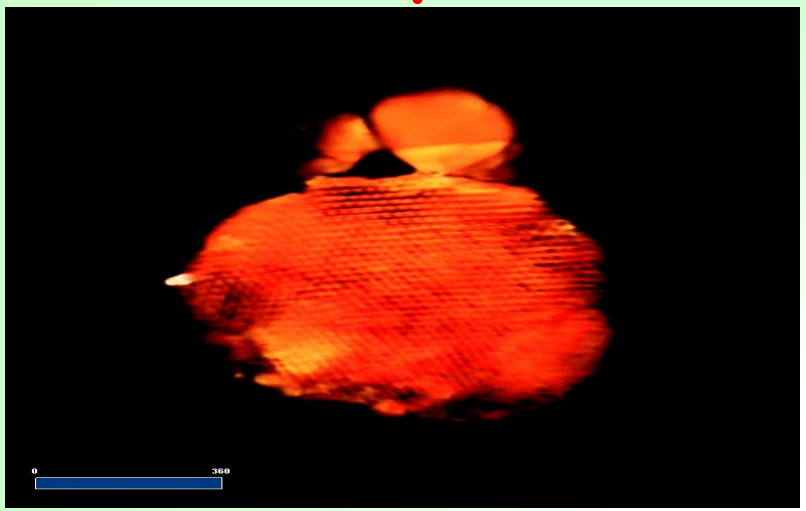
**Taiwan United University System (Tsing-Hua)**
UST-Core Facility for Nano Lithography and Nano Biotechnology

**National Cheng-Kung University**
HRTEM, Micro PL+ Micro-Raman,FESEM, SPM, LPCVD, MBE,Nano Imprint, 快速雷射光刻系統

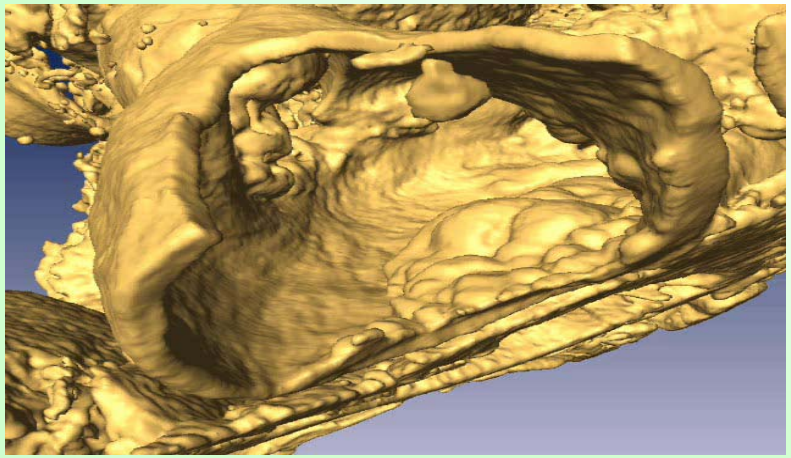
**Taiwan United University System (Chiao-Tung)**
Low Temperature / High Magnetic Field System, High-resolution transmission electron microscope, Veeco Gen II (MBE), ICP-RIE System of III-V Compound Device Production, X-Ray diffractometer, Sb based molecular beam epitaxy

**National Sun-Yet-Sen University**
Nano-laboratory for Kaohsiung and Ping-Tung Area

# Development of High Spatial and Temporal Resolution Imaging Techniques



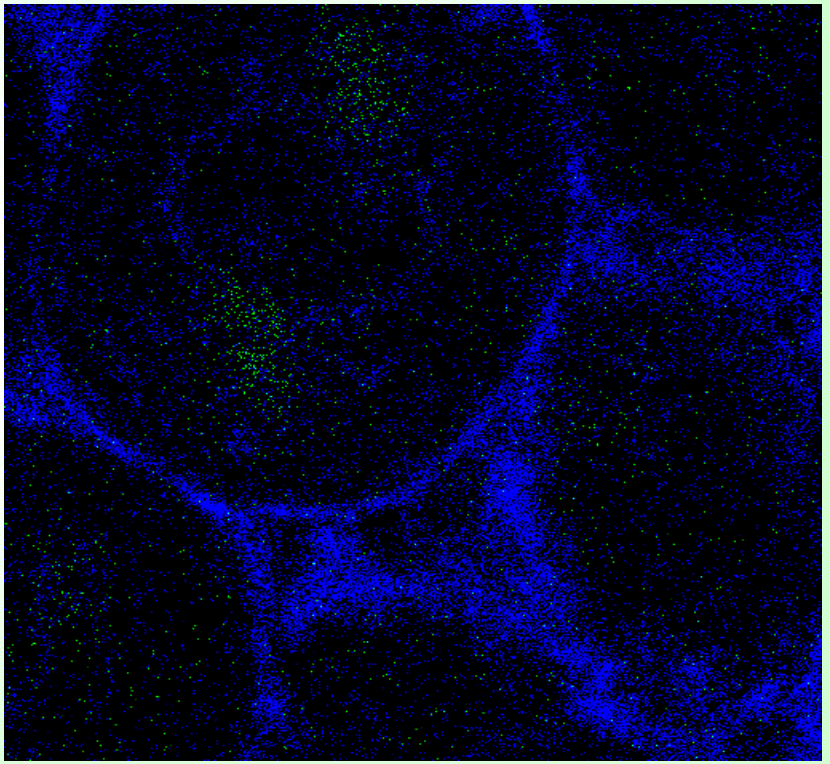
3D Tomograph of Porous $SiO_2$ by STEM (*C.H. Chen et al.*)



Endoscopic observation of arteriosclerosis in mouse by X-ray microscopy (*Y.K. Hwu et* ***al.*** **)**

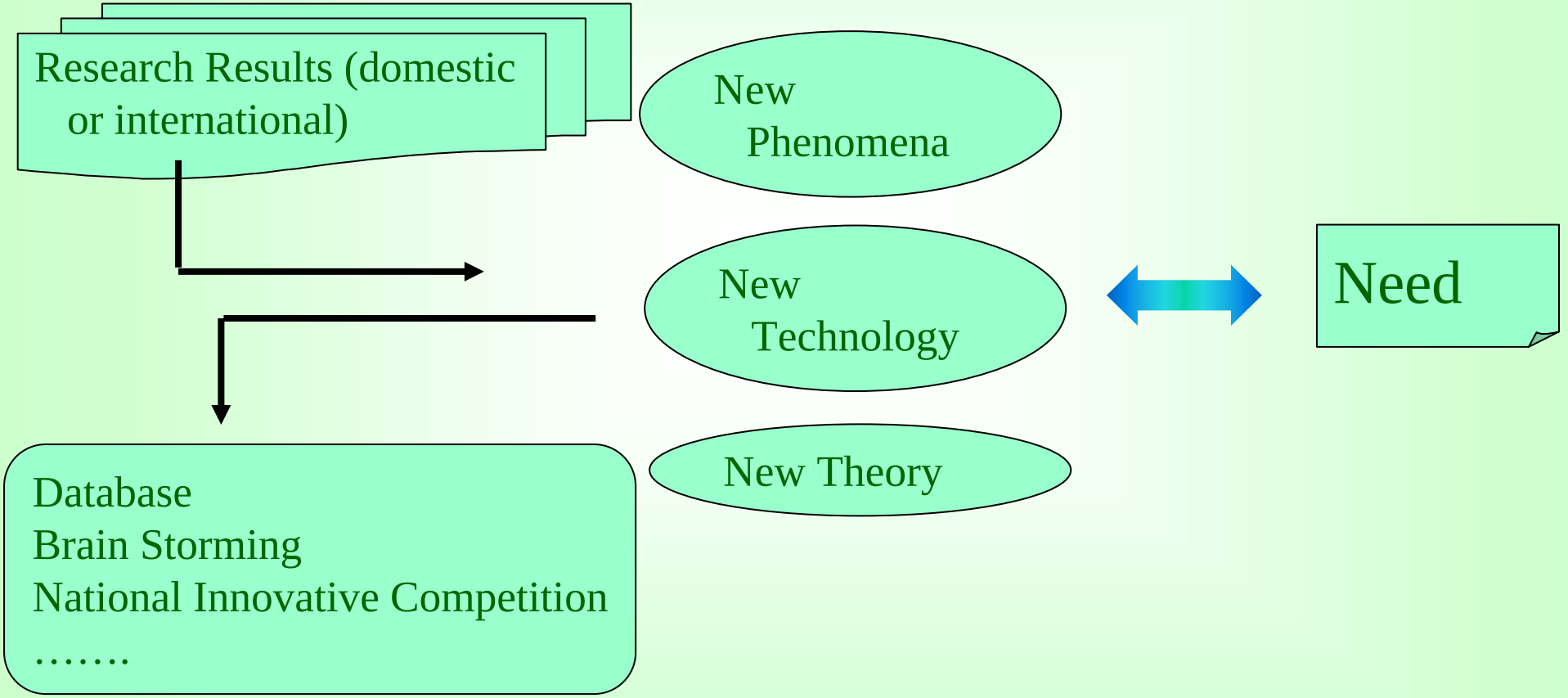
**Mitosis of blastomeres (stem cells)**

THG + SHG **(53μm x 53μm)**



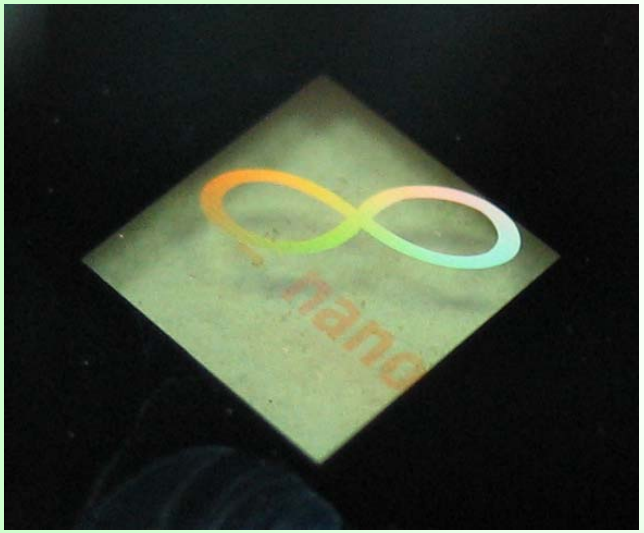
Functional Imaging Microscopy Using Plasmon Resonant Enhanced Higher Harmonic Generation (*C.K. Sun et al.*)

# Project to Promote Creative Prototype Products



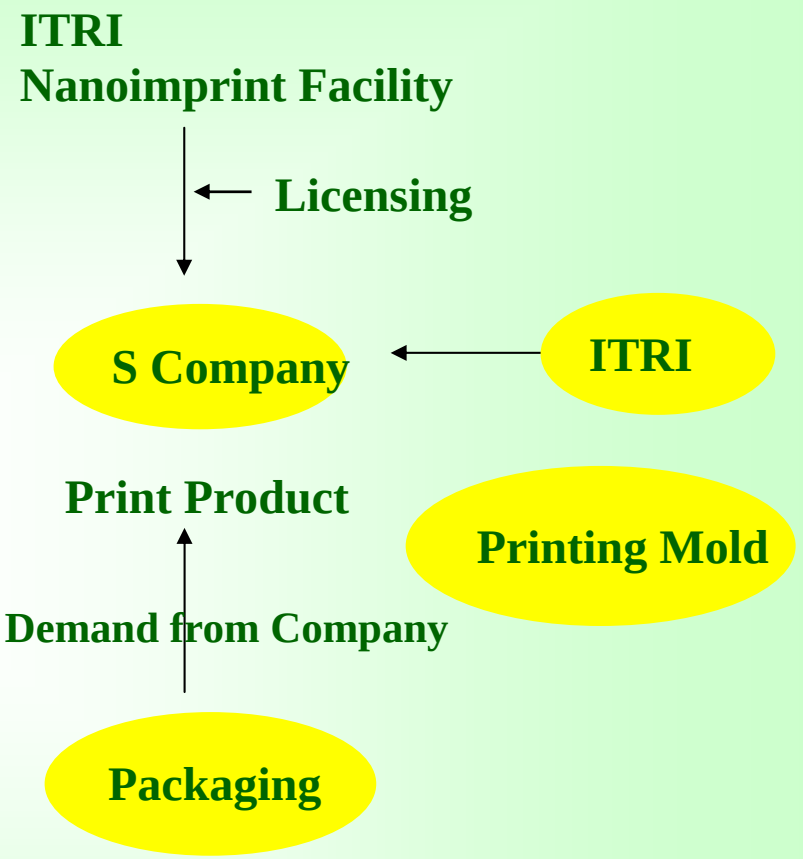
# New product—Anti-forgery Color Card

**Why Nano：**
**Use the difference between Nano and Micro-dimension To**




Micro-grating
Grating period Λ = 1 μm
Thickness dg = 0.3 μm
Film thickness dw = 0.6 μm
Filling factor f = 0.6
n = 2.15

Nano-grating
Grating period Λ= 0.35 μm
Thickness dg = 0.3 μm
Film Thickness dw = 0.6 μm
Filling factor f = 0.6
n = 2.15




**Patent:** • **Diffraction grating recording media (TW:96124116、US:11/947792)**
• **Recognition device (TW:95129465、US:11/594.811、CN:200610127732.2)**

# New Prototype Products—Anti-fog Film

**Why Nano：**

**Long term anti-fog spray: humidity-proof and wash-proof, long term effect**

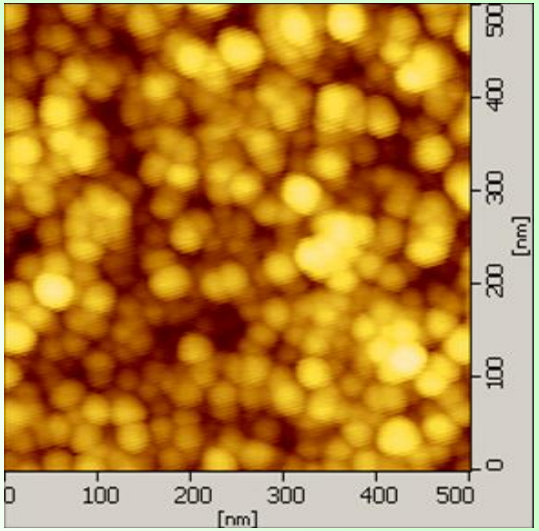
**Nano-powder: high surface area film structure, transparet**

**Long-term anti-fog spray (on glass, mirror, the effect sustained for up to 7-day. The condensed water droplet form transparent water film)**

**Q Company is working on market acceptance**

**M Company is going to request for technology transfer**

**Patent: Long-term anti-fog film using nano-material (TW:96142082、US: 12/011,839、China)**




**Nano-structure of anti-fog film**

**The difference between with film coating and without.**

行政院國家科學委員會
National Science Council

# Touch the Nano-World

## - Every Lab Has Its Own AFM

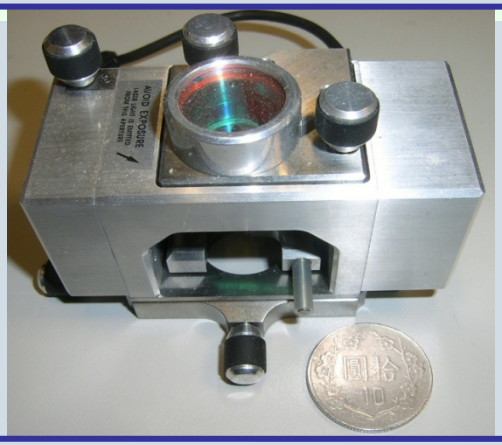
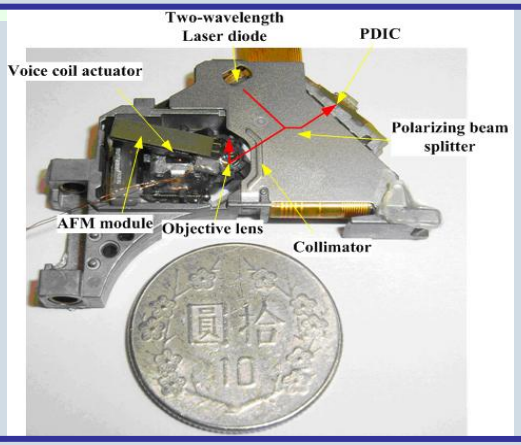
**(Atomic Force Microscope)**


洪紹剛 胡恩德 李嘉宜
陳彥甫 黃仰山 陳彥廷
**(All are R. A. at IoP)**

***the team from NTUME, NTUEE & Institute of Physics, Academia Sinica, Taiwan***

email: licy@phys.sinica.edu.tw
office.tpi@gmail.com

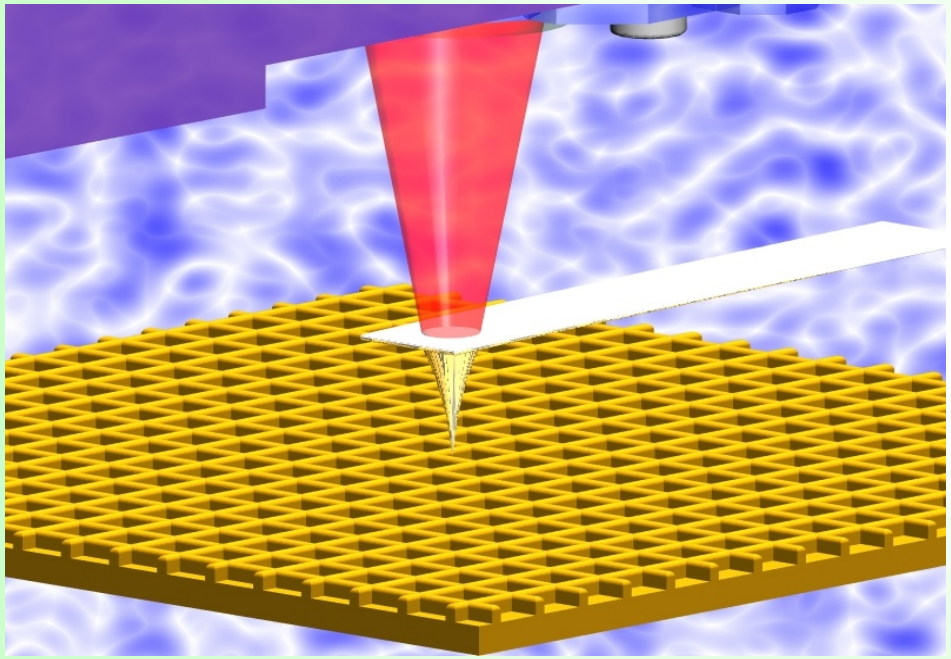
# New Device vs. Current Model

| | Existing AFM (3MNT$) | New Innovative AFM |
|---|---|---|
| **Product** |  |  |
| Key principle | **Optical lever (mechanical)** | **DVD Read head (Laser scattering)** |
| 2005 World share | ~$10^4$ | ~$10^8$ (DVD head) |
| Manufacturing cost | ~300,000 NT$ | **300 NT$*** *Win* |
| Vertical resolution | 0.03nm | 0.03nm |
| Signal Bandwidth | ~1MHz | **100MHz** *win* |

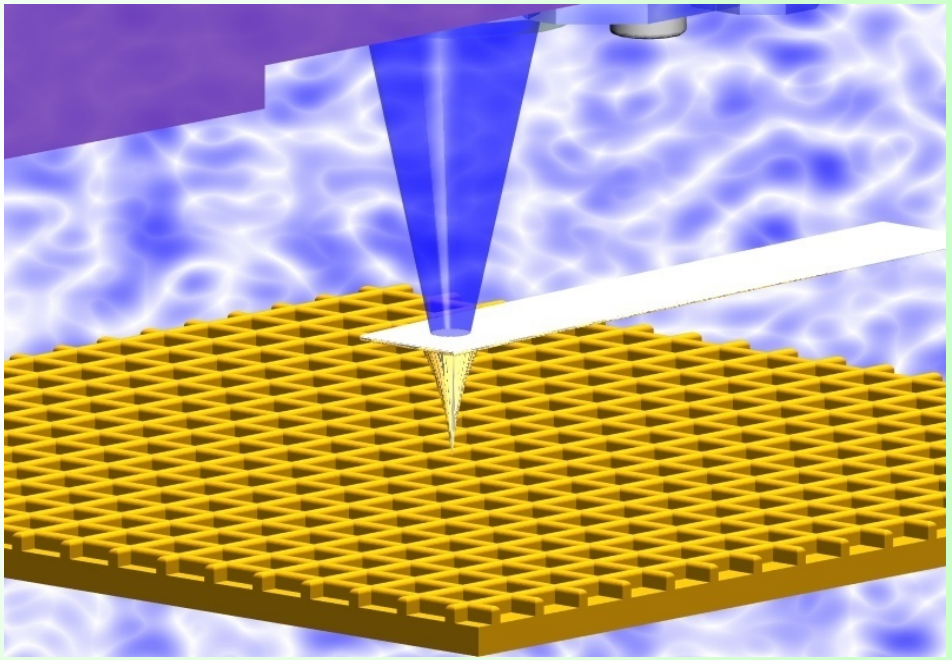
*** Mass productions greatly reduce the cost**

# New System Allows the use of Blue light

**Dia. of red-light spot = 325 nm**

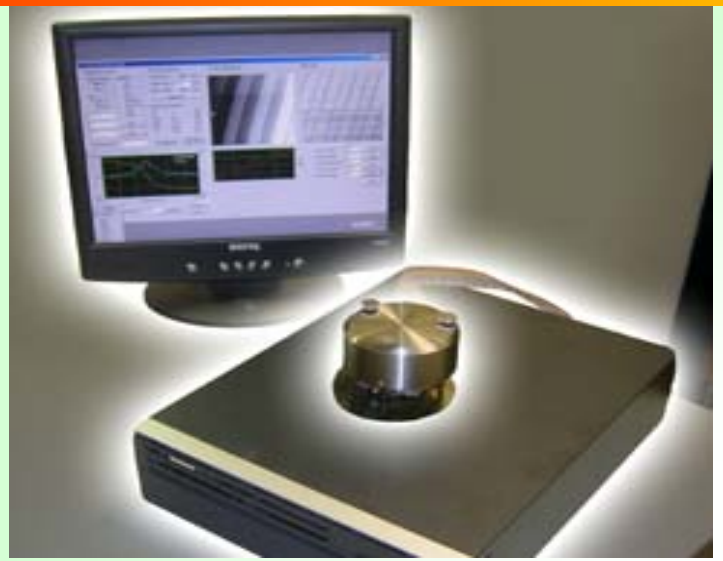


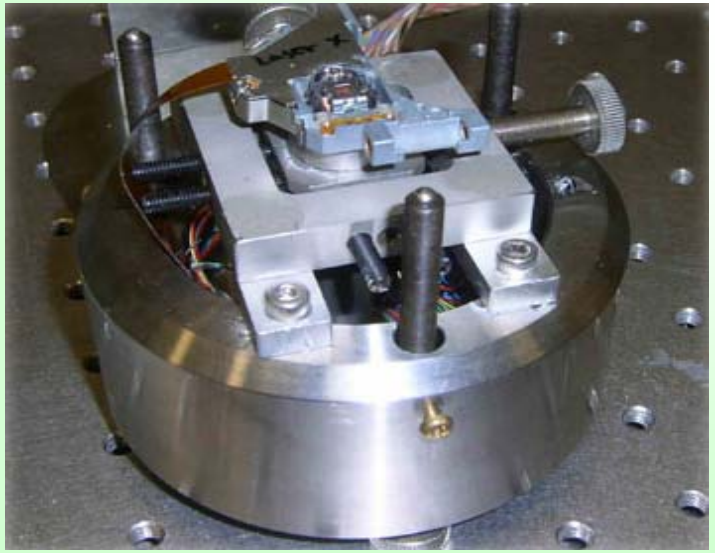
**Dia. of Blue light spot = 203nm**



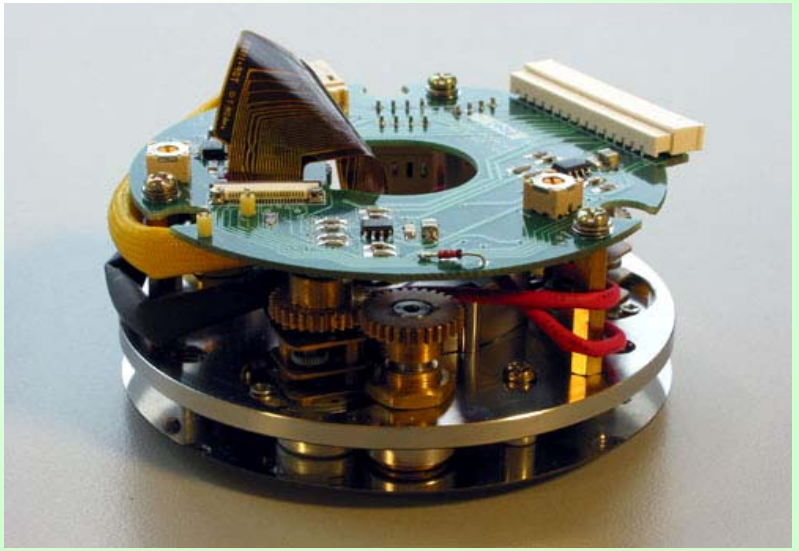
**Tip size = 3nm**

# Prototype





First-generation



Second Generation

# Intellectual Properties

## Patents owned by the team

| 公告號 / 申請號 / | 主發明人 | 專 利 名 稱 | 簡 介 |
|---|---|---|---|
| 95130735 | 胡恩德 | 掃描探針顯微術之懸臂樑量測方法 | 描述利用DVD讀取頭量測AFM探針懸臂樑彎曲(deflection) 的**核心技術**。全新的偵測原理，可以**避開 IBM 等主要AFM 量測原理的既有專利** 。 |
| 申 請 中 | 胡恩德 | 創新多軸位移量測系統 | 上一篇基礎專利的推廣衍生，除了量測懸臂樑deflection位移外，更可以量測出deflection的角度。本專利意味著**更精確的AFM 形貌量測**。 |
| 94138312 | 胡恩德 | 物體表面高度、角度及其變化之量測系統 | 上一篇專利的推廣衍生，待測物不一定要是AFM探針，也可以是一般的鏡面物體。此技術可泛用於各式精密位移量測，**不侷限於AFM**。 |
| I243531 | 洪紹剛 | 位移致動器 | 適用於AFM的尺蠖式(inchworm)步進機構。將樣品探針彼此靠近到數個奈米的距離而不相撞。 |
| 11249477 | 胡恩德 | 剪力式奈米位移致動器 | 上一篇專利的推廣衍生，剪力式的步進機構提供剛性更高的支撐，適用於超高真空與超低溫等嚴苛環境。 |
| 申 請 中 | 胡恩德 | 創新一體式探針夾持機構 | 配合DVD讀取頭的特殊AFM夾針機構設計。 |

# Comparison with Existing Products

| | No. 1 | Foreign Products | | | | Domestic Products | |
|---|---|---|---|---|---|---|---|
| Brand Name | Veeco | Seiko | Nanosurf | NT-MDT | PSIA | TPI | 傳亞 |
| Country | USA | Japan | Swiss | Russia | Korea | Taiwan | Taiwan |
| Owner of IPR | DI | Seiko | University of Basel | RAS | Park | IoP, AS | ITRI |
| Working principle | Light lever | Light lever | Light lever | Light lever | Light lever | Light scattering | Light interference |
| Z-resolution | 0.03nm | 0.3nm | 0.07nm | 0.3nm | 0.05nm | 0.03nm | 1nm |
| XY-resolution | 0.1nm | 1nm | 0.15nm | 1nm | 0.15nm | 0.1nm | 5nm |
| Price (NT$) | ~3 M | ~2 M | ~1.2 M | ~1.5 M | ~1.5 M | 0.6 M | 0.95 M |

*TPI v.s. No. 1 brand: Comparable in performance but much cheaper

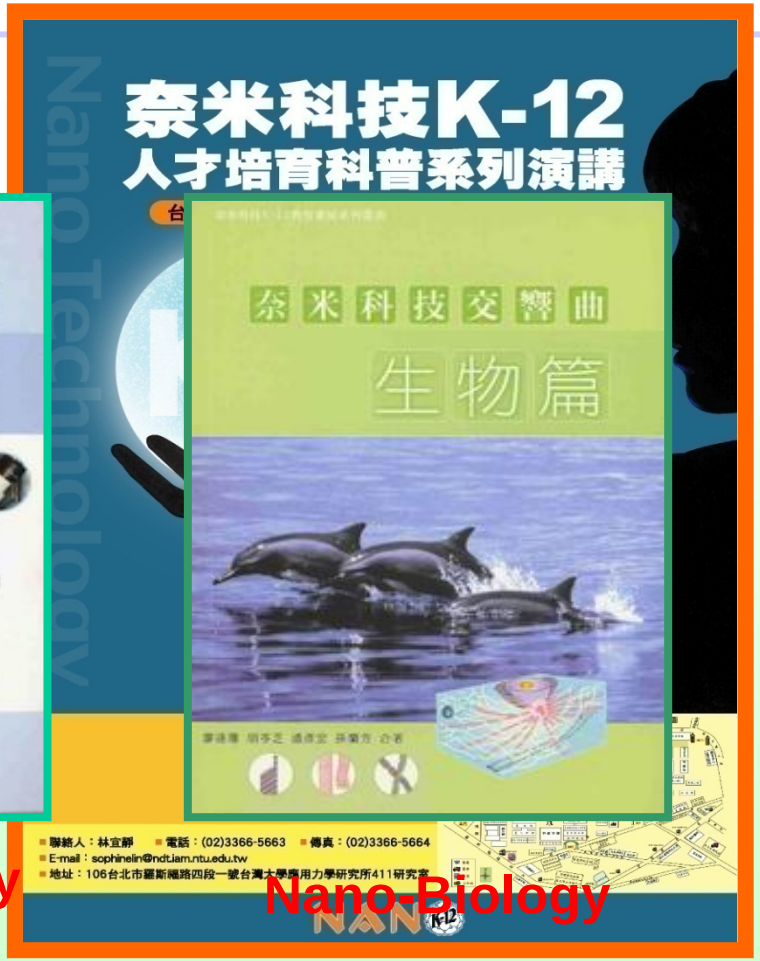
# Objectives of the Education Program

- To promote life-long learning in nanotechnology education
- To build an interdisciplinary, creative, and intellectual-propriety-right-concept learning subject
- To upgrade higher professional education and K-12 education
- To accomplish wider science education to the general public
- To narrow the gap between urban and rural areas, as well as reduce the disparity of resource deployment
- To build an administration support system to coordinate resource deployment and to minimize overlapping investment.

# Outreach Education

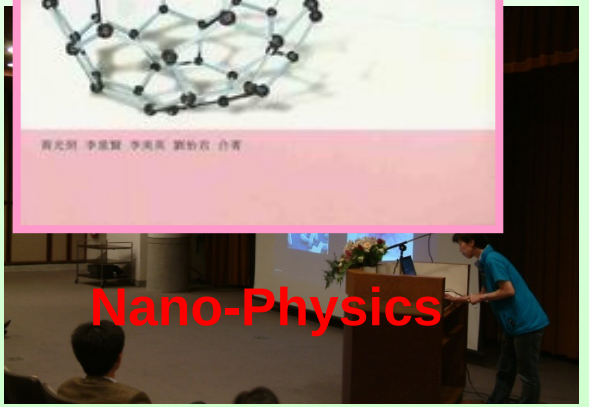
## K-12 Education Program







Nano-Chemistry

Nano-Biology

Nano-Physics

# Closing Remark

## Past

**Superiority in "Manufacturing" and "Management"**

**Global division of labor system ensured position in "Production & Manufacturing"**

**Low manufacturing costs and attractive markets have made Taiwan the manufacturing Centers of current high-tech products**

## Future

**Expand capacities in "Innovation" and "R&D"**

**Shift toward "Innovation," "Brand Names," and high value-added products**

**Taiwan will become an R&D center for high value-added, information serviced industries**


Working Together
We can Advance
Taiwan
Into Higher Orbit
And Beyond ….
Thank You for Your Attention