The Evolution and Challenges to the Innovation System in Taiwan

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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
Government R&D Organizations

Executive Yuan

Academia Sinica

National Science Council Meeting

S&T Advisory Group

National Science Council

Ministry of Education

Ministry of Economic Affairs

Ministry of Transportation

Ministry of Defense

Ministry of Interior Affairs

Agriculture Council

Atomic Energy Council

Department of Health

Environmental Protection Agency

Cultural Develop Council
<table>
<thead>
<tr>
<th>Type of Research</th>
<th>Sponsoring Government Organizations</th>
<th>University &amp; Government Labs.</th>
<th>Non-profit Research Institutes</th>
<th>Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental Research</td>
<td>AS NSC MOE DOH</td>
<td>University; Academia Sinica;</td>
<td>ITRI NHRI NARI INER CSIST</td>
<td>Public/ Private Enterprise Research Laboratory</td>
</tr>
<tr>
<td>Applied Research</td>
<td>MOEA MOTC MOD COA DOH EPA etc</td>
<td>National Applied Research Institutes; Synchrotron Radiation Research Center; etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technological Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NSC Missions

 valido País

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
### Promote Science and Technology Development

**Assumption:** GDP increase rate 5.0%, Gov/Private Ratio 38:62

Government spending increase 15% in years 2005~2006

Unit: 100M NT

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP</th>
<th>R&amp;D in GDP%</th>
<th>R&amp;D Fund</th>
<th>Gov. Invest</th>
<th>Private Invest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>+11%</td>
<td>+8%</td>
<td>deficit with 8%</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>97,488</td>
<td>2.30%</td>
<td>2,244</td>
<td>854</td>
<td>1,390</td>
</tr>
<tr>
<td>2003</td>
<td>98,476</td>
<td>2.47%</td>
<td>2,434</td>
<td>967</td>
<td>1,547</td>
</tr>
<tr>
<td>2004</td>
<td>103,399</td>
<td>2.60%</td>
<td>2,688</td>
<td>1,029</td>
<td>1,722</td>
</tr>
<tr>
<td>2005</td>
<td>108,569</td>
<td>2.80%</td>
<td>3,040</td>
<td>1,148</td>
<td>1,916</td>
</tr>
<tr>
<td>2006</td>
<td>113,998</td>
<td>3.00%</td>
<td>3,420</td>
<td>1,287</td>
<td>2,133</td>
</tr>
</tbody>
</table>

**Total** | **421**

*R&D expenditure reaches 3% GDP by 2006*
Taiwan Government Spending on Science and Technology Research

Million USD

Year

2001 2002 2003 2004 2005 2006

1,567 1,709 1,870 2,035 2,134 2,620

1,567 1,709 1,870 2,035 2,134 2,620
Support Academic Research

Science Education

Promotion of Research results

Individual Projects

Industrial-Academic Collaboration

Talent Cultivation Programs

International Collaboration

Common Facilities
National Laboratories—NARL and NSRRC

Advanced Techniques

NSRRC-SC Cavity

Cosmics-Formasat-III

SOC Testing Platform

Earthquake monitoring

R&D Platform

Animal Breeding Center

Taiwan Research Network

Data Center

Micro-biochips

Information Platform

Talent Cultivations

NDL

NSPO

NLAC

NSRRC

NCHC

STI

ICIC

R

NCDR
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
Sites of Science Parks

- Tung-lo Park (350)
- Tainan Park (1038)
- Lu-chu Park (571)
- Long-tan Park (198)
- Tung-lo Park (350)
- Hsinchu bio-medical Park (38)
- I-lan Park (890)

Sites of Science Parks

- Hsinchu Park (625)
- Chu-nan Park (141)
- Taichung Park (332)
- Hu-wei Park (97)

Total revenues in 2005 ~ 1.3 trillion NT (~12% GDP)
# One-Stop Service System

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

12
Industrial Clusters

Semiconductors (Southern Taiwan Science Park)

- 22 companies have been approved by June, 2005.
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

Academia + R.I & Industry

MOEA

MOE

NSC
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 & Nanotechnology

- **Promote environmental safety and develop digital learning**
  - Digital Archives—e-Learning

- **Promote innovative bio-technologies**
  - Agricultural Biotechnology, Biotechnology and Pharmaceuticals, Genomic Medicine
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

(from Dr. C.K. Lee of NSC)
Opportunities: Diversity
Unique Characteristics of Taiwan

- Cultural Diversity
  - Recognize,
  - Respect,
  - Enjoy,
  - Cherish

- Bio-diversity
- Geo-diversity
- Industrial Diversity

Time

Space
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
  - 軸子線形最佳化設計
  - 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
Phase I of National Nano-Program
Total Budget (USD 605 Millions)

Distributions of Budget

- Core facility: 15%
- K-12 Education: 2%
- Academic Excellence: 19%
- Industrialization: 64%

Appropriations from Ministries

- NSC—National Science Council: 23.1%
- MoE—Ministry of Education: 1.8%
- DoH—Department of Health: 2.3%
- AEC—Atomic Energy Council: 1.2%
- EPA—Environmental Protection Agency: 0.3%
- LAC—Labor Affair Council: 0.3%
- MoEA—Ministry of Economic Affairs
  - MoEA-Standard: 1.3%
  - MoEA-Energy: 1.2%
  - MoEA-Industrial Bureau: 1.2%
  - MoEA-Tech: 66.4%
1-D Functionalized Integrated Systems

Wire/Rod

Tube

Belt

Nanotip

Core-shell

Peapod

Other Thin Films:


APL 86, 203119 (2005)

US Patent 6,960,528,B2

APL (2006)

1-D Functionalized Integrated Systems

JACS 123, 2791 (2001)
JACS 127, 2820 (2005)

APL 79, 3179 (2001)
APL 81, 4189 (2002)
APL 86, 203119 (2005)
JACS 128, 8368 (2006)


1D: Au Peapodded in SiO₂ NW

SiO₂ 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)

Terahertz Imaging

With 10nm QDs in head

316GHz MMW images of seahorse

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

Research Highlights

Terahertz microchip offers a sensitive nose to sniff out drugs

Detecting trace amounts of substances in important for many biosensing applications, where the terahertz wave can range from DNA to illegal drugs. For real-time 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 Taiwan's researchers have developed a terahertz microchip that can detect minute concentrations of drugs and other substances in a non-invasive way.

Biologists can be distinguished according to their terahertz "fingerprint" - 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 badly.

Ja-yu Su 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 transceiver. 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, the radiation is up to 100 times stronger 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, amphetamines, potato starch, lactose, and flour. The microchip was shown to distinguish each compound and could detect drug powders with weights as low as 10 nanograms. This sensitivity matches that of current forensic techniques used to detect drugs, yet preserves the native state of the sample. By incorporating microscopic channels into the device, water-based molecular sensing could become possible and improved sensitivity could open up detailed studies of molecular dynamics.
Type II Nanoparticles as Contrast Agent of THz Imaging

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

THz imaging system

Dry seahorse
- Brain cavity
- Abdominal cavity
- Spine
- Contrast agent: Type-II QDs

Sample under test
- PE film
- PE fiber
- Picarin lens
- Motion controller
- Parabolic mirror
- Gunn oscillator module

Contrast agent: Type-II QDs
- 4.4nm CdSe
- 8nm CdSe/CdTe
- 10.4nm CdSe/CdTe

4.4nm CdSe 8nm CdSe/CdTe 10.4nm CdSe/CdTe
Development of High Spatial and Temporal Resolution Imaging Techniques

3D Tomograph of Porous SiO₂ by STEM (C.H. Chen et al.)

Mitosis of blastomeres (stem cells)
THG + SHG (53µm x 53µm)

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

Functional Imaging Microscopy Using Plasmon Resonant Enhanced Higher Harmonic Generation (C.K. Sun et al.)
Project to Promote Creative Prototype Products

Research Results (domestic or international)

New Phenomena

New Technology

New Theory

Need

Database
Brain Storming
National Innovative Competition

…….
New product—Anti-forgery Color Card

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

- Micro-grating
  Grating period $\Lambda = 1 \mu m$
  Thickness $d_g = 0.3 \mu m$
  Film thickness $d_w = 0.6 \mu m$
  Filling factor $f = 0.6$
  $n = 2.15$

- Nano-grating
  Grating period $\Lambda = 0.35 \mu m$
  Thickness $d_g = 0.3 \mu m$
  Film thickness $d_w = 0.6 \mu m$
  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)
Why Nano:
Long term anti-fog spray: humidity-proof and wash-proof, long term effect
Nano-powder: high surface area film structure, transparent

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

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

<table>
<thead>
<tr>
<th>Product</th>
<th>Existing AFM (3MNT$)</th>
<th>New Innovative AFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key principle</td>
<td>Optical lever (mechanical)</td>
<td>DVD Read head (Laser scattering)</td>
</tr>
<tr>
<td>2005 World share</td>
<td>$\sim 10^4$</td>
<td>$\sim 10^8$ (DVD head)</td>
</tr>
<tr>
<td>Manufacturing cost</td>
<td>$\sim 300,000$ NT$</td>
<td>$300$ NT$*</td>
</tr>
<tr>
<td>Vertical resolution</td>
<td>0.03nm</td>
<td>0.03nm</td>
</tr>
<tr>
<td>Signal Bandwidth</td>
<td>$\sim 1$MHz</td>
<td>100MHz</td>
</tr>
</tbody>
</table>

* 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 = 203 nm

Tip size = 3nm
Prototype

First-generation

Second Generation
<table>
<thead>
<tr>
<th>公告號/申請號</th>
<th>王發明人</th>
<th>專利名稱</th>
<th>簡介</th>
</tr>
</thead>
<tbody>
<tr>
<td>95130735</td>
<td>胡恩德</td>
<td>掃描探針顯微術之懸臂樑量測方法</td>
<td>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。</td>
</tr>
<tr>
<td>申請中</td>
<td>胡恩德</td>
<td>創新多軸位移量測系統</td>
<td>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。</td>
</tr>
<tr>
<td>94138312</td>
<td>胡恩德</td>
<td>物體表面高度、角度及其變化之量測系統</td>
<td>上一篇專利的推廣衍生，待測物不一定要是AFM探針，也可以是一個鏡面物體。此技術可泛用於各式精密位移量測，不侷限於AFM。</td>
</tr>
<tr>
<td>1243531</td>
<td>洪紹剛</td>
<td>位移致動器</td>
<td>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。</td>
</tr>
<tr>
<td>11249477</td>
<td>胡恩德</td>
<td>剪力式奈米位移致動器</td>
<td>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。</td>
</tr>
<tr>
<td>申請中</td>
<td>胡恩德</td>
<td>創新一體式探針夾持機構</td>
<td>配合DVD讀取頭的特殊AFM夾針機構設計。</td>
</tr>
</tbody>
</table>
## Comparison with Existing Products

<table>
<thead>
<tr>
<th>No. 1</th>
<th>Foreign Products</th>
<th>Domestic Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brand Name</strong></td>
<td>Veeco</td>
<td>Seiko</td>
</tr>
<tr>
<td><strong>Country</strong></td>
<td>USA</td>
<td>Japan</td>
</tr>
<tr>
<td><strong>Owner of IPR</strong></td>
<td>DI</td>
<td>Seiko</td>
</tr>
<tr>
<td><strong>Working principle</strong></td>
<td>Light lever</td>
<td>Light lever</td>
</tr>
<tr>
<td><strong>Z-resolution</strong></td>
<td>0.03nm</td>
<td>0.3nm</td>
</tr>
<tr>
<td><strong>XY-resolution</strong></td>
<td>0.1nm</td>
<td>1nm</td>
</tr>
<tr>
<td><strong>Price (NT$)</strong></td>
<td>~3 M</td>
<td>~2 M</td>
</tr>
</tbody>
</table>

*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-property-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
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