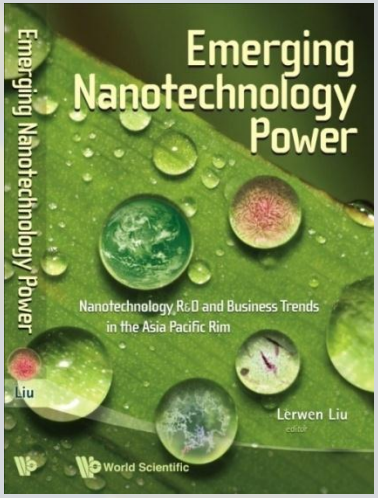
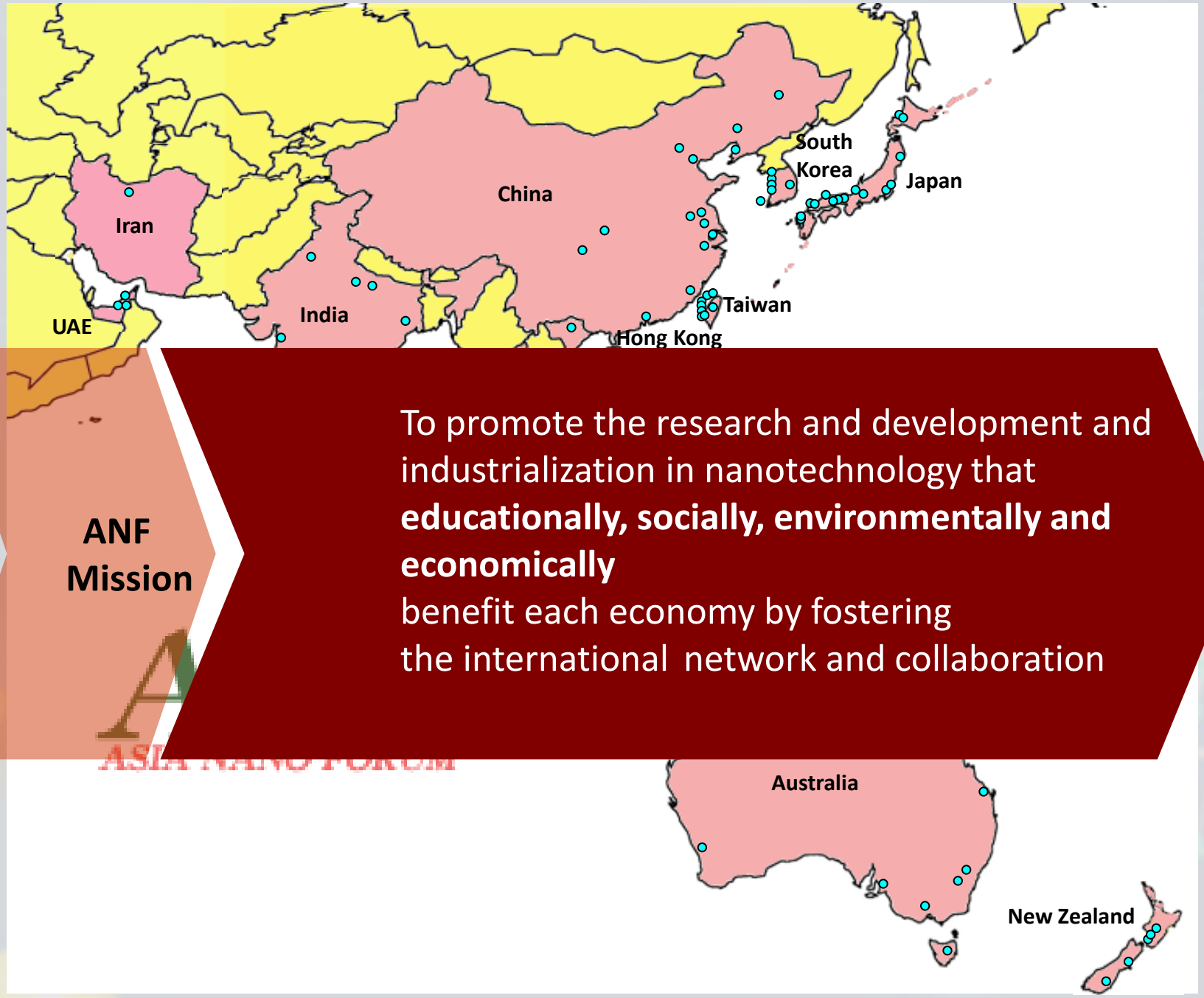
NANOGLOBE

NanoTechnology Business Development Consultants

Asian's Efforts Towards Sustainable Development of Nanotechnology



Dr. Lerwen Liu
Managing Director of NanoGlobe
Secretary of Asia Nano Forum



ANF Mission

To promote the research and development and industrialization in nanotechnology that **educationally, socially, environmentally and economically**
benefit each economy by fostering
the international network and collaboration

Asia Nano Forum (ANF) Network

- Includes government organizations and leading R&D institutes of 15 economies in the Asia Pacific region: Australia, China, Hong Kong, India, Indonesia, Iran, Japan, Korea, Malaysia, New Zealand, Singapore, Taiwan, Thailand ,Vietnam, UAE

ANF Objectives

Foster nanotechnology in the region by creating mechanisms to share information, human and physical resources and expertise

Coordinate joint investment in and mutual access to major infrastructure by member economies

Promote and coordinate standardization and safety of nanotechnology concepts and measurements

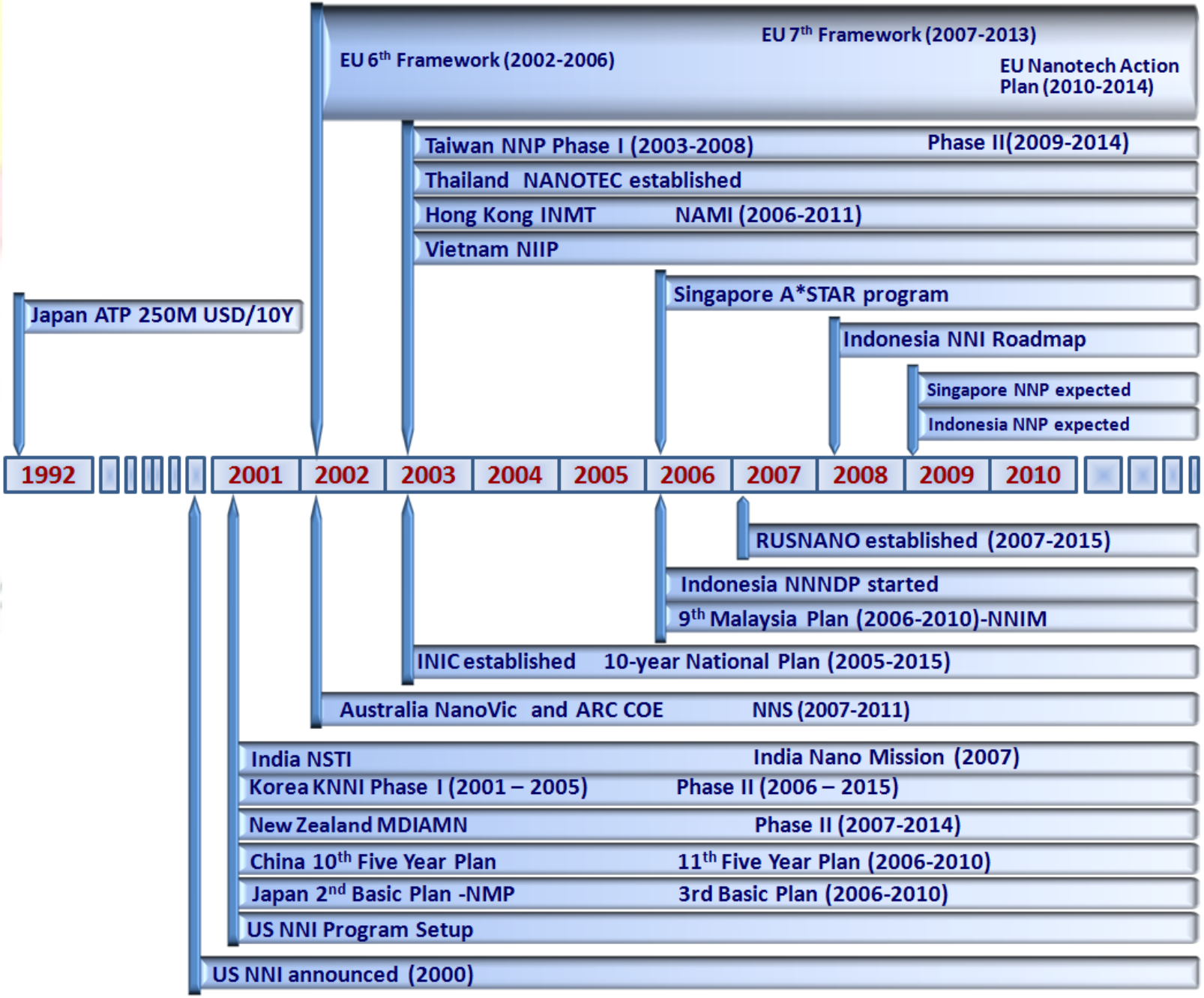
Support regional economic and environmetal development through joint projects addressing major regional issues, with an empasis on support of developing and emerging economies

Act as an advocacy group for nanotechnology in the region and for adequate regional representation of nanotechnology at global forums

Initiate, **promote and manage co-operative** scientific and technology research projects within the member economies

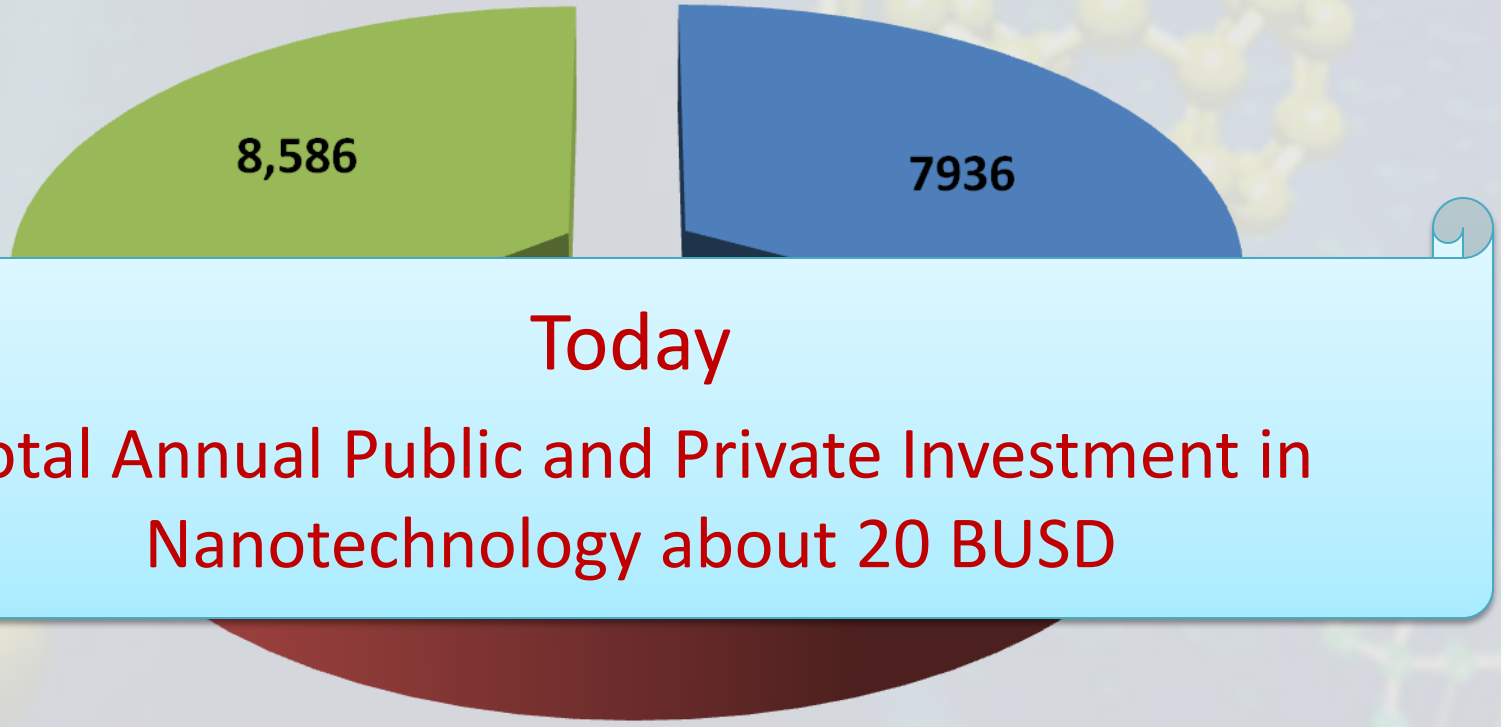
Enhance public awareness and education of nanotechnology and associated social, environmental, health and economic issues

Nanotechnology National Initiatives Timeline in Asia Pacific Region



Ref "Emerging Nanotechnology Power" by Dr Lerwen Liu (World Scientific, 2009

Public Nnaotechnology Funding Comparision Among European Union, USA, and Asia Pacific during 2006-2010

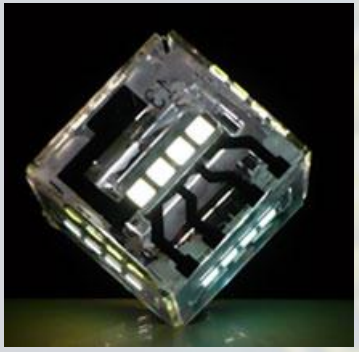


Today

Total Annual Public and Private Investment in Nanotechnology about 20 BUSD

Benefits of Nanotechnology

- **Eco Friendly**
  - Energy saving
  - Reduce CO_2 emission
  - Reduce/eliminate chemicals

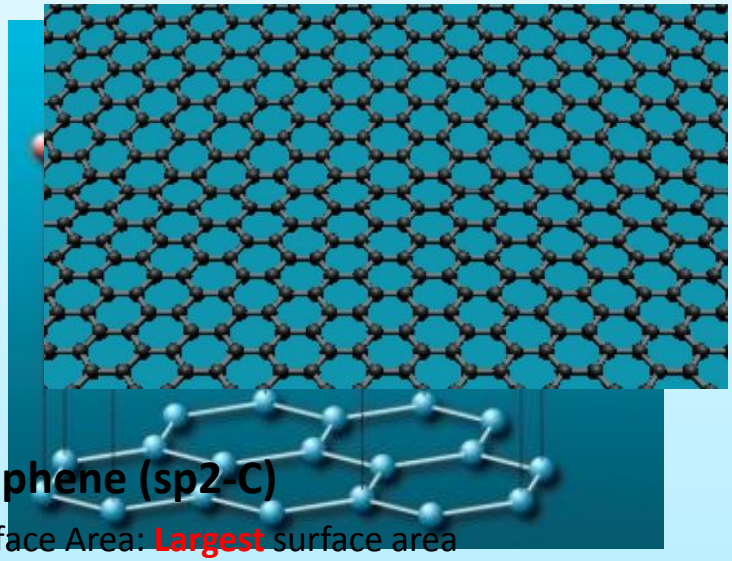


- **Safe**
  - Light weight and high strength nanocomposites
  - sensors
  - Water / air purification

- **Low Cost**
  - Low maintenance cost
  - Wet process
  - Saving energy
  - High efficiency

From Coal to Nano Carbon - Graphite

Charcoal and pencil -- the discovery and application of graphite can be traced back to the ancient times and everywhere in our daily life



Graphene (sp2-C)

-Surface Area: **Largest** surface area

-Tensile Strength: **200 times** stiffer than steel

-Young's Modulus: **5~7 times** stronger than steel

-Electric conductivity: **highest** intrinsic mobility, **100 times** of Si

-Thermal conductivity: **10 times** more thermally conductive than copper

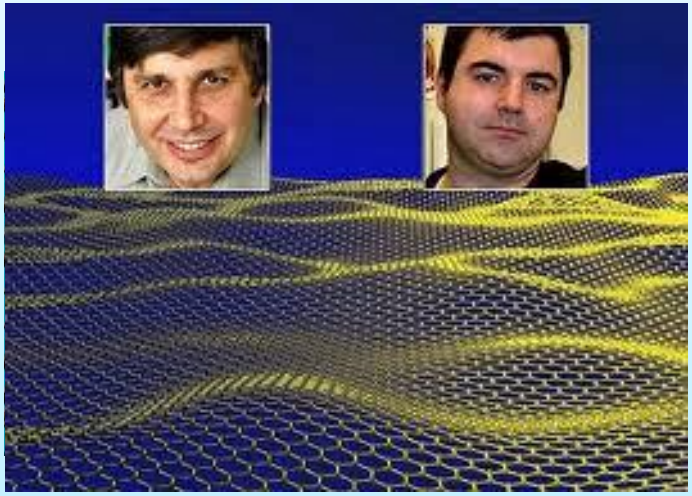
-Impermeability: **Completely impermeable**, even He atoms cannot squeeze through

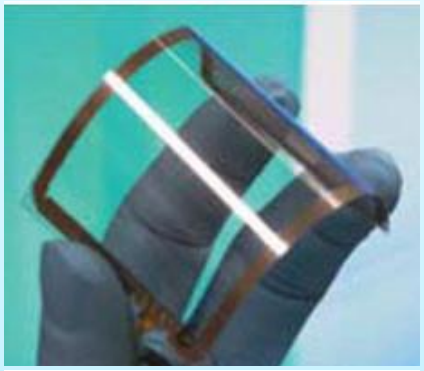
Graphite (sp2-C)

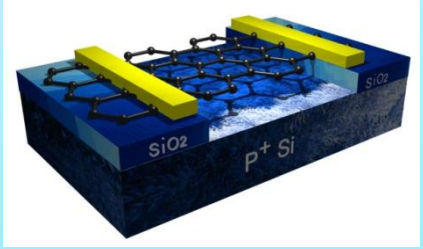
- Usually soft materials
- Highly anisotropic properties

From Coal to Nano Carbon - Graphene

The R&D and commercialization of graphene has been most active worldwide since Andre Geim & Konstantin Novoselov received the 2010 Nobel Prize in Physics for their discovery of graphene - the one atomic layer materials with superior mechanical, optical, electrical and thermal conductive properties.







Graphene (sp2-C)

-Surface Area: **Largest** surface area

-Tensile Strength: **200** times stiffer than steel

-Young's Modulus: **5~7** times stronger than steel

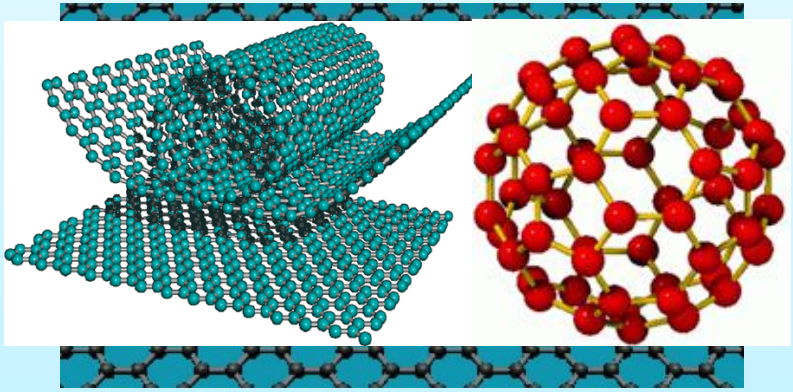
-Electric conductivity: **highest** intrinsic mobility, 100 times of Si

-Thermal conductivity: **10 times** more thermally conductive than copper

-Impermeability: **Completely impermeable,** even He atoms cannot squeeze through

From Coal to Nano Carbon – Carbon Nanotubes

Single-wall carbon nanotube (SWCNT) and buckyball can be considered to be formed by rolling of graphene into a seamless cylinder or sphere, which has been widely used in the high performance composites, electronics and energy industries in the last 10 years.



Carbon Nanotube

-Single wall, few wall or multi-wall

-Metallic or semiconducting

-Tensile Strength: **100 times** stiffer than steel

-Modulus: **5~7 times** stronger than steel

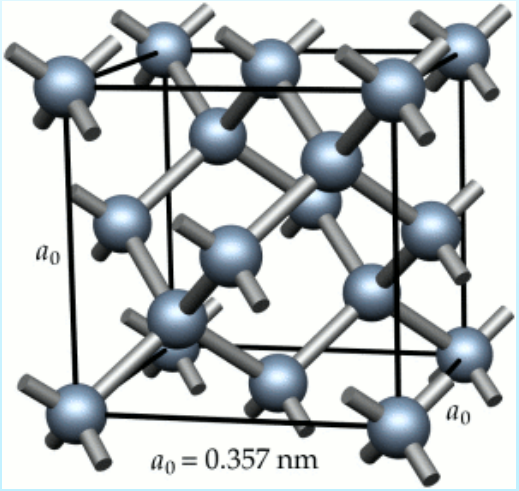
-Electric conductivity: **1000 times** more capacity to carry electric current than Cu-wire

-Thermal conductivity: **10 times** more thermally conductive than copper

From Coal to Nano Carbon

Strongest Material in the World? – Diamond or Graphene? → Diamond (sp3-C) V.S. Graphene (sp2-C):

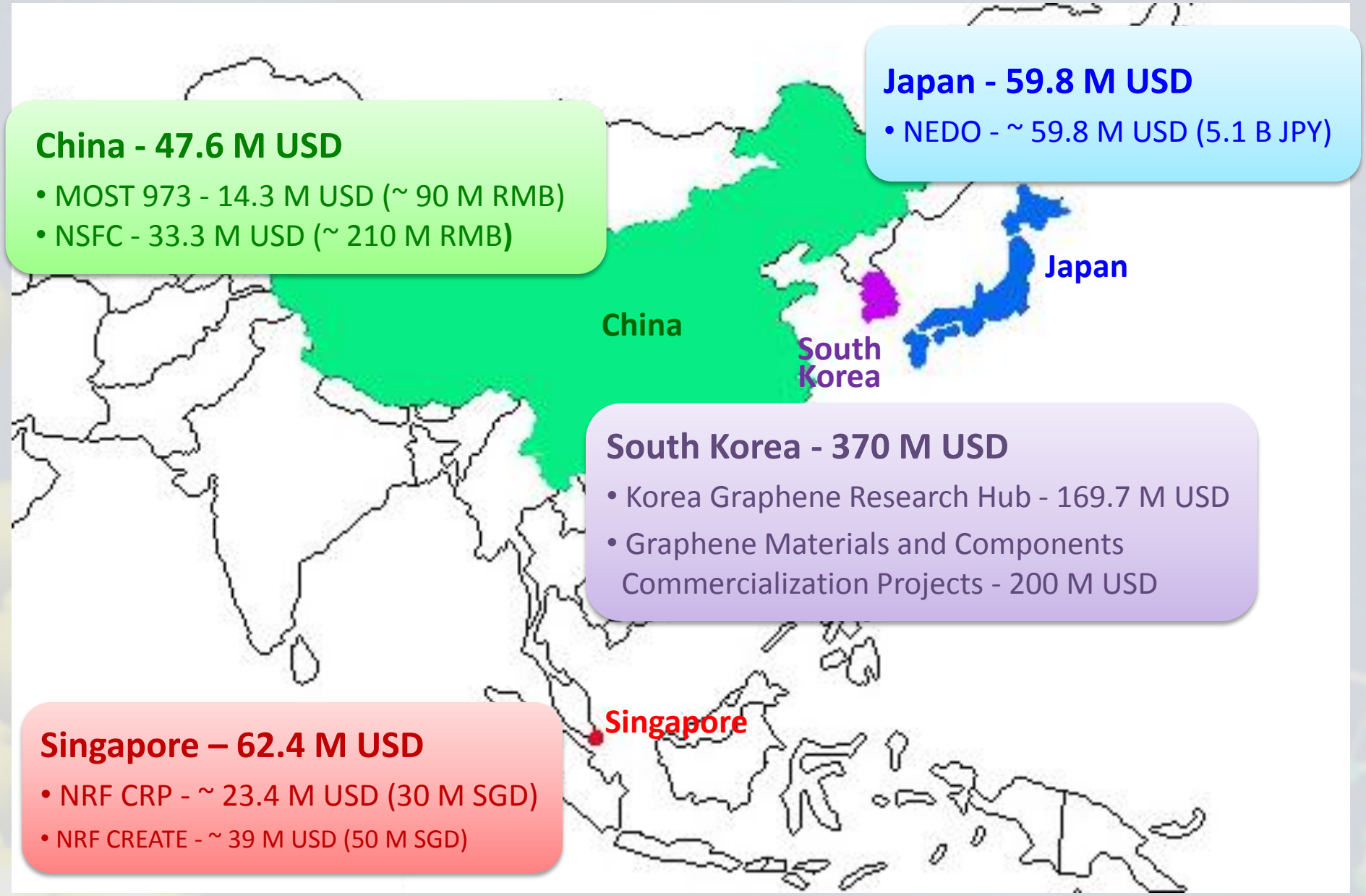
Graphene is stiffer than diamond → **Strongest Material "Ever Measured"**



Diamond (sp3-C)

- Most glorious and brilliant
- Stiffest material known before the discovery of graphene

Strong Govn't Support for Nano Carbon R&D in Asia (since 2011)



China - 47.6 M USD

- MOST 973 - 14.3 M USD (~ 90 M RMB)
- NSFC - 33.3 M USD (~ 210 M RMB)

Japan - 59.8 M USD

- NEDO - ~ 59.8 M USD (5.1 B JPY)

South Korea - 370 M USD

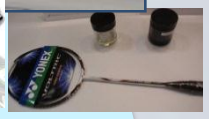
- Korea Graphene Research Hub - 169.7 M USD
- Graphene Materials and Components Commercialization Projects - 200 M USD

Singapore – 62.4 M USD

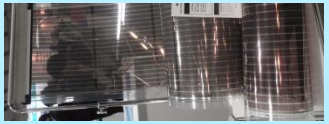
- NRF CRP - ~ 23.4 M USD (30 M SGD)
- NRF CREATE - ~ 39 M USD (50 M SGD)

Nano Carbon Adoption & Applications

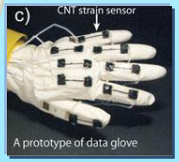
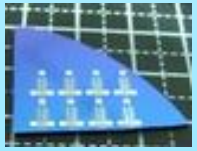
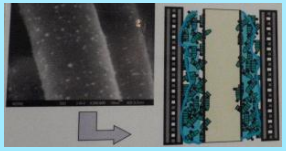
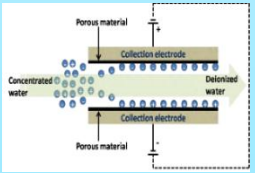
Entry Market — Now

Electronics	Energy	Automotive	Aerospace	Marine	Sports
 	 	  	 	 	   
Samsung, Hanwha, NanoMirae	Showa Denko, Hodogaya, Cnano Bayer, Zyvex	Audi, Honda; Zyvex; Future Carbon	Zyvex	Zyvex	Zyvex, Yonex, Mitsubishi

Prototype — In 1-3 yrs

Consumer Electronics	Flexible Electronics	Building	Lighting
     	   	 	 
Samsung, Top Nanosys, Foxconn, Canatu, ANI	Samsung, LG, Foxconn, Konarka Technologies	CeEntek Samsung	Hanwha, World Tube

R&D — In 3-5 yrs

Sensor	Printable TFT	Catalyst for Fuel Cell	Membrane for CDI
 	 		

Nanosafe Australia (Courtesy of Prof. Paul Wright)

Nationwide research network of toxicologists & risk assessors

Mission:

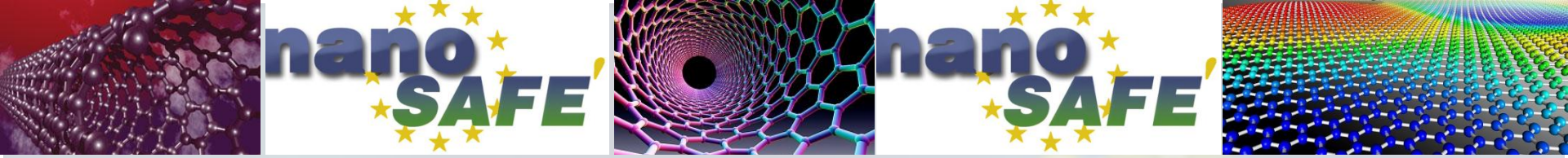
- To support government, industry and non-government organisations (NGOs) in their efforts to understand the occupational and environmental health and safety issues surrounding nanotechnology products and their manufacturing processes
- To provide quality data for the appropriate risk assessment of nanoparticles (NP) and nanomaterials (NM)

www.rmit.edu.au/nanosafe

Nanosafe Australia Expertise

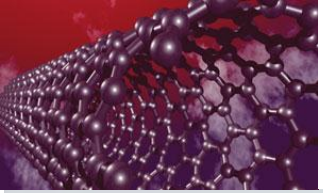
Well Coordinated Interdisciplinary Efforts

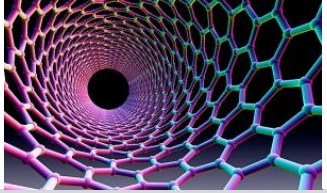
- **In fields directly related to nanotoxicology:**
  - Characterisation of physico-chemical properties
  - Measurement of ultra-fine particles in ambient air
  - Toxicokinetics of particles
  - Pre-clinical safety testing
  - Immuno-, neuro- & biochemical toxicology
  - Occupational & food allergy
  - Occupational hygiene, OHS & workplace monitoring
  - Ecotoxicology & environmental toxicology
  - Ecological & human health risk assessments

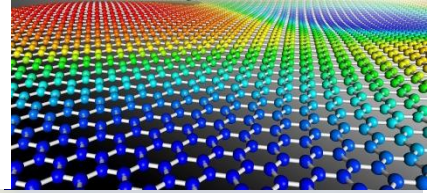


Asia NanoSafety Research Network Initiative

- **Why?**
  - Current activities are fragmented
  - Unnecessary duplication of efforts
  - Diversity of nanomaterials in types and applications makes proper screening insurmountable
  - Need for coordinated response for community concerns and engagement
  - Need for harmonization of Safety-by-design approach
- **What?**
  - A network of Asian nanosafety researchers
  - Inclusive of academic and industry R&D players and government regulatory bodies
- **Where?**
  - Championed by Australia
  - Coordinated by ANF Secretariat in Singapore
- **Next Steps**
  - TODAY: ANF delegates to agree to Identify local champions in each economy by end of Sept. 2012
  - Early Oct. 2012: Set up Nanosafety webpages in ANF website
  - Early 2013: Establish the Kick-off workshop to set up priorities







ISO/TC229 Nanotechnologies

ISO/TC 229 Nanotechnologies

Secretariat: UK (BSI)
Chair: Dr. Simon Holland (UK)

JWG1
Terminology & Nomenclature

"What you call it"

Leadership:
Canada (SCC)

JWG2
Measurement & Characterization

"How you measure/test it"

Leadership:
Japan (JISC)

WG3
Health, Safety & the Environment

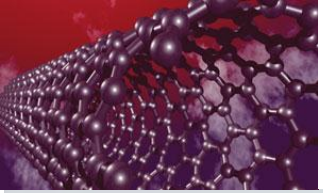
"What effect might have to health & environment"

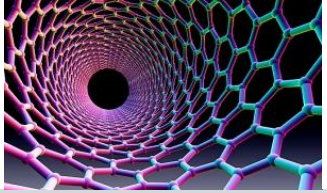
Leadership:
United States (ANSI)

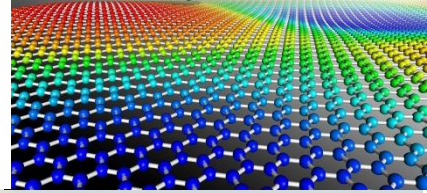
WG4
Materials Specifications

"Reverent compositions, properties and characteristics"

Leadership:
China (SAC)







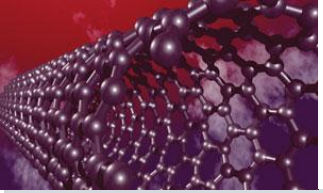
ISO/TC229 Nano Carbon Related Standardization

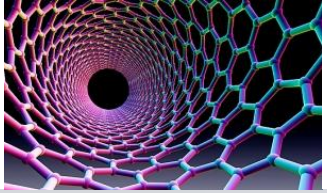
JWG1 Projects Status - Terminology & Nomenclature

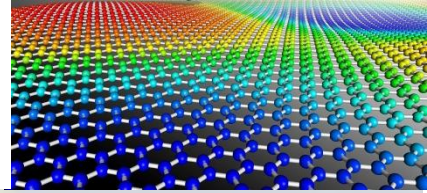
PG03	TS 80004-3:2010 Nanotechnologies — Vocabulary — Part 3: Carbon nano-objects	Published, 2010
NWIP	Vocabulary- Part 11: Nanofilms, nanocoatings, nanolayers	NWIP invited

JWG4 Projects Status - Materials Specifications

NWIP	Specification of carbon nanotubes in liquid: characteristics and measurement	NWIP beginning







ISO/TC229 Nano Carbon Related Standardization

JWG2 Projects Status - Measurement & Characterization

PG01	TS 10797 Nanotubes -- Use of transmission electron microscopy (TEM) in single-walled carbon nanotubes (SWCNTs)	Publication process
PG02	TS 10798 Nanotechnologies -- Characterization of SWCNTs using scanning electron microscopy and energy dispersive X-ray spectrometry analysis	Published
PG03	TS 10868 Nanotechnologies -- Characterization of SWCNTs using ultraviolet-visible-near infrared (UV-Vis-NIR) absorption spectroscopy	Published
PG04	TS 10867 :2010 Nanotechnologies -- Characterization of SWCNTs using near infrared photoluminescence spectroscopy	Published
PG05	TR 10929 Measurement methods for the characterization of multi-walled carbon nanotubes (MWCNTs)	Published
PG06	TS 11251:2010 Nanotechnologies. Characterization of volatile components in SWCNT samples using evolved gas analysis/gas chromatograph-mass spectrometry	Published
PG07	TS 11308 Nanotechnologies -- Use of thermo-gravimetric analysis (TGA) in the purity evaluation of single-walled carbon nanotubes (SWCNT)	Published
PG08	TS 10812 Nanotechnologies -- Use of Raman spectroscopy in the characterization of SWCNTs	Cancelled
PG09	TS 11888 Determination of mesoscopic shape factors of MWCNTs	Published
PG12	TS 13278 Carbon nanotubes -- Determination of metal impurities in carbon nanotubes (CNTs) using inductively coupled plasma-mass spectroscopy (ICP-MS)	Published

ANF Nano-Standard Highlights

-Courtesy of Dr Tsung-Tsang SU (ITRI Taiwan)-

- **Nano activities are in good progress among ANF members**
- **EHS issues caught much attention as commercialization progresses**
- **ISO/TC 229 progress increases the influence on National Standardisation**

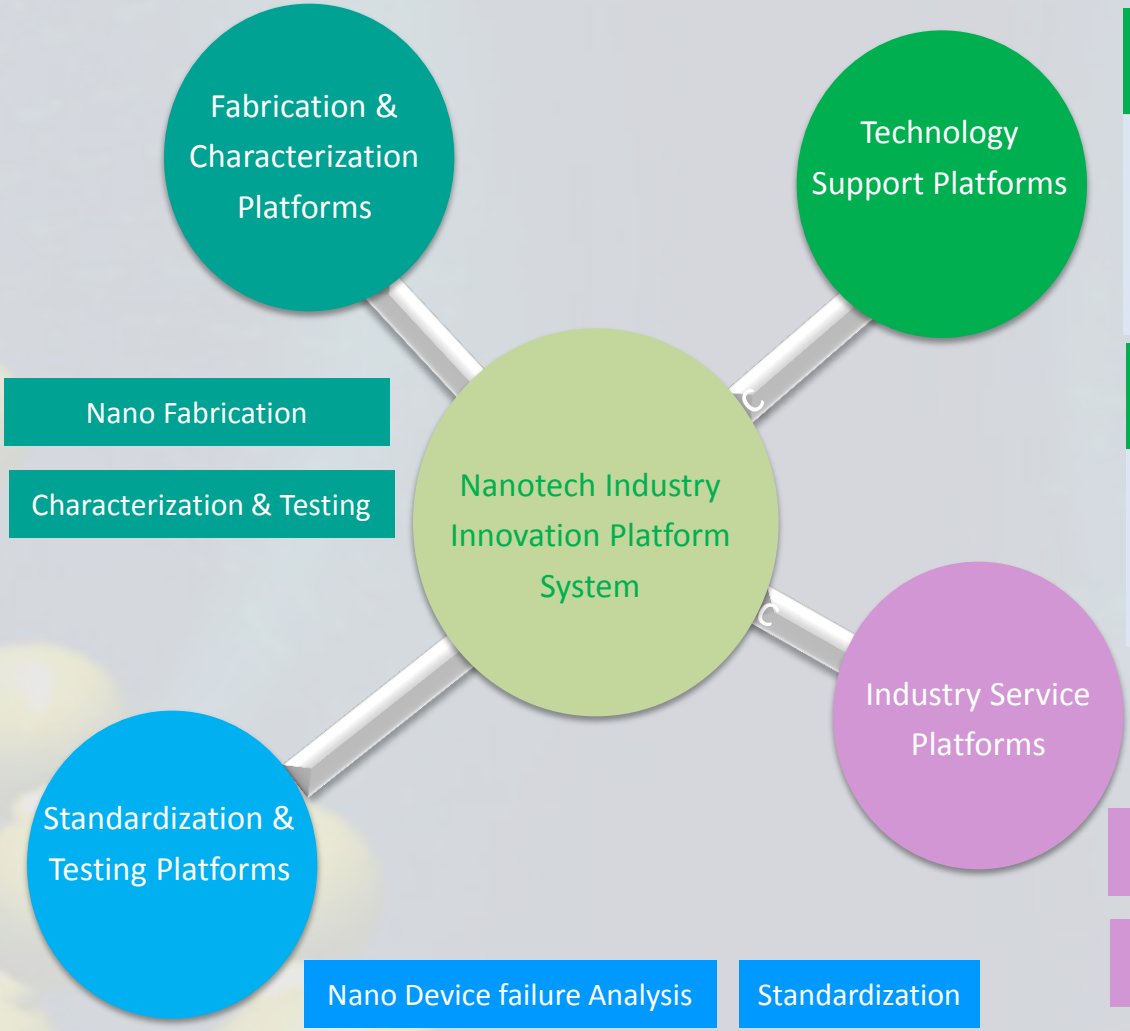
- **China**
  - Adopt ISO/TR 12885:2008 : Nanotechnologies -- Health and safety practices in occupational settings relevant to nanotechnologies
    ISO/DTS 11751: Terminology and definitions for carbon nano-objects
    ISO/TS 28687: Nanotechnologies – Vocabulary – Part3: Carbon nano-objects
    ISO/TS 80004-1: 2010 : Nanotechnologies -- Vocabulary -- Part 1: Core terms
    ISO/TS 80004-5: Nanotechnologies -- Vocabulary -- Part 5: Nano/bio interface
  - 4 new standards published:
    - GB/T 25898-2010：Instrumental nanoindentation test methods for thin film indentation hardness and elastic modulus
    - GB/Z 26082-2010：DC magnetic susceptibility (magnetic moment) measurement for nanomaterials
    - GB/T 26489-2011：Methods for measuring super amphiphilicity of nanomaterials
    - GB/T 26490-2011：Methods for measuring super hydrophobicity of nanomaterials

- **Taiwan**
  - Chinese Version on Nano-objects: Nanoparticle, nanofibre and nanoplate published (ISO/TS 27687)
  - 6 new V&V standards announced:
    - nano-material coated foam for heat resistant and Anti-shrinking
    - nano modified textiles for Instant cool feeling
    - amphiphobic architectural coatings for antifouling
    - Self-cleaning nano photocatalyst paint
    - Wooden board containing nano metal oxides for anti-bacterial
    - Consumer electronics enclosure containing nano silver for anti-bacterial
- **Korea**
  - Translation of ISO 10801, 10808 :2010
    ISO10801-Standard for Generation of Metal Nanoparticles with the Evaporation /Condensation Method for Inhalation Toxicity
    ISO10808-Standard for Characterization of Nanoparticles in Inhalation Exposure Chambers for Inhalation Toxicity Testing
  - National standard for "Guidance on safe handling and disposal of manufactured nanomaterials" under development
  - Standards in draft
    --Guidance on safe management of nanotechnology based product
  - 3 new standards published:
    - KSA6203-2011：Guidance on safe management of nanotechnology-based products
    - KSC8014-2011：Carbon nano tube(CNT) panel for general lighting – Safety requirements
    - KSC8015-2011：Carbon nanotube (CNT) panel for general lighting – performance requirement

ANF Nano-Standard Highlights-continued

- **Iran**
  - 6 Published national standards
    - -- ISIRI 12098 Nanotechnology-Vocabulary and Main Definition (In Farsi language)
    - -- ISIRI 12693 Nanotechnologies- Analysis of hemolytic properties of nanoparticles
    - -- ISIRI 13566 Nanotechnologies-Nanotechnology-Evaluation of the effect of nanoparticulate materials on the formation of mouse granulocyte- Macrophage colonies-Test method
    - -- ISIRI 12325 Nanotechnology - Health and safety in nano-occupational settings – code of Practices
    - -- ISIRI 13731 Characterization of Single Walled Carbon Nanotubes using Near Infra Red Photoluminescence Spectroscopy (adopt from ISO)
    - -- ISIRI 13736 nanotechnologies- safe packaging and transport of nanomaterails – code of practice
  - 7 national standards are under development (Drafting)
    - -- Test method for evaluation of safety for food packaging based on nanotechnology
    - -- Test method for dermal toxicity evaluation of silver nanoparticles
    - -- Generation of metal nanoparticles for inhalation toxicity testing using the evaporation/condensation method (adopt from ISO)
    - -- Development of in vitro Toxicity Method for Risk Assessment of Inhalable Nanoparticles
    - -- Endotoxin test on nanomaterial samples for in vitro systems(adopt from ISO)
    - -- Nanotechnologies -- Characterization of single-wall carbon nanotubes using scanning electron microscopy and energy dispersive X-ray spectrometry analysis (adopt from ISO)
    - -- Nanotechnologies -- Characterization of single-wall carbon nanotubes using ultraviolet-visible-near infrared (UV-Vis-NIR) absorption spectroscopy (adopt from ISO)

SIP Nanotech Ecosystem - Innovation and Commercialization Platforms



Nano Fabrication

Characterization & Testing

Micro-Nano Manufacturing

- MEMS
- Nano Optoelectronics Device Fabrication & Assembly
- Flexible Electronics
- Printed Electronics
- Robot & Micro System

Nano Medicine

- Pharmaceutical High-throughput Screening
- Targeted Drug Delivery
- Stem Cell and Tissue Engineering

Advanced Functional Nano Materials

- Functional Nano and Soft Materials
- Nano Carbon Materials & Devices
- GaN Materials and Applications

Energy & Green Technologies

- Li-ion Battery Pilot Production
- Environment and Biosafety

Incubator

Investment

IP Management

Information Sharing

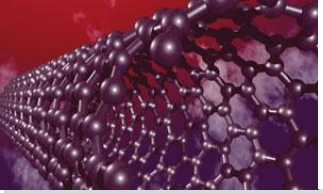
Tech Transfer

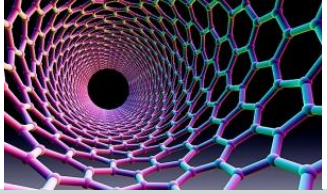
Nano Device failure Analysis

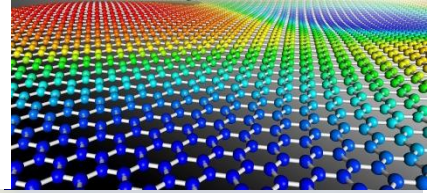
Standardization

Safety Evaluation

Certification & Accreditation





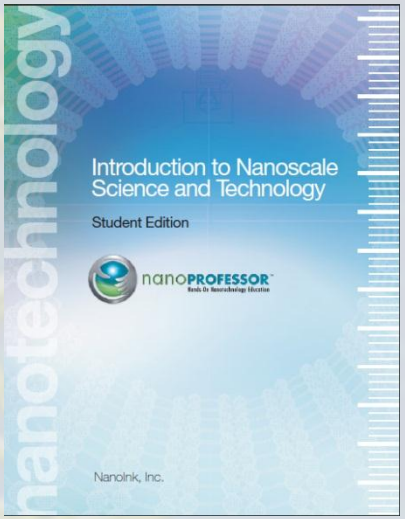


Nanotech Education and Outreach in Iran

- Nano Club For Children
- Nano-Olympia (reached 160,000 students within 3Y)
- Student Nanotech Educational Exhibitions
- 28 univ with MSc and 14 univ with PhD in nanotech
- Industrialists Knowledge Promotion On Nano-tech (Workshops, Newsletters, Leaflets And Industrial Show)
- More than 50% of nanotech workforce is women in Iran.

Expert-Designed Nanoscience Curriculum

State-of-the-Art Instrumentation

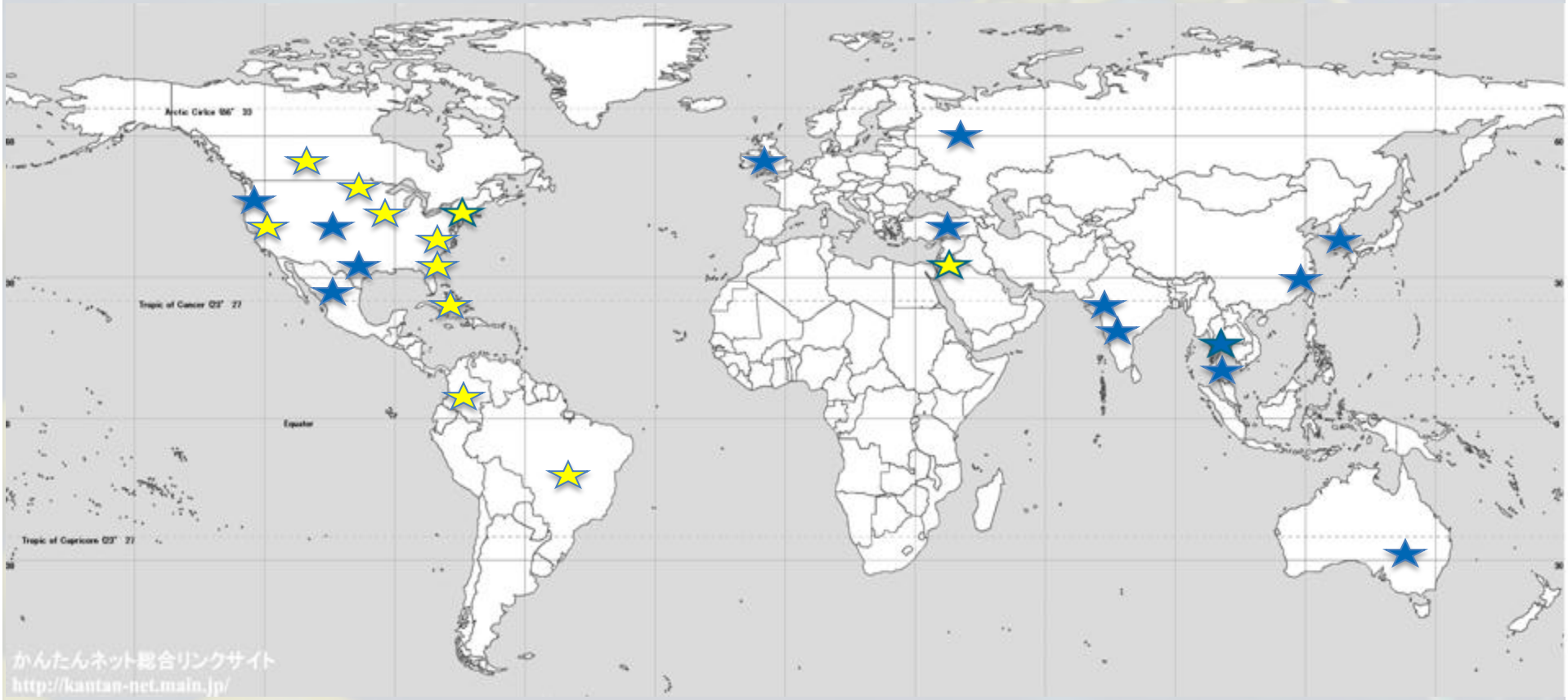


NANOPROFESSOR

Extensive Instructor & Institution Support

Hands-On Lab Experiments

NANOPROFESSOR TOMORROW



SUMMARY

- Nanotechnology National Initiatives and Government Investment
- Benefits of Nanotechnology – General Introduction
- Superior Properties of Nano Carbon Materials and Technologies
- Evolution of Nano Carbon Materials – from Charcoal to Nano Carbon
- Asia is Leading the Adoption of Nano Carbon Materials and Technologies with Strong and Aggressive Government Support
- Smart and Responsible Development of Nanotechnology
  - NanoSafety – Case Studies: Work of Australia and Asia Nano Forum
  - Standardization – Case Studies: Nano Carbon Related
  - Outreach – Case Studies: Iran

Sustainability: Public Private Partnership (PPP)

Role of Govn't	+	Role of Private
Funding Guideline Regulation		Responsibility Transparency

Thanks for Your Attention

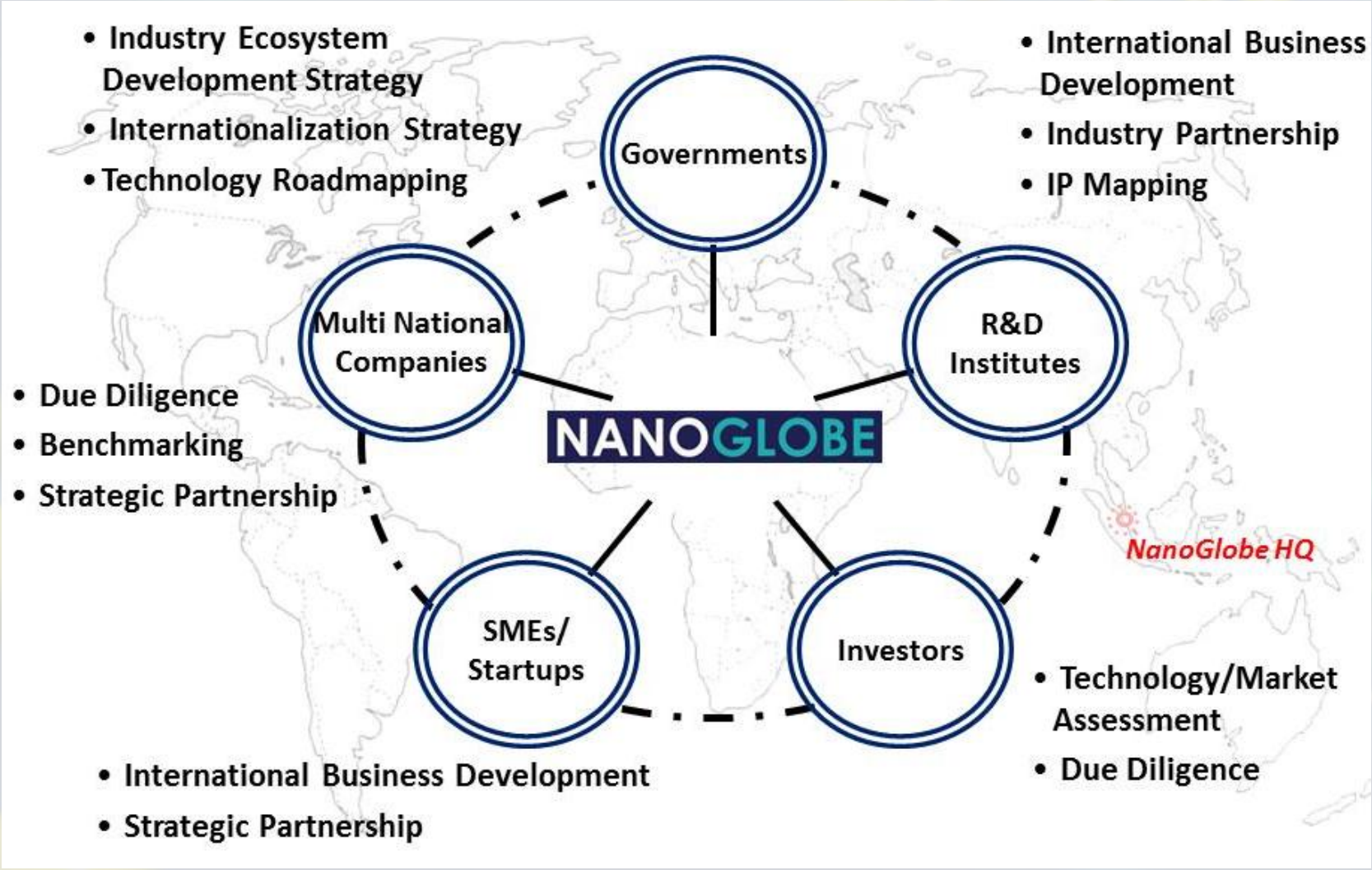
We look forward to helping you connect to Asia Nano Space!

Dr. Lerwen Liu
Managing Director
NanoGlobe Pte Ltd
contact@nano-globe.biz
www.nano-globe.biz

Personalized Intelligence & Business Development Services

NANOGLOBE
NanoTechnology Business Development Consultants

NanoGlobe Connects You to Partners & Opportunities Worldwide



Expertise

NANOGLOBE
NanoTechnology Business Development Consultants

- ✓ Advanced Materials (e.g. Nano Carbon and Its Applications, Composites, etc.)
- ✓ Battery Technologies
- ✓ Membranes Technologies (e.g. Water Filtration)
- ✓ Printed Electronics
- ✓ MEMS
- ✓ Photovoltaic
- ✓ Power Electronics
- ✓ More…