KEMENTERIAN SAINS, TEKNOLOGI DAN INOVASI
MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

Sains & Inovasi Pemacu Transformasi
DEKAD INOVASI 2010 - 2020

NANOMALAYSIA™

Internet of Nano-Things (IoNT): Enabling New Advancement via Nanotechnology

Internet of Things (IoT) Week

Date : 24th – 26th August 2015

Venue : MIMOS Berhad and
Hotel Istana Kuala Lumpur.

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Statement by Prime Minister

"***Nanotechnology development*** *would be given and be made of the resources of the country's new economic model. Thus, it is important for Malaysia to not be left behind in the field of nanotechnology and we have decided to give importance…."*

YAB Dato' Sri Mohd Najib Tun Razak
29 Oct 2009

NANOMALAYSIA™

NanoMalaysia Berhad (NanoMalaysia) was mooted during **National Innovation Council (NIC) meeting,** chaired by the Right Honorable Prime Minister, Y.A.B. Dato' Seri Najib Tun Razak on **14 February 2011.**

NanoMalaysia was then incorporated as Company Limited by Guarantee (CLG) in August 2011 under Section 24, Company Act 1965 to take the lead in **commercialisation of nanotechnology products**

Key functions of NANOMALAYSIA™

- Plan and coordinate the commercialization of R&D in nanotechnology
- Strategize the positioning of nanotechnology industry of Malaysia
- Facilitate investment in nanotechnology commercialization
- Commercialization and development of nanotechnology
- Plan and execute activities that contribute to the development of nanotechnology-based industries
- Facilitate the development of human capital

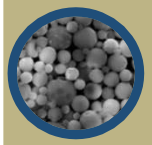
Contents

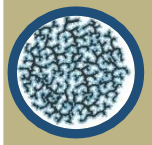
Phase Development of nanotechnology

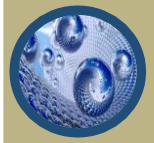
Nanotechnology: *"The application of scientific knowledge to control and utilize matter in the* ***nanoscale (1 nm to 100 nm),*** *where properties and phenomena related to size or structure can emerge."*

2010 — 2020 — 2030 — 2040…

Passive nanostructures (2000-2010)


Nanoparticles


Nanocomposite


Nanocoating

- **Nanostructure materials**

Active nanostructures (2010-2020)


Sensors

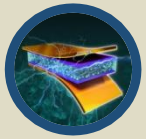

Electronics

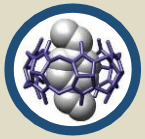

Targeted drugs

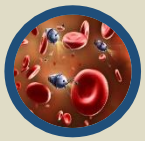
- **Adaptive structures (Nanomaterials & devices)**

Systems of Nanosystems (2020-2030)


3D networking


Advanced materials

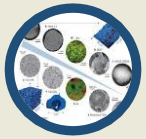

Molecular assembly


Nanorobotics

- **Supramolecules**

Molecular Nanosystems (2030-2040)


Molecules by design


Hierarchical functions

- **Evolutionary nanosystem**

1st Gen

2nd Gen

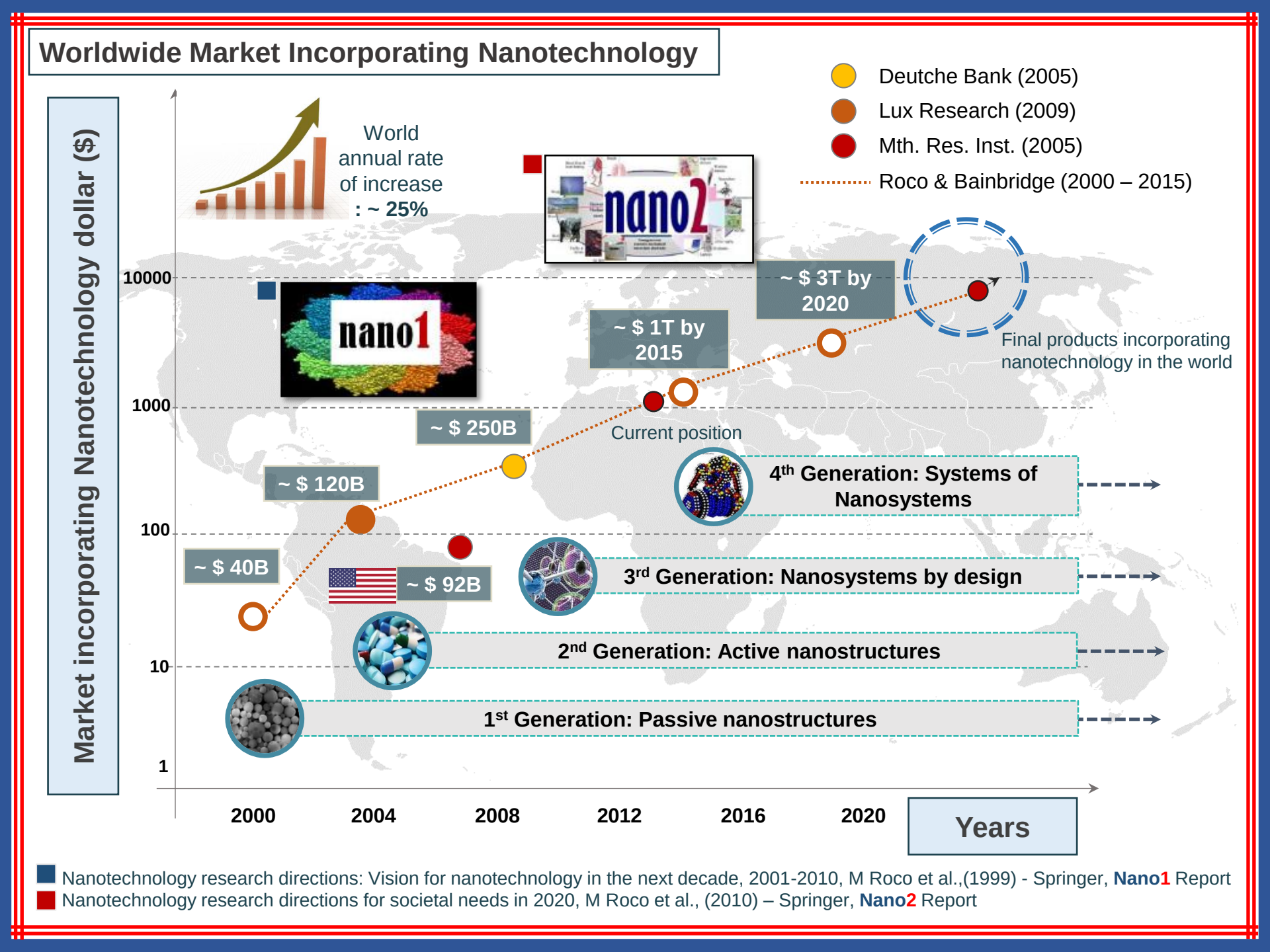
3rd Gen

4th Gen

Adapted from Roco, MC (2004) AI Che J. 50 (5)

ISO/TS 80004-1:2010

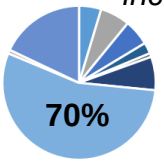
Worldwide Market Incorporating Nanotechnology



Nanotechnology research directions: Vision for nanotechnology in the next decade, 2001-2010, M Roco et al.,(1999) - Springer, **Nano1** Report

Nanotechnology research directions for societal needs in 2020, M Roco et al., (2010) – Springer, **Nano2** Report

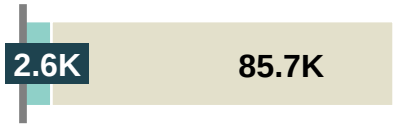
[1] "*The U.S. is once again the leader in corporate nanotechnology spending; increase of 19% 2015 to reach $4.1 billion.*"



VC funding

> $400 million

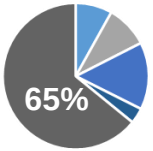
70%: Nanotechnology



[2]

Nanoscale technology impact in 2007 ($M)

Predicted Nanoscale technology impact in 2015 ($M)

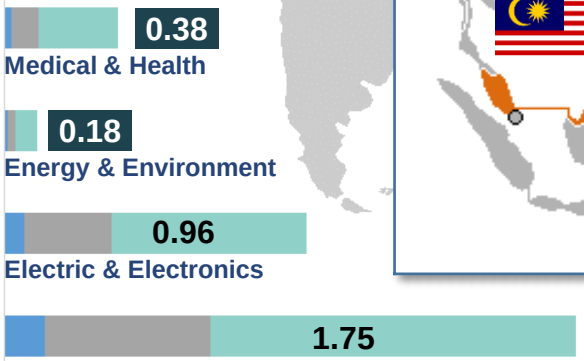


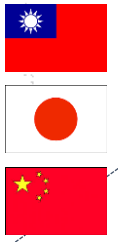
[2] "*Seventh Framework Programme (FP7);The Nanosciences, Nanotechnologies, Materials, and New Production Technologies (NMP) sub-program runs 7 years*"

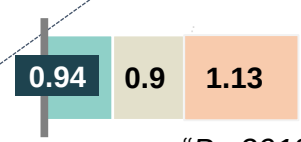
$4.7 billion

65%: Nanotechnology

[1] "*Nanotechnology initiatives and development **in Malaysia are aligned** with the growing global revenues **($ trillions)** of nano-enabled sectors*"







[1] Revenue from Nano-enabled Products by Region (in US$ Trillions)

Europe

US

Asia

"*By 2018, Asia will emerge as a leading producer of nano-enabled products with more than $1 trillion in revenue, compared to in the U.S and Europe.*"

[1] LuxResearch, February 2014

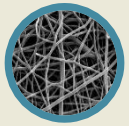
[2] Nanotechnology: a UK Industry View, 2012

Contents

Commercialization through four (4) Jump Start Sectors

1

Food & Agriculture

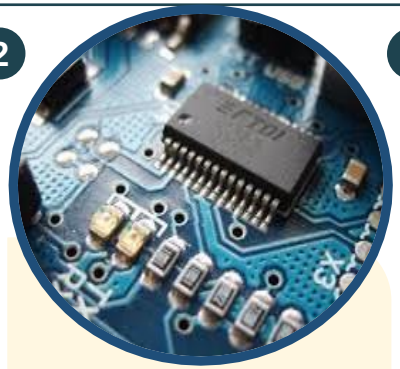


Nanofiber, Nanocellulose
(Forestry Nanotechnology, Filtration system)

Food processing and management
(smart packaging)

Nano-encapsulation, Nanofertilizer
(Bio-active ingredient detection and database)

2



Electronics, Devices & Systems

Nanosensors
(Scalar sensors & system)

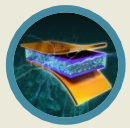
Nanolectronics
(Processors, NEMS)

Nanodevices
(Phones, cameras etc.)

3

Energy & Environment

Li-ion battery anode / ultra-capacitors
(Power system)



Advanced materials
(Nanogenerators, Nanochip)

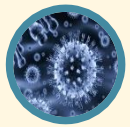
Green energy and power technology
(Sensors for alternative power sources)

4

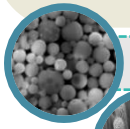
Wellness, Medical & Healthcare

Drug delivery
(Nanomedicine, biosensors)

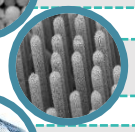
Packaging and systems
(*Nanonetworks for healthcare applications, RFID*)



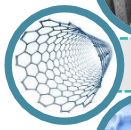
Antimicrobial applications
(Antimicrobial assays)



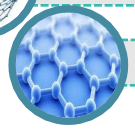
Nanoparticles and Bionanotechnology Platform (wearables development)



Nanowire: electronic devices and sensors



CNT: Nanotechnology engineering and nanocomposite application



Graphene: Nanotechnology engineering and nanocomposite application

Alignment with NKEAs of Economic Transformation Programme (ETP)

ECONOMIC TRANSFORMATION PROGRAMME

1 Agriculture

Food & Agriculture

GNI

Incremental GNI by 2020
RM 29 billion

Additional Jobs by 2020
109,335

EPP Highlights

1 High-value Herbal Products

4 Establishing Malaysia as a Global Biodiversity Hub

2 Electrical & Electronics

Electronics, Devices & Systems

GNI

Incremental GNI by 2020
RM 53 billion

Additional Jobs by 2020
157,000

EPP Highlights

20 Enabling industries through Nanotechnology

7 Increasing solar module producers

18 Enable EV component manufacturing

3 Oil, Gas and Energy

Energy & Environment

GNI

Incremental GNI by 2020
RM 131 billion

Additional Jobs by 2020
52,300

EPP Highlights

10 Building up renewable energy and solar capacity

4 Healthcare

Wellness, Medical & Healthcare

GNI

Incremental GNI by 2020
RM 35 billion

Additional Jobs by 2020
181,000

EPP Highlights

2 Creating supportive ecosystem to grow clinical research

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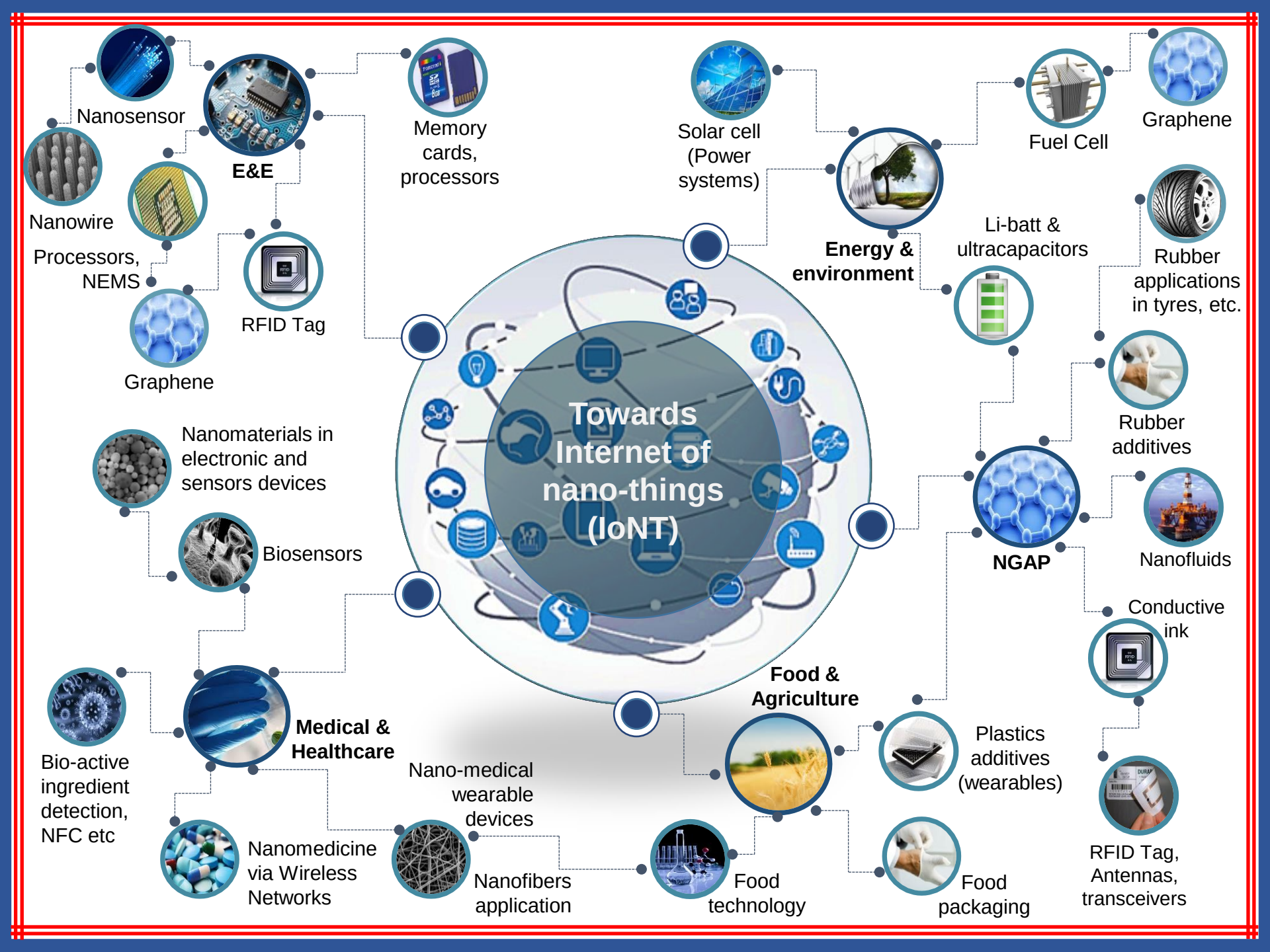
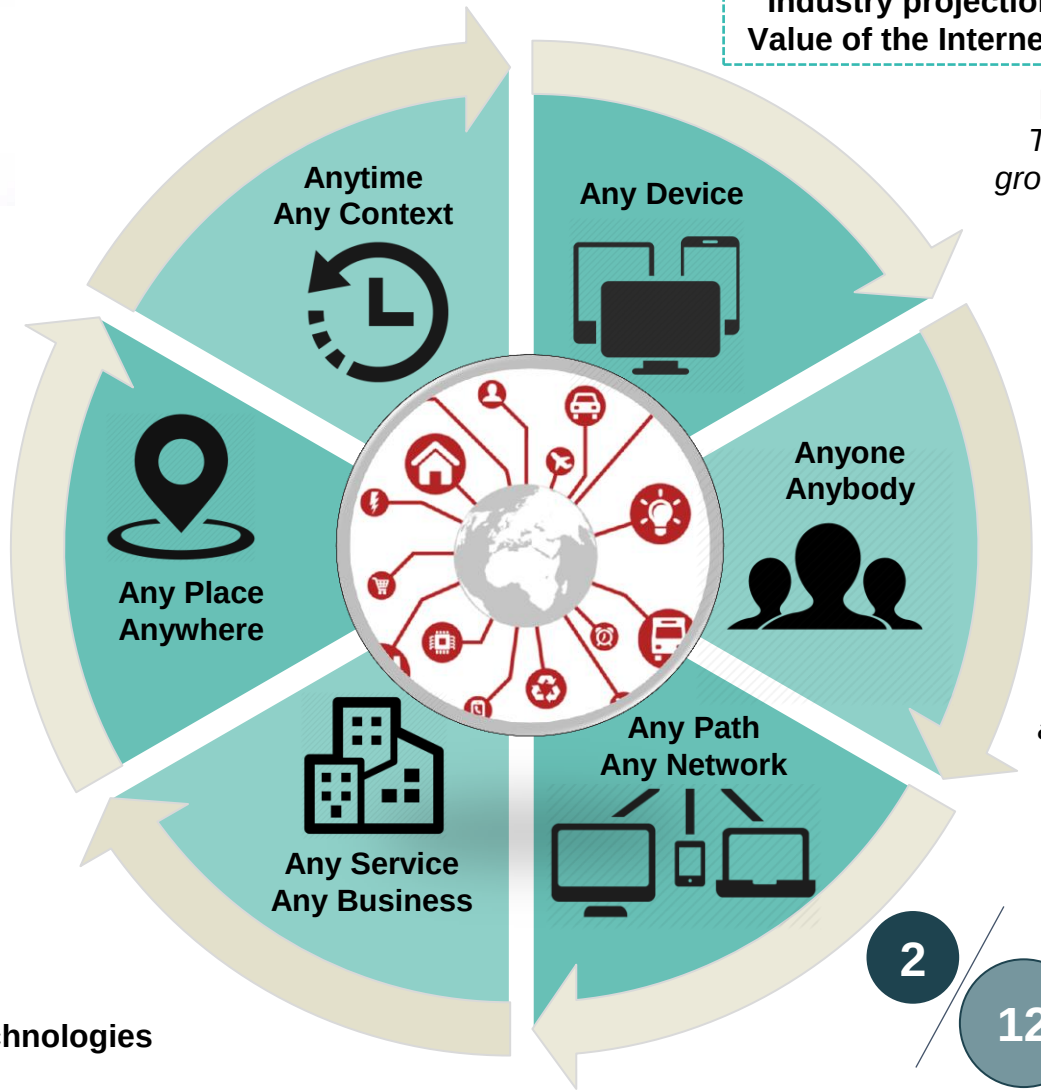

Towards Internet of nano-things (IoNT)
Nanosensor
E&E
Memory cards, processors
Nanowire
Processors, NEMS
RFID Tag
Graphene
Solar cell (Power systems)
Energy & environment
Fuel Cell
Graphene
Li-batt & ultracapacitors
Rubber applications in tyres, etc.
Rubber additives
NGAP
Nanofluids
Conductive ink
RFID Tag, Antennas, transceivers
Nanomaterials in electronic and sensors devices
Biosensors
Bio-active ingredient detection, NFC etc
Medical & Healthcare
Nanomedicine via Wireless Networks
Nano-medical wearable devices
Nanofibers application
Food & Agriculture
Food technology
Plastics additives (wearables)
Food packaging

Internet of Nano-Things Ecosystem and Prospects

The interconnection: New networking paradigm

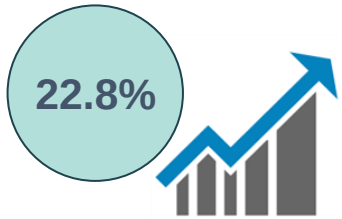
A scalable approach to connect everything

Rapid growth of communication & technologies



Industry projections for Global Economic Value of the Internet of Nano-Things in 2020

[1] "*The Internet of Nano Things (IoNT) is expected to grow from $4.26 billion in 2016 to $9.69 billion by 2020*"



Compound Annual Growth Rate (CAGR) of 22.81% from 2016 to 2020.

[2] "*The Internet of Things (IoNT) and Advanced materials (nanotechnology) are potentially economically disruptive technologies by 2025*"

2

- √ **The Internet of Things (IoT)**
- √ **Advanced materials (Nanotechnology)**

12 **Disruptive technologies by 2025**

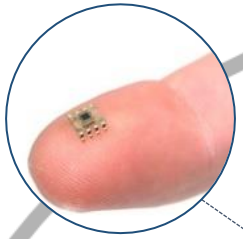
[1] Internet of Nano Things Market, by sectors -Worldwide Forecast & Analysis (2016-2020)

[2] 'Disruptive technologies: advances that will transform life, business, and the global economy', McKinsey Global Institute, 2013

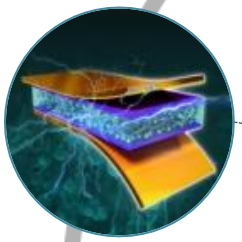
Nanotechnology Attributes
toward Internet of Things (IoT)

Nanotechnology
Driving New IoT Ecosystem

Direct Impacts
of Internet of Nano-Things (IoNT)



Miniaturization
(viable and smaller **sensors, controllers** and **transmitters)**



Highly advance material
(New **technological devices/systems)**

Wider network
(**Increased capacity)**

High performance
(**Faster processors**, better communication medium with **denser memories)**

Towards
Internet of Nano-things
Big Data Analytics

Social

Complex networks
Networking technology captures wider interaction

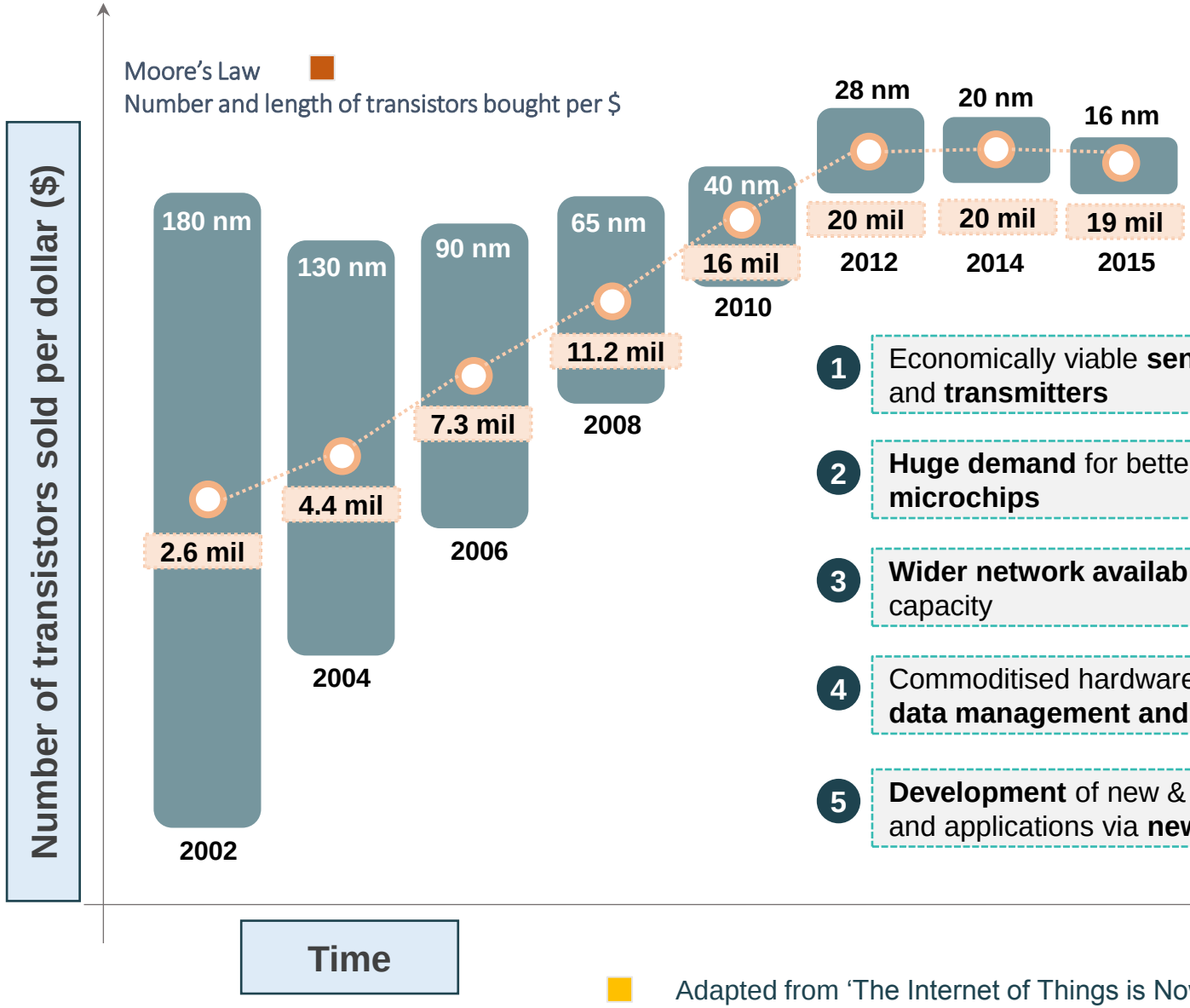
Environment

Waste to wealth
Crafting value and concept toward environmental sustainability

Economy

Full value chain
Social/people economy

Underlying Trends Driving The New IoT Ecosystem.



1. Economically viable **sensors, controllers** and **transmitters**
2. **Huge demand** for better & smaller **microchips**
3. **Wider network availability** and increased capacity
4. Commoditised hardware and cloud-based **data management and storage**
5. **Development** of new & powerful analytics and applications via **new technologies**

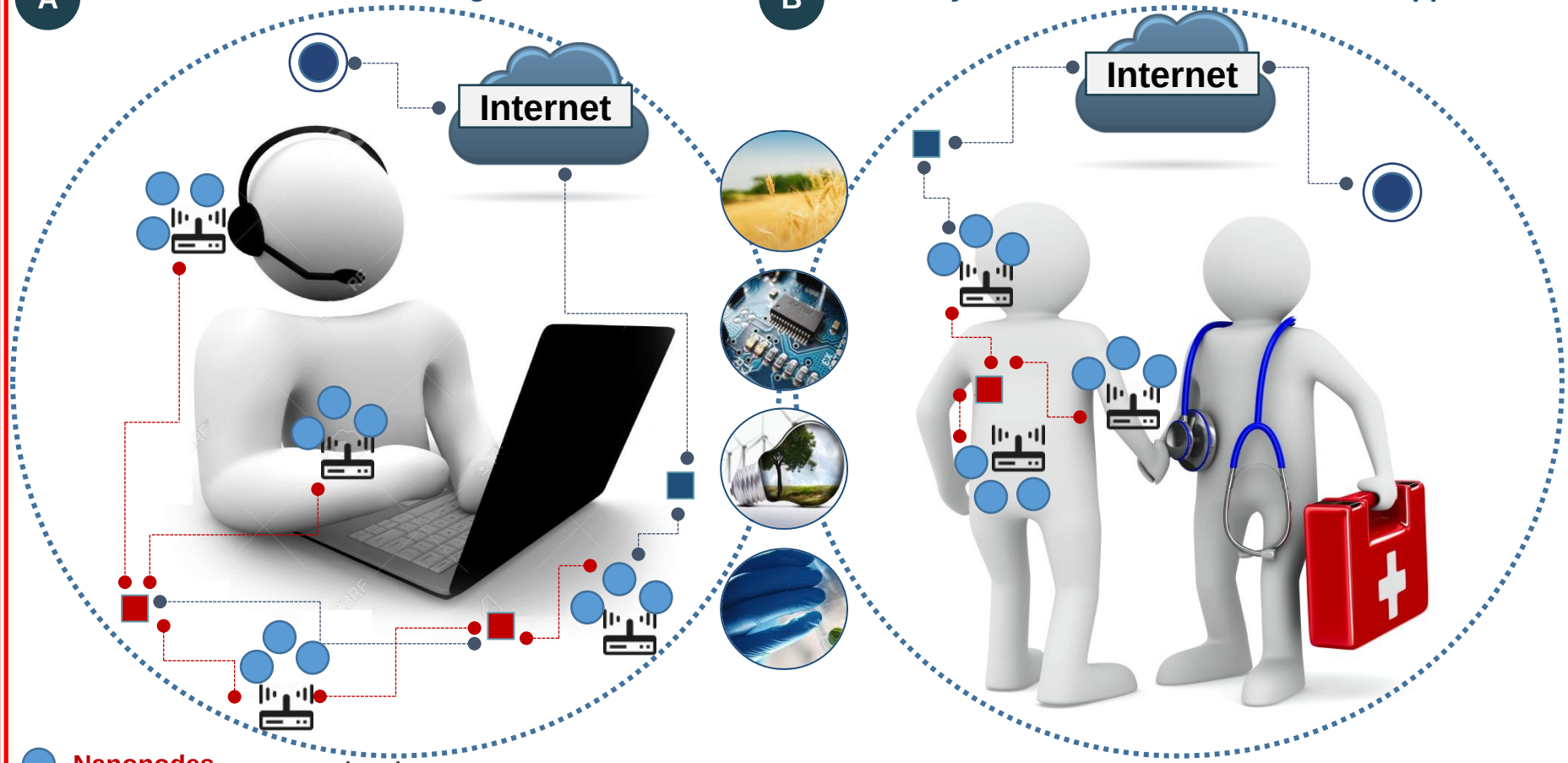
Adapted from 'The Internet of Things is Now', Morgan Stanley, 2014
The Communications Market Report', Ofcom, 2014
http://hexus.net/tech/news/cpu/65901-arm-updates-midrange-cpu-roadmap-cortex-a17/

Contents

Overall Architecture of Internet of Nano-Things (IoNT)

A Interconnected office through network

B Intrabody nano-networks for healthcare applications



Nanonodes
Simplest Nanomachines: able to perform simple computation, limited memory, and can only transmit over short distances

Nano-router
Larger computational resources: suitable for aggregating Information and control by exchanging simple control commands

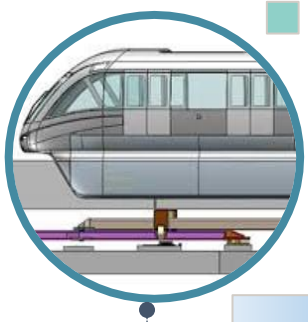
Nano-micro interface
Aggregate the information: converting conventional communication networks.

Gateway
Remote control of the entire system over the Internet: interface in in our body/device to our healthcare/service provider.

Sevice / Healthcare provider
Micro-link
Nano-link

NanoMalaysia IoNT Program 1 : Transportation

NANOMALAYSIA™



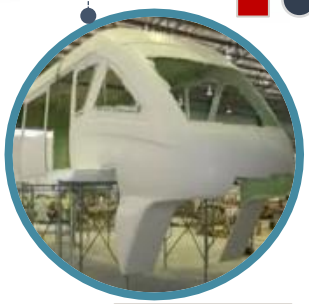
Nanostructured Energy Storage
(Nano Battery/ Ultracap & power monitoring & management system)

Antibacterial Internal Handrail & Seats
(Nano-Anti-microbial technology, nano-silver coating)

Integrated Rail System
(Nano- Electronics & Mechanical system integration & interconnectivity for data management, big data analytics)

Internal Control Network
(Nano-Sensor & signalling system with Nano-Enhanced Electronics)

Rubber Tires
(Nano/Graphene enhanced tires provides lighter and mechanically stronger tires allowing the vehicle to cope with steeper grades, Nano-sensors for tire wear monitoring system)



Exterior
(Nano/Graphene enhanced framework for lightweight rail cars enhanced by Integrated Nano Structural Batteries, Coatings & Performance Monitoring System)

Nano-Solar Powered Station
(Lightweight Nanostructured Light Energy Panels for enhanced power generation)

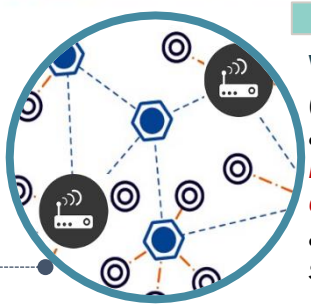
- Internet of Things (IoT) solutions
- Nanotechnology
- Energy & Environment
- Engineering
- Readiness & Applicability (Low – High)

NanoMalaysia IoNT Program 2 : Swiftlet Farming

NANOMALAYSIA™

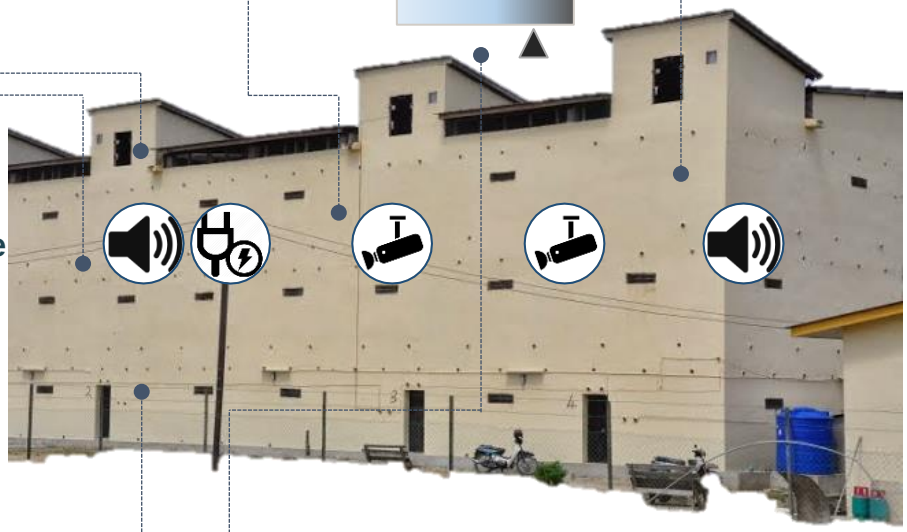
Nanostructured Energy Storage
(Nano Battery/ Ultrcap & power monitoring and management system

Big Data Analytics
(Interconnectivity for remote data access and management. Performance enhancement through nanoelectronics)



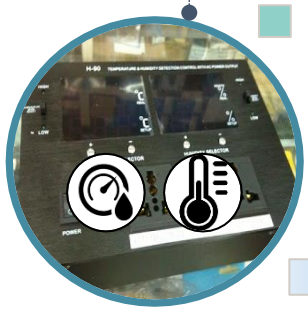
Wireless Network
(System integration application with nano-enhanced electronics to monitor and control the swiftlet habitat)

Internal Maintenance
(Antimicrobial and nano-coating, technology)



- Internet of Things (IoT) solutions
- Nanotechnology
- Energy & Environment
- Engineering

Readiness & Applicability
Low — High



Internal Control Network
(Indoor environmental monitoring through nano-sensor system and close-loop control system)

Nano-Solar Powered System
(Lightweight Nanostructured Light Energy Panels for enhanced power generation)

Exterior
(Nano-coating for exterior protection; outdoor environmental monitoring through nano-sensor system; & RFID tagging for tracebility)

NanoMalaysia's Commercialization Programs

Technology and Business Due Diligence

Nanotechnology landscaping and Business opportunities

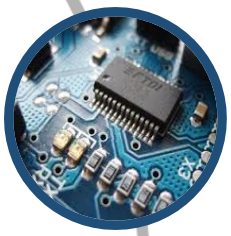
Strategy planning & consulting in commercialization of Nanotechnology R&D

Facilitation of investment in Nanotechnology

Development of human capitals in Nanotechnology

1 iNanovation

Food & Agriculture



Electronics, Devices & Systems

Energy & Environment

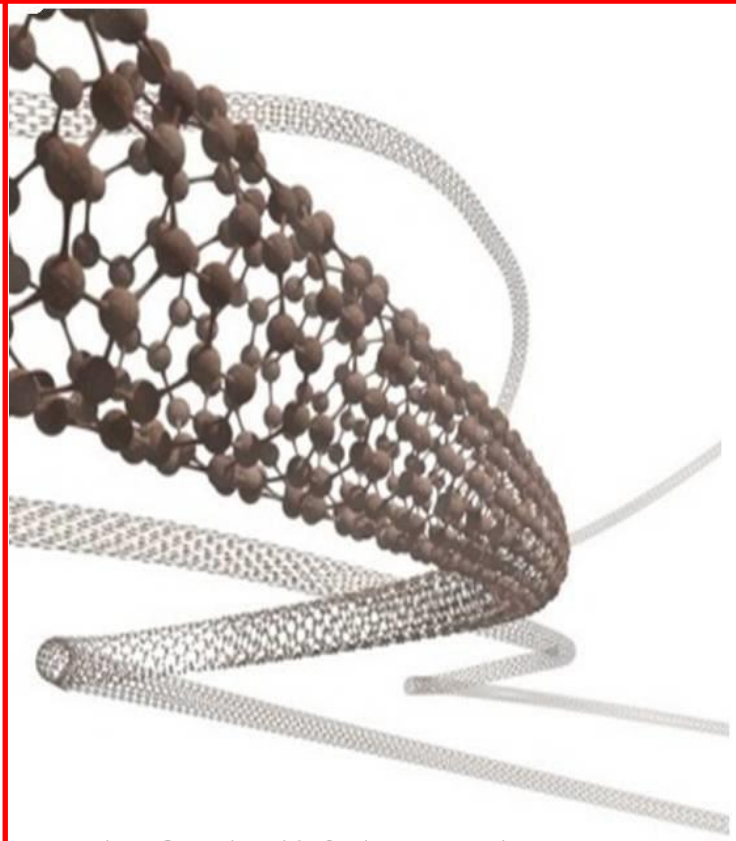
Wellness, Medical & Healthcare

2 National Graphene Action Plan 2020 (NGAP2020)

- Nanofluid
- Plastic additives
- Conductive ink
- Li-ion battery/ ultra-capacitors
- Rubber additives

NANOVerify Programme

Nanotechnology Product and Process Verification and Certification supporting iNanovation and NGAP 2020



THANK YOU

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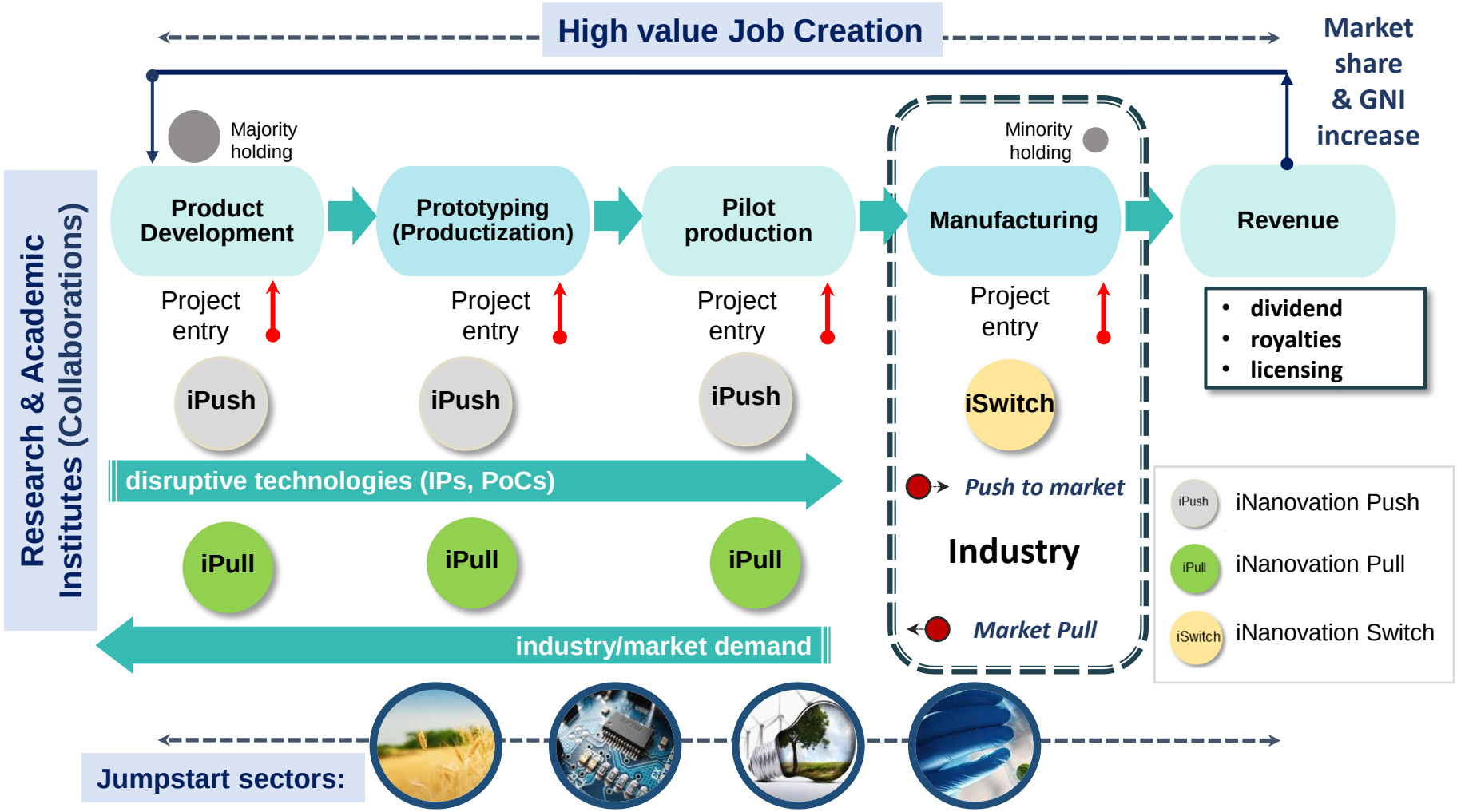
Facebook : www.facebook.com/NanoMalaysiaBerhad
Twitter : www.twitter.com/NanoMalaysia
Instagram : @nanomalaysia #nanomalaysia #nanoforall

Commercialization Program 1 : iNanovation

NANOMALAYSIA™

- **Multiple-helix facilitation scheme** for nanotechnology ventures
- **Interfacing with pre-existing facilities and programs throughout** the innovation value chain
- **Industry-driven incremental** and revolutionary **nanotechnology processes** and **products**



Commercialization Program 2 : NGAP2020 Project Execution

NANOMALAYSIA

- **Focus on downstream applications** when innovating with **Graphene**
- **Priority** on **five applications** areas**;** Based on **technical feasibility, economic viability, time to adoption, relevance and impact to Malaysia (2020 timeframe)**
- **Comprehensive delivery framework** in facilitating and executing projects

Project execution

1 Awareness building & facilitating "projects"

2 Access to R&D funding and prototyping
Facilitate "minority" funding for R&D and required prototyping facilities

3 Information on Graphene supply
Facilitate connection to potential source of Graphene

4 Access to technical experts
Manage & connect companies to expert networks

5 Access to IP advice
Facilitate introduction to IP advisory services for patent application or protection

6 Scale-up support

7 Co-ordination and monitoring

Li-ion battery/ ultra-capacitors | **Conductive ink** | **Plastics** | **Rubber additives** | **Nanofluid**

NANOVerify Programme