Nanotechnology Development in Malaysia: Current Status and Implementation Strategy

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Abstract

Nano-technology development needs all the support it could get to ensure the technology is being leveled up and benefits all mankind. Malaysia has started it own micro-technology and nano-technology development since the early millennium year and arise until this day. Some major plans have proven effective and others may not. This paper will discuss about strategies and practices planned in Malaysia with some relevant finding through experiences in industries collaboration observations and UniMAP involvement in nanotechnology. Some suggestion and ideas are also presented.

Keywords: *Nanotechnology, R&D, Industry, Strategy, Practice, Malaysia.*

1. Introduction

Nanotechnology has becomes a new industrial revolution and many countries are investing heavily in this technology to maintain their market competitiveness. Since this is new yet growing and emerging, there is still a scarcity of research in this, particularly in developing countries like Malaysia. In term of investment amounts, the USA leads other countries by investing USD3.7 billion through its National Nanotechnology Initiative (NNI), followed by Japan with USD750 million and European Union with USD1.2 billion in investment. (source: MIGHT Report, September 2006).

Nanotechnology has caused a stir in worldwide because of its potential. Big countries has invested in nanotechnology and taken a full concern over the development of nanotechnology. Malaysia has to have its own nanotechnology policies and initiative as well as strategic plan to manage the technology, as extensively stressed by the Deputy Prime Minister in his several meetings about this management of nanotechnology (for example: The News Straits Times, 20th of June 2007). To sustain the technology, major agencies are also needed to guide the direction of nanotechnology management. Currently, Malaysia is lack behind in this aspect because of the technology is still new to the Malaysian expertise. The Ministry of Science, Technology and Innovation (MOSTI) oversees the nanotechnology development in this country, and particularly to develop policies, initiatives and strategic plans for nanotechnology.

Malaysia aspires to become a developed nation by 2020. Harnessing the energy and ingenuity of our scientific community is essential for a prosperous and innovative future of Malaysia. The world changes rapidly and dramatically. With these changes, the world becomes all the more connected and integrated, where boundaries no longer exist. Economic growth is being driven increasingly by the application of knowledge and ideas, rather than the production and trade of physical goods.

The start of the 21st century will be remembered as the era in which nanotechnology flowered. We are seeing new technologies, ideas and things emerge in profusion, all of which are destined to bring about big changes in our everyday lives. But let's not forget that the groundwork has to be laid for this flowering of nanotechnology. It was about fifty years ago that the word "nanotechnology" was coined, and the latter half of the twentieth century could be considered as its incubation period. As first described in a lecture titled, 'There's Plenty of Room at the Bottom' in 1959 by Richard P. Feynman, there is nothing besides our clumsy size that keeps us from using this space. In his time, it was not possible for us to manipulate single atoms or molecules because they were far too small for our tools. Thus, his speech was considered at that time completely theoretical and seemingly fantastic. He described how the laws of physics do not limit our ability to manipulate single atoms and molecules. Instead, what was holding us back was our lack of appropriate methods to do so. However, he correctly predicted that there would inevitably come a time when atomically precise manipulation of matter would become a reality.

This is a new field of science and technology where the component parts can be measured in a billionth of a metre. This not only means that complex and sophisticated systems can be incredibly small, but because they work at the atomic scale, new principles of physics apply and novel and revolutionary applications are indeed possible. Nanotechnology is small science with huge and immense potential. Nanotechnology exploits benefits of ultra small size, enabling the use of particles to deliver a range of profound and important benefits.

Nanotechnology is defined as “the science of materials and systems with structures and components which display improved novel physical, chemical and biological properties; phenomena that exist in the nano size scale (1-100 nm)”. A nanometer (nm) is one thousand millionth of a meter. For comparison, a single human hair is about 80,000 nm wide. People are interested at the nanoscale because it is at this scale that the properties of materials can be very different from those at a larger scale. Chemists have been making polymers, which are large molecules made up of nanoscale subunits. (source: NNI Report, May 2008).

The properties of materials can be different at the nanoscale for two main reasons.

- First, nanomaterials have a relatively larger surface area when compared to the same mass of materials produced in a larger form. This can make materials more chemically active and affect their strength or electrical properties.
- Second, quantum effects can begin to dominate the behaviour of matter at the nanoscale particular at the lower ened, affecting optical, electrical and magnetic behaviour of materials.

Nanotechnology includes various fields of sciences which are related to each other as shown in the Figure below. The convergence of various disciplines towards nanotechnology is clearly shown with synergistic effort between the nanoscience and nanotechnology disciplines.

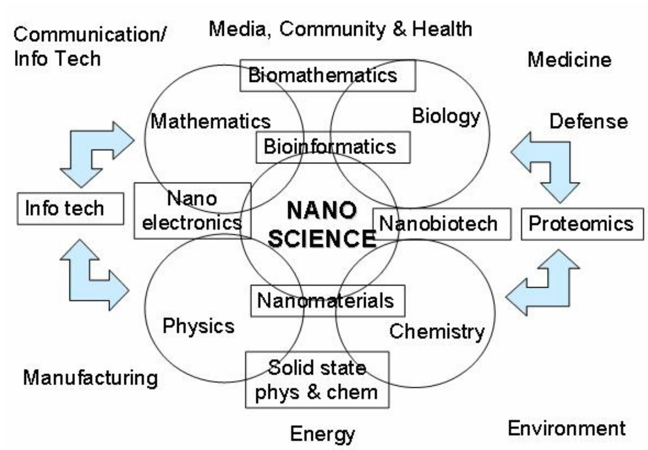

Figure 1: The interdisciplinary field of sciences in Nanotechnology

Nanotechnology is about our future way of life. The worldwide annual industrial production in the nanotech sectors is estimated to exceed USD1 trillion in 10 - 15 years from now, which would require about 2 million nanotechnology workers.

2. The Economics of Nanotechnology

Virtually all industrialized countries have in development or have established a national strategy for nanotechnology. The focus varies from a general science-based strategy (for example the United States and France) to industry relevance-driven strategy (for example the European Community, Korea and Taiwan) from broad spectrum of areas (as in United States, Japan and Germany) to specific strengths. The level of investments in nanotechnology R&D has increased in most countries since 1997 (Table 1). Breakdowns of other APEC economies are given in Table 2.

Table 1: Estimated government sponsored R&D in USD million (Roco, J of Nanoparticle, 2005)

Year	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***
W Europe	179	200	~225	400	650	950	1050
Japan	157	245	550	753	800	900	950
USA	255	270	422	697	774	989	1081
Others	96	110	380	550	800	900	1000
Total	687	825	1577	2400	3024	3739	4081

Table 2: APEC estimated nanotechnology R&D in USD million

Year	***2001***	***2002***	***2004***
China	35.6	35.6	200
Korea	54	142	300

Singapore	7.5	9	-
Chinese Taipei	10	22	110
Australia	15	40	100

Research spending on nanotechnology, mainly within the USA is large and growing as part of a National Nanotechnology Initiative worth approximately USD1000 million in FY2005. The largest US spender on nanotechnology research is the National Science Foundation (USD338 million), followed by the Department Of Defense (mainly the Defense Advanced Research Projects Agency (DARPA)) which is spending around USD257 million in the area. The next biggest spender is the Department of Energy (USD210 million) with the National Institutes of Health spending USD142 million.

Continental European research currently at USD175 million, is on the increase but does not match the level of US investment. Japan also has a substantial research programme funded by government to a level of about USD85 million. Within the UK the Research Councils are starting a number of initiatives in support of building expertise and knowledge in nanotechnology. The Engineering and Physical Sciences Research Council (EPSRC), and the Medical Research Council (MRC) are each already sponsoring a number of related grants together worth more than USD25 million and have both separately conducted 'theme day' conferences in the past year. Furthermore, they together with the Biotechnology and Biological Sciences Research Council (BBSRC) and Ministry of Defence (MOD) are considering sponsoring a small number of nanotechnology Interdisciplinary Research Collaborations worth a total of about USD5.2 million.

In Asia Pacific, almost all countries including Korea (July 2001), China (2002), Taiwan (September 2002), India (2003), Australia (2003), Singapore (2003) and Thailand (2003) have launched their National Nanotechnology Initiative. Asia countries have spent more that USD1.5 billion for nanotechnology development.

3. Malaysia Master Plan in Nanotechnology

Nanotechnology R&D started by government in 2001 and categorized as a Strategic Research (SR) program under IRPA in the Eight Malaysia Plan (8MP) which spans from 2001 to 2005 and funded by the MOSTI.

Malaysian government has taken a serious concern over the development of nanotechnology in the country. In the Third Industrial Master Plan (IMP3) that will span a 15-year period (2005-2020) is reported to recognize nanotechnology as the new emerging field. The Malaysia's National Budget 2006 unveiled the allocation of RM868 million to be provided under MOSTI for R&D. The focus will be on biotechnology, nanotechnology, advanced manufacturing, advanced materials, ICT, and alternative source of energy, including solar, to encourage innovation among local companies and developing new products.

However, the current development of nanotechnology in Malaysia still suffers from some shortfalls such as (Source: National Symposium on Science and Technology):

1. Linkages between the various projects
2. Lacks of central facility
3. No definitive plan to realized and develop nanotechnology industries
4. No clear road-map on nanotechnology R&D
5. Lack of efforts to promote awareness in nanotechnology
6. It should be noted that the important factors in that for further investigation can be categorized as having dedicated or specialized initiatives and plans. Furthermore, dedicated agencies were designed to implement those initiatives and plans.

3.1 Strategic Analysis of Nanotechnology in Malaysia

Table 3 listed strength, weaknesses, opportunities and threats as proposed by Malaysian Industry-Government Group for High Technology (MIGHT) for Economic Planning Unit (EPU), Prime Minister's Department.

Table 3: strength, weaknesses, opportunities and threats

Strengths	***Weaknesses***
▪ Government development policies towards nanotechnology ▪ Government policies in various economic sectors that can benefits from nanotechnology ▪ Political and economical stability and national unity ▪ Availability of research bases	▪ No dedicated policy for nanotechnology ▪ Need for short-term and long-term human resource planning ▪ Lack of private sector participation and investment ▪ Lack of facilities ▪ No world class companies to raise standards
Opportunities	***Threats***
▪ Rapid global development in nanotechnology ▪ Opportunities in nanotechnology outsourcing services ▪ Enhancing products in agriculture, biotechnology, medicine, energy and environment ▪ Potential for technology transfer to provide business opportunities ▪ Better explanation of innovation at the national level through easier access to venture capitals	▪ Continued fragmentation of efforts in research ▪ Potential public perception on risks of the uses of nanotechnology ▪ Young researchers lost via brain drain ▪ China, India are ahead in nanotechnology R&D and businesses ▪ New nanotechnology materials/ products threaten Malaysia's current major exports.

Malaysia has for decades trained scientists capable of contributing to the national development in science and technology (S&T), where some pioneering work in nanotechnology were initiated since the Seventh Malaysia Plan (7MP). Current database indicates that there are about 150 local scientists directly involved in various areas of nanotechnology research.

The Intensification of Priority Research Areas (IRPA) programme of the Eighth Malaysia Plan (8MP), which is administered by MOSTE, identified nanotechnology as one of the 14 research priority areas, and is categorized under “Strategic Research” (SR) (see Table below). The SR projects are for a maximum period of 60 months, with potential for enhancing future competitive socio-economic development or new breakthroughs with commercial potential. Additionally, the projects must be multi-disciplinary, and have industrial linkages, with potential for commercialization.

Table 4: Research categories and its allocations under IRPA; (source: MOSTI (2001))

Research Category	***Allocation (%)***	***Priority Areas (% - Allocation)***
Experimental Applied Research	30	Agriculture and Food Security Natural Resources and Environment Manufacturing and Services Social Transformation Knowledge Advancement
Prioritised Research	35	Manufacturing Plant Production and Primary Products Information and Communication Health Education and Training
Strategic Research	35	Design and Software Technology Nano-technology and Precision Engineering Specialty Fine Chemicals Technology Optical Technology

At the end of Eighth Malaysia Plan, MOSTI has awarded about RM160 million to nanotechnology related research projects. The inclusion of nanotechnology as a priority area under IRPA for 8 & 9 MP is timely, and is poised to position the country in the long term to nurture a nanoscience research culture among researchers, and develop world class nanotechnology laboratories in Malaysia.

The short term strategy of Malaysia is geared towards identifying researchers in various areas of nanotechnology with specific expertise; upgrading and equipping nanotechnology laboratories with state-of-the-art facilities; and to prepare a comprehensive human resource development programme for producing nanotechnologists (Hamdan, 2002, Abd Hamid 2003). MOSTI is now entrusted to spearhead the planning and development of the National Nanotechnology Initiative (NNI).

4. Progress of Malaysian Nanotechnology

Some recent developments of Malaysia in nanotechnology are:

- Establishment of well-equipped nanoscience/nanotechnology research centres, for example: the Ibnu Sina Institute for Fundamental Science Studies (IIS), Universiti Teknologi Malaysia; Institute of Microengineering and Nanotechnology (IMEN), Universiti Kebangsaan Malaysia; Advanced Materials Research Centre (AMREC) of SIRIM Bhd; and the Combinatorial Technology and Catalysis Research Centre (COMBICAT), Universiti Malaya.

- Increased number of postgraduates in nanoscience/advanced materials. The government has introduced the National Science Fellowship (NSF) scheme, which is open to postgraduate studies in nanoscience and technology. There are more than 300 graduate students in the country actively pursuing research in nanotechnology;
- Commendable number of journal publications; Organization of national seminars on nanoscience and nanotechnology, for example, the Palm Oil International Congress (PIPOC), Electron Microscope, Advanced Technology Congress, Green Chemistry, SKAM, etc.;
- Categorization of nanotechnology as a priority area under IRPA of 8MP, where RM1 billion is available to IRPA under 8MP; and 9MP where a total of 2.5 billion is allocated.
- Collaborations with international research organizations.

UniMAP recently has announced it's newly establishment Institute of Nanoelectronics Engineering which will serve as an excellence landmark for the university specifically in the field of nanotechnology engineering research, and will function as one of the regional reference centers focusing in Nanoelectronic Engineering, for the northern Malaysia Super Corridor. This establishment will be in-line with National Nanotechnology Initiative effort. As for the beginning, the Institute will establish five research groups namely nanobiochips, photonics, non-volatile memory devices, novel devices and smart sensor. In addition, its will compliment with the existing nanotechnology research group in the country.

5. Nanotechnology Activities in Malaysia

The potential benefits of nanoscience and technology are pervasive, as illustrated in the burst of interest and effort worldwide in several fields outlined below: materials and manufacturing; nanoelectronics and computer technology; medicine and health; aeronautics and space exploration; environment and energy; biotechnology and agriculture; national security; and science and education.

There are many groups actively involved in nanotechnology R&D in Malaysia. The list is far from comprehensive, as virtually all IHL and GRI are actively engaged in such research. The committed support from the government, seen in the increased R&D funding to MOSTI for nanotechnology R&D, enabled the growth of a significant number of research centers pursuing nanoscience and technology:

- Material and Manufacturing
- Nanoelectronic and Computer Technology
- Life Sciences/Medicine and Health

Conclusions

Currently in Malaysia there are research activities of world class standing being conducted by our local scientists in the universities and research institutes. They are currently working on important areas such as nanostructured mesoporous materials, hybrid catalysts and others. In addition, there are many young Malaysian scientists undergoing post-graduate studies in areas of nanotechnology locally and overseas.

This new wave of industrial innovations requires early integration of science, technology and manufacturing to achieve world class product and services. That means 'skilling up' and improving access to education and training. Nanotechnology is about people. It is about making sure we educate, integrate ideas, technology and knowledge to produce better products with novel properties at the nanoscale which enhances our environment and standard of living.

It is therefore critical that young people and the broader community recognise that nanotechnology-related careers are integral to the development of a successful economic future. Many sections of the community need to understand nanotechnology and the government is keen to ensure that nanotechnology is understood by the society. Pursuing nanotechnology is a global trend and requires global cooperation. We must therefore be integrated into the global nanotech community. In this context, we are honoured to be a network member of the Asia Nano Forum and are keen to work closely with ANF network and contribute to the regional and global advancement in nanotechnology.

Becoming more innovative and creative will ensure that Malaysia not only keeps abreast with the rest of the world, but it will become a global player in nanotechnology that will drive future economic growth. The outcome of many of the nanotechnology endeavours will not happen overnight. Industries must be at the forefront in adopting this emerging technology so that when the time comes, the country is well prepared.

Biographical notes:

Uda Hashim received his PhD in Microelectronic from Universiti Kebangsaan Malaysia (UKM) in 2000. He is a Professor and Head of the Nanoelectronics Engineering Institute in Universiti Malaysia Perlis (UniMAP), Malaysia. He is the core researcher of microelectronics & nanotechnology cluster and also the team leader in the UniMAP Nano-Biochip Research Group. His current research interest includes Research Managements, Nanoelectronics, Biochips, E-Beam Lithography, Photolithography, Nano-structure formation, Semiconductor processing, CMOS process and devices. He has produced more than 30 academic papers in journals as well as conference proceedings worldwide in nanotechnology especially in nanoelectronics related field of research.

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