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# Nanotechnology development in Malaysia: current status and implementation strategy

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## ABSTRACT

*Nanotechnology development offers the promise of advances within and connections across many disciplines-biology, chemistry, physics, materials science and engineering. Determination of the critical success factors in nanotechnology development and industrialization strategy in developing countries is very crucial. Among all the research done, there are several factors that need to be taken into consideration while implying the nanotechnology strategy in developing countries, in which are: Economic and political, human resource, technical issue, operational and financial issue, knowledge and technology partnership.*

**Keywords:** *Nanotechnology, MOSTI, knowledge, nanoelectronics, inter-discipline, strategy.*

## 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

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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.

## NANOTECHNOLOGY DEVELOPMENT STATUS

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):
Linkages between the various projects
Lacks of central facility
No definitive plan to realized and develop nanotechnology industries
No clear road-map on nanotechnology R&D
Lack of efforts to promote awareness in nanotechnology
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.

### Strategic Analysis of Nanotechnology in Malaysia

In final report proposed by Malaysian Industry-Government Group for High Technology for Economic Planning Unit (EPU), Prime Minister's Department. table 1 listed strength, weaknesses, opportunities and threats as proposed by MIGHT report.

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

To enhance development in nanotechnology, it is vital to identify the strengths, weaknesses, opportunities and threats that can influence the strategies and action plans towards achieving success.

Malaysian government has allocated RM868 under MOSTI for R&D scheme which will focus on nanotechnology and other areas such as biotechnology, advanced manufacturing, advanced material, ICT and sources of energy to encourage innovation among local companies and developing new products. The effort is to encourage the private sectors to invest in this new area. On the recent 9th Malaysia Plan, has also stated that nanotechnology will focus on areas with high potential for applications in local industries. The second strength is in government policies in other sectors that can benefit from nanotechnology. Nanotechnology can be applied for value added technologies/products in other sectors in which government has policies sectors such as biotechnology, agriculture, environment, medicine and energy. Malaysia is blessed with the stability in political and economical areas. Both areas are beneficial for attracting foreign investment and business. Among other strength that Malaysia has is the richness in biodiversity and the vast collection of unique flora and fauna found here can be explored and exploited as co-requisites to the development of new

nanotechnology applications that can be applied to biotechnology and agro-based industries. Finally the important of the availability of research base proven to be the strength required to achieve sustainability in the implementation of nanotechnology in Malaysian industries. Several research centers clusters in nanotechnology has provided this country with R&D capability in nanotechnology

Although the government has indicated the efforts to intensify the development of nanotechnology, currently there are no dedicated policies for this area in Malaysia. The lack of dedicated policy affects the private sector in terms of creating a galvanized and focused approach and the private sector participation in term of investment. These are the main important weaknesses identified in the report. Secondly, there is yet no a short-term and long-term definitive plan or clear roadmap on nanotechnology development.

Nanotechnology has been exploited at an accelerating rate, it is likely to develop a new economy as well as creation of wealth and skilled jobs. The opportunities in rapid global development in nanotechnology should be grab by Malaysian government because it is undeniably the potential derives from this technology will be prevalent in many new and improved products. Malaysia can become a niche player in number of outsouring opportunities such as those in the clinical trials market for new drug enhanced with new delivery system. Being a enabling and multidisciplinary technology which includes materials, devices and processing, nanotechnology technological capability helps enhances products in biotechnology, agriculture, medicine, energy and environment. Thus the opportunities are wide open to any possibilities. Further potential opportunities in nanotechnology are global cooperation and partnering. It will enhances knowledge sharing and technology transfer among business partners. As nanotechnology industries involves a magnitude of cooperation and investment, as its application is in various industries and the development provides multiple horizontal and vertical opportunities.

Furthermore the economic potential arising from nanotechnology is tremendous and better exploitation at the national level through easier access to venture capitals

The biggest threats identified in the report are Malaysia is a country with limited resources. With continued fragmentation of efforts in research and clustering, and linking the resources and knowledge of the local researches, industry and government, Malaysia will achieve greater benefits. Second threat of nanotechnology implementation in Malaysia is potential public perception on risks of uses of nanotechnology. Greater awareness and education on biotechnology and fundamental issues relating to nanotechnology should be addressed to change public negative view. The potential hazards of new materials on the environment, human and animal health are the general negative perception of public on nanotechnology. Another threats to be addressed are young researchers lost via brain drain. The opportunities such as modernized laboratories, attractive remuneration packages, and availability of interesting breakthrough programs provided by foreign countries which investing heavily on nanotechnology are luring our researchers. This country need to speed up the efforts in developing

nanotechnology activities and strengthen the scientific and technological capacity. China and India are ahead in nanotechnology R&D and businesses. These two countries already developed a plan to become a forefront player among advanced countries like USA and Japan. This reduces room for a small economy country like Malaysia. New nanotechnology materials/ products threaten Malaysia's current major export. Nanomaterials have the potentials to transform and replace naturals products like rubber. With better properties and performance being developed, in no time nanomaterials will be widely used.

**Malaysia Agencies Involved in Nanotechnology**

Based from MOSTI Report, there are currently 9 existing local research centers in Malaysia. Table 2 lists the research centers and their focus areas:

| Research Centers | Specialiasation |
|---|---|
| Nanochem and Nanophys Lab (IIS-UTM) | Nanocatalyst, nanoelectronics devices, carbon nanotubes, nanostructured materials |
| Universiti Putra Malaysia (UPM): Advanced Material | Nanocomposites, carbon nanotube |
| 3) Universiti Sains Malaysia (USM) Nanomaterials Research | Supramolecules, carbon nanotube, nanocomposites, OLED |
| Medical Biotechnology | Drug delivery systems, sensors |
| 4) Universiti Kebangsaan Malaysia (UKM) IMEN | Nanoelectronics |
| 5) SIRIM (AMREC) | Nanomaterials, processes |
| 6) Universiti Malaya (UM): Combicat | Advanced materials and catalysis, glycolipids and photonics. |
| Centre for Nanotechnology, Precision and Advanced Materials | |
| 7) Universiti Teknologi Petronas (UTP) | Devices and Sensors |

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.

**Nanotechnology in Ninth Malaysian Plan**

Ninth Malaysian Plan highlight to give capacity and capability in key technology areas. Nanotechnology recognizes the potential impact on a wide range of industries. Furthermore, the efforts were focused on capacity building in nanoscience and nanotechnology research. R&D and nanotechnology areas undertaken were related to nanoparticles, micro-matching and fabrication as well as sensors for electronics, communication, automotive and chemicals industries.

During the Plan period, greater emphasis will be placed on targeted R&D to build competence and specialization in technology to build new sources of growth. Nanotechnology is the parts of the focus a priority towards developing a few niche areas. There also including biotechnology, advanced materials, advanced manufacturing, and ICT to generate 300 Science and Technology based companies through public funded and 50 companies with global partnerships. R&D in nanotechnology during this Plan will be focus in areas with high potential for application in local industries. Apart from that, the R&D capacity in nanotechnology will develop a strong knowledge base among researchers to enable them to participate in international and global. So we know the important of nanotechnology in our country and in the world.

Besides that, the former Science, Technology and Innovations Ministry Parliamentary Secretary Datuk Dr Mohd Ruddin Ab Ghani said photonics was expected to take over from electronics or electron-based technology within 20-30 years. So it shown that, the government has support research in the technique of generating energy from photons or light particles known as photonics. Government also takes serious with nanotechnology which will develop our country in globally.

**Strategic Development of Nanotechnology**

Managing the technology needed a strategy to sustain the development of technology. In the previous works done on the technology stategy do not explain the firms strategic behaviour on the programmes. Instead they focused on what technology strategy is and what it composed of. Maidique and Patch (1988) defined technology strategy as a portfolio of choices and plans that enabled the firms to responds effectively to technological threats and opportunities. Technology strategy is describe as the set of strategic decisions and actions

required by managers to transform input into output to achieve competitive advantages (Spital and Bickfords , 1992). Zahra (1994) specifies its components and dominants orientation : it denotes the 'what' aspects of a firm's possible technological actions and choices.

In order to gain significant entry to the markets, the technology strategies in developing countries will have to reflects the trends and meet the priorities found in the developed world; more rigorous quality standards and demanding customers, shorter products life-cycle, greater products diversity, more fragmented markets and environmental consciousness (Shariff, 1997).

## Critical Success Factor of Nanotechnology Strategy Implementation

To determine the nanotechnology strategy in Malaysia, there are several factors that need to be taken into consideration.

### *Economic and Political*

In research by Nasierowski (2000) discussed the limited availability of skilled people as one of the drawback in technological change in developing country. Low level of education may create problem with the absorption and diffusion of knowledge (Nasierowski, 2000), thus the skilled people tend to leave the county and find employment in foreign based or international oriented companies. This situation lead to deep permanent recession to the developing country unable to pay for the skilled people. Shea (2005) has stated that nanotechnology-based innovation will help economic performance, as well as its application will spread through many economic sectors with varying magnitudes and forms of impact on existing firms and industries. Such spread of new innovation is essential for developing countries.

### *Human Resources*

It is increasingly acknowledge that sound human resource practices and the systematic investment in human resource development, have long term organizational and national economic benefits (Horwitz, Bowmaker-Falconer and Searll, 1996). Human resources are important factor to be considered. Lack of effective human resources management can force the most productive employees to leave, taking with them crucial knowledge and experience (Menefee, Parnell, Powers and Ziemnowicz, 2006). Commitment to ongoing training is beneficial for both, firms and employees, without a proper training, an effectively planned implementation is useless (Kearns et al, 2006).

***Technical Issues***

Combining technologies secured from external sources with internal resources can offer radically new products and upgrade existing ones (Zahra et al, 1999). These is the benefits gained from transfer of core technology to acquirer. Technology transfer is a process involving technical, economical, social and political aspect and expected to improve the technological capabilities of the receiver (Putranto et al, 2003).

Robustness of technology would become increasingly important as firms sought to transfer technology to a broader range of applications without adaptation to local conditions. From the study done by Hipkins (2004) this condition permitted competitors to imitate and replicate more easily the competitive advantages held by first mover.

***Operational and Financial Issues***

The costs involved in obtaining an innovative technology is high, usually the capital investment do not instantly contribute to the improvement of performance. Implementation of new changes in operation may cause delays and overrun costs. The important items to be considered are cost of technology and maintenance. Additional hidden cost from implementing new technology typically arose from difficulties in system integration, further training and unexpected maintenance. In selecting new technology it cost a major factors, thus reflects on huge amount of R&D expenditure. (Zahra & Bogner, 1999). Strong R&D investment is crucial in maintaining the modernized facilitilies and internal infrastructure and excellent researchers.

***Knowledge***

The diffusion of intangible knowledge is important in adopting a new technology, however, a low level of education and limited commitment to technology development hamper the efficient absorption and diffusion of knowledge (Nasierowski, 2000). It is believe that the importance of having the knowledge to maximize the potential benefits coming from nanotechnology is crucial in developing countries. In understanding a new technology, the knowledge gained at any one point in times become a foundation for later R&D efforts. Zahra et al (1999) has stated that internal R&D is important because technological knowledge usually develops a path-dependent way, thus allowing the knowledge gained at that time to be used later in cemented the R&D efforts.

***Technology Partnership***

The use of external technology sources such as strategic alliances and licenses to augment a firms own R&D efforts (Foo & Foo, 2000; Zahra & Bogner, 1999).

Strong R&D investment in maintaining the internal infrastructure, modernized facilities and excellent researcher are important. Internal R&D also ensures the ventures ownership and controls of key knowledge, giving the ventures the ability to profitably exploits its technological development and built the proprietary research platforms that lead to future success (Zahra et al, 1999).

## CONCLUSION

Nanotechnology in Malaysia is still in its infancy stage. With the abundance source, little knowledge and scarcity nanotechnology experts and research on the related areas, Malaysia still in a long way to become one of the strongest key player in Nanotechnology.

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Uda Hashim received his PhD in Microelectronic from Universiti Kebangsaan Malaysia (UKM) in 2000. He is a Professor and Head of the Nanotechnology 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.

## REFERENCES

[1] The Malaysian Industry-Government Group for High Technology (MIGHT). (2008). http://www.might.org.my/news.php?id=153

[2] The Malaysian Industrial Development Authority (MIDA). (2008). http://www.mida.gov.my/beta/view.php?cat=3&scat=6&pg=130

[3] National Nanotechnology Initiative. Unit of Computational Chemistry, UTM. (February 19. 2008). http://www.nano.gov.my/?National_Nanotechnology_Initiative

[4] Eighth Asian Bioethics Conference (ABC2007) concurrent with the Second UNESCO http://www.unesco.org/wfeo/tffinal.pdf

[5] Bangkok Bioethics Roundtable (BBRT2), (2007) http://www.eubios.info/EJAIB52007.pdf

[6] Casper and Murray, (2005). Careers and clusters: analyzing the career network dynamic of biotechnology clusters. Journal of Engineering and Technology Management. v22 i1/2. 51-74.

[7] Foster, (2006). Nanotechnology: Science, Innovation, and Opportunity. Pearson Education, NJ.

[8] Franken et al., (2005). The citation impact of research collaborations: the case of European biotechnology and applied microbiology (1988-2002). Journal of Engineering and Technology Management. v22 i1/2. 9-30.

[9] Kinsler, M., (2006). ttp://www.marksclerk.com/attorneys/Nanotech.htm.

[10] Shea. (2005). Future management directions in nanotechnology: a case study. Journal of Engineering and Technology Management. v22. 185-200.