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# PATENT PROTECTIONS, CHALLENGES AND APPLICATIONS OF NANOTECHNOLOGY

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## ABSTRACT

*The primary focus of this paper is to highlight the importance of nanotechnology in terms of patents, challenges and applications. The nanotechnology has become a "key value driver" and significant role in the modern economy. The study contains an extensive review of existing literature related to patent issues, challenges and applications of nanotechnology. One of the challenges is when a nano-based product or process been recognized as a viable patented product. Chances for the patented nano-based product to be marketed is comparatively high as compared to non-patented product. It carries the weight as a high quality product, new, has better requirements, and can be very practical to be used. Patenting is a useful tool to protect its inventor, especially in an industry such as nanotechnology that is constantly producing new findings that eventually lead to the generation of commercialized products. Manufacturers of nano-based product often see the process of filing a patent is time consuming, yet once being granted, the effort would be very much worthy. It is timely to consider issues pertaining nanopatenting as a main feature among various parties involved for farecasting a better solution for the betterment of mankind. Authorities should grab opportunites related to nanotechnology and treat it as a new source of wealth combined with the protection provided by patent. Suggestions and recommendations are elaborated in details.*

**Keywords:** *nano category, nanotechnology, patent, intellectual property rights*

## INTRODUCTION

The prominent term of "nanotechnology" is being defined as entities that cover a geometrical size of at least one functional component below 100 nanometers in one or more dimensions susceptible of making physical, chemical or biological effects available which are intrinsic to that size. It covers equipment and methods for controlling analysis, manipulation, processing, fabrication or measurement with precision below 100 nanometers. This definition is being used by the European Patent Office (EPO). At the same time, this definition reflects its own character of being a bridging technology (Preschitshek *et al*.,2010). The source of nanoparticles or nanocrystals came from metals, semiconductors, or oxides which drives the the main interest of scientist and manufacturers for their unique composition of its

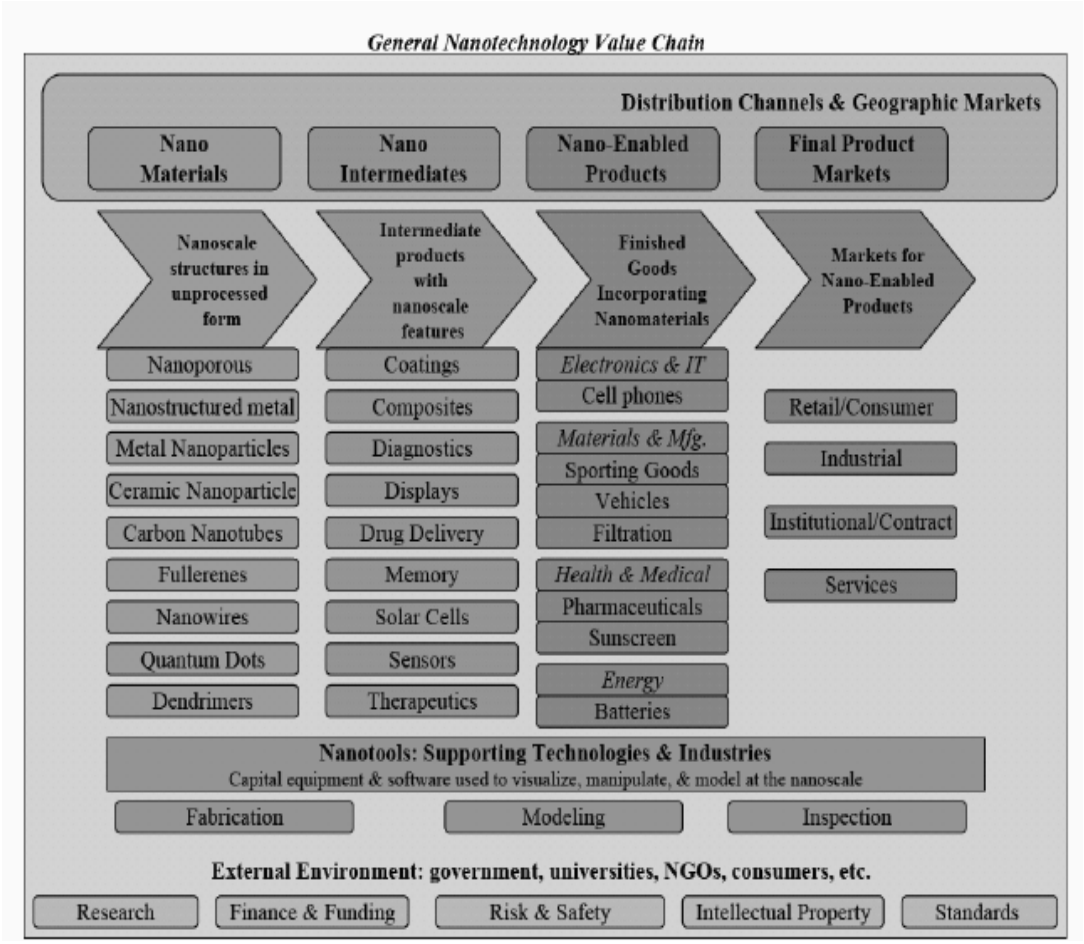
mechanical, electrical, magnetic, optical, chemical and other properties. It has been widely used as quantum dots and as a chemical catalysts such as nanomaterial-based catalysts (Buzea *et al*., 2007). Nanoparticles managed to get great attention among scientist due to its unique characteristics that able to link between bulk materials and atomic or molecular structures. Bulk materials have its own identifiable physical properties but when in nano scale, the physical properties cannot be identified (Hersam *et al*., 2012). Evolution and presence of nanotechnology created opportunities for new industrial applications with supports from the technological innovations. In addition, the convergent character of nanotechnology is spelled out. Some nanotechnology innovations are being utilized among various scientific disciplines and industry application fields. With the acceptance of the community, the situation leads to the fusion of nanotechnology and adjacent scientific disciplines, like modern biotechnology and information technology (OECD, 2009). The major impact of nanotechnology was derived from its various implications and applications in very different industries, ranging from manufacturing over life sciences to traditional industries like electronics or textiles (OECD, 2009). The success or failure of innovation in nanotechnology commercialization can be determined through the high quality of patents and licensing agreement (Frederick, 2009).

With the rapid technological advancement, it can be seen that nanotechnology may further maturing and the promised breakthroughs increasing. In this case, patents are forecast to generate more licensing revenue, provide more forces in deals and mergers, and reduce the likelihood of infringement (Bastani *et al*., 2003). It is estimated in 2014 that more than 2.6 trillion dollars will be spent for new products including nanotechnology product in one form or another. This number is said to be around 15% of the total global output. Even from now onwards, it is forecasted more than 300 nanotechnology based products has been in the marketplace (Nanotech Project, 2007). Other major constraints when dealing with nanotechnology patenting is the strong tendency of so many unknowns which in the long run creates many risks associated with it. To overcome this scenario to happen, providing a patent portfolio is the common action done by any companies for their business to move further (Wartburg & Teichert, 2008).

According to Nantechnology Researchers Network Center of Japan (2006), there are four world' largest patent organizations; (i) the Japan Patent Office, (ii) the U.S. Patents and Trademark Office, (iii) the European Patent Office, and (iv) the World Intecllectual Property Organization (WIPO). However, with advent and complex technologies arise, more innovations are coming from nanotechnology continuosly. Thus, with capacity of patent offices presently are not sufficient to manage and control the diversification all over the world. They have lack of examiners with nanotechnology expertise needed in various areas (Gosain, 2005). In addition, there is a concern as to whether patent examiners are capable of examining these multidisciplinary technologies.

As overall patent types are categorized by nine technology area (*See* Table 1). Meanwhile, for companies to sustain and develop a strong patent, it is advisable for them to patent along the entire nanotechnology value chain (Wild, 2003; Frederick, 2009). These patent could be among the nine nanotechnology category as described in Table 1. Therefore, understanding the whole concept of value chain might help

companies to get a comprehensive view of the geography and activities of stakeholders involved from taking a good or service from raw material to production, and then to the consumer. Value chain mapping involves activities internal (firms) and external (business and sector-specific environment) to the chain, and is represented in graphical form (Frederick, 2009). Figure 1 below shows the importance of intellectual property rights being the external environment that has a significant impact towards the survival of the nanotechnology invention and innovation.




Source: Frederick (2009)

**Figure 1**
General Nanotechnology Value Chain

The first element, to evaluate the strength of a patent is whether the patent can be defended. It is best for a start-up company to concentrate on building a patent portfolio that can be defended based on its process, tools and applications. If the patent can be traced back according to the chemical processes and physical structures, then this will indicate more value to the patent portfolio (Frederick, 2009). The second element to evaluate the strength of a patent is regarding the availability for inventing-around. In general, nanotechnology patents have the highest tendency to invent around, since there are so many ways to do the same thing.

**Table 1**
Nanotechnology Patent Category

| Classification Number | Technology Area | Technology Content (Examples) |
|---|---|---|
| 1 | Materials | Catalysts/Carbon/Organic/Metals |
| 2 | Medicine/Life Sciences | Cosmetics/Biodegrable/Cancer |
| 3 | Electronic Devices | Semiconductor/Silicon/Quantum |
| 4 | Information/Communication | Signaling/Quantum Computers |
| 5 | Optoelectronics | Microstrucrure/Microlens/Silicon |
| 6 | Measurement/Testing | Nanocrystal Index/Gene Sequence |
| 7 | Environment/Energy | Water/Wastewater/Sewage/Sludge |
| 8 | Processing | Separation/Processing/Manufacturing |
| 9 | Printing/Photography | Nano Thickness/Electronic Photograph |

## LITERATURE REVIEW

The word patent originates from the Latin “patere”, which means "to lay open".The first patent statute was promulgated in Venice, Italy in 1474. It is comes from England brought by immigrant which is in that time no uniform patern system was yet implemented. In modern practice, the term patent usually refers to the right granted to anyone who invents any new, useful, and non-obvious process, machine, article of manufacture, or composition of matter (Bawa, 2004). Nowdays, most of the property have their own patents,trademarks,copyrights and trade secrets which is this property will be a legal document granted by the federal government so the other inventors exclude to promulgated the patent. However, not all the property can be patentable because they must meet the following criteria (*See* Table 2).

**Table 2**
Patent’s Criteria

| | |
|---|---|
| 1 | It must be novel; |
| 2 | It must be non-obivious to a person with knowledge in the field related to the invention, meaning that the person would not automatically arrive at the present invention from a review of existing ones; |
| 3 | It must have utility; |
| 4 | It must be adequately described to the public in order to demonstrate “possession” of the invention at the at the time of filling; and |
| 5 | It must enable a person with knowledge in the field related to the invention to make or carry out the invention without “undue experimentation”. |

Source: Nanotechnology Law and Business (2004)

In the case of nanotechnology scenario, products as an outcome of nanotechnology innovation are rapidly being commercialized. If the quality of nanotechnology patents and licensing agreements improved accordingly, this will become more

significant in determining the success of commercializing nanotechnology innovation. In theory, the patent system is geared towards providing 'technology-neutral protection' to all kinds of innovation (Lemley & Burk, 2003). Apart from that, the great primary challenge in relation to the quality of patenting of nanotechnology stem from the persistent of nanotechnology. It also derives from the complexity of the union of the multiple scientific and engineering disciplines that come together within nanotechnology-related patents (Featherstone & Specht, 2004).

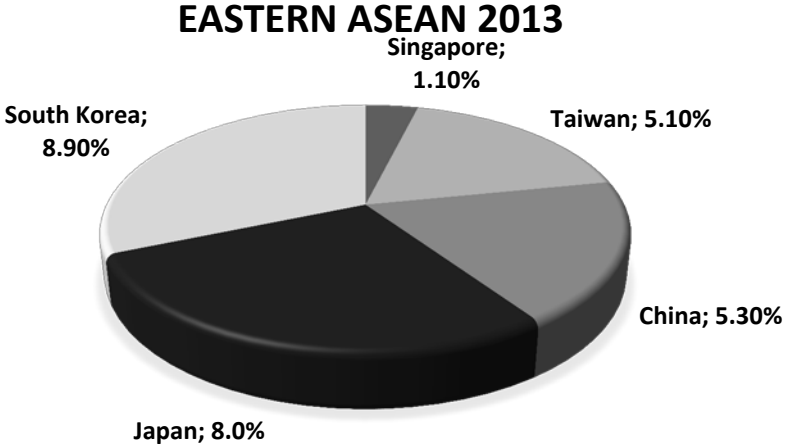
Discoveries on the commercialization of nanotechnology products to protect financial gains can be made by entrepreneurs and companies using intellectual property especially patents. Knowledge on Patent Landscaping is necessary for industry practitioner because patents can become as the most reliable source of information about a particular industry. Data gathered from patents are structured, comparable, objective and information rich. Description on information for technology, inventors, linkages to other fields are being provided. It provides practitioner to define your technology space. As an example, a simple search for patents 'silicon device' returns 671,882 patents showed how extensive silicon device in the current market and show direction where and what is not being explored in detail yet (Iliev, Tannock, & Jain, 2010).

There are also uncertainty pertaining nanotechnology filed patents. Even there has not been any patent wars in nanotechnology, a lot of prevalent fear that overlapping intellectual property exists. It creates risk of failing in legal battles in future for nanotechnology patent due to inability of the company to assure freedom of the said nano product. This involves inability to control enough of the IP load from material synthesis to application to integration (Crawley, Koponen, Tolvas, & Marttila, 2012). There is a growing concern among industry players, academics, business societies, and many others about the field of nanotechnology particularly on its intellectual property landscape. It has its own big impact due to its tremendous development based on evolution on technological discovery in the future. According to Bawa (2004), nanotechnology implementation in the next decade, with the field maturing and the promised breakthroughs accruing, patents can generate licensing revenue, provide advantages in deals and mergers, and reduce the likelihood of infringement. Needless to point out, one cannot deny that nanotechnology patents still have its important feature of behaving as a security instrument for tomorrow's financial and strategic business objectives (Pal, 2012). In worldwide of patenting implementation, there are over 1,200 companies have develop application in nanotechnology. Among of these companies are 3M, DuPont, GE, Sony, Samsung, IBM, Intel and others. As overall, there are nine category of nanotechnology but the huge market potential lies in three major areas (Gosain, 2005);

i. Medical applications – miniaturized dianostics, nano implant, nano-based coatings, biocompatibility of implants, sustained-release delivery systems, nanoparticles, cytotoxins and others;
ii. Information technologies – data storage, nano high densities technology, flexible plastic displays, and others; and

iii. Materials sciences – nanoparticels, nano-based te4chnology in cosmetics, reinforcing materials, nano-structure and others in marine, aeronauticals and space industries.

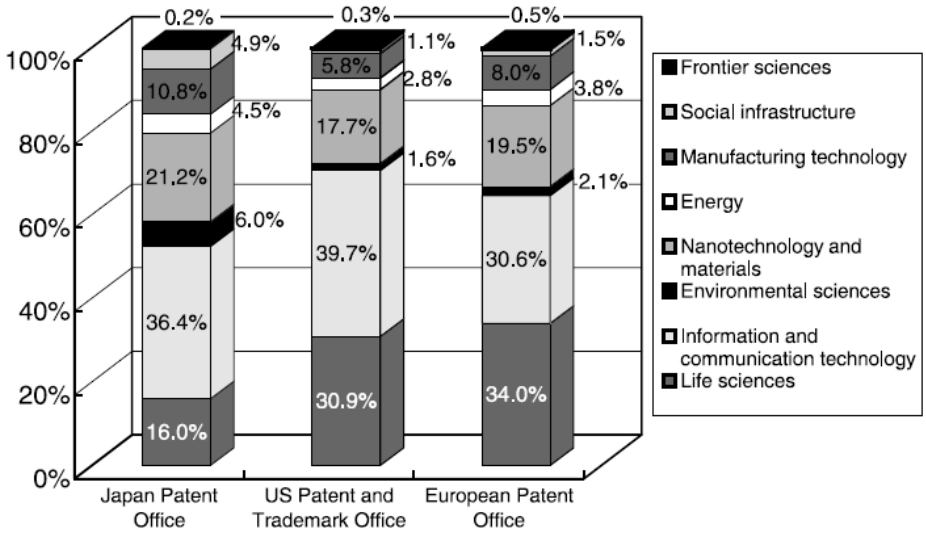
When this occurs, it is critical for doing the valuation know-how of nanotechnology patents especially in deal making and implementing new innovation. As to what is happening now in the market, innovative products have nanotechnology-enabled products which also consist of a multitude of patented technological components. These components come from different stages in a value chain and also belong to a various owners (Wartburg & Teichert, 2008). The patent is obtained through a costly and lengthy process. In Europe, Japan and the Asia Pacific, the "first to file" system applies. Whereas, in the United States, the principle of "the first to invent applies". However, a patent application must be filed within one year of first offer for sale of the product or the patent filing will be void (Bastani *et al*., 2003). For an individual country, the U.S. maintains its dominance observed in previous years with about 54% of the nanotechnology patent literature published in 2013 being assigned to U.S.-based entities, followed by South Korea at 8.3%, Japan at 8%, and Germany at 5.8% (*See* Figure 2). To maintain their market competitiveness, this country are investing heavily in the nanotechnology as a new industrial revolution. Malaysia also not an exception in this leading nanotechnology. By year 2020, Malaysia through their NanoMalaysia program development will expect to contribute 1% to 3% to the gross of economic income. To achieve the technology contribution, Malaysia needs more agencies to lead and guide the development of technology and also to patent any kind of new discovery. Presently, Malaysia is still lack behind the technology achievments and because of that, the respeonsible public agency which is Ministry of Science, Tecnhology and Innovation (MOSTI), they will attempt to develop the new competitive policies, initiatives and strategic plans for the development of nanotechnology.




Source: McDermott Will and Emery, (2014)

**Figure 2**
Nanotechnology Patented Contribution in Eastern Asean

In the United States, the new regulation has stated that "First to File" system has been practiced to replace the previous "First to Invent" system. The new system emphasis from the date it was invented to the date its inventor dropped an application at the patent office. It is been more accurately termed as "First Inventor to File" (Hurst, 2011). Patent also can be used as bargaining chips to cross-license other proprietary technologies. It is understood that the huge amount of money invested for company startups came from the expenditure of intellectual property. Nanotechnology industry analyst forecast that long awaiting and costly patent litigation battles could have some effects in creating conflicts in the near future (ETC, 2005).




Source: Japan Patent Office, (2006)

**Figure 3**
Nanotechnology Patented Contribution in Japan, US and European

The development of nanotechnology are coming from three main sources namely; the government, private companies and the public and private universities (or other research centers). Table 3 presents the among the top 15 nanotechnology providers in various source, country, and sector in year 2011 (Jordan *et al.*, 2012).

**Table 2**
Nanotechnology Providers

| Providers/Organizations | Country | Sector |
|---|---|---|
| Samsung | South Korea | Computers/Electronic |
| IBM | U.States | Computers/Electronic |
| Hon Hai Precision Industry | Taiwan | Computers/Electronic |
| University of California | U.States | Government/University |
| Tsinghua University | China | Government/University |
| 3M | U.States | Consumer Product |
| Massachusetts Institute of Technology | U.States | Government/University |
| GeneASys | Australia | Healthcare |
| Xerox | U.States | Computers/Electronic |
| DuPont | U.States | Chemical |

| | | |
|---|---|---|
| Micron Technology, Inc. | U.States | Computers/Electronic |
| Atomic Energy & Alternative Energies | France | Energy |
| BASF | Germany | Chemical |
| General Electronic | U.States | Energy/Healthcare |
| National Center for Scientific Research | France | Government/University |

## NANOTECHNOLOGY CHALLENGES IN PATENTING

In advent of technology achievement, more complex technologies are emerged in the marketplace. Such technologies like biotechnology, computer software, data storage, computer implemented inventions and quantum mechanics, medical innovations, marine, aeronauticals and space industry, are require some specific patent examining guidelines in the respective area (Gosain, 2005). However, there are specific bodies that regulate the nanotechnology patents such as Japan Patent Office, US Patent and Trademark Office and European Patent Office, anyway all these offices are located at develop countries inclusing Germany, France, China and South Korea. To developing countries like Brazil, Mexico, Argentina (and others Latin America countries), Asian countries (*i.e.*, Indonesia, Brunei, Vietnam etc), and African countries (*i.e.*, South Africa, Morocco, Eygpt, etc) are still struggling to draft and obtain approval on nanotechnology guidelines and patent applications.

According to Bawa (2004), there are two main issues related to nanotechnology patenting;

i. Lack of a Technology Center – Insuffient of technology center that producing or using the nanotechnology in products or services. Also that technology center suppose to be a center of pooling all surrounding of small or micro technology from smaller industries; and

ii. Lack of a Classification System – there are different codes, classification or categorization of nanotechnology developed by different authorities worldwide.

In addition, there are more challenges of nanotechnology from dominant development trends such as (Mihail, 2011);

i. Development of single nanoscale of component into creating on active, and complex nanosystems;

ii. Development from specialized or prototype research into more advance materials, nanostructured chemicals, electronics, and pharmaceutical products;

iii. Development of nanotechnology for new demanding areas such as food scarcity, energy renewable, nanomedicine and engineering simulations and other direction of expected solutions needed; and

iv. Development of nanotechnology areas that need to be commercialized, well-institutionalized in programs and courses at public universities and research centers.

On the other hand, patent application for some areas of nanotechnology also rise at more rapid rate. This is because more and more manufacturers are expanding their R&D departments to innovate products with nanotechnology application. For example, a product called "GuardIN Fresh". This product provide farmers, distributors, retailers, and consumers with value-added packaging solutions that reduce waste, extend shelf-life, and greatly improve the taste and appearance of fresh produce. Other example is "LiteWire", it is a carbon nano-tube conductor in wire form. The LiteWire is a direct replacement for copper wire. It also replaces any other metallic conductor used today. Therefore, patent offices around the world at the moment are struggling to evaluate and prosecute nanotechnology patent applications. An enormous applications makes the patent offices have overburdened responsibility as it attempt to manage them at fast rate. They also need to differentiate and to categorize a wide range of nanotechnology areas such as "nanoscience", "nanomaterial" or "nanotechnology".

## NANOTECHNOLOGY APPLICATIONS

Presently, nanotechnology areas have been recognized by wide range of consumers. They are better in choosing products or services that make use of nanotechnology. Nanotechnology is helping to considerably improve, even revolutionize, many technology and industry sectors such as information technology, energy sector, environmental science, medicine, homeland security, food safety, and at least the transportation, and among many others. Described below is a sampling of the rapidly growing list of benefits and applications of nanotechnology;

i. Nanoscale additives in polymer composite materials for baseball bats, tennis rackets, motorcycle helmets, automobile bumpers, and luggage can make them instantaneously lightweight, stiff, durable, and strong;

ii. Nano-engineered materials in automotive products include high-power rechargeable battery systems; thermoelectric materials for temperature control; lower-rolling-resistance tires; high-efficiency and low-cost sensors and electronics; thin-film smart solar panels; and fuel additives for cleaner exhaust and extended range;

iii. Displays for many new TVs, laptop computers, mobile phones, digital cameras, and other devices incorporate nanostructured polymer films known as organic light-emitting diodes (OLEDs). The OLED screens offer livelier images in a flat format, as well as wider viewing viewpoints, lighter weight, improved picture density, lesser power consumption, and extended lifetimes;

iv. Nanostructured materials that are greatly advance the hydrogen membrane and storage materials and the catalysts needed to realize fuel chambers for alternative transportation technologies at reduced cost; and

v. Gold nanoparticles that can be used to detect early-stage for Alzheimer's disease.

## DISCUSSION

Many of the patents in nanotechnology areas are being taken on basic inventions, since the circumstance that this is a new research's area and a wide broad entitlements. A patent of nanotechnology can become as a strategic weapon to gain competitive advantage of newest produtcs in market. One of the examples is NanoTech Entertainment and their flagship product known as UltraFlix (https://ultraflix.com/).

This is a corporation of entertainment businesses with US$26 billion capital focused on leveraging technology to deliver state of the art entertainment and communications products (*i.e.*, 3D, gaming, media and IPTV, mobile applications, and manufacturing). Thus, this is one of the ways for the company to improve its chances to compete registering patent in the nanotechnology sector. It is going to be beneficial for a company when they feel that their dominance on the nanotechnology market being threatened, it can slowly reduce their competitors performance by fighting the war on the IP front. Patenting the outcomes from nanotechnology also costly due to patent litigation that are rising quickly. Morever, the nanotechnology products available at markets even have been patented still having tendency to be reinvented, since there are so many methods to develop the same entity. Therefore, the responsible authority of nanotechnology patents should be cooperated from all around the world in order to secure and protect the ownership of the producers (the nanotechnology products and services).

On the other hand, it is crucial for nanotechnology invention to be safe for human consumption when it dealing with something related to genetic pollution. It has very massive differences as compared to chemical pollution. One of these inventions is the genetically modified organism (GMO). It is any organism which is genetically has been modified by using genetica engineering techniques. Now, the GMOs are the source of modified foods that used by scientific research to produce products other than food. However, the GMOs are considered alive and their behavior is more unpredictable when they react in the environment. GMOs can easily mutated, proliferated, and migrated from one residence to another (Bjerregaard, 2010; Powers *et al*., 2005; Patent Act, 1952). At the moment, it is well-recognized that nanotechnology has achieved remarkable success in research and development, products and services innovation, legal protections and commercialization. As example, a nano product develop by Thailand has a remarkable achievement during the managing the big foolds. It is known as Nano-Sack or N-Sack, a product that resembles giant, superabsorbent diapers (nappies). It uses hydrogel and nano coating to absorb water, and is being promoted as a potential replacement for traditional sandbags for flood control. Unfortunately, the only conflict that arises is pertaining intellectual property rights protection and non-commercial laws. The major challenges would be to the criteria of novelty, inventive step, being capable of industrial application (Koosha *et al*., 2012). This is because those three criteria are the reasons for a particular invention or innovation can be awarded a patent.

## CONCLUSION

The emerging of nanotechnology in products and services has brought human capability to next level in invention and innovation fields. It also enhances the intellectual property in terms of authencity and security in patenting of the nanotechnology's outcomes. The scope or area of nanotechnology also has expanded from single nanoscale into complex nanosystems. Now, there are many authorities from various country established to manage the nanotechnology patents (in products and services). Issues pertaining nanopatenting should become a main feature among various parties involved in making sure that any problem arises can be overcome in a timely manner. For a particular patent to become as a strategic weapon to achieve competitive advantage, it should be considered as a main priority among companies. Top management of the company, responsible authorities (public and private) and the community should be aware of the hidden potential embedded in a particular patent. The benefits come from a patent can bring enormous impact if it be treated accordingly (*i.e.*, increase profits, respectable company's reputation).

One of the consequences of the nanotechnology outcomes is to deal with replicating of the products and services. Therefore, for the long future route, hiring a sufficient number of qualified personnel to become an agent for intellectual property for nanotechnology agency is a must. This is important to avoid conflict arises especially in determining the three main criteria for a patent which are novelty, inventive step, and being capable of industrial application. The expectation from nanotechnology outcomes may have been underestimated in the short term, but for long term in future, it will be gigantic and fantastic's impact. As depicted in Figure 3, nanotechnology posses high potential in many areas such as social infrastructures, medicines, manufacturing technology, environmental sustainability, energy and so many others. Besides a noble results from nanotechnology, it also has the dark sides. For example, the usage of nanotechnology in non-natural food productions such as GMOs. Other example includes the potential for mass poisoning over a period of time. Whereas nanoscience can produce all kinds of new and improved products, the elements that are created are so amazingly small that may cause eventual health problems in the buyers that use them. Since almost everybody uses a product that has been blended by nanotechnology it is potential that the eventual health effects could be large scale.

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