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An Empirical Study of Nanowire Technological Trends

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ABSTRACT

This paper follows a bibliometric method for nanowire case to make evident the technological trends; to present the relationship between patents; to help the researchers to discover relatively significant patents and to analyse important relationships between patents to identify those with most commercial potential and those which are critical technologies. This research focuses on the nanowire case study due to fact that this field is one of the most mature nanostructures and is one of the highly invested fields in nanotechnology. In terms of methodological approach, this study uses a different patent collection method than previous studies. This new method offers a new taxonomy that could make a significant impact on accurate patent data quests and increase the reliability of the patent analyses. As patent data are valuable sources of technology innovation and for forecasting technical change, this study utilises nanowire patent documents to pick out the technological trends, to identify nanowire technologies which both have the most commercial potential and which are critical at the organisational, national and international levels.

1. Introduction

Nanotechnology is the manipulation and production of nanomaterials and nanodevices at the level of atomic and molecular precision (Ramsden, 2005). Nanotechnology is interdisciplinary, as it depends on the knowledge and expertise found in conventional disciplines such as chemistry, physics, biology, material sciences and medicine (Islam & Miyazaki, 2009). For this reason, there is much varied research being conducted in order to gain insights into this field and to forecast its possible effects.

The focus of this study is nanowires and it aims to shed light on various technology trends and dominant actors by analysing nanowire patents granted up until 2012. The nanowire is one of the most mature nanostructures that are available today and so an analysis of the patents in this field is significant as there are more applications for nanowires and the technology is closer to its commercial exploitation. For this study, 4484 nanowire patents have been analysed and the data covers all the granted patents until March 2012.

Patent data provide valuable sources of information for the purpose of research in innovation and for forecasting technical change (Archibugi & Planta, 1996). Reliable and valid information about a particular technology or innovation system can be gathered if the patent data is analysed systematically (Choi & Park, 2009; Lee, Jeon, & Park, 2011). Some of the reasons why patent analyses are pursued include the discovery of promising technologies, assessment of technological advances and new trends, or to help in strategic decision-making for an organisation (Firat, Woon, & Madnick, 2008). Patent analysis can benefit various individuals and organisations such as inventors, R & D departments, policy-makers, academics and managers. Generally, looking at various patent analyses, the most commonly used methods are bibliometric and statistical analysis; if some of these studies are clustered under various categories, these can then be subjected to network analysis, citation analysis, trend extrapolation/impact analysis, life cycle analysis,

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innovation system modelling, roadmapping studies and economic base analysis (Chang, Chen, & Huang, 2012; Daim, Rueda, Martin, & Gerdsri, 2006; Guan & Liu, 2016; Johnson & Liu, 2011; Kostoff, Toothman, Eberhart, & Humenik, 2001; Miyazaki & Islam, 2007; Wartburg, Teichert, & Rost, 2005).

This paper follows a bibliometric method to make evident the technological trends; to present the relationship between patents; to help the researchers to discover relatively significant patents and to analyse important relationships between patents to identify those with most commercial potential and those which are critical technologies. This paper analyses the nanowire case at the national and organisational context. The dominant actors, their intentions regarding nanowire technology usage and various nanowire applications are examined.

Although there have been previous studies that used bibliometric studies to analyse patents and focused on implementing nanotechnology related patent documents, these studies did not particularly focus on the nanowire case. In any event, there is a need for up-to-date studies in various areas of nanotechnology, as it is an emerging field undergoing rapid development. Previous studies used a different methodology in terms of collecting patent documents and this paper increases the efficiency of nanotechnology patent analysis as a more reliable patent data collection method is used.

2. An Overview of Nanowire Materials and Applications

Nanowires (also known as quantum wires) are nanostructures less than tens of nanometres long. There is a possibility that silicon nanowires will provide the next architecture for transistor designs. Nanowire transistors can be at least four times faster than traditional silicon devices and could result in high-performance, low-cost, flexible and miniaturized electronic circuitry for many products and applications.

In today's various applications many materials such as steel, plastic and ceramic is greatly used. These types of materials are followed by advanced materials such as; fibers, titanium and silicon as they offer different properties than traditional materials in terms of their mechanic, electrical or thermal properties (Harris, 2009). These materials can be replaced by some prospective materials such as nanowires due to their extraordinary characteristics such as their conductivity level, rapid thermal response or high flexibility. Nanowires are one of the next enabling materials that will reshape the future of various technologies, products and systems. For illustration purposes, the following Fig. 1 is generated.

Nanowires have many current and prospective applications in electronics, optics, magnetics and sensors (Dresselhaus, Lin, Rabin, Black, & Dresselhaus, 2004). Some of these applications are at incremental and radical level. At the present, there are very limited numbers of nanowire related applications and they are at incremental level. However, there are significant numbers of potential applications and some of them are at radical level so some technologies may change or be replaced by nanowire related advancements. Some of these potential applications of nanowires are lie in the magnetic information storage devices (Dresselhaus et al., 2004). By using nanowires, it is possible to increase the capability of storing information in a smaller area and to suppress the onset of the superparamagnetic limit that is important for avoiding magnetically recorded information.

There are many potential applications that are based on silicon nanowires (Shin, 2007). Silicon nanowires will be designed to contour the transistor's channel, surrounded on all sides by a wrap-around silicon oxide, high-K metal gate. These new nanowire transistors will have different characteristics to the most improved FinFET transistors. FinFET transistors have a three-dimensional gate (FinFET/Tri-Gate) while nanowires have a cylindrical shape so the gate can be in multipoint all around the device. Nanosensors are another promising application that will be produced by nanowires. These new nanosensors are likely to be highly sensitive for the detection of single molecules. As nanowires are at a very small scale, when molecules make contact with the nanowires, they will generate a measurable change in the current passing through the nanowires. There are many possible applications for nanowires by using them in nanosensors, one of their important applications being to detect cancer proteins. This would allow cancer tests to be more accurate in an inexpensive way.

Having mentioned potential applications of nanowires, it is essential to mention that commercialization of nanowire related

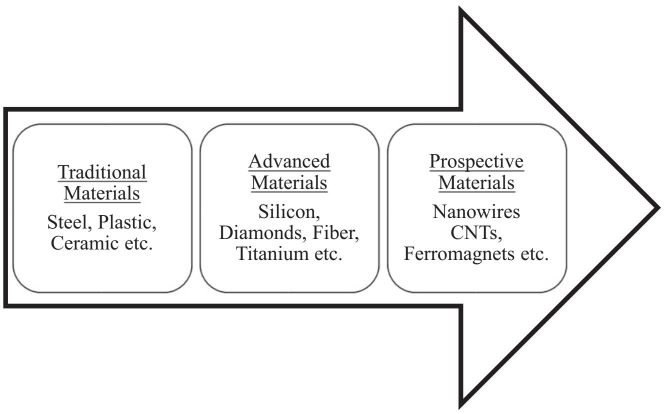

Fig. 1. Advancement of Materials.