Nanotechnology Development in Japan Based on Patent Analysis

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Abstract. Based on nanotechnology related patents applied in Japan from 1991-2010, which are collected by Derwent Innovation Index database, this paper elaborates the distribution and development trends of nanotechnology in Japan, through the quantitative analysis of patent distribution in five nano areas (materials & process, electronics & devices, biology & medicine, instrument & measurement), in hope of providing an objective statistic reference for future policy directions and academic researches.

Introduction

Ever since 1980s, nanotechnology has gradually become one of the three science and technology (S&T) mainstreams of 21st century, along with biological technology and information technology. Nanotechnology is believed to have huge applications in a wide-range of high-tech sectors, such as biology, electronics, information, manufacture and material. .Many countries, with investments from governments, have devoted in the research and development (R&D) in nanotechnology. Companies and research institutes have also been engaged. As a result, nanotechnology have achieved huge progress all over the world.

Japan is one of the first countries to carry out nanotech basic and applied research in the world. In its 2nd,3rd and 4th Science and Technology Basic Plan, nanotechnology has been highlighted. Under the strong support of government, both research institutes (Osaka University, Kyoto University, etc.) and well-known enterprises (HITACHI LTD, FUJI PHOTO FILM CO LTD, etc.) have obtained outstanding achievements in nanotechnology, a number of conceptual nanotechnology products with huge market potential have emerged.

Patents are the achievements of science and technology, and they can reflect the latest technological inventions as well as represent innovative capability of a nation. Accordingly, patents provide a reliable indicator of measuring technology development [1-3]. Consequently, nanotechnology patents have become an important indicator of evaluating national nanotechnology competitiveness. More and more countries, as well as world-renown institutes, are devoting more efforts to nanotechnology patent analysis and applying the corresponding results for policy references.

Thus, the present study has retrieved and compiled nanotechnology patents applied in Japan from 1991 to 2010, in hope of studying patent' layout in Japan's nano-market in recent years. The research first reviewed the history of, nanotechnology patent applied in Japan and exhibited distribution of different nanotechnology areas. Then, the research moved into deep analysis of patent assignees. Overall, this paper provided an objective statistic reference for nanotechnology market arrangement and competitor analysis through the study of nanotechnology patents.

Methodology

The patent data were retrieved from Derwent Innovation Index (DII) database and downloaded on May 2nd, 2012. The data contained all the application patents related to nanotechnology in the world from 1991 to 2010. Many attempts have been made to design the best search strategy for the identification of nanotechnology patents [4-13]. After reviewing a variety of such efforts, Wong et al. refined the keyword-search strategy of previous researchers together with the inclusion of an up-to-date set of Class 977 patents that have been reclassified by USPTO as nanotechnology[14]. This study, similar search strategies as used by Wong et al, as follows:

TS=(Nano$ OR Selfassembl$ OR Self assembl$ OR Atomic force microscop$ OR Atomic-forcemicroscop$ OR Scanning tunneling microscop$ OR Scanning-tunneling-microscop$ OR Atomistic simulation OR Biomotor OR Molecular device OR Molecular electronics OR Molecular modeling OR Molecular motor OR Molecular sensor OR Molecular simulation OR Quantum computing OR Quantum dot$ OR Quantum effect$) NOT TS=(nanoliter OR nanogram OR nanometer OR nanoampere OR nanofarad OR nanomole OR NaNO OR nanosecond)

There are several international patent classifications for nanotechnology, in which, USPC 977 and ECLA Y01N are available in the patent retrieval. Some scholars have put forward their own nanotechnology classification in the study, too. For example, Wong et al divided nanotechnology into five fields, including electronics, biology & medicine, chemical process & materials, instrument &standard, the others [14]. Based on previous studies, nanotechnology is divided into five areas by using the subject searching method, that is materials & process, electronics & devices, biology & medicine, instrument & measurement, and the others, as seen in appendix table. Since one patent can simultaneously belong to different fields, the sum of patents in these five fields would exceed the total patent retrieved.

Results and discussion

The total number of nanotechnology patents applied in Japan from 1991 to 2010 was 27,344, which is the world's second biggest application of nanotechnology patents after the U.S., as shown in Fig. 1. Since the Second World War, science and technology has always been considered as the most important means to ensure national competitiveness in Japan. Nanotechnology was one of the three science and technology mainstreams, thus it's bound to draw great attention by Japanese government and enterprises.

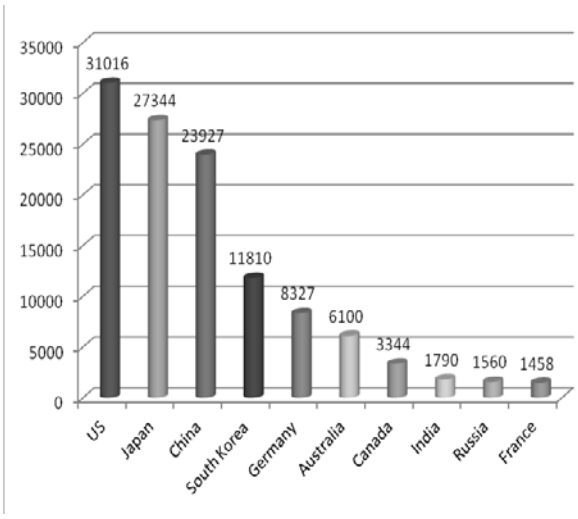

Figure 1. Nanotechnology Patents Distribution of Countries in the World

Before the year of 1996, public investment in nanotechnology R&D was relatively small, and the number of patents and patent assignees didn't exhibit obvious growth, as shown in Fig.2. After 1996, at the promotion of relative science and technology plans, the patent assignees involved in

nanotechnology grew quickly, and then the number of nanotechnology patents applied in Japan increased rapidly too. The fast growing trend ended in 2005. Ever since then, both the patents and patent assignees dropped dramatically, which represents the decline of R&D in nanotechnology. The decline may be due to the economic recession, which results in less public investment in nanotechnology R&D. This phenomena may also due to technology bottle neck, some patent assignees withdraw from the nanotechnology R&D.

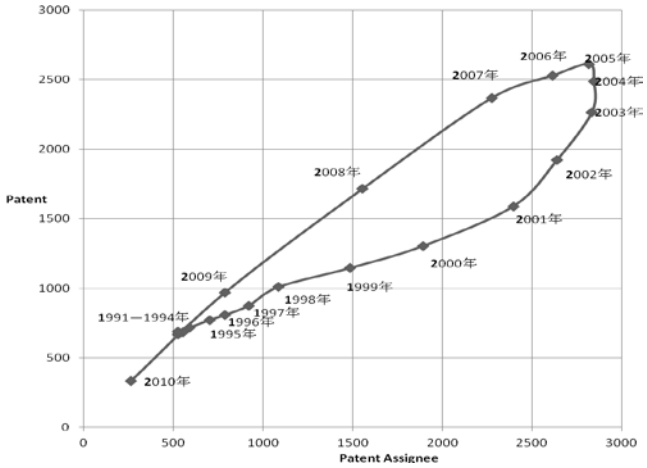

Figure 2. Technology Life Cycles of Nanotechnology in Japan

During the past 20 years, the overall distribution of five nanotechnology fields in the Japan is depicted in Fig.3, where nano-materials& process technology patents ranked the first, with the number of 12,082. The number of nano- electronics& device patents was nearly the same as nano-materials& process technology, with the number of 11,762. The number of nano-biology & medicine, nano-instrument& measurement and others were almost the same as each other, all around the number of 6,000.

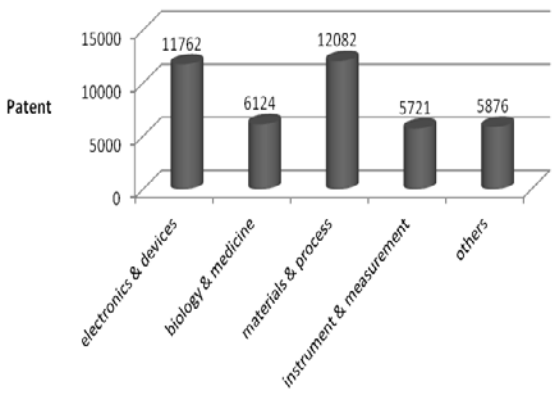

Figure 3. Patent Layout of Five Nanotechnology Areas in Japan

Simply from the number , we can say that nano-materials& process and nano- electronics& device were the R&D focus of Japan in the past twenty years. But it should be mentioned that the number of patents in different areas were not comparable, because of distinctively different R&D behaviors as well as patent strategy in different technology areas. As shown in Fig. 4, different nanotechnology areas exhibited similar development trends. The number of patents in all the five nanotechnology fields increased quickly after 1996, while began to decline after 2005, consistent with the overall nanotechnology patents.

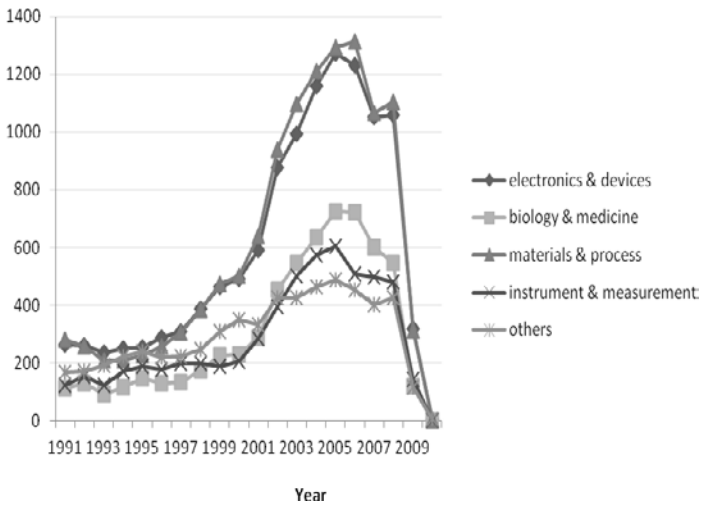

Figure 4. Patents of Five Nanotechnology Areas in Japan by year.

Over the past 20 years, the top 10 corporations in the number of nanotechnology patent applications were Hitachi, Fuji, Mitsubishi, Panosonic, Sumitomo, Canon, Seiko, Sharp, Fujitusu and Sony, as described in Fig. 5. The patents applied by top 10 companies were 923, 817, 810, 802, 764, 660, 562, 489, 489 and 442, respectively. The top 10 companies all belong to Japan. This reflects that , in Japan's nanotechnology market, Japanese companies held the leading positions, companies from other countries obviously ocuppied very little share.

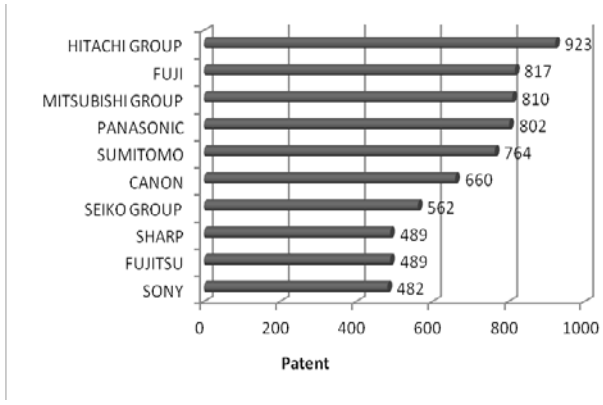

Figure 5. Top 10 corporations with nanotechnology patents in Japan

The top 10 corporations can be classified into two categories. One is represented by Hitachi, in which nano-electronics & device and nano-materials& process obviously exceeding the other fields, as shown in Fig. 6. This kind of companies also included Panasonic, Fuji, Mitsubishi, Sumitomo, and Sony. In the other category, nano-instrument & measurement was also quite important in their patent layout, such as Canon and Fujitsu. All the top 10 corporations have few patents in nano-biology & medical market, may probably due to the long R&D time needed by biology and medical research.

Conclusion

Based on the analysis of the mechanical theory as the foundation, designed the soccer robot pick the ball institutions optimal design process, found aim function, select design variables and the corresponding optimization algorithm to optimize a complete set of institutions. At last through the test to get the final performance parameters of the institution. Experiments show that the system has higher accuracy and stability, the new optimize pick the ball have design basic requirements, and achieved good ideal control effect.

The technology information in patent documents make patents an effective tool to study technology development and market layout. Through analysis of nanotechnology patents applied in

Japan from 1991 to 2010, the research herein has drawn the following conclusions. Japan's nanotechnology market has drawn great interest from enterprises, especially Japan domestic corporations. 27,344 nano-related patents were applied in Japan, which makes Japan become the world's second biggest country after the U.S. in the respect of nanotechnology patents. Before the year of 1996, the number of patents and patent assignees didn't exhibit obvious growth in Japan, may because public investment in nanotechnology R&D was relatively small. With the promotion of relative science and technology plans, the patent assignees and the patents involved in nanotechnology grew quickly after 1996. However, the fast growing trend ended in 2005, as as both the patents and patent assignees dropped dramatically. The decline of R&D in nanotechnology may be due to the economic recession or due to technology bottle neck.

During the past 20 years, nano-materials& process and nano- electronics& device patents dominate the Japanese market, with the number of patents far exceeding the other nanotechnology areas. While, different nanotechnology areas exhibited similar development trends, which increased quickly since 1996 and began to decline after 2005, which consistent with the overall nanotechnology patents in Japan.Detailed studies in enterprise tells that Japanese companies held the leading positions in Japan's nanotechnology market, since the top 10 corporations in the number of nanotechnology patent applications were all Japanese companies. Companies from other countries obviously occupied very little share. And in all the top 10 corporations, patents of nano-electronics & device and nano-materials& process were either more than the other areas or nearly equal to the others. That is also why nano-materials& process and nano- electronics& device patents dominate the Japanese market. Analysis of patent data together with other information, such as R&D input of different nanotechnology fields in countries and corporations, would be an effective compliment for revealing and analyzing potential competitors in nano-market. Those above-mentioned points will be added in future studies.

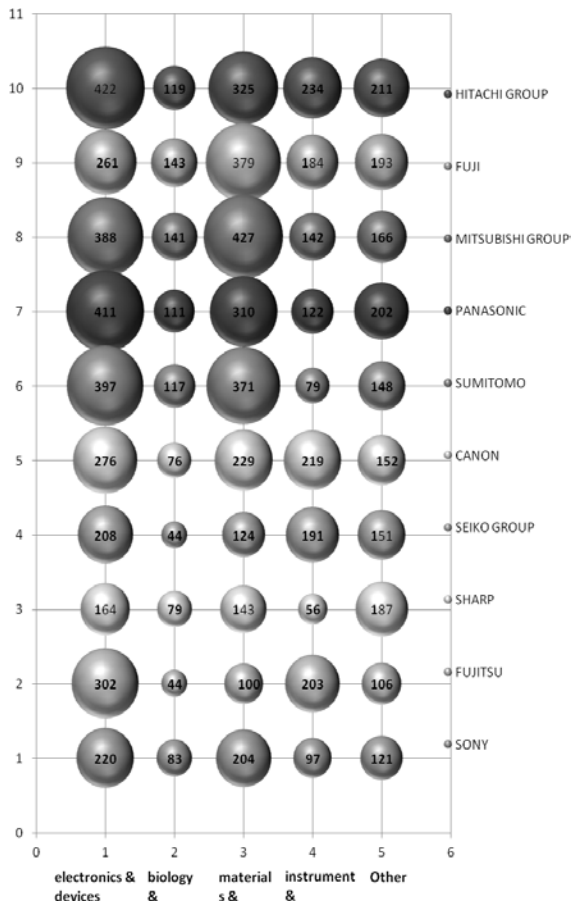

Figure 6. Patent Layout of Five Nanotechnology Areas in Top 10 corporations

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