

# Nanotechnology Market Layout in Germany: From a Perspective of Patent Analysis

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**Abstract.** Patents are the manifest output of nation's market layout. This paper explores the development of five nanotechnology fields in Germany, including Nano- materials & process, nano-electronics & devices, nano- biology & medicine, nano- instrument & measurement and the others, through the analysis of nanotechnology patents applied in Germany, in hope of providing an objective statistic reference for future policy directions and academic researches.

## Introduction

As one of the three science and technology (S&T) mainstreams of 21st century, Nanotechnology have many applications in a wide-range of high-tech sectors, such as biology, electronics, information, manufacture and material. Thus, nanotechnology is believed to have a huge market potential. Since 2000, global venture capital in nanotechnology market grew rapidly, with an annual increase rate as high as 25%. Many world-renown corporations have paid more attention to nanotechnology research and development (R&D) and carried out a strategic patent layout, in order to seize this huge market in advance.

As world leading nation in nanotechnology, Germany has more R&D input in nanotechnology area than any other European county. In Germany, lots of universities, research institutes and enterprises have been involved in nanotechnology research and industry development. Meanwhile, foreign universities research institutes and enterprises all pay great attention to the scientific achievements of Germany's advanced nanotechnology, especially due to its world well-known manufacture and instrument.

Patents can reflect the latest technological inventions as well as represent innovative emphasis of a company, which are the achievements of science and technology. Accordingly, patents provide a reliable indicator of measuring technology development [1-3]. Consequently, nanotechnology patents have become an important indicator of measuring national nanotechnology R&D trends and market development focus; it has also become an effective tool to reveal and study potential market competitors. Governments, as well as world-renown institutes, are devoting more efforts to nanotechnology patent analysis and applying the corresponding results for policy references and market analysis.

Thus, the present study has analyzed nanotechnology patents applied in Germany from 1991 to 2010, aiming at studying market layout in Germany's nano-market in recent years. The research first tells the overview of, nanotechnology patent applied in Germany, including the history and distribution of five nanotechnology areas. Then, the research made deep analysis of patent assignees, including the relative strength and technology focus. Overall, this research provided an objective statistic reference for nanotechnology market arrangement of Germany 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

As shown in Fig. 1, the total number of nanotechnology patents applied in Germany from 1991 to 2010 was 8,237, which ranked fifth in the application of nanotechnology patents after the U.S., Japan, China and South Korea. Since the Second World War, science and technology has always been considered as the most important means to ensure national competitiveness in Germany. Though there is a big gap between Germany and the four countries mentioned above, Germany, still, held the largest application of nanotechnology patents in Europe. In other words, Germany is the leading country in European nanotechnology market. It is bound to draw great attention from other countries.

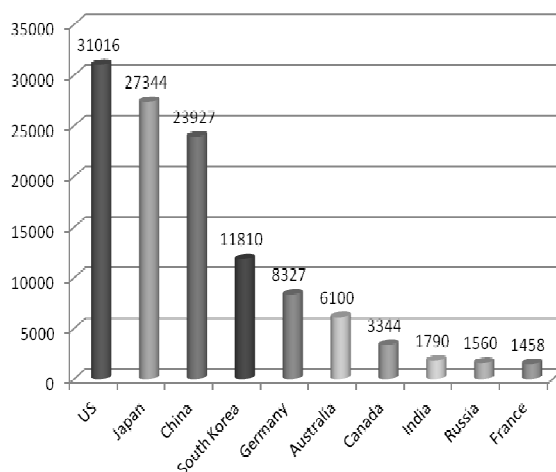


Fig. 1. Nanotechnology Patents Distribution of Countries in the World

Before the year of 1993, nanotechnology once showed decline in both patents and patent assignees. The reason was not clear, maybe public was not sure about nanotechnology foreground. After 1993, the patent assignees involved in nanotechnology gradually increased, and then the number of nanotechnology patents applied in Germany grow up too, at the promotion of relative science and technology plans. However, the growing trends was slow, not very fast. This growing trends ended in 2001, first is the patent assignees, then after the year of 2005, patents were also decreasing. It is worth mentioning that in the year of 2000, the U.S. government has released the National Nanotechnology Initiative (NNI), which arouse global passion for nanotechnology for nanotechnology. However, in

Germany, which is famous for its nanotechnology manufacture, some enterprises began to quit this market.

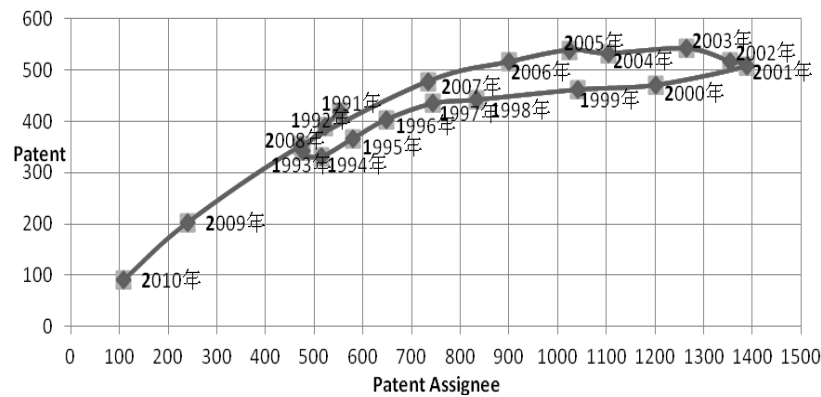


Fig. 2. Technology Life Cycles of Nanotechnology in Germany

Fig 3 shows the distribution of five nanotechnology fields in Germany during the past 20 years. Nano-materials& process technology patents ranked the first, with the number of 2,935. The number of nano- electronics& device and other patents was nearly the same as nano-materials& process technology, with the number of 2,624 and 2,764, respectively. The number of nano-biology & medicine ranked the fourth, with the number of patents 1967. The last one is nano-instrument& measurement, but there is no significant different in the number of patents among the five areas. Thus, in Germany, all the nanotechnology fields have got developed during the past 20 years.

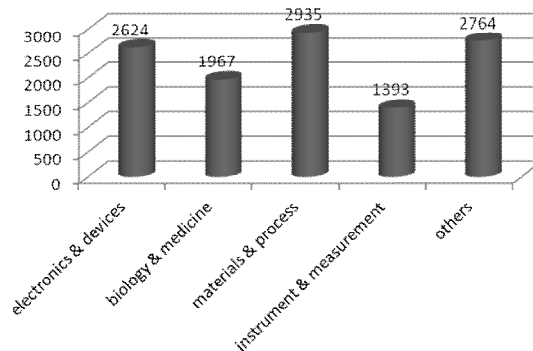


Fig. 3. Patent Layout of Five Nanotechnology Areas in Germany

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 depicted in Fig. 4, different nanotechnology areas exhibited roughly the same development trends. The number of patents in all the five nanotechnology fields began to grow up after 1993, while began to show decline trend after 2001, consistent with the overall nanotechnology patents.

Over the past 20 years, the top 10 corporations in the number of nanotechnology patent applications in Germany were Siemens, Bosch, Bayer, BASF, Infineon Technologies, Sumitomo, Samsung Group, Merch Group, and HP, as described in Fig. 5. The patents applied by top 10 enterprises were 191, 136, 122, 103, 93, 67, 66, 55, 52 and 51, respectively. Among the top 10 enterprises, seven were from Germany domestic, the other three were from Japan, South Korea and the U.S. That is to say, Germany companies held the leading positions in its nanotechnology market, but meanwhile, enterprises from other countries also pay lots of attention to its market. The competition should be severe in Germany's nanotechnology market.

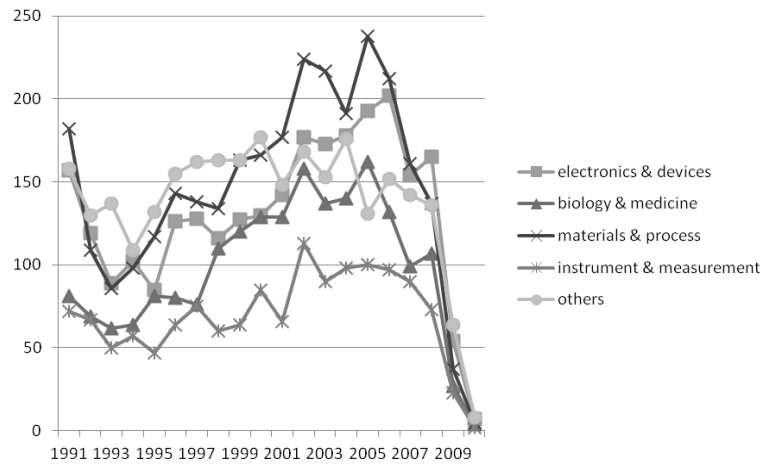


Fig. 4. Patents of Five Nanotechnology Areas in Germany by year.

The top 10 corporations can be roughly classified into three categories. One is represented by HP, in which nano-electronics & device obviously exceeding the other fields, as shown in Fig. 6. This kind of companies also included Sumitomo, BASF and Siemens. In another category, nano-materials & process was the most important in their patent layout, such as Carl Zeiss, Samsung Group, Infineon Technologies and Bosch. As for Merck Group and Bayer, there is no significant focus. Both of them have few patents in nano-biology & medical market, may probably due to the long R&D time needed by biology and medical research.

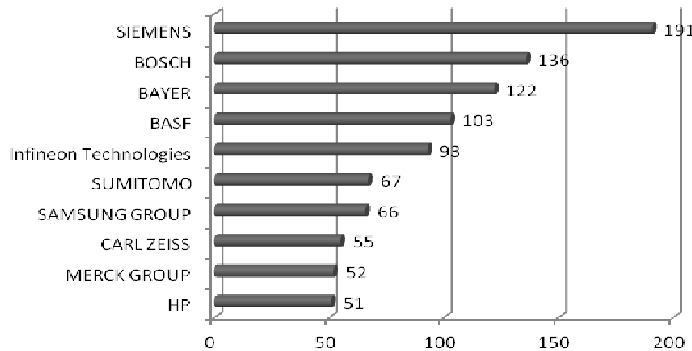


Fig. 5. Top 10 corporations with nanotechnology patents in Germany

## Conclusion

Through analysis of patent classifications from nanotechnology patents applied in Germany, the research herein has studied nanotechnology patent market layout and drawn the following conclusions.

Although Germany ranked fifth in the application of nanotechnology patents after the U.S., Japan, China and South Korea, it held the largest application of nanotechnology patents in Europe. Thus, Germany is the leading country in European nanotechnology market, which has drawn great attention from other countries. Before the year of 1993, public may be not sure about nanotechnology foreground, thus, nanotechnology once showed decline in both patents and patent assignees. After 1993, the patent assignees and patents applied in Germany showed slow growing trends. However, when the U.S. government released the National Nanotechnology Initiative (NNI) and aroused global passion for nanotechnology R&D in the year of 2000, some enterprises in Germany began to quit this market.

During the past 20 years, nano-materials & process and nano-electronics & device technology dominate the Germany's nano market, with the number of patents significantly exceeding the other nanotechnology areas. Different nanotechnology areas exhibited roughly the same development trends.

The number of patents in all the five nanotechnology fields began to grow up after 1993, while began to show decline trend after 2001, consistent with the overall nanotechnology patents. Detailed studies in enterprises tells that Germany companies held the leading positions in its nanotechnology market, but meanwhile, enterprises from other countries also pay lots of attention to its market. The competition should be severe in Germany's nanotechnology market. Since among the top 10 enterprises, seven were from Germany domestic, the other three were from Japan, South Korea and the U.S.

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.

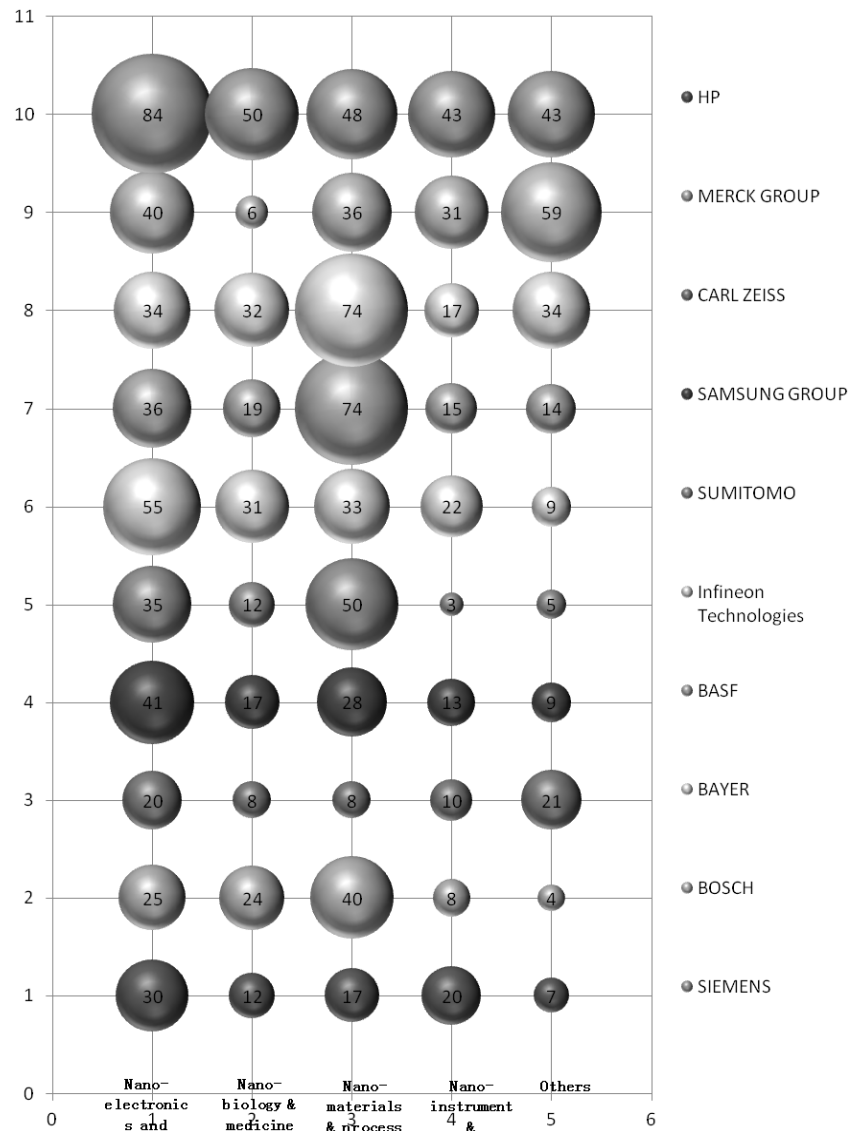


Fig. 6.. Patent Layout of Five Nanotechnology Areas in Top 10 corporations

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