Tracing the Carbon Nanotube Value Chain: The Intellectual Property Landscape

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Abstract

INNOVATION AND DIFFUSION OF NANOTECHNOLOGY: A PORTRAIT OF THE CARBON NANOTUBE INTELLECTUAL PROPERTY LANDSCAPE
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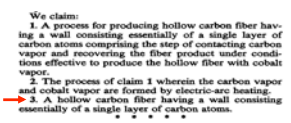
Continued downstream innovation (new technology based on prior art) and diffusion of nanotechnology is becoming increasingly difficult due to shortcomings within the structure of intellectual property (IP) regulation. Nanotechnology innovators are being restricted by an increased volume of patent applications, the issuance of broad and overarching patents, and a lack of resources allocated for comprehensive review of nanotechnology patents. By isolating the carbon nanotube (CNT) industry in the United States and examining public records of CNT related intellectual property using both qualitative and quantitative methods, we will identify key players in the United States' CNT industry and patterns in the distribution of CNT related intellectual property. Our research highlights some of the complex and dynamic interconnections between universities, the carbon nanotube industry and the government. This research contributes to a larger group project which will create a graphical representation of the interconnection between firms and value in the global market (also known as a global value chain) with regard to carbon nanotubes. This research will provide industry, government and academic contributors with vital information about patterns, trends and key contributors of IP in the carbon nanotube industry.

Introduction

All great inventions start with an idea and nanotechnology is no different. Intellectual property (IP) regulators such as the World Intellectual Property Organization and the United States Patent & Trademark Office (USPTO) are in place to make sure inventors receive exclusive rights to their discoveries. Unfortunately these regulators of IP can create just as many problems as they solve.


We claim:
1. A process for producing hollow carbon fiber having a wall consisting essentially of a single layer of carbon atoms comprising the step of contacting carbon vapor and recovering the fiber product under conditions effective to produce the hollow fiber with cobalt vapor.
2. The process of claim 1 wherein the carbon vapor and cobalt vapor are formed by electric-arc heating.
3. A hollow carbon fiber having a wall consisting essentially of a single layer of carbon atoms.
* * * * *

The issuance of patents making broad and overarching claims can lead to temporary monopolies or unwanted litigation over patent infringement. A good example of a broad claim can be seen in US Patent #5,424,054 (pictured left) filed June 13, 1995 by IBM.

Patents that make such generalized claims can create IP bottlenecks that stifle the innovation of new technologies. One of these bottlenecks, called a patent thicket (pictured right), consists of a networks of patents claiming fundamental aspects of a technology. In order for a start up company to utilize said technology, they would have to license a slew of fundamental patents from other inventors. This alone can discourage some inventors entirely from participating in nanotechnology industries.

A proactive approach to analyzing patent data as well as patent claims on a case by case basis is necessary to fully understand how intellectual property is synthesized and what effects it's regulation has on industry.

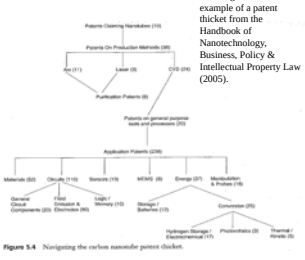


Figure 5.4 Navigating the carbon nanotube patent thicket.

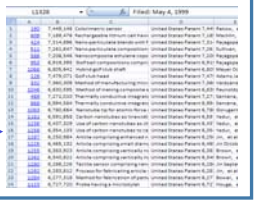
Tracking innovation: an example of a patent thicket from the Handbook of Nanotechnology, Business, Policy & Intellectual Property Law (2005).

Methods

First a population consisting of carbon nanotube patents was gathered from the USPTO full-text and image database. All patents filed with the US that included the term "carbon nanotubes" in the title, abstract or claim were gathered from the database using a script called an Oogler written by Jerry Macala, a science and policy fellow at CNS UCSB.

Next the Oogler copied the patent data from each resulting link and dumped the data directly into a rich text file. This raw data provided the researchers with over 10,000 pages of text made up of the 1328 patents filed in the US related to carbon nanotubes.

Finally the raw data was converted into a Microsoft Word file and imported into Excel. Once the data was in spreadsheet form it was organized for analysis using the parsing function to separate cells in Excel and meticulous hand cleaning by the researchers.



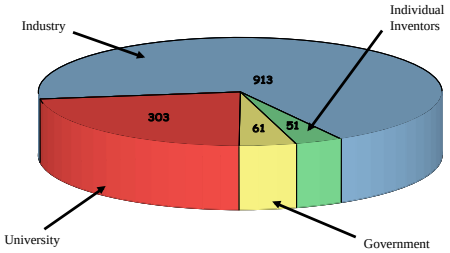
Results

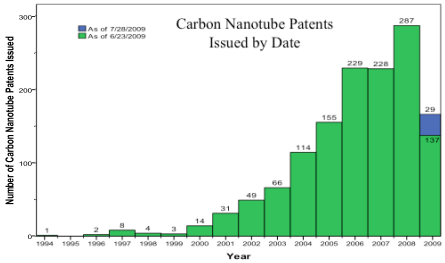
After cleaning the data gathered from the USPTO it was ready to be analyzed. Descriptive statistics were used to show the distributions of carbon nanotube (CNT) patents across several variables. The chart to the right shows the breakup of CNT patent by sector in the United States. This chart shows us that private industry dominates the genesis of intellectual property relating to carbon nanotubes within the US, followed by universities and then government. In addition to these three sectors there were 51 additional CNT patents that were filed by individual inventors that did not have an assignee related to any specific sector.

Below we can see the number of CNT patents issued by the USPTO organized by date. Notice the dramatic increase of the issuance of CNT related intellectual property in the last five years. According to Miller (2005) congress diverts revenues generated by patent review into general funding. If the volume if patent applications and issued patents continues to increase at such a staggering rate it will be impossible to keep up with the demand for qualified reviewers of patent claims and prior art.

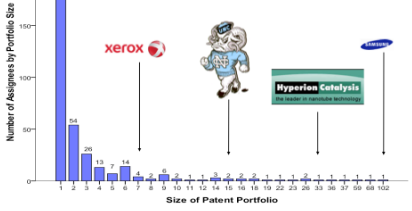
Finally we see the CNT patent assignees organized by the size of their patent portfolios (bottom right). At first we assumed that the holders of larger portfolios would contribute proportionately more products and value to CNT industry. This, however, was not the case; exemplified by the fact that Samsung holds over 100 CNT patents without having a single CNT enabled consumer product on the market.

Carbon Nanotube Patents Distribution by Sector



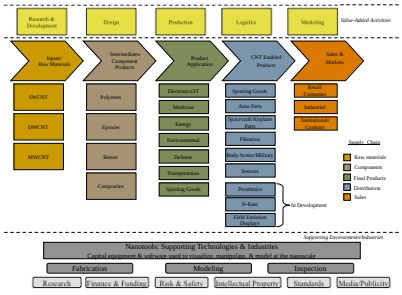


Carbon Nanotube Patent Assignees by Portfolio Size



Carbon Nanotube Value Chain

According to the Global Value Chain Initiative the value chain describes the full range of activities that firms and workers do to bring a product from its conception to its end use and beyond. This includes activities such as design, production, marketing, distribution and support to the final consumer. The activities that comprise a value chain can be contained within a single firm or divided among different firms. Value chain activities can produce goods or services, and can be contained within a single geographical location or spread over wider areas. (http://www.globalvaluechains.org)



Conclusion

Through our research we discovered many interesting things about the innovation and diffusion of intellectual property in nanoscale industries. It is apparent that the increased volume of patent applications and issuances will only make litigation over patent infringement a more common occurrence, thus validating the need for continued research.

The need for an in depth case by case analysis of patents also came to light when looking at the size of assignees' patent portfolios. It would be helpful not only to those trying to enter the arena of CNT research and development but to the regulators of policy and industry to have access to a complete snapshot of the CNT intellectual property landscape.

As with most academic research, the provision of some clarity regarding the genesis of CNT technology has been accompanied by some fundamental questions for future researchers. Some of the questions that have arisen as a result of our study include:

- How does the CNT industry compare to other nanoscale industries?
- How can the patent thicket be avoided?
- How does the US compare with other countries with regards to nanoscale research and development?

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*Resulting U.S. patent #5,424,054

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