

Reframing the Concept of Nanotechnology

An industry? No. But product applications abound—and so do technology transfer issues.



It is now 14 years since the concept of a research center for nanotechnology was first conceived by Rick Smalley and subsequently approved by the Board of Governors of Rice University. As a consequence, the Center for Nanoscale Science and Technology (renamed the “Smalley Institute” in memory of Rick) was funded without federal or state money and the world’s first university building dedicated to nanotechnology was opened on Rice’s campus in 1997. Subsequently almost every university in the United States has formed a nanotechnology center of one kind or another, and many have constructed buildings as foundations for future research. One of the stated goals of each nanotechnology center is to promote the development of applications of nanoscience and nanotechnology.

While nanotechnology can be defined as the creation of materials, devices and systems through the control of matter on the nanometer (10^{-9} m) length scale, this definition has its limi-

tations. It indicates that size is the only thing that matters. A more practical definition holds that nanotechnology is the ability to work at the nanometer level to achieve purposefully engineered structures with novel and improved size-dependent properties and functions. The key characteristic of a nanotechnology, therefore, is that the unique property or performance can only be achieved through the use of a nanomaterial.

An Industry or Not?

With such an array of potentially useful applications for nanomaterials it was inevitable that the popular and business press should push the concept of a nanotechnology industry. Many observers have assumed that an entire industry would thus have grown up around nano-

Top photo: Nanotechnology has resulted in so many applications that consumers are likely unaware that many products they use rely upon it.

Andrew R. Barron

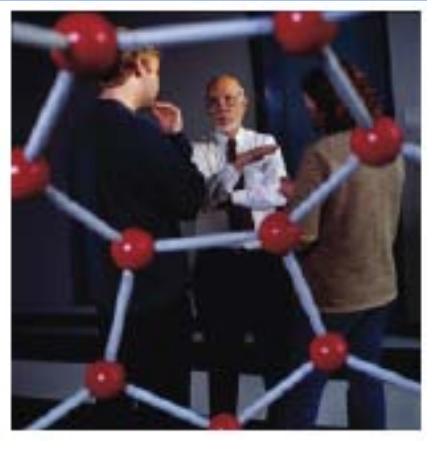


Photo courtesy of Rice University

The late Richard Smalley, center in photo at right, conceived the idea of a nanotechnology research center in 1993. Rice University opened what is now known as the Smalley Institute in 1997.

technology, and these same observers have become critical of the perceived failure of nanotechnology to develop into its own industry. Why is it then that, while nanomaterials provide such special and unique properties, we do not have a nanotechnology industry? In finding an answer to this question it is worth considering the recent history of nanotechnology based companies.

Many of the early nanotechnology companies adopted names with variations on the theme of “Nano-X” and “Y-Nano Materials”. The majority of these companies positioned themselves as being nanomaterials’ manufacturers. They each had a particular nanomaterial (be it fullerenes, carbon nanotubes, or ceramic nanoparticles) and believed the existence of this new nanomaterial was enough incentive for its adoption. In other words, they expected new markets to grow to meet their technology without appreciating who would buy their nanomaterials, why they would buy them, and for how much. Few actually addressed a real need in industry or, even if they did, the markets available were small and specialized. Many of these early companies have fallen by the wayside or been acquired. Thus critics have declared that the nanotechnology industry has failed and that the promise of nanotechnology was simply hype.

In order to understand the real present commercial potential of nanomaterials one should consider early nanotechnology

successes. Examples of industries where nanomaterials have already found markets include sports and leisure (Wilson Double Core Tennis Balls), clothing (Dockers Go Khaki with Stain Defender) and health care (Smith & Nephew Acticoat 7 antimicrobial dressing). Clearly none of these applications creating a new “nanotechnology market;” instead each is providing added value to presently understood market areas. The nanotechnology market or industry can be thought of as being a “stealth market.” In each case the product applications are low-profile products, where the customer is buying a product due to improved performance rather than the presence of a nanomaterial.

So where did the idea that nanotechnology should be a separate industry

come from and is nanotechnology any different from other technological breakthroughs that have apparently developed their own industries?

An Enabling Technology

Nanotechnology is often compared to biotechnology. However, it is clear that biotechnology is also really impacting existing industries (pharmaceutical, health, and agrochemical). If this is true, then why is there a biotechnology industry? Without wishing to be offensive, I would propose that the “biotech industry” is more a creation of venture capital and Wall Street, rather than being a fundamentally new industry. After all, “biotechnology” sounds new, it sounds good, it must be better! But fundamentally biotechnology is similar to nano-



Clothing benefits from the stain- and rain-shedding capabilities of nanomaterials.

Reframing the Concept of Nanotechnology

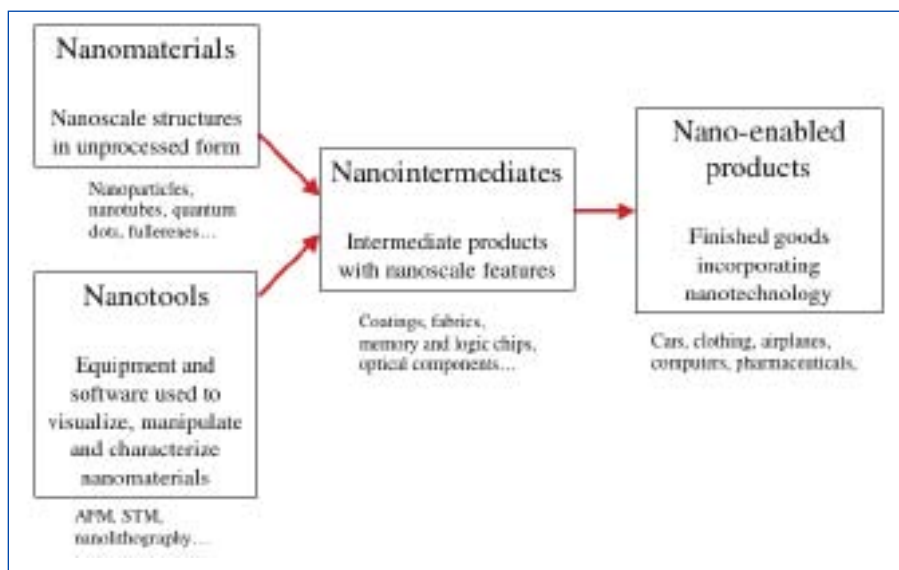


Fig. 1 The nanotechnology value chain.

technology in being an enabling technology. Given this comparison, is there a “nanotechnology industry” in an analogous manner to the actuality of biotechnology? In other words is there a group of firms focused on bringing nanotechnology processes, materials, tools and devices to market? The answer is yes, but within the scope of meeting real needs in a wide range of commercial applications.

A consideration of commercial applications of nanotechnology suggests that there are significant growing applications of nanomaterials with use as part of a value chain for a usable end product (Fig. 1). In a typical example, SCP provides clay nanoparticles to a number of customers who, in turn, use them in manufacturing a material containing the nanoparticles. One such customer, Basell Polyolefins, mixes the clay nanoparticles with its polypropylene products to prepare a nanocomposite material. These materials are sold as components to GM for the auto market. This is an example of an interdependent nanotechnology value chain where the “nanotechnology industry” is only the first step in creation of a system containing a nanomaterial. The end user (GM’s customer) has no idea that her or his new car contains a nanomaterial. Possibly more important, she or he doesn’t care about the nanotechnology component. What is of interest is that the

car is safer, costs less, has a nicer finish, or better performance.

This “nanotechnology industry” does not have to be simply one step in the value chain. Just as GE changed the face of business by providing solutions not products, there are a growing number of examples of self-contained nanotechnology value chains, where a single company makes the nanomaterial, uses it to make an intermediate material or component part and then sells a product into a specific market area. Nanotechnology thus appears to provide a new approach to impacting a value chain of a present perceived need. An indication of this trend is that newer and growing nanotechnology companies have chosen apparently meaningless names or those that engage the industries or markets their business is aimed at. These companies focus on using their nanotechnology to improve a product or process that already has a market, and are positioned to sell into that market. It appears, therefore, that the nanotechnology industry is undergoing a thematic paradigm shift where solutions to a specific commercial need are the focus rather than the material itself. In addition to the entrepreneurial spirit of new technologies, larger national and multinational companies have begun to understand the potential benefit of nanotechnology to their core business, and are either developing expertise and technol-



Tennis balls and paint reap big rewards from nanomaterials.

ogy in house or are seeking to partner with academia and/or small entities.

Thus the question arises whether the real future of the “nanotechnology industry” is to be a vital component of all industries rather than creating an industry of its own. If such is the case, it suggests that nanotechnology is not the “next big thing” that Wall Street is forever seeking but, instead, it is all of the “next big things” that a wide range of industries will be looking to for future solutions. Nanotechnology is not a single business but has the potential to impact all industries. In this regard, there are now companies using nanotechnology in energy, electronics, aerospace, automotive, sports equipment, pharmaceuticals, medical devices, and the food and beverage industry.

Intellectual Property Rights

If nanotechnology companies are moving away from the simple manufacture of a particular nanomaterial to providing solutions to commercial needs, how can these companies protect their

technology? The traditional protection by industry and academia of new technologies is through intellectual property. The most pervasive of these has become protection through the patent process. The purpose of a patent is “to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries.” The term of a patent is 20 years from the date on which the application for the patent was filed. U.S. patent grants are effective only within the United States, U.S. territories, and U.S. possessions. A U.S. patent provides no protection outside of these areas and this must be kept in mind when considering what rights a license or patent actually provide to a company. It is also a potential issue with regard to international collaboration between universities or companies.

It is often misunderstood that a patent does not give the assignee the right to make, use, offer for sale, sell or import the invention, but provides the right to exclude others from making, using, offering for sale, selling or importing the invention. This difference means that an assignee or inventor can be issued a patent but will be unable to commercialize their invention if there is another, controlling patent. It is in this area that nanotechnology has fallen foul of the United States Patent and Trademark Office (USPTO) possibly more than other technologies in recent years.

So where did the problem arise? It may be unfair to lay the blame in any one area, and there are clearly mitigating circumstances, but much of the present and future problems with nanotechnology patents, and subsequently a company's freedom to operate, are due to the USPTO. A review of nanotechnology patents finds many with too broad claims that are too broad based upon the examples and/or known science. Alternatively, there are those that attempt to reach through to discoveries made after the filing of the patent. Finally, there are nano patents that contain no nano! So how did this situation arise?

In order to answer this question one must consider how a “nanotechnology”

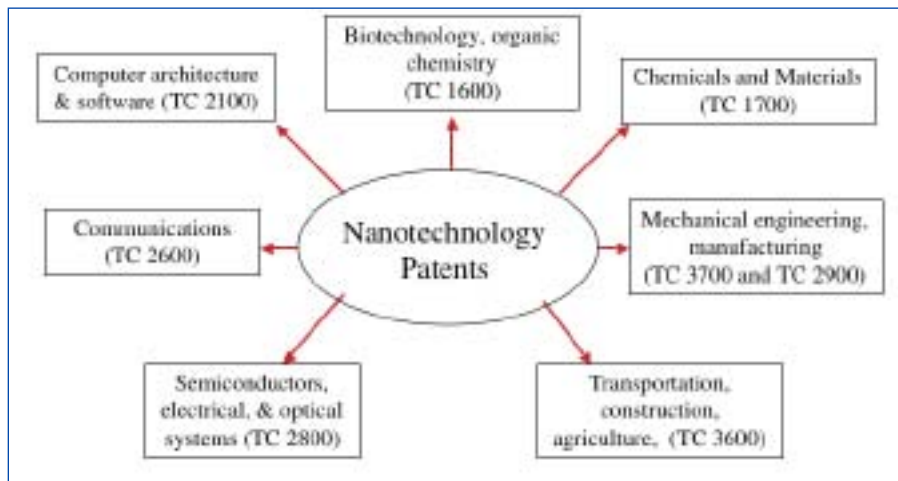
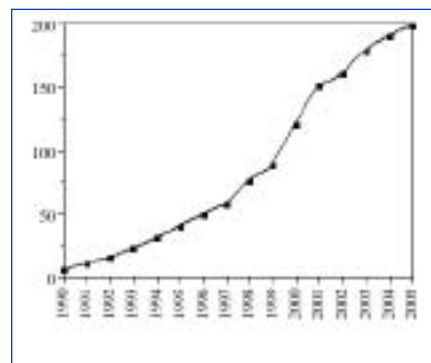


Fig. 2 Patent and Trademark Office areas where nanotechnology patent applications may be reviewed.

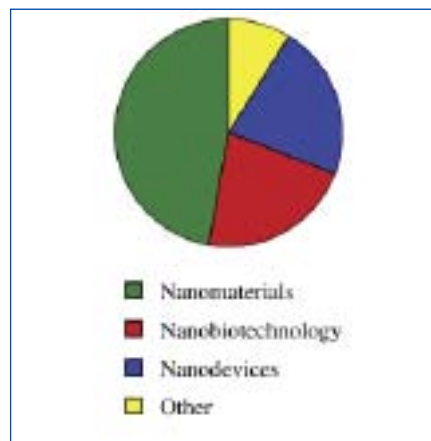
patent application is reviewed. There is at present no subject area for nanotechnology. Instead, an application is examined in one of seven general areas (Fig. 2). Within each of these the individual patent examiners may have a wide range of technical knowledge, but given the newness of the field, their knowledge of nanotechnology can be marginal at best. Thus, is a semiconductor nanoparticle reviewed by Chemistry and Materials, or Semiconductors, Electrical, & Optical Systems? In a hypothetical case the examination of a single application in these two groups may result in different outcomes. Examiners in each area may find different prior art, and have a different idea of obviousness. Thus, one examiner might reject the application, while another would not only allow it but also allow claims that are beyond the scope of the invention. The upshot of this confusion is that the freedom to operate is questionable even when an exclusive license is obtained. As an example, there are more than 10 overlapping patents claiming the composition of matter of carbon nanotubes. Clearly, reform of the USPTO practices with regard to nanotechnology is a must but, in many cases it is already too late.

Litigate or Cooperate

So what does the future hold for the nanotechnology industry? Well there are two potential outcomes. We can either brace ourselves for an explosion in litigation, or we must develop a way



Number of startups in nanotechnology.



Distribution of nanoindustry.

to cooperate. In the former only the lawyers and the expert witnesses will be winners. (I am of course offering myself at a reasonable rate in this regard!) It is my belief that it is only in cooperation that we can promote the future development of commercial applications of nanotechnology. However, as an alternative to universities and companies

Reframing the Concept of Nanotechnology

“playing nice” and cooperating, it has been proposed that federal mandating of licensing may become reality. A more palatable solution would be that universities consider pooling patent portfolios to provide a stronger license. As an alternative, university/industry partnerships could be formed that are problem/product driven.

Yet there are significant disadvantages to pooling for an assignee. Firstly pooling results in a lower income for any individual assignee and, secondly, there is a reduction in control over the future of the technology. In addition, there are antitrust issues that may need to be resolved. Irrespective of the advantages or disadvantages of pooling patents, it is important for every director of a university office of technology transfer and every professor seeing his or her invention providing that retirement in the South of France to consider that 5% of something is better than 100% of nothing.

The ‘Onion’ Strategy

Many venture firms claim (erroneously) that they are the bridge across the valley of death between a university invention and a sellable product. Irrespective of the reality of this claim, the gulf between what comes out of a university laboratory and what enters the market place is real. While a university will generally file patents on a composition of matter (e.g., a nanomaterial) or a method of making or using the composition of matter (e.g., a particular synthesis of the nanomaterial), commercial advantage is gained by the protection of the end product or system and each of the components of that system rather than a “core technology.” Given the direction in which the nanotechnology industry is heading, a successful patent strategy should involve a layered protection of the core technology, much like the layers of an onion (Fig. 3). Such an approach provides a valid model for both the granting of university licenses to established companies as well as the creation of university spinoff companies.

In one illustration of the “Barron onion” model, the core nanotechnology

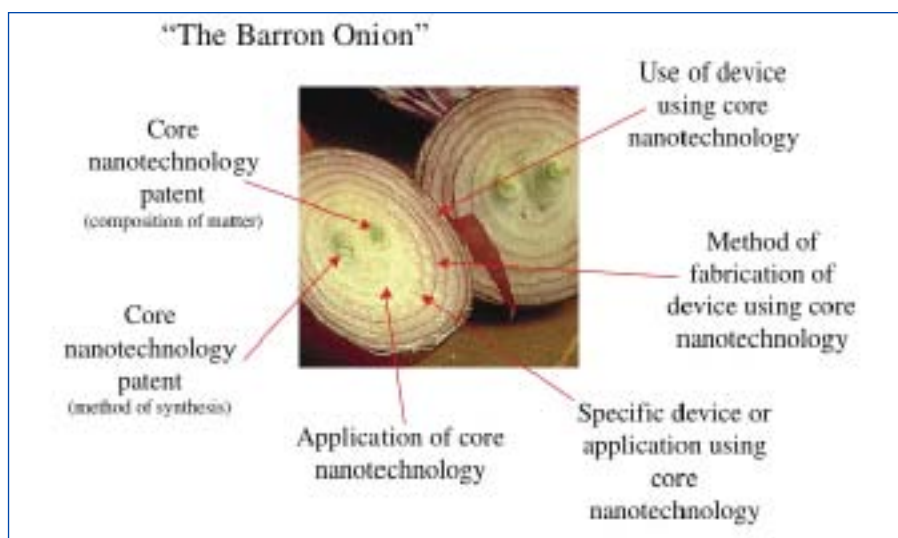


Fig. 3 Pooling: Protection of core technology.

patents (the heart of the onion) would originate in a university. The university would grant a license to a company in a particular industry with its own intellectual property associated with its products. Subsequent patent applications would be made (the outer layers of the onion) to combine the core nanotechnology with the eventual end use. In the case of a startup or university spinoff, the university would license the core patents to this new company. This new entity should make it a critical goal to provide the additional layers of the onion rather than assume the license of the core technology is sufficient for commercial success. Adhering to these approaches will provide a significantly greater protection for the company. After all, a single patent (or key claims of a patent) can often be made invalid during a court battle; however, the likelihood that all the claims of multiple patents will be invalidated diminishes as the number of patents to be overcome increases. The onion concept of protection is especially important in the present nanotechnology industry, where commercialization is in current markets meeting present needs, rather than creating entirely new markets.

In summary, nanotechnologies provide unique or enhanced properties that will impact every aspect of our lives, in much the same manner as the microchip and

Internet have done. However, at present products are of more interest to the readers of *People Magazine* than the *Wall Street Journal*. Broadly speaking, nanotechnology is an enabling rather than a self-standing industry. Thus the earliest impacts of nanotechnology will be “stealth” in mode, but its contributions will be insidious until there is no area of our lives not impacted by it. Commercialization of nanotechnology is at present hampered by a crowded and conflicted patent space in which expensive litigation or cooperation are the only paths forward. In this regard, patent pooling and/or protection of the end-uses in addition to the core technologies are vital to ensure smooth and profitable commercialization of nanotechnology. ■

About the Author

Andrew R. Barron is the Charles W. Duncan, Jr. – Welch chair of chemistry, a professor of materials science, and the associate dean for industry interactions and technology transfer at Rice University, Houston.

Editor’s Note

This article is based on a presentation given at the 31st International Conference on Advanced Ceramics & Composites held at Daytona Beach.