NanoFabrication: Implications For The Viability Of Intellectual Property Protection

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I. Introduction

One of the most popular topics for legal analysis today is "Nanotechnology." One way that this topic is addressed is to apply historical experience and existing ideas to the development of this technology. However, many times this analysis flows from the assumption that nanotechnology is, from an Intellectual Property (IP) perspective, no different than other technologies, such as the development of early radio. As such, these approaches often ask questions from the perspective of how IP law will influence the development of the technology.

This short paper takes a different approach by posing the reverse proposition: how will nanotechnology (and nanofabrication in particular) affect existing systems of IP law and, more importantly, can these IP systems be viable in view of realized nanofabrication? As implied above, the proposition is worth exploring because nanofabrication is/will be different from most other technologies that are patented. Firstly, nanofabrication, as discussed below, will enable relatively inexpensive, distributed, fabrication of numerous products which would otherwise, in today's world, have been manufactured in plants and distributed to buyers. Secondly, the scope of people which will desire to have these products (i.e., products fabricated via nanotechnology) will be large in comparison to historical experience. Both of these factors, and likely others, may raise questions of whether existing IP systems, such as patent protection, are viable.

A. Nanotechnology

This paper distinguishes nanotechnology from nanofabrication for a number of reasons. First, nanotechnology (in the broadest sense) already exists. For example, one popular...
The definition of nanotechnology is anything that relates to devices having dimensions less than 100 nanometers. For example, the National Science Foundation defines "nanotechnology" as research and technology development at the atomic, molecular or macromolecular levels, the length scale approximately 1-100 nanometers (nm). Under this definition, however, nanotechnology is already well established. For example, IBM has manufactured CMOS transistors having a gate length measuring about 36 nm, well below the above definitional threshold. Moreover, devices such as this are already subject to patent protection as they may already be covered by broad device claims in existing patents or pending applications. Also, these devices are created mostly through the extension of otherwise conventional technology. For example, many semiconductor devices that could characterized as being in the nano-realm have been fabricated using extreme Ultra-Violet lithography, which could be called conventional, but for the scale of the device.

B. Nanofabrication

For reasons listed supra, this paper discusses the implications of "nanofabrication" rather than the broader topic of nanotechnology. Therefore, as discussed herein, "nanofabrication" relates to the manipulation of matter at the atomic level. Specifically, nanofabrication means the manipulation of matter to provide structures that are limited only by design and what natural physical law allows. In other words, "nanofabrication" is limited by what nature allows so that, for example, atoms can be assembled in any way that provides a stable state even though the arrangement has not previously been provided by evolution or synthesis.

This paper also discusses programmed assembly as part of the definition of nanofabrication. Programmed assembly provides for the nanofabrication of whole products rather than just the manipulation of matter at the atomic level. To this end, programmed assembly is the end result of the development of nanofabrication to provide complete products that consumers would find desirable. In this sense, nanofabrication deals with how products are made rather than the products themselves.

II. Nanofabrication

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A. A Proposed System ForDirected Nanofabrication

One system of nanofabrication has been proposed by Eric Drexler⁸, which depicted in Figure 1. According to this system, products would be assembled in a bottom-up fashion using reservoirs of basic materials. The products would be assembled in stages where each stage is provided with either the basic materials or with the product of a lower order stage. In operation, this system would be capable of fabricating any product for which the atomic structure is known. For example, any conventional product could be manufactured by this system once its structure is programmed into the system. As discussed above, this type of system may allow the relatively low cost fabrication of products by, for example, an end user having access to the system and the program needed to fabricate the product.

⁸ K. Eric Drexler is the author of numerous books, articles, and papers in the field of nanotechnology including *Engines of Creation*, 1986.
Proposed desktop-scale molecular manufacturing appliance. Tiny machines join molecules, then larger and larger parts, in a convergent assembly process that makes products such as computers with a billion processors. (Parts shown as white cubes.)

Most conventional manufacturing processes are based on what could be referred to as a top-down approach, where larger objects are processed resulting in smaller objects. For example, large objects can be cast, sawed, or machined into precisely formed products by removing unwanted matter. Even though the results of such conventional processes may be small (e.g. integrated circuits, etc.) the approach taken by nanofabrication is quite different. In contrast, nanofabrication involves a bottom-up rather than a top down approach. In particular, the type of nanofabrication provided by the appliance shown in Figure 1, starts with raw feed stock material from the bottles shown in the upper left followed by successive stages of assembly shown progressing from the left most portion of the appliance toward the

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9 The “bottom up” characteristic of nanotechnology (and nanofabrication) is perhaps its most defining characteristic. See generally, Glenn Reynolds, Nanotechnology and Regulatory Policy: Three Futures, 17 Harv. J. Law & Tech. 179 (2004).
right most portion of the appliance. Each stage of the nanofabrication appliance uses a subassembly produced by the proceeding stage and can be controlled to add predefined structures to the subassembly provided. The final product is the result of all proceeding stages of nanofabrication which is shown in the right most portion of the appliance immediately below the opening. The particulars of how this type of appliance would work is not provided herein, however, the operation an architecture of a similar appliance is described in detail in Nanosystems by K. Eric Drexler.\(^\text{10}\)

Another way to think of nanofabrication is by analogy to the growth of living organisms. In particular, most living organisms are constructed by tiny molecular machines, such as cells and organelles, working from the bottom up. As described by Fiedler and Reynolds in *Legal Problems of Nanotechnology: an Overview*:\(^\text{11}\)

By organizing individual atoms and molecules into particular configurations, these molecular machines are able to create works of astonishing complexity and size, such as the human brain, a coal reef, or a redwood tree. This approach can produce results that would seem impossible if judged by the standards of conventional top-down production technology, but that are taken for granted in their proper context. For example, the human body begins as a single cell, a fertilized ovum. Yet a mature human being consists of approximately 75 trillion cells, complexly arranged and consisting of many different varieties. The molecular machinery responsible for this amazing, though commonplace, feat of production is capable of such dramatic results because it performs operations in parallel (i.e., with many cells operating at the same time through most of the growth process), and from the bottom up.

As Eric Drexler states:

Nature shows that molecules can serve as machines because living things work by means of such machinery. Enzymes are molecular machines that make, break, and rearrange the bonds holding other molecules together. Muscles are driven by molecular machines that haul fibers past one another. DNA serves as a data-storage system, transmitting digital instructions to molecular machines, the ribosomes, that manufacture protein molecules. And these protein molecules, in turn, make up most of the molecular machinery just described. Putting these natural molecular machines to work is nothing new, of course, as every living thing does so constantly. Nor is deliberate human programming of those machines particularly new, as it is what genetic engineering (or even selective breeding) is all about. What makes nanotechnology different is that it attempts to go farther than natural mechanisms and would allow. Using special bacterium-sized "assembler" devices, nanotechnology would permit on a programmable

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basis exact control of molecular structures that are not readily manipulable by organic means (e.g., diamonds, or heavy metals).

With nanotechnology, atoms will be specifically placed and connected, all at very rapid rates, in a fashion similar to processes found in living organisms. Trees, mammals, and far less complex organisms make use of molecular machinery to manufacture and undertake repairs at a cellular and sub cellular level. The key to the application of nanotechnology will be the development of processes that control placement of individual atoms to form products of great complexity at extremely small scale.\(^\text{12}\)

B. Access to nanofabrication may change society's view of the value of property and the fairness of protecting it

As discussed above, one of the changes that nanofabrication could precipitate is that people will have a fundamentally different valuation of some physical products (i.e., those products that can be nanofabricated). This stems from the fact that these products may seem, more readily available and will leave the impression that they are simple to make. Moreover, these products will be relatively inexpensive to manufacture. In turn, this may have several effects. One effect may be that people view it as unfair that they cannot have these products without paying an unreasonable high price. After all, people may ask, how could it be expensive when it can be manufactured automatically without any human intervention? This could lead to people justifying illicit fabrication based on a sense that to deny them that would be unfair. Moreover, the scope of people to whom these products might appeal would be great, which may increase societal pressure to exempt these types of products from protection.

C. Historically analogous experiences: Napster and "One-click."

The above conjectures have some historical parallels. Napster was software that allowed users to share digital copies of music recordings via the Internet.\(^\text{13}\) The copies could be made relatively easily (no understanding of music recording was necessary although some basic understanding of how computers and the Internet function was needed), required little intervention, and the copies were of the same quality as the original. In other words, it was easy and the copy of the product was as useful as the original. Moreover, the copies could be used as originals themselves to further propagate illicit copying. One of the reasons why this may have happened was that people believed the price of copyrighted music was too high.

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\(^{12}\) Supra note 10.

\(^{13}\) The Napster technology is described in, *A&M Records v. Napster*, 239 F.3d 1004, 1011-12 (9th Cir. 2001).
(after all, according to the reasoning of file swappers, how could it be so expensive, I downloaded it in 30 seconds via the Internet, and after all it doesn't hurt the artist). This type of activity appealed to a relatively narrow section of society, but the fact remains that many people were willing to knowingly copy protected property without permission because they believed the price was unfair, they had a strong desire for the product, there was little chance of being caught/punished, and it was easy to do. All of these factors may have contributed to this group's unwillingness to abide the rule of well accepted law.

Some support for this type of behavior can be found in a recent study commissioned by the Business Software Alliance (BSA) to investigate the attitudes of students toward the elicit downloading of copyrighted material via the Internet. According to the BSA study, just under two thirds of college university students surveyed in 2005 saw nothing unethical about swapping or downloading digital copyrighted files (i.e. software, music, and/or movies) without paying for them. In particular, over 80% of students surveyed agreed with the rationale that it made no sense to charge hundreds of dollars per user license when the cost to reproduce the music is so low (i.e., pennies). Other rationales cited by the students in the study are to cut costs, and that the technology industry is so prosperous that the few people using unlicensed software would not make a substantial difference.

The similarities of the Napster situation to nanofabrication are that these same factors may well exist once the reality of the technology is realized. Copying of products, using a system theorized by Eric Drexler, would be relatively easy. Moreover, the type of product which could be produced might be limited only by access to the program needed to fabricate the product. This could mean that the number of people which might find the justification described above in reference to the Napster situation as attractive could be quite large. This follows from the fact that the products being illicitly produced could be as varied as societies needs. In other words, nanofabrication may be applied to make almost any product so the likelihood that illicit copying will appeal to many people is probably high.

Another historical analogue is that of the "One click" patent issued to Amazon, Inc. From a patent law perspective, this subject matter was well established as patentable. Although the patent was characterized as a business method patent, it was embodied in an e-commerce web site and, therefore, fell within the scope of software (which had been patentable for sometime). Despite the conventional nature of the subject matter, the

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controversy centered on whether the Internet (or e-commerce) was a legitimate area for protection. Part of the rationale for the opposition flowed from the fact that so many people were involved with e-commerce. The fact that practically anyone who could design e-commerce web pages could be a potential infringer may have contributed to a type of populist movement to exempt the Internet (or at least e-commerce) from patent protection. In comparison, larger business entities (like Barnes and Noble) approached the issue in more traditional legal means: litigation/licensing/design around.\(^{15}\)

**III. Conclusion**

The above historical situations provide some support for what the author believes could be a fundamental shift in how society views the fairness of IP systems and ultimately, whether these systems will be viable. Logic dictates that for any legal framework to be accepted, there must be at least an implied acknowledgement that it is fair. The above examples show two instances where at least some portion of society believes the bargain was not fair. The number of people that will make the same evaluation at the realization of nanofabrication will be vast compared to those examples given as the number and type of products which will be affected will be far greater than previously known. This logic leaves some doubt as to whether current IP systems could be viable in view of such developments.

\(^{15}\) See generally **David Baumer and J.C. Poindexter, Cyberlaw and E-Commerce, 313-20** (2002).