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Securing the Future for the Nano Revolution in the United States

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Abstract

Nanotechnology promises huge potential for innovation in the coming decades. Globally, countries are scrambling to ensure they will not be left behind by building up their intellectual property regimes. Strong intellectual property leads to strong innovation. For the first time in modern history, the United States is not the prime contender for supremacy over this new field of technology. With the passage of the American Invents Act in September, the United States began the reform process. However, there are still many problems that need addressing including the training of patent players, dealing with the problems of university patenting, and educating the future generation of scientists in United States schools.
I. Introduction

Nanotechnology holds the key to the next revolution in technological advances. While it may have started out in the 1970s and 1980s as curiosity experiments, it is now a full-blown field of science and technology.\(^1\) Nanotechnology is the result of the intersection of varied fields, ranging from electronics to chemistry to medical devices, all exploring the new ability to achieve greater uniformly than previously thought possible at the nano-scale (1-100 nanometers).\(^2\) There are great possibilities for innovation in these new substances (for example, the Beijing Concert Hall sports self-cleaning glass, through nanotechnology\(^3\)). In the near future, advances in materials, medicine, energy, and electronics will yield breathtaking changes.\(^4\) Globally, governments and corporations recognize the potential for nanotechnology, with $12.4 billion dollars spent on nano-research in 2006.\(^5\) Companies worldwide also recognize the potential for nanotechnology – 1500 so far have announced plans to develop nanotechnology commercially.\(^6\) In fact, nanotechnology will be a $20 billion dollar per year industry by 2020.\(^7\)

Unfortunately, the development of nanotechnology is extremely research intensive, requiring significant investment by researchers and companies, and protection by their governments.\(^8\) Trade secrets do not protect innovators from accidental disclosure as patents do.\(^9\) Patents will be the most viable method for exploitation of the technology. And the country that

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4 Van Lente, supra note 2, at 174.
6 Van Lente, supra note 2, at 181.
7 Id. at 182.
8 Bawa, supra note 5, at 719.
9 Van Lente, supra note 2, at 185.
best enables its industry to obtain and utilize this technology will see benefits to its trade and economy.

While the United States has been at the center of many technology revolutions in the past, it is losing its status as a global leader in science and technology. Many countries who were not economic competitors for previous technological revolutions now present serious competition. In fact, China now ranks third, behind the United States and Japan, in the number of patents and publications concerning nanotechnology produced per country.\(^\text{10}\) Nanotechnology allows developing countries, like China to leapfrog through their technical development, allowing rapid progress.\(^\text{11}\) The United States needs to catch-up in order to keep from falling behind.

In order for the United States to keep its domestic industry prospering amongst global competition, it needs a strong patent system that fosters innovation and encourages progress. Globally, patent offices are struggling to cope with challenges specific to nanotechnology.\(^\text{12}\) Nanotechnology innovations often involve miniaturization of long-known patented technologies, creating intricacies in claim-drafting. Issues also arise over who holds current nanotechnology patents. Universities hold a much higher percentage of patents in nanotechnology than any other field. Some have argued that this makes universities equivalent to patent trolls, hindering the development of nanotechnology products.

The United States just passed the first major reform to the patent system since the 1950s – the America Invents Act (AIA). Currently there is a very long backlog at the patent office – it may take several years from the application date for a patent application to get to the desk of the examiner – and then the examination process begins. The AIA seeks to cut down on this backlog

\(^{10}\) Liu, supra note 3, at 467.

\(^{11}\) Rachel Parker, China’s Nantechnology Patent Landscape: An Analysis of Invention Patents Filed with the State Intellectual Property Office, 6 NANOTECHNOLOGY L. & BUS. 524, 525 (2009).

\(^{12}\) Bawa, Supra note 5, at 703.
and promote efficiency. The America Invents Act also changed the United States from a First-to-Invent system to a First-Inventor-to-File, bringing it in line with all other major patent systems in the world. The First-Inventor-to-File system encourages innovation by forcing companies to file for patent protection quickly and often.

Unfortunately, the America Invents Act does not fix all the problems in the United States patent system. There is still a long way to go to ensure that the nanotechnology revolution occurs in the United States. The downfall of science in the American education system needs addressing. There is also the issue of university stockpiles of nanotechnology patents. The United States needs to ensure future exploitation of nanotechnology and education of the future nano-scientists. This paper addresses possible reforms that will address these problems and lays out several possibilities for reform.

This paper first looks to the background of nanotechnology and the history of its development in the United States. Then the discussion moves to the intricacies related to patenting nanotechnology in particular and the current state of affairs at the patent office. It then considers the current state of affairs in university patent practices and how those affect the current and future development of nanotechnology innovations in the United States. The paper then addresses the impact of the current reforms in United States patent practices – including the America Invents Act. The paper then addresses future reforms that are important to ensuring that nanotechnology prospers in the United States. The United States can be the place for the nanotechnology revolution if action and reforms are taken quickly.

II. Fuel for the Nano-Fire

Modern technology is about refining instruments to reach smaller and smaller sizes-better understanding and manipulating DNA interactions, shrinking computer chips, etc. As their
instruments become more refined, innovators realize the ability to refine technology at the nano level. Nanotechnology naturally integrates science and technology on a scale not seen before.\textsuperscript{13} Nanotechnology refers to a broad category of technologies across a wide range of science and technology fields – from chemistry, to biology, to medicine.\textsuperscript{14} Nanotechnology falls into two categories, the term often referring to both basic research and materials science products.\textsuperscript{15} Nanotechnology and nanostructures refer to structures that are less than 100 nanometers.\textsuperscript{16} At this scale, the properties of materials change as the laws of classical physics and chemistry no longer apply the same way.\textsuperscript{17} Controlling the structure size, then, has huge potential for innovation. For example, titanium dioxide is an active ingredient in sunscreen at the micro-level. Shrinking titanium dioxide particles to the nano-level results in transparent sunscreen.\textsuperscript{18}

Nanotechnology as a field has rapidly expanded. In 1981 there were no publications discussing nanotechnology, in 1998 there were 12,000.\textsuperscript{19} Currently technology allows for the creation of novel nano-products such as carbon nanotubes and bucky balls.\textsuperscript{20} Carbon nanotubes have pervaded products, making tennis rackets lighter and smaller, making semi-conductors smaller and faster, and reinforcing automobile bumpers to make them lighter and stronger. However, the nanoparticles in these products are all inert. In the future, it is expected that

\textsuperscript{13} Dana Nicolau, \textit{Innovation and Knowledge Transfer in Emerging Fields: The Case of Nanotechnology in Australia}, 2 \textsc{Nanotechnology} \textsc{L.} \& \textsc{Bus.}, 384, 387 (2005).
\textsuperscript{14} Terry Tullis, \textit{Current Intellectual Property Issues in Nanotechnology}, 2004 \textsc{UCLA} \textsc{J. L.} \& \textsc{Tech. Notes}, 12, 1 (2004).
\textsuperscript{15} \textit{Id.} at 2.
\textsuperscript{16} Laurie Axford, \textit{Patent Drafting Considerations for Nanotechnology Inventions}, 3 \textsc{Nanotechnology} \textsc{L.} \& \textsc{Bus.}, 305, 305 (2006).
\textsuperscript{17} Jeffrey Mills et al., \textit{Protecting Nanotechnology Inventions: Prosecuting in an Unpredictable World}, 7 \textsc{Nanotechnology} \textsc{L.} \& \textsc{Bus.}, 223, 224 (2010).
\textsuperscript{18} See Consumer Reports Health, \textit{Nanotechnology: Our First Test, Nanoparticles are found in many sunscreens}, CONSUMER\textsc{HealthReports} (Nov. 26, 2011, 9:05 PM), \url{http://www.consumerreports.org/health/conditions-and-treatments/nanotechnology-7-07/nanoparticles-in-sunscreens/0707_nano_sunscreens1.htm}.
\textsuperscript{19} Nadine Hoser, \textit{Nanotechnology and its Institutionalization as an Innovative Technology: Professional Associations and the Market as Two Mechanisms of Intervention in the Field of Nanotechnology}, 7 \textsc{Nanotechnology} \textsc{L.} \& \textsc{Bus.}, 180, 186 (2010).
\textsuperscript{20} Smart Garment People, Ltd. \textit{Carbon Nanotubes and Buckyballs}, SMART\textsc{GarmentPeople} (Nov. 26, 2011, 9:10 PM), \url{http://www.smartgarmentpeople.com/index.php?q=Carbon}. 
nanotechnology products will be active – capable of self-assembly. Many of the imagined but not yet realized applications of nanotechnologies require automation of atomic manipulation.\textsuperscript{21} During the entire history of technology, products have been designed top-down. Nanotechnology will change that, allowing products to be designed from the bottom-up, starting with the atomic scale.

The country that hosts this revolution in technology will reap the economic benefits associated with new factories, new jobs, and benefits in global trade. In fact, over 40 countries globally are betting that nanotechnology will be the key to a large future market.\textsuperscript{22} The United States recognized the potential of nanotechnology in 2003 by passing the Nanotechnology Act.\textsuperscript{23} The Nanotechnology Act declared nanotechnology the highest priority since the space race. However, nanotechnology represents the first technological expansion where the United States does not already have a clear advantage in the field. And the United States is not alone in trying to exploit nanotechnology. China plans to use nanotechnology to become an ‘innovation-oriented’ nation by 2020.\textsuperscript{24} Europe is also funding nanotechnology heavily – the European Commission lists nanotechnology as a research priority.\textsuperscript{25} Policy makers in the United States and abroad agree that nanotechnology will be a key technology for the 21\textsuperscript{st} Century.\textsuperscript{26}

However, the United States is not out of the running yet. The biggest impediment to new technologies is the acquisition and exploitation of the necessary intellectual property. The most important intellectual property for nanotechnology will concern patents and trade secrets. However, in order for industry to get the necessary patents, its country must have a strong and

\textsuperscript{21} Tullis, supra note 14, at 2.
\textsuperscript{22} Parker, supra note 11, at 525.
\textsuperscript{23} Tullis, supra note 14, at 1.
\textsuperscript{24} Parker, supra note 11, at 525.
\textsuperscript{26} Id. at 428.
supportive patent system. The first country to get a strong patent system responsive to the challenges nanotechnology presents will be in the best position to reap the rewards of the nanotechnology revolution.\textsuperscript{27}

**III: Weaving Nanotechnology Intricacies into Patents**

Nanotechnology companies will be successful only if they are able to obtain and defend their intellectual property efficiently and with minimal cost.\textsuperscript{28} In order to get a patent in the United States, an invention must be novel, nonobvious, clearly described in the application, and cannot be a discovery.\textsuperscript{29} There are some inherent difficulties in patenting nanotechnology because of claim drafting intricacies necessary to overcome the patent requirements. The United States Patent and Trademark Office (USPTO) responded to these concerns by creating a new technology class of patents, class 977. However, there is still a need to educate for patent examiners and prosecutors on navigating these difficulties.

The first issue for nanotechnology companies is getting the patent protection. Discoveries are inherently unpatentable.\textsuperscript{30} Patent prosecutors need to draft carefully to show that nanoparticles are engineered, not discovered. Discoveries concern scientists finding anomalies with recurring structures whereas inventions are manipulations of said structures.\textsuperscript{31} However, there are other types of patent rejections that need to be overcome through clear patent drafting – inherent anticipation, obviousness, and enablement.\textsuperscript{32} The obvious requirement presents a problem as many nanotechnology products involve smaller versions of previously patented compounds at the micro level. An examiner evaluates obviousness by determining the scope of

\begin{flushleft}
\textsuperscript{27} Tullis, *supra* note 14, at 1.  
\textsuperscript{28} Axford, *supra* note 16, at 305.  
\textsuperscript{29} Mills, *supra* note 17, at 224.  
\textsuperscript{30} Tullis, *supra* note 14, at 3.  
\textsuperscript{31} Nicolau, *supra* note 13, at 388.  
\textsuperscript{32} Koppikar, *supra* note 1, at 27.  
\end{flushleft}
prior art, comparing it to the claimed invention, and determining the ordinary skill level of the art.\textsuperscript{33} Patent prosecutors need to clearly discuss the different properties of their nano-products compared to the same compounds at the micro-level. Discussing the challenges the inventor overcame in the specification of the patent will also help get over the obviousness hurdle.\textsuperscript{34} Enablement concerns arise when prior art would have enabled a practitioner skilled in the art to manufacture the claimed invention without undue experimentation.\textsuperscript{35} Providing numerous working examples of the nanotechnology invention in the specification will make it clear to the patent examiner that future practitioners can use the invention with minimal experimentation.\textsuperscript{36} As patent prosecution get more expensive and lengthy with different rejections, careful drafting up front is crucial to cut costs and reduce the examination time.

Patent prosecutors often tailor patents to their specific fields by careful claim drafting.\textsuperscript{37} Nanotechnology, however, often involves contributions from different fields as well as miniaturization that may not be field specific. An interdisciplinary approach to patent drafting will streamline the patent process.\textsuperscript{38} Patent applications needs to describe clearly the differences between the new nano-product and the pre-existing technology. Innovators also need to avoid trying to put too much into a patent application. A better strategy may involve filing multiple patents – an initial patent describing the new technology, and later patents going through the applications and improvements to the nanoparticles.\textsuperscript{39} It is also very important to clearly state that the size differential is part of the innovation.\textsuperscript{40} Clear articulation of the problem-solving

\textsuperscript{33} Mills, \textit{supra} note 17, at 225.
\textsuperscript{34} \textit{Id.} at 229.
\textsuperscript{35} Koppikar, \textit{supra} note 1, at 29.
\textsuperscript{36} Mills, \textit{supra} note 17, at 236.
\textsuperscript{37} Axford, \textit{supra} note 16, at 305.
\textsuperscript{38} \textit{Id.} at 308.
\textsuperscript{39} \textit{Id.} at 306.
\textsuperscript{40} \textit{Id.} at 306.
capabilities of the new technology helps to avoid high scrutiny by patent examiners.\textsuperscript{41} Specific, well-defined words can make the invention readily apparent.\textsuperscript{42}

The doctrine of equivalents is another potential problem for nanotechnology where there are broad claims. If size is not clarified in earlier patents, a nanotechnology inventor may find themselves paying royalties to a patent-holder on a corresponding micro-scale product.\textsuperscript{43} The reverse doctrine of equivalents is important in nanotechnology litigation because it distinguishes nano and micro scale products “where a device is so far changed in principle from a patented article.”\textsuperscript{44} Patent prosecutors need to make it clear to examiners and potential users of technology that nanotechnology works on an entirely different set of principles of molecular operation and physics than their micro-sized counterparts.\textsuperscript{45}

The multidisciplinary nature of nanotechnology causes difficulties for the patent office. Patent applications are normally sorted by technology class, and then compared against the prior art specific to that class. However, nanotechnology often encompasses multiple technologies. Patent examiners often do not have access to all relevant prior art across technology fields. In response to this issue, the patent office created class 977 for nanotechnology.\textsuperscript{46} The examiners for this new class come from different tangential fields, as does the prior art.\textsuperscript{47} The ultimate goal is to create a new nanotechnology classification system to handle all patent references pertinent to the different subfields.\textsuperscript{48} The patent office has created a two-pronged test to classify patent applications in the nanotechnology class. A structure falls into the nanotechnology category if it

\textsuperscript{41} Id. at 307.
\textsuperscript{42} Id. at 307.
\textsuperscript{45} Id. at 11.
\textsuperscript{46} Axford, \textit{supra} note 16, at 305.
\textsuperscript{48} Mouttet, \textit{supra} note 47, at 262.
“(1) [has] at least one physical dimension of approximately 1-100 nanometers; AND (2) [possesses] a special property, function or effect.”

The patent office also faces an education problem with its examiners. There have been only a few experts to come to the USPTO to lecture on nanotechnology. There also are no guidelines concerning nanotechnology available for examiners yet. Without examiners well versed in handling nanotechnology patent applications, the USPTO has little hope of controlling the quality of granted applications. The patent office needs to re-think its isolationist approach, and create a program to instruct its examiners in the intricacies presented by interdisciplinary patent applications.

Patent prosecutors need to rethink their approach to nanotechnology, anticipating rejections and emphasizing the innovative features of the patent carefully, in light of prior art. The patent office, in turn, needs to take steps to ensure that its examiners are educated and able to scrutinize patents carefully. With both parts of the system working together, the United States will produce strong nanotechnology patents.

IV: The University Dilemma

Another large issue with nanotechnology concerns who is applying for and receiving patents. Universities do not have a long history as patenting entities; however, market and policy changes drove universities to the patent office in order to cover their bottom lines. Universities are no longer exploiting the more traditional method of free technology transfer through journal disclosure as often as they used to. With the passage of the Bayh-Dole Act, universities are

49 Id. at 262.
50 Bawa, supra note 5, at 727.
51 Id.
52 Nicolau, supra note 13, at 386.
53 Id.
able to control ownership of their intellectual property, regardless of government sponsorship.\textsuperscript{54} And with the enactment of the Nanotechnology Act in 2003, the government institutionalized nanotechnology research and development by granting funds to universities.\textsuperscript{55} In combination, this puts American universities in a great position to research and obtain patents pertaining to nanotechnology. Universities, then, will have a very important role to play in the future of nanotechnology in the United States. Universities also have an advantage over specialized corporations in that they regularly experience the blurring of specialties crucial to the fostering of inter-disciplinary nanotechnology through conferences and interdepartmental communication.\textsuperscript{56} Universities are also more likely to see collaboration within college departments and between different colleges than companies who have higher trade secret concerns.\textsuperscript{57} However, the question remains: will university involvement in its current form stifle or foster future nanotechnology innovation?

The traditional measure of academic performance looks to the number and variety of publications by professors and their students.\textsuperscript{58} This practice of early disclosure is conducive to fast patent filing and assertion of rights. However, the patents held by Universities appear similar to patents held by so-called patent trolls.\textsuperscript{59} Universities do not manufacture or practice the products they invent; they often only enter into license agreements so others may produce. These license agreements are usually exclusive because of the higher license fees that accompany exclusive licenses. This results in fewer cross licenses, which may stifle the ability for different industries to further advance the technology. However, it is important to note that

\begin{footnotes}
\item[54] Tullis, \textit{supra} note 14, at 5.
\item[55] Id. at 2.
\item[56] Nicolau, \textit{supra} note 13, at 386-7.
\item[57] Id. at 387.
\item[58] Tullis, \textit{supra} note 14, at 4.
\end{footnotes}
the technology transfer system between universities and industry in the United States works, if not perfectly.\textsuperscript{60} China is still working to find a way to create an effective technology transfer system as many of their domestic patent applications are from universities.\textsuperscript{61}

Universities are much more extensively involved in the process of patenting nanotechnology than other technology areas. In fact, universities have ten times the percentage of nanotechnology patents than utility patents in other fields.\textsuperscript{62} Universities are also among the top holders of nanotechnology globally.\textsuperscript{63} This trend likely is a result of both the Bayh-Dole Act and the fact that patent revenues are now increasingly needed as part of the bottom line for universities.\textsuperscript{64} Universities held sixteen times as many patents in 2004 as they held in 1980, and the trend is only increasing. Universities currently hold two thirds of the patents on the building blocks of nanotechnology.\textsuperscript{65} It is important to remember that this bottleneck of patent ownership in universities is supported in part by federal grants through the Nanotechnology Act and other federal granting agencies. In theory, federal research funds are supposed to be transferred to the private sector through intellectual property transfers from universities.\textsuperscript{66} However, when the patents are licensed exclusively and cross-licenses are not readily negotiated, blocking patents threaten the future of nanotechnology. However, with cuts to the funding of universities, exclusive patent licenses are an easy financial solution to budget shortfalls. This process is

\textsuperscript{60} Parker, \textit{supra} note 11, at 531.
\textsuperscript{61} Id.
\textsuperscript{63} Id. at 316.
\textsuperscript{64} Lemley, \textit{supra} note 59, at 614.
\textsuperscript{65} Id. at 615.
driving universities further towards commercialization, possibly harming the strength of the United States university system.\textsuperscript{67}

The issue of university involvement will be one of the next largest issues to be resolved. While universities have the potential to further research in the nanotechnology field, the practice of exclusive licensing may prove harmful to the future of nanotechnology. Policy makers need to find a balance between universities ability to use patents to fund education and preventing exclusive licenses from stifling innovation.

\textbf{V: Current United States Patent Reform and Competition}

The United States has historically led the way in technological revolution. The United States participated strongly in the industrial revolution. America fostered the computer revolution. The internet revolution took place in Silicon Valley. The genetic revolution also had its share of activity in the United States. However, the location of the nanotechnology revolution has yet to be set. Japan offers a strong challenge to the supremacy of the United States in the nanotechnology field through its own strong investment in research and development.\textsuperscript{68} The United States fostered many of these revolutions through its strong patent system. The United States Federal Government has led the long-term development of nanotechnology through the Nanotechnology Act and the process of grant awarding for research.\textsuperscript{69} However the last time the United States patent law was updated was the early 1950s. Much has changed in the technological landscape since then. It is imperative that the United States patent doctrine responds effectively to the intricacies and changes nanotechnology brings.\textsuperscript{70} The USPTO currently faces allegations including “rejection of valid claims, issuance of a broad and

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\item \textsuperscript{67} Id. 406.
\item \textsuperscript{68} Edward Foley et al., \textit{Assessing the Need for Nanotechnology Education Reform in the United States}, 3 \textsc{Nanotechnology} L. & BUS. \textit{467}, 470 (2006).
\item \textsuperscript{69} Id. at 469.
\item \textsuperscript{70} Wasson, \textit{supra} note 43, at 3.
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overlapping claims, a fragment and chaotic IP landscape, insufficient expertise at the PTO, lack of centralized review of nanotechnology, non-comprehensive searching of the prior art, a high backlog of applications, issuance of patents that are too broad, and issues of too many patents in a given technology area.”

Currently, the USPTO faces a backlog of over three years between application and grant of patents. The USPTO also has a patent grant rate between 77% and 95% of filed applications. This very high rate of patent grant suggests that some of the granted patents were subject to less than rigorous review and may suffer from over breadth as a result. Japan, on the other hand, is working to create a much stricter patent system. In a comparison of patents granted for applications filed in the USPTO, EPO, and JPO, 10% of applications granted in the US and Europe were rejected by the Japanese Patent office. However, recent reforms have taken place both within the USPTO and in the form of legislation. The Patent office is working to ensure that granted nanotechnology patents are of high quality. In addition, the America Invents Act passed September 16, 2011 brought a myriad of much needed reform to the United States Patent Act; both bringing the United States in line with the international regimes and giving needed flexibility.

Nanotechnology now affects at least 10% of applications filed in the USPTO. The creation of a nanotechnology class was a very important first step, but it is not an end goal. In the past, new technologies saw a slew of low-quality patents issue from the patent office shortly after discovery. This was the case for software patents and business method patents - which the

71 Van Lente, supra note 2, at 201.
73 Bawa, supra note 5, at 718.
74 Okuyama, supra note 72, at 460.
75 Tullis, supra note 14, at 5.
76 Mouttet, supra note 47, at 263.
Supreme Court curtailed in Bilski v. Kappos. The USPTO is taking nanotechnology patenting seriously to avoid having the same problem of low-quality patents arise again. The USPTO is scrutinizing nanotechnology patent applications to ensure that only high-quality patents are granted. For example, the decision In Re Kumar saw higher scrutiny by examiners who took great care to go through the prior art and rejected several claims for obviousness.

The America Invents Act initiated a wave of changes that promise to bring the United States Patent Act into the twenty first century. The most talked about change is a switch from the First-to-Invent standard to a First-Inventor-to-File standard. This means that the right to a patent goes to either the first inventor to file a patent application or the first inventor to publish results and then file within the one year grace period. The main critique of first-to-file systems is the effect on small businesses who often are not the first to file because of the need to take time to find and secure venture capital financing. This will also affect the strategies of Universities, who are often the first to publish, but not the first to file. However, it is important to note that the America Invents Act created a new defense to patent infringement that will ameliorate some of the effects – one of commercial use. This means that if a company chose to protect its nanotechnology through trade secrets instead of patents, it would not be punished by an inventor who files for a patent after the company started using the technology. Along with this change, the AIA also created a fast-track system for inventors willing to pay a higher fee or

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78 Mouttet, supra note 47, at 263.
80 Id. at 345.
81 (Due to the United States grace period, the filing date can be put off for a year after an initial publication. It is important to note that this is not the case for most other countries, however, where publication destroys the ability to file for a patent).
83 Lemley, supra note 58, at 619.
for technologies important to the nation’s economy.\textsuperscript{85} This could be a very important method for making nanotechnology patents available to companies willing to exploit them faster.

The grace period also changed because of the America Invents Act.\textsuperscript{86} While it is still a year in length, the triggers for the grace period are very different. For example, a secret offer for sale no longer triggers a grace period.\textsuperscript{87} This is advantageous for small businesses and universities seeking to sell or license the rights to a patent. The grace period starts with publication of results, and allows the inventor to use that publication date for priority purposes.\textsuperscript{88} This is incredibly advantageous for universities, who do publish frequently.

The other important change to the patent system is the institution of more post-grant review options.\textsuperscript{89} Litigation over patents is incredibly expensive. However, post-grant review is a mini-litigation over the validity of the patent only, which costs considerably less.\textsuperscript{90} A third party may only institute post-grant review procedure within nine months of the patent grant.\textsuperscript{91} And, after a post-grant review, the challenger may not attack validity of the patent again, lowering the cost of infringement litigation.\textsuperscript{92} There is also more opportunity now for more supplemental review by the patent owner to correct errors in the record or prior art submission.\textsuperscript{93} In addition, during the patent application process, there is a greater opportunity for third parties to submit art for review, further ensuring quality in patents granted.\textsuperscript{94}

\textsuperscript{86} Crouch, supra note 84, at 212.
\textsuperscript{87} Id. at 44.
\textsuperscript{88} Id. at 212.
\textsuperscript{89} Id. at 158.
\textsuperscript{91} Crouch, supra note 84, at 158.
\textsuperscript{92} Id. 161.
\textsuperscript{94} Crouch, supra note 84, at 14.
The America Invents Act also gives the USPTO more control over the fee rates and money generated by patent applications. This will give the USPTO the funds to hire more patent examiners and update the USPTO’s technology system – cutting down the backlog and allowing greater searching efficiency.\textsuperscript{95} It also gives the tools to better control the quality of granted patents by greater third party participation.

\textbf{VI: Taking Control of the Future of Nanotechnology}

The United States has taken great strides to set itself up as the ideal place for the nanotechnology revolution. However, there are still some important problems to solve. One of the biggest problems with new technologies is the specter of patent thickets, choking the ability of businesses to use their patents effectively without infringing those of others.\textsuperscript{96} Ensuring that the USPTO only grants patents to quality applications will solve the patent thicket problem. Another problem addressed earlier is the need to educate the patent players. The inventors understand why their innovations are new, but patent prosecutors and examiners also need a firm understanding of how nanotechnology patents differ from their micro- and macro-counterparts.

The public also needs education. The United States is falling behind in math and science education in high schools. Nanotechnology is only going to continue to evolve over the coming decades. In order to sustain the nanotechnology revolution, the United States needs to ensure that the scientists of the future are educated in the United States. In addition, university reform needs serious consideration, as universities are large holders and creators of nanotechnology inventions.

\textsuperscript{96} Van Lente, \textit{supra} note 2, at 174.
Patents in new fields often suffer from being too broad or not well defined, giving the owner great control over the emerging area.\textsuperscript{97} Moreover, the development curve for nanotechnology is predicted to be steep; later waves of advances occur while the patent rights on the foundation technologies are still active.\textsuperscript{98} This creates prohibitions on future users to work with and improve the earlier technology without clearance to use it. This results in patent thickets. The first generation of claims on nanotechnology is mainly composition of matter claims. These claims are usually very broad and tend to block later applications trying to use the matter claimed in the first application without a license.\textsuperscript{99} The second generation of nanotechnology patents includes claims that express the properties and uses the nanomaterial claimed in the composition of matter patent.\textsuperscript{100} A great example of this process is the carbon nanotube patent, which expired in 2004.\textsuperscript{101} The original carbon nanotube composition of matter claim covered any device that used multi-walled nanotubes.\textsuperscript{102} The original patent also stated uses like “reinforcements for other materials… to enhance electrical or thermal conductivity, to increase surface area of an electrode.”\textsuperscript{103} This broad definition effectively prevented anyone else from using multi-walled structures as reinforcing mechanisms for products.

This raises the question: what is the right balance necessary between freedom of operation and rewarding innovation?\textsuperscript{104} Compulsory licensing is not an unknown phenomenon to intellectual property in the United States. It is more commonly used in copyright than in patents. However, it might be time to consider compulsory cross-licensing to ensure that

\textsuperscript{97} Halluin, \textit{supra} note 82, at 227.
\textsuperscript{98} Henry Heines, \textit{Carbon Nanotubes: Identifying and Confronting the Blocking Patents}, 7 NANO\textsc{tech}NOLOGY L. \& BUS. 330, 330 (2010).
\textsuperscript{99} \textit{Id.} at 331.
\textsuperscript{100} \textit{Id.}
\textsuperscript{101} \textit{Id.} at 332.
\textsuperscript{102} \textit{Id.}
\textsuperscript{104} Tullis, \textit{supra} note 14, at 4.
innovation is not stymied because different inventors have blocking patents. To ensure inventors still gain economic benefits from their innovation, the convention could require compulsory licensing on foundation patents while allowing monopolies to exist for the secondary applications.105 In addition, for university owned patents, the government agency awarding grant money retains rights in the patents for royalty-free licensing.106 It might be time to consider expanding that right. Alternatively, it might be time to consider adding further strings to federal grant money given to universities creating these patents – allowing nonexclusive licenses to other universities or companies that want to advance the technology further. There is also the option of patent pooling – allowing (or even encouraging) the companies who hold prominent patents to pool their intellectual property and allow others to license access to the pool. This has survived antitrust scrutiny in the past, so long as one company does not hold a majority of the patents on its own and does not intend to obtain a monopoly.107

Reform has already begun at the patent office. The USPTO is working to assemble a better database of prior art for the nanotechnology class of technology. However, emerging technologies provide prior art problems because of their novelty.108 Since nanotechnology is also a multidisciplinary field, new approaches may be necessary altogether. It may be necessary to consider a team approach to nanotechnology patents so that all relevant prior art is understood by examiners in the relevant fields.109 It is also important to remember that education is also necessary for patent prosecutors and litigators to ensure that they can adequately protect their clients’ inventions.110 Patent prosecutors also need to gain familiarity in addressing new

105 Van Lente, supra note 2, at 208.
106 Tullis, supra note 14, at 5.
107 Van Lente, supra note 2, at 203.
108 Halluin, supra note 82, at 226.
109 Id. at 228.
110 Axford, supra note 16, at 305.
rejections specific to nanotechnology. Education will also be necessary for all players in the patent game with respect to the patent reform. The USPTO also needs to implement a program to get outside help in keeping patent examiners up-to-date on nanotechnology techniques.

It is also important to keep in mind the future for nanotechnology. It will take a long time to realize the full potential of nanotechnology advances. This requires strong education in science and math for the next generation. STEM education is eroding in the United States, and this trend needs to be reversed. The United States’ economic strength and security is tied into the wealth brought by intellectual property. STEM programs in high schools drive innovation from those students in college and beyond. There is a strong correlation between STEM programs and the long-term economic health of a country. Other countries are already working to strengthen the base of future scientists. China is undergoing reform to stimulate national innovation in higher education. The US government, through its National Nanotechnology Initiative, is developing education resources to address this deficit. The United States faces a serious threat to its global economic leadership in nanotechnology if the global dominance in science and technology follows the talent pool to Asia. The rate at which other countries are assigned nanotechnology is increasing. Between 1988 and 2002, the United States saw an factor increase of 6.3 in patent assignments while Japan production increased by a factor of 11. In fact, in some areas the United States has already been outpaced – South Korea held 31% of the carbon nanotube display application patents in 2005 compared to

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111 Koppikar, supra note 1, at 24.
112 Foley, supra note 68, at 467.
113 Id. at 474.
114 Id.
115 Parker, supra note 11, at 531-2.
116 Foley, supra note 68, at 481.
117 Id. at 468.
118 Id. at 471.
119 Id.
the United States’ 17%. If the future of nanotechnology is not secured through education for future innovators, the United States will lose its supremacy in nanotechnology. Without addressing the future of innovation, the United States will only stave off the inevitable.

Education reform should not be limited to high schools. University behavior desperately needs reform. Global productivity is measured by publications, start-ups, and patents. University behavior needs watching to make sure that the patents they obtain are available for further innovation and do not inhibit the start-up of new businesses. Currently, the United States leads the world in nanotechnology start-ups and venture capital funding. Often, university patents are part of the process of creating start-ups – which should continue to be encouraged. However, universities need to be cognizant of their role in the technology transfer process. Universities have a large impact on training future scientists, increasing and spreading knowledge, inventing and refining instrumentation and methodologies, stimulating interaction and networks resulting in the creation of new companies. The technology and innovations universities create needs to make its way to the benefit of the public. If that technology transfer process breaks down, it may be time to consider reforming how the technology transfer occurs – it might be time for the government to step in and require non-exclusive licenses or cross-licensing. It also may be necessary to consider limiting the patentability of nanotechnology obtained through government grants. It may be better for all for that technology to enter the public domain immediately. It also may be time to reform the Bayh-Dole Act to effect this change.

120 Id.
121 Id. at 469.
122 Id. at 471.
123 Lemley, supra note 59, at 611.
124 Heinze, supra note 25, at 436.
125 Lemley, supra note 59, at 612.
126 Rutt, supra note 66, at 408.
The United States is, as of yet, only a potential location for the nanotechnology revolution. However, it is not the only potential place. The country where the nanotechnology revolution takes place will have a strong patent system allowing its innovators to control the foundation and advancing technologies necessary to exploit nanotechnology. The United States has taken strides to strengthen its own patent system and reform the patent office to better handle the challenges nanotechnology presents. However, that is not enough. Education and university reform are two big steps that the United States needs to effect. Both legal education and high school education need bolstering to ensure the future of nanotechnology in the United States. These are the steps the United States needs to take in order to ensure the future of the nanotechnology revolution here.