Nanotechnology Commercialization Best Practices

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1 Introduction

In this paper, we survey some of the key factors for success in technology commercialization in nanotechnology. Our consulting firm, Quantum Insight$_{SM}$, has had exposure to hundreds of nanotech startup companies. Our observations on successful and unsuccessful tactics and strategies comes primarily from this exposure which has been gleaned by working with venture capital (VC) firms, corporate VC groups, and startups in the area of nanotechnology. In looking at all these nanotech startup efforts, trends began to appear. For example, we would see common strategies used by companies to gain VC funding. While other companies that were struggling with funding were using different strategies.

Our firm also works with large corporations that are making investments in the area of nanotechnology. From these engagements, we have seen the full spectrum of issues related to commercializing nanotechnology.

The organization of this paper is to first focus, in section 2, on issues that are specific to nanotechnology startups. The reason for this is that much commercialization of nanotechnology will be through this path. Secondly, we look at issues relevant to all nanotechnology commercialization in sections 3 and 4. Throughout we sprinkle a good number of examples that illustrate the points being made. These examples come from both pure nanotech startups and other small-tech startups in areas such as MEMS.

2 Phases of a Nanotech Startup

2.1 Inception

Common Strategies

In some industries, patents are not critical to business success – firms focus more on swift execution than on intellectual property (IP) protection. This is not the case for nanotech firms. IP has been a central issue to every nanotech startup that we have looked at. IP is such an important topic in the realm of nanotechnology commercialization that we devote one section of this report (4) to discussing it. From our point of view, inception of a company is synonymous with the acquisition of the company's initial IP.

Licensing IP

Most commercialization efforts start with taking steps to protect IP through the filing of patents. Most patents in the area of nanotech are generated by either large companies or by universities or by government labs. Many startups in nanotechnology get at least their initial IP from universities or government labs. Some of the California based government labs/agencies that license IP in the area of nanotech are NASA, Lawrence Livermore National Labs, and Lawrence Berkeley Labs. NASA funds a quasi-independent organization called the Girvan Institute to help in this process of promoting NASA's IP.

Likewise, universities have offices that focus on the commercialization of their locally generated IP. In California, Stanford and CalTech have very good reputations for being easy to work with. Although the universities in the UC system generate a good amount high quality IP in the area of nanotech, they unfortunately have the reputation for being more difficult to work with. A leading nanotech researcher from HP, Stan Williams, has publicly stated that his group no longer looks at patents being generated from UC Berkeley due to their previous experiences in trying to license from that university. Despite these limitations, it has been our qualitative observation that the majority of IP that is licensed by startups comes from universities and not from government labs.

The most currently visible nanotech company, Nanosys, was formed in this way. Nanosys' stated strategy is to "build a dominant technology and intellectual property estate through a combination of aggressive technology in-licensing, teaming with the world's leaders in academic nanoscience, internal technology development, discovery and patent filings". Nanosys has licensed IP from the following universities to date: Columbia, Harvard, LBL, MIT, UCLA, UC Berkeley, and Hebrew University.

It is very common for the filer of a patent to be involved in the commercialization of the technology. One study[1] shows that 70% of university inventions can't be utilized without the involvement of the inventor. We have seen many examples of this – for example Axon Technology Corporation was formed with IP from Arizona State University and the professor who generated the IP is still involved with the company.

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[1] "Grilichesian Breakthroughs: Inventions of Methods of Inventing and Firm Entry in Nanotechnology", Michael Darby and Lynne Zucker, National Bureau of Economic Research, July 2003

Spin-Outs

Another way that nanotech startup companies are formed is by a parent company spinning-out a business unit. In the recent IPO market environment, these spin-outs have not gone public, but are typically held as subsidiaries. A recent small-tech example of this is the MEMS CAD company Coventor, who spun out their RF MEMS unit to create WiSpry. Previously Coventor had spun-out another business unit into a new company to focus on optical MEMS.

The parent company has a number of advantages in doing this. First, the net value of the two separate companies can potentially be higher, especially if the parent is a large company. Although this will not be a major consideration until the markets for IPO's returns. Secondly, by spinning out a division, the parent allows for other sources of capital to fund the operation.

Independent Entrepreneur

The final way we see nanotech startups formed is through the independent entrepreneur who generates IP. This case is not the norm and we have not seen any companies likely to make an impact which were started in this firstly manner. We believe the reason for this is that the complexity and expense required to both develop a new nanotechnology and to file the appropriate IP is considerable, and therefore not accessible to most independent entrepreneurs.

The development phase is expensive for a number of reasons. Nanotechnologies are based on physical science. Therefore the capital costs to setup a laboratory to do research and development tends to be high. One commonly used piece of equipment in nanotechnology, an atomic force microscope (AFM), costs on the order of $100,000 for the least expensive model. And there are many more pieces of equipment that are typically required. At the far extreme, many nano companies plan to use semiconductor-like manufacturing facilities. It is widely known that a state of the art semi-fab today costs in the billions of dollars. This is opposed to a dot-com company or a software company where the only capital costs are those of computers and inexpensive software development tools.

One of the key attributes of nanotechnology is the convergence of different areas of science. Because of this, most nanotechnology projects require a multidisciplinary team. There for the labor costs required to develop nano IP also tend to be high.

Success Factors

It should be no surprise at this point that we believe one key success factor is a strong IP position at the inception of the company with a plan to develop that asset over time. Another success factor is a clear, concise, well thought-out and compelling business plan. A good business plan shows that the founders have thought through all the major issues they are likely to encounter in building their business. The critical components of a business plan focus on the issues that will enable the company to bring its products to market. A good business plan also allows for efficient communication of the business idea to potential investors which will become important in the next step – funding. The business plan needs to be comprehensive and cover more than just the technology. Technologist founders are known for not thoroughly thinking through key business issues such as manufacturing and sales channel strategies.

Another area of the business plan that is linked to success is the executive summary. This section needs to get key points across in a few words and must give a concise and comprehensive picture of what the company will do and how it will make money. Writing this well is also frequently challenging for a technologist founder, which is usually the case in nanotechnology. Luckily there are many resources available to help in writing executive summaries and business plans.

Another success factor is that of a well-balanced team – or at least having a plan to put one in place in the future. There are two aspects to a well balanced team that we believe are important to a nanotech startup. First, the team needs to have the multi-disciplinary skill-sets needed to accomplish the business plan goals. Sometimes we have seen founding teams where all the members were from the same academic discipline but where the product required a multi-disciplinary team to execute. An example of this was a micro-array company started by two geneticists. Their planned product required a significant amount of MEMS and electrical engineering talent to be designed but that knowledge was not present in the founding team.

The other aspect of a well-balanced team is having senior people who come from the domains where the product will be sold. An example of this is that if you are forming a nano-based memory company, then you better have a founder who comes from the semiconductor memory space. Without this person, the company is in great danger of developing products that are not appealing to the marketplace. Or worse, the company could be blind-sided by an incumbent technology that challenges the benefits of the new nano-based technology. Finally, having a founding team member with contacts into the space helps facilitate both sourcing relationships and generating first sales. An example of this is an RF MEMS company that we looked at that has executives from both Intel and Analog Devices. The former relationships of these executives are ideal for this company both on the supply side and on the sales side.

Pitfalls

One common pitfall at the inception stage is what Tom Baruch, founder and managing partner of CMEA Ventures in San Francisco, calls "a cure looking for an illness". A classic example of this is the discovery in 1991 of the carbon nanotube by Sumio Iijima of NEC in Japan. It took approximately a decade before significant numbers of researchers began looking for applications of this novel new material class. Even today, we know of no commercial products that make use of carbon nanotubes.

We previously discussed the importance of clearly thinking through manufacturing and sales channel strategy early on. Because this is so frequently not done adequately, it is worth re-emphasizing here. For example, in many of the nanotechnology companies that we have looked at, the founders could not convincingly articulate a realistic and fundable manufacturing strategy. One example is a roll-to-roll electronics company planning to develop devices based on new materials using a new manufacturing process. By requiring both the development of a new technology and the development and construction of a new manufacturing methodology, this company was putting itself in a difficult position of requiring a significant amount of capital to take its products to market. Particularly in these times of recession, when investors are focusing sharply on "capital efficiency", this type of strategy is unlikely to gain much interest.

One buzz-word that one frequently hears these days is that of "platform technologies". This is usually meant in a good way – that a technology will underlie many other new technologies thereby deriving revenue streams from many different application domains and becoming a de-facto standard. The problem with platform technologies is that they can also cause lack of focus in a startup company. Nanotechnology is ripe with platform technologies – a few prominent examples are quantum dots, carbon nanotubes, and nano wires each of which can be used for bio, IT, and other applications. But the danger of not focusing on a particular application can often be deadly for a startup company. So much so that most VCs will force a startup that has multiple divergent products to drop all but one. An example of this is Nanomix – a carbon nanotube focused company that was focused on applications in both hydrogen storage and in sensors. They have shifted their priorities to de-emphasize the hydrogen storage application in favor of attacking the many market sub-segments that can be served by their carbon nanotube sensor technology.

A final common pitfall that we see in nano startups is failing to plan for the progress that an incumbent technology will make during the time it takes to develop the nano-based technology. This is a classical mistake that many made long before nanotech was a buzzword. The reasons that it is such a common problem in the area of nano is that many nano technologies are focused on disrupting already existing markets and not on creating new markets. An illustration of this pitfall is provided by the multiple initiatives in the nano-based memory space. There are multiple startups as well as large company efforts in this area. In this space the incumbent technology is semiconductor memory: DRAM, SRAM, and flash memories specifically. It is not sufficient if a nano-based memory technology in prototype stage is competitive with today's semiconductor memories. It must be competitive with the future generation of semiconductor memories that will be mainstream when the nano-based memory becomes a commercial product. A further requirement is that the nano-based technology must be able to at least track the roadmap for semiconductor memories otherwise it will fall behind in a future generation.

2.2 Funding

Common Strategies

There are many sources of funding. The ones typically considered for a nanotech startup are: friends and family, angles, VCs, government, and corporate partners. We can consider friends, family and angels as a single category. Usually this category can only fund the writing of the business plan and perhaps for licensing some IP from an university or other source. As stated before, nanotech companies usually have significant capital requirements to make real progress. But because nanotech is a hot area in the press, it is possible to find high net-worth angels that will put in significant funds. An example of this is MagiQ Technologies. This company's last round of funding of $6.9M was done entirely by angels which included Jeff Bezos, the founder of Amazon.com.

The government is another source of potential funding. There are many government programs, only a few of the most prominent ones will be discussed here. One program, the SBIR (Small Business Innovation Research) reserves a specific percentage of federal R&D funds for small business. The funds are distributed via many government agencies such as DOE, DOD, and NASA and are awarded in response to solicitations from those agencies. DARPA (Defense Advanced Research Projects Agency) is another common source of funding for new nanotechnologies. DARPA awards grants in accordance with its interest in developing technologies for military use. A final high profile government project is NIST's ATP (Advanced Technology Program). ATP is unique in that it does not solicit projects in any particular areas. Instead, projects are awarded this grant if they can be shown to be of high risk and of high value to the nation. The ATP program seems to favor projects where a startup company teams up with a large established company. An example of this in the nano space is the teaming of GE and Molecular NanoSystems which received a $5.8M ATP award to develop a synthesis platform for growing large arrays of aligned nanorods. For the year 2003, the ATP program is not active. It is anticipated that it will become active again in 2004.

One of the most well known forms of funding is through VC's. There are about 10 VC's in Silicon Valley that have funded "nano" deals. The most active and visible of these is Draper Fisher Jurvetson (DFJ) which has invested in roughly eight nanotechnology startups. Looking across the entire US, some of the most prominent "nano VCs" are: Venrock, Harris and Harris, NexGen, Apax Partners, Morgan Stanley, and Ardesta. Many other VC's have an interest in nano as the "next big thing" but have not made investments yet. A recent example of a nano company that successfully raised $30M in its third round from eight investors, both VC's and corporate VC's, is Optiva.

A difficulty with raising money from traditional VC's is that they have very stringent requirements on what constitutes a good investment. Typical negatives are too high capital costs (e.g. needing to build an expensive manufacturing plant), too small a market for the end product, or too long a time frame to reach revenue. VC's that are part of large corporations (corporate VCs) may not be as stringent on these requirements because they typically make investments that have a strategic value to the corporation. Corporate VC's can be a very good funding avenue for a nano startup also because they can bring some of the non-financial resources of the corporation to benefit the startup. Corporate VC's also have the additional benefit of frequently acting as a respected source of due diligence on a startup company – frequently attracting other traditional VC's that may have had a difficult time to evaluate the nano startup's technology. An example of a corporate VC making a nano investment is Eastman Chemical's investment in Konarka. Eastman sees Konarka's technology as a possible consumer for Eastman's advanced polymers – more than just a vehicle for pure financial return.

Besides being investors, large corporations can also be partners in a joint venture, or simply a customer, or some combination of investor, partner and customer. For example, we have seen a number of times when very prominent Silicon Valley based chip-makers have been both investors and customers for a startup company.

Success Factors

There are many success factors in funding. In government funding, writing a good proposal that satisfies the soliciting agency's requirements is one. For VC's, having a strong "done it before team" addressing a large market opportunity is a good start. But these are not unique to nanotechnology. Probably the one thing that seems somewhat unique to nanotechnology is the strategy of having "luminaries" involved with the company. Typically these luminaries are on the founding team or on one of the advisory boards. Frequently these luminaries are high profile academics who have actually generated some of the IP that the company is based on. One example is Nanosys that has a scientific advisor board of the "who's who" in nanotechnology.

Pitfalls

One common pitfall that we have mentioned in the section on Inception was that of lack of focus. This is an important issue with investors such as VC's which is why we are bringing it up again here. VC's are do not generally like investments where there are multiple disparate target markets. If a VC invests in a company that has such a business plan, it will usually use its influence on the board of the company to focus on just one market. Frequently investors just pass on companies that have defocused business plans. One example of this that we saw was a nano startup that was having trouble raising capital. The firm was targeting the following markets: memories, logic, displays, and batteries.

Another pitfall is looking for the wrong kind of money (really the wrong kind of investor). An example of this is if a nano company is too far away from a potential product (more than five years) then it should not approach VC investors, it should focus on government sources of funding if applicable.

Nanotechnology is frequently pushing the edge of knowledge thereby making some investments opportunities very difficult for conventional VC's to assess from a technical point of view. A nano company may have more success going to a corporate VC that has very deep technical resources that can evaluate the technology of the startup. An example of this is a nano company whose technology was based on "new physics". Many traditional VC's shied away from the investment since they were not able to ever convince themselves of the validity of the technology. The company finally got funding from a large technology corporation that has hundreds of researchers capable of verifying the new nanotechnology and understanding its potential application to the big corporate products.

A problem related to the lack of technical understanding is a lack of business understanding by VC's. Since the idea of a nano company is relatively new, there are not a lot of success models for investors to compare to. Worse yet, VC partners typically come from previously successful companies in a particular hot application area. Since nano has not produced those companies yet, there are not a set of VC's who come from nano companies. All this leads to a higher barrier for nanotechnology companies to get funding from conventional VC's.

Although government funding is good because it does not dilute the equity of the company, it can have the negative impact of altering the company from the planned path of execution. A company that is funded by government grants needs to be careful that they accept only grants that are highly aligned with the direction that they were already heading in. If not, the startup could end up becoming a company that exists for the purpose of getting government grants without ever having a commercial application.

Just as accepting government grants can have a negative consequence, so can accepting corporate VC funding in some circumstances. As we mentioned before, corporate VCs usually have strategic objectives in their investments. This can become a conflict if the corporate investor insists on terms of investment that hinder the nano startup from having relationships with the investor's competitors. We have seen an example of this happen where a nano materials company got an investment from a large electronics company, but the investment came with restrictive terms on who the startup could sell its product to in certain application domains.

2.3 Growth

Common Strategies

We have seen a few different strategies that are commonly used by nanotech startup executives to grow their companies. One is to partner with a larger corporation. We discussed this in the context of funding, but it can also be a viable strategy for growth. Partnering can give a company access to manufacturing and to sales channels, both of which are expensive to develop for a startup. An example of this is Thinfilm Electronics and Intel Corp. Thinfilm is working on developing a new type of nonvolatile memory technology. Although we don't know the precise nature of their relationship, besides that Intel has made an investment in them, we know from conversations with Thinfilm that they are working very closely with Intel. If Thinfilm's technology is successful, they will presumably have access to a large market via Intel's existing market position.

Another strategy for growth, that we have seen a number of nanotech startups take, is to spin off technologies from a common underlying technology. This approach, as long as it is taken in a serial approach and is not defocusing, can be a good one for a company that has developed a platform technology that can impact many application areas. One example of this strategy in action is General Nanotech. They have developed a pool of IP centered on atomic force microscopy (AFM). The created a core business, General Nanotechnologies, based on this IP and have spun out one application of this technology. The spinout, RAVE LLC, is focused on using AFM's for making semiconductor mask repairs.

Success Factors

The single most important success factor that we have seen for the growth phase of nano companies is that of having a management team that has strong target market knowledge. For a company to pass the funding stage, they usually need to prove convincingly that they have a nanotechnology that has high market potential. But taking that raw technology to a market is a different skill set than developing the technology in the first place. We mentioned this as a success factor in the funding phase, but it is even more important in the growth phase. We have seen examples of companies that have created a nano-based technology with a target market in mind to discover that the product did not meet the needs of that target market. This oversight was due to lack of domain knowledge on the management team.

Pitfalls

There are a number of pitfalls that we have seen nanotech companies fall into in the growth phase. One is making the transition from academic lab to commercial product. It is common for academic founders to underestimate the difficulty in commercializing a new technology. It is much more difficult to make something in high quantities in at a certain level of quality and consistence than to show demonstrate something in a lab. A prominent example of this is a nano materials company that we looked at which took five years, versus their planned two years, to bring their new material to market.

Another pitfall, that we anticipate will be a problem for numerous nanotech based companies, is that of resistance to new approaches by conservative incumbent markets. Many nanotechnology based products are targeted at existing markets as previously noted. To be successful, these new products will need to displace the incumbents based on price or performance. But beyond this, the nano based products will need to be proven to have the same quality and reliability as the existing solutions. In conservative industries, such as IT or telecommunications, gaining the track record on reliability could take longer than nanotech company CEO’s expect. Virtually every nano based memory company that we have looked at had the expectation that they would ramp the volume significantly within the first year after the introduction of their first commercial part. We have been skeptical of this position.

As we have previously stated, many nanotechnology companies are targeting existing markets with superior nano-based products. Some nanotech solutions can have the effect of potentially unifying fragmented markets. An example of this is using carbon nanotubes (CNTs) as sensors. CNTs can be used as a platform technology for building many types of chemical and other types of sensors and potentially greatly reduced cost as compared to existing technologies. The difficulty for the company attacking this opportunity is that the sensor market is really a combination of fragmented markets that are currently served by a variety of vendors. This will make channel development more difficult for the startup.

The final difficulty that we see in nanotech companies in the growth phase is the lack of industry infrastructure. Once again, because these companies are typically on the cutting edge of technology, there is not an existing well-developed infrastructure to leverage. Things that other companies can take for granted such as - abundant technically trained workforce, manufacturing equipment, manufacturing services, design software – are all minimal or nonexistent for various nanotechnologies. Therefore, nanotech startups are forced to create more of their own infrastructure as they progress.

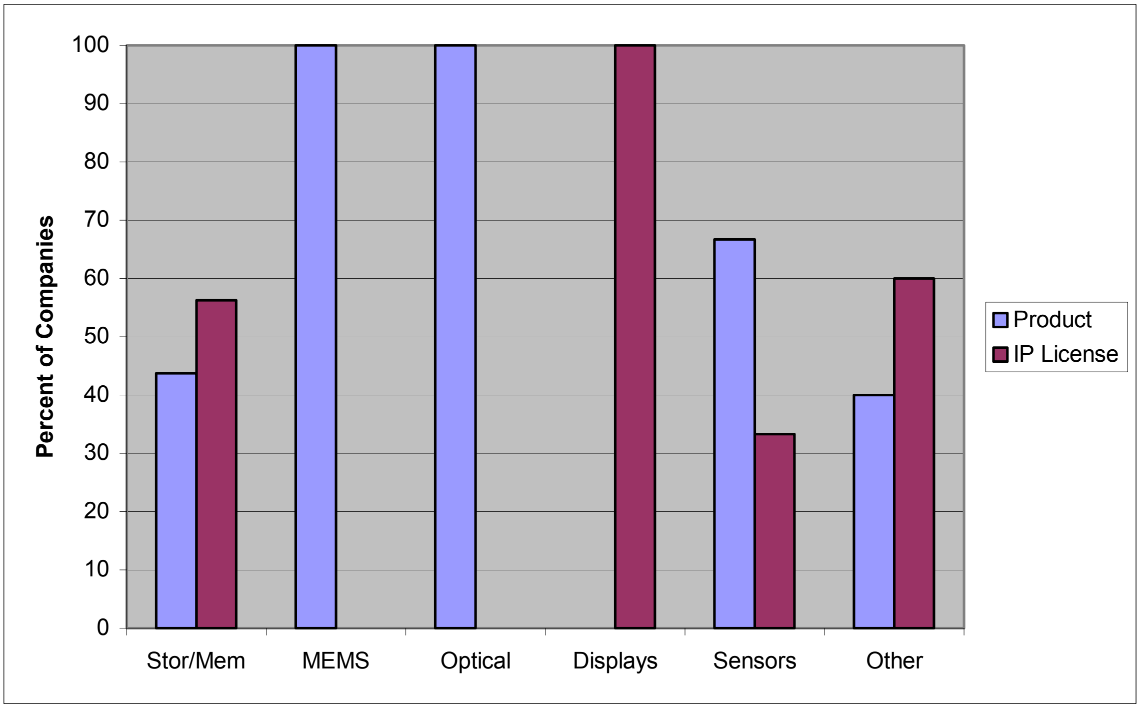
2.4 Exit

Very few nanotech companies have had successful exits to date. This is due to a combination of the state of nanotechnology and the state of the economy. For this reason, it is difficult to talk about "best practices" regarding exits for nanotech companies. Of course there are a limited number of options here: IPO, acquisition, merger, or staying private. We are only aware of one nanotech IPO (of course this depends on how you define nanotech) that is Nanophase. This company has been public for many years and has a relatively small revenue and market cap so it will not act as much of a model for others to follow.

In the current market, an acquisition is much more likely. Coatue, a molecular memory company, was recently purchased by AMD, a large semiconductor memory and microprocessor company. The purchase is strategic for AMD since it gives them a potential position in a technology that will eventually be disruptive to one of their current businesses. This acquisition is believed by some analysts to be the catalyst to force many of the semiconductor memory companies to make similar acquisitions. In turn this will most likely drive up valuations on the remaining independent molecular memory companies. Similar events may unfold in other applications areas that are impacted by nanotechnology.

3 Business Models

We have seen a number of different businesses models employed in nanotechnology companies. They range from IP licensing, to product, and to service company models. The service model is virtually non-fundable so we won't consider it here. The IP licensing model is quite common, particularly in areas where there are large incumbent players such as memories, storage, and displays. The following graph shows the mix of product versus IP licensing models that we have seen broken down by various application areas. These results are based on our surveys of nanotechnology companies that we have looked at in detail over the past two years



Source: Quantum Insight

The IP licensing model has the advantages that it allows the nanotech startup company to avoid the expense of setting up manufacturing and sales channels – both expensive propositions. The way the IP licensing model works is that a company develops IP, then licenses it to other companies for commercial applications and finally collects a royalty on the use of the IP. The royalty revenue is then used to fund more IP creation.

The downside to the IP licensing model is that it is difficult to be really successful with it. We can see examples from other industries such as semiconductors. Rambus is an IP licensing company that had a large amount of success for a period. They licensed IP that was used in the design of high-speed memories for computers. But with their success came motivation for their licensees to find alternatives, which they did, thus, diminishing Rambus' potential going forward. This type of scenario is likely to also happen in the nanotech arena. Therefore it will be important to ensure very strong IP protection for nanotech companies that are taking this approach. We will talk about IP more in the following section.

Taking the path of being a product company has the drawbacks that were mentioned previously – the potential high costs of setting up manufacturing and sales organizations. The upside is that being a product company is usually a much more defendable position in the value chain. The trick for nanotech companies is to find a strategy that will work well for their particular IP portfolio and the industry that they are targeting.

4 Intellectual Property

Intellectual property (IP) has been discussed many times in the preceding sections as being crucial to nanotech companies. Many have drawn an analogy between nanotech and biotech in the importance of IP to both. In fact, if you remember, we consider the acquisition of initial IP to be equivalent to the inception of a nanotech startup.

The value of IP is widely recognized. The number of patents filed at the USPTO is increasing rapidly. In 2000 there were 293,000 patents filed while in 2006 it is estimated that there will be 538,000 patents filed – almost doubling in six years. Nanotech patents issued have been increasing at a higher rate. In 1998 there were about 350 nano patents issued while three years later in 2001 there were over 700 nano patents issued[2].

This increase in patents being filed and issued is driven by multiple factors. One of those factors is the increased use of aggressive IP tactics such as "patent flooding". In this technique, the aggressor company issues many incremental patents that surround the defending companies IP. This creates a deadlock situation were neither company can use their IP without infringing on the other companies IP. They are therefore forced to cross license to each other. This essentially gives the aggressor access to the defending companies IP.

With tactics like this being employed, it is becoming very important for companies to have strong IP positions in the technologies that are important to their business. This means not having single patents filed but rather having a layered approach to IP filing. Patents should be filed, if possible, to protect the following levels: composition of matter patents, process patents, and finally application patents. Although we are not lawyers and can't give legal advise, we have seen the above strategy being implemented by savvy firms developing nanotechnologies.

5 Summary

We have looked at the different phases of the life of a nanotechnology startup. There are challenges that are unique to nanotechnology that will be faced by the startups. These include the role played by various sources of risk, technology, management, and market. We have looked at the importance of IP in the field of nanotechnology and the strategies being followed by startups and large companies. We have examined the various business models being pursued by nanotechnology startups.

Like all technology startups, the majority of nanotechnology startups will not be successful. However, the ones that do succeed will have the opportunity to either re-define current industry segments or to create new ones.

[2] Foley Lardner Attorneys at Law