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## **Make Nanotechnology Research Open-Source**

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### **Précis**

Despite being an extremely active area for academic research, publishing and patent applications,<sup>1</sup> nanotechnology development is being hindered by current intellectual property (IP) law.<sup>2</sup> Patenting of basic science and entire classes of nanotechnologies with overly broad claims is leading to higher transaction costs, slower and sub-optimal technical development and the removal of obvious knowledge from the public domain. This effectively hamstring the current primal nanotechnology development, in contrast to the history of other emerging scientific and technical fields.

The growing dominance of the open-source paradigm from software development provides a viable means of guiding the accelerated development of a technology. The application of the open-source paradigm from software development can both accelerate nanotechnology innovation and improve the social return from public investment in nanotechnology research. This can be accomplished by requiring: 1) free open access to all publicly-funded nanotechnology research, 2) all future publicly-funded innovation in the nanotechnology sector be placed in the public domain, and 3) a moratorium on patenting fundamental nanotechnologies (e.g. size dependent properties). Following an open-source approach, everyone in the nanotechnology field would be working in a community with the same access and rights to knowledge and contributing back to the community with new knowledge. In this way, the full potential of nanotechnology can be reached to drive the next industrial revolution, where matter can be manipulated as easily as software.

### **Intellectual Property Shackles**

The dominant international IP system has been criticized for being a roadblock to innovation as it creates the following inefficiencies: i) higher transaction costs for information exchange slow progress (even for publicly-funded research), ii) patenting of building block technologies impedes downstream research and development,<sup>3</sup> iii) the flexible non-obvious requirement of patents locks away common-sense approaches to solving problems, and basic, obvious algorithms for creating innovations, and v) despite the increasing rate of patent applications, many patents are not used, providing road-blocks to others working in the area.

All of these generalized IP problems are being repeated in the field of nanotechnology with even worse results because of the relative immaturity of the field. While technologies in other fields had time to develop due to a lack of patenting or legal restrictions on the patenting of basic science, the sharing of critical knowledge in the nanotechnology field is being limited.<sup>4</sup> As a large number of the nanotechnology patents are for new knowledge about basic science in the quantum field, the privatization of basic science has begun<sup>5</sup> resulting in the locking away of basic knowledge from the public domain.<sup>6</sup>

Currently, there is intense competition in a nanotechnology patent “land grab”, where “nanopatent

prospectors” and “patent trolls” compete to acquire pioneering patents in order to extract as much profit as possible from often minor contributions to science and technology. In many cases, even universities that are over-represented in nanotechnology patenting act as patent trolls engaging in both “hold ups” and exclusively license patents for certain basic building blocks or “enabling technologies”.<sup>7</sup> This prevents opening up licensing to many innovators who can develop different uses that will generate substantial improvements, rather than the exclusive license that is expected to generate relatively fewer improvements. In addition, it is now clear that such proliferation of broad patents in nanotechnology leads to “patent thickets” – a dense web of overlapping patent rights, which impedes the work of scientists and engineers, while employing throngs of lawyers to fight through the required patent litigation. These patent thickets can be attributed to the complex nature of nanotechnology itself, the lack of oversight of the full literature in patent offices due to access restrictions, and to the fact that much of the field is simply science, the results built on the cumulative innovations of researchers throughout the world over decades. As nanotechnology patents have spiraled out of control, multiple patents from competing organizations often cover each incremental innovation to some varying degree, and the need for the licensing of a large number of overlapping patents is inevitable. Patent thickets, thus, hamper innovation rather than spur it.

A now classic patent thicket has been developed in the area of single-walled carbon nanotubes (sw-CNTs)<sup>8</sup>, where the rights to use a naturally-occurring material that can be produced by common flames is viscously fought over. If innovators have a new product idea that utilizes sw-CNTs, they need to wade through the 1,693 patents that currently mention sw-CNTs in the USPTO database. They will have to license the right to use the naturally-occurring material as U.S. patent 6,683,783 covers “a composition of matter comprising at least about 99% by weight of single-wall carbon molecules” (as do patents from NEC, IBM, Nantero, Hyperion, etc.) and develop some form of licensing scheme to avoid lawsuits from the owners of dozens of broad patents covering all the obvious applications of sw-CNTs if they have any hope of seeing their innovation in the market. The same is true of multi-walled CNTs and a host of other nanomaterials. This, of course, will result in higher costs to consumers of the CNT-containing (or other nanomaterial) products, an enormous drag on the innovation process because of the higher transaction costs, and may effectively bar products from the market. This will in turn, limit downstream innovation from any other following idea, as innovators will have to navigate a similar legal quagmire to gain access to use basic rights to nanotechnology knowledge to develop more complex technologies. Similar dense patent thickets exist for most other fundamental nanotechnologies (e.g. quantum dots, nanowires, and fullerenes). In this way, the patenting of nanotechnologies retards innovation and reduces commercial competition by arbitrarily making the use of many nanotechnologies prohibitively expensive.

### **The Open-Source Alternative for Nanotechnology**

This IP madness in nanotechnology is encouraged under the idea that it is necessary to provide an incentive to innovate. The argument is: because development of technology is extremely research intensive, without the market exclusivity offered by patent law, development of these products and their commercial viability in the marketplace will be hampered. This argument is made for nanotechnology today and certainly was for the development of complex software at the dawn of the computer revolution. The argument, however, has been proven false. There is now another well-tested and effective method of enabling innovation found in the open-source paradigm. Due to this tremendous

success of open-source software development it is now becoming the standard rather than the exception. The open-source community runs on a gift economy, which rewards contributors through a process of peer review. In contrast to the IP system, it is actually better to freely share in an open-source framework. Yet, simultaneously, the open-source paradigm allows for commercial success, as demonstrated by the profits enjoyed by both traditional firms using open-source software, but also the plethora of businesses built on selling services around the open-source products they give away for free.

In the long term, nanotechnology offers the promise of enabling matter to be manipulated as easily as software, so software characteristics of low-cost reproduction and dissemination would apply to material goods.<sup>9</sup> An open-source model of nanotechnology design would help to overcome the limitations of the IP system by reducing the potential for stagnant monopolies, reducing roadblocks and transaction costs to innovation, increasing the speed of innovation through collaborative production, and by making knowledge open and accessible to a larger community. Thus, open-source approaches could greatly expand access to future benefits from nanotechnology.<sup>2</sup> Everyone in the nanotechnology field would have the same access and rights to knowledge and would contribute back to the community with new knowledge.

The application of open-source paradigms will drive fundamental changes in nanotechnology-based businesses. Innovation will accelerate, and companies that do not adapt will be overrun by the new ideas and products generated by mass collaboration. Companies would have open access to knowledge in the nanotechnology community and could partially rely on user-developers from the larger community for research and development (R&D). Since companies would no longer have to recoup the losses associated with transaction costs or pay as much into R&D per unit of output, more research could be undertaken and relevant nanotechnologies could be developed explicitly for social benefits. In addition, the cost of entry for businesses into the nanotechnology market would be lowered, encouraging the rapid innovation brought by competition. Nanotechnology-based businesses will need to create value without relying on the artificial scarcity created by monopolies that have little incentive for progress. The recent rise of profitable open-source hardware companies provide a model that nanomaterial and nanotechnology businesses can follow. These companies leverage the rapid innovation of the open-source community to provide superior hardware products while selling the hardware and service as a package. Thus, open source nanotechnology is likely to foster service models with nanotechnology companies behaving more like open-source software companies, than traditional firms. This model can be extremely profitable, as perhaps best demonstrated by Red Hat, an open-source software company with more than \$1 billion a year in revenue.

Due to its interdisciplinary nature, the field of nanotechnology is a combination of information (e.g. chemical formulas), software (e.g. modeling tools), and hardware (e.g. atomic force microscopes). The open-source concept can be applied to the field of nanotechnology in all of these areas. NanoHub.org already exist for members of the nanotechnology community to share information. Free and open-source software in the field of nanotechnology is proliferating rapidly and ranges from microscope control software to molecular modeling tools. Finally, open-source hardware as a whole is in its infancy, but quickly maturing and offering potential applications in nanoscience. Faced by inaccessible proprietary hardware, nanotechnology hobbyists and innovators have already created home-brewed DIY hardware for working with nanotechnology.

## **A Path Forward**

Many governments have adopted nanotechnology as a key funding focus and the public can best receive a return on that investment following three new requirements that foster an open-source nanotechnology paradigm.

First, there is a growing consensus, which began in medical research, that the public that funds research should have open access to the results of this funding. Thus, a first step on the path to open-source nanotechnology would be a blanket requirement for all publicly-funded nanotechnology research to be made freely available on the Internet, following established open-access protocols. This can be accomplished immediately by the NSF adopting the NIH Public Access Policy. Open-access to the documentation for nanotechnology research would speed innovation, help reduce the patents issued for overly-broad claims, bring more public oversight of government-funded nanotechnology projects and help allay public fears of the potential negative effects of nanotechnology,<sup>10</sup> which would be a benefit to everyone in the field.

Secondly, the full open-source paradigm is applied to publicly-funded nanotechnology research. Simply stated, all publicly-funded innovation in the nanotechnology sector is immediately put in the public domain. Again this can be enforced by federal funding programs and laid out in their RFPs. This would enable those most focused on the basic-science of nanotechnology to set up enormous “international parks” of basic nanotechnology science, which everyone could use free of IP concerns. As has already been seen by the explosion of growth in the open-source software sector, a similar explosion in nanotechnology-related innovation would be expected to outpace the current closed development of nanotechnology.

Finally, to prevent further damage created by overly-broad patents making a thicket around basic nano-science, the USPTO can issue a moratorium on patenting fundamental nanotechnologies (e.g. size dependent properties). This can be done, simply by using a firm interpretation of the obvious requirement for patents, as it is clear that any innovation based on fundamental science would be obvious to anyone knowledgeable in the field. These three changes to the requirements of publicly-funded nanotechnology research and nanotechnology patent interpretations would ensure an innovative nanotechnology market and leverage the best value from research investments.

In conclusion, if nanotechnology is to meet its full potential as rapidly as possible in driving the next industrial revolution, it must be set free and open-sourced. There is an urgent need for opening up nanotechnology before too much of the basic scientific knowledge gets locked into proprietary systems, hobbling technological development for decades. Nanotechnology researchers and our institutions, organizations, companies and governments should encourage open-source nanotechnology to maximize the social return from investment in nanotechnology research.

### **Competing financial interests:**

The author declares no competing financial interests.

## <sup>1</sup>References

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