Current Issues in Patenting Nanotechnology

by

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1 Introduction

1.1 What is nanotechnology?

The prefix nano derives from the Greek word 'nanos' that means dwarf. A nanometer (nm) is a unit of measurement equal to one billionth of a meter. For example, a single sheet of paper is about 100,000 nanometers thick. Another commonly used example is the thickness of a human hair: one nanometer is about 1/80,000 of the diameter of the average human hair. The size of a red blood cell is around 7000 nanometers. Clearly nanotechnology refers to things on an incredibly small size scale.

Nobel-prize winner Richard Feynman delivered a lecture in 1959, in which he explored the question of whether in the future it would be possible to manipulate matter at atomic level[1]. Feynman was the first one to introduce the idea of nanotechnology. Nanotechnology is the study of manipulating matter on an atomic and molecular scale, and generally it deals with structures sized between 1 and 100 nanometers in at least one dimension. The term nanotechnology defined by the European Patent Office "*covers entities with a controlled geometrical size of at least one functional component below 100 nanometers in one or more dimensions susceptible of making physical, chemical or biological effects available which are intrinsic to that size. It covers equipment and methods for controlled analysis, manipulation, processing, fabrication or measurement with a precision below 100 nanometers*".[2] Because at this size scale the laws of quantum mechanics begin to affect the basic properties of matter, atoms and molecules have different properties and provide a variety of surprising and interesting uses[3], for example, in the field of heat and electric conductivity and strength[4].

Nanotechnology has infinite possibilities and huge potential. Nanotechnology today is, for example, used in several materials to improve their qualities: the substantial structure of carbon nanotubes makes them stronger and lighter than any other composition of material. In addition, carbon nanotubes have unique electrical properties and efficient conduction of heat, which makes them potentially useful in a wide variety of applications. The somewhat futuristic belief of some experts is that nanodevices distributed throughout the brain may permit copying of thought patterns and copy a person's personality in order to create artificial intelligence.

[1] Feynman, 1959.

[2] http://www.epo.org/topics/issues/nanotechnology.html 11.2.2011.

[3] HelsinkiNano loppuraportti, p. 7.

[4] Schellekens 2010, p. 48.

1.2 Intellectual property issues related to nanotechnology

Nanotechnology is an emerging technology and thus interesting intellectual property questions arise related to its protection. Characteristic to nanotechnology is its interdisciplinary nature. Nanotechnology is a broad multidiscipline science covering aspects of biology, chemistry, physics, and other disciplines. The interdisciplinary nature of nanotechnology makes it challenging for the patent authorities to examine the patentability of nanotech inventions; the difficulty lies in finding all relevant prior art. Typical to nanotechnology is also the fact that the building blocks of the technology were patented at the outset. More and more of the patents issued in the field of nanotechnology are issued to universities, which is no wonder considering the fact that universities conduct most of the basic research. As patentees, universities differ from private equities.

Research and development of nanotechnology requires a huge investment; researchers and their financiers need an incentive to continue research and innovation. The potential income from patenting and licensing inventions serves this purpose well. Thus one important issue is the licensing of nanotechnology, and of course proper protection of the intellectual property rights against infringement.

The special characteristics of nanotechnology in this paper are approached from the European and the United States point of view, but the aim is to keep the paper on a generic level and address nanotechnology related problems common around the globe.

2 Patentability of Nanotechnology

2.1 Discovery or an invention?

To be patentable, a nanotechnology invention must consist of patentable subject matter. The first question raised by nanotechnology is whether some nanotechnology inventions are inventions at all, or are they rather scientific discoveries or products of nature. It is globally accepted that abstract ideas and "products of nature" or discoveries[5] are not patentable[6].

As the U.S. Supreme Court has stated, "phenomena of nature, though just discovered, mental processes, and abstract intellectual concepts are not patentable, as they are the basic tools of

[5] In the U.S. the term "invention" means invention or discovery (35 U.S.C. 100a), and thus according to the U.S. terminology discoveries are patentable. In the EPC the term "discovery" has a similar meaning as the term "product of nature" in the U.S., and it is not patentable according to the EPC 2000 Art 52(2).

[6] European legislation EPC 2000 Art. 52. In the U.S. "product of nature" is a judicially created doctrine, see Gottschalk v. Benson, 409 U.S. 63, 67 (1972) and Benson, 409 U.S. at 67. Statutory law does not restrict patentability subject-matter.

scientific and technological work"[7]. In the U.S., the concepts encompassed by the product of nature doctrine have not been clearly defined by the United States Supreme Court or the United States Court of Appeals for the Federal Circuit, which has lead to a situation where the Patent Office and district courts have been left to determine whether a particular invention is properly classified as a product of nature. This has resulted inconsistent rulings, and because of the presumption of validity that attaches to issued patents has been significantly discredited, this jeopardizes both investments in emerging technologies and incentives to innovate.[8]

In the European patent system only inventions can become object of a patent right, and the examples of what cannot be regarded as inventions are listed in the EPC. According to article 52(2) EPC, discoveries, scientific theories and mathematical methods, aesthetic creations, schemes, rules and methods for performing mental acts, playing games or doing business, and programs for computers and presentations of information are not regarded as inventions. This means that a naturally occurring substance or a new found property of such substance can not be regarded as an invention. However, it has to be kept in mind that only discoveries *as such* are not patentable, which means that products and processes that arise from the human effort are inventions and thus may be patentable. For example, the process for isolating or synthesizing naturally occurring substances are patentable inventions, if they also meet the other requirements of patentability.[9]

Sometimes it is still difficult to distinguish between an unpatentable scientific discovery and a patentable invention. Questions like 'should an obvious practical application of a newly discovered natural phenomenon be patentable' or 'should a product or process claimed in such broad terms that it covers any practical application of a newly discovered natural phenomenon be patentable' arise.[10] I agree with Holman on answering both these questions in the negative. However, the problem is that it is hard to maintain consistent practice in issuing patents, because of the large amount of patent authorities.

2.2 Patentability requirements

2.2.1 Novelty

To be patentable, an invention has to meet a number of requirements: it has to be novel, inventive and susceptible of industrial application. These are called the patentability requirements. The novelty and inventive step criteria are most discussed in the field of nanotechnology.

[7] Benson, 409 U.S. at 67

[8] Parasidis 2010, p. 333.

[9] Schellekens 2010, p. 60.

[10] Holman 2007 p. 540.

An invention is novel, if it is not a part of the state of the art. To be patentable, it also has to be new. The most obvious questions regarding nanotechnology inventions and their novelty are size-related. Is size alone enough to confer novelty upon an invention? Could prior art that does not specifically refer to nano size anticipate a nano-scale invention? If the prior art refers only to the size scale of micro or larger, the nano-scale equivalent is generally not anticipated, for an invention is only anticipated if it has been described completely in the prior art. The Technical Board of Appeal addressed the issue of size in *Orica Australia/BASF* case[11] as follows:

> Orica's patent concerned addition polymer particles that can be stably dispersed in liquids. The particles are less than 100 nm and can be dispersed because of their core-sheath structure. BASF sought revocation of the patent inter alia for the lack of novelty. It elicited a prior US patent about dispersions for the preparation of high gloss coatings. The particle size in this patent was limited to a minimum of 111 nm. The TBA found no implicit disclosure of particle sizes of between 10 and 100nm and upheld Orica's patent.

Therefore, little or no problems are to be expected, if the ranges mentioned in a patent and the prior art are disjunctive.[12]

Another issue to discuss is what happens in cases where the ranges mentioned in a patent about a nano-scale invention overlap with those mentioned in the existing prior art. The issue was addressed in *Smithkline Beecham Biologicals/Wyeth*[13]. The invention in this case concerned the adjuvant qualities of a lipid in a vaccine. If an adjuvant substance in a vaccine is combined with an effective substance it reinforces the latter's effectiveness. According to the patent, the adjuvant effect of the lipid in this case can be improved by reducing its particle size. The patent in question describes experiments that empirically demonstrate the improvement in effectiveness at smaller particle sizes, but the reason why this effect occurs is not given. A range for the particle size mentioned in prior art documents is 80–500 nm, while the patent indicates a partially overlapping range of 60–120 nm. In consideration whether this prior art document destroyed the novelty of the invention or not, the Technical Board of Appeal (TBA) formulated as its criterion whether a person ordinarily skilled in the art (POSITA) would seriously contemplate applying the technical teaching of the prior art document in the range of overlap. In this case, the TBA found based on certain circumstances[14], that the overlap was not novelty defeating. The patent office scrutinizes whether the prior art document seriously contemplates the application of the invention in the overlapping part of the range. It has allowed claiming an

[11] T0547/99.

[12] Schellekens 2010, p. 51-54. See also Kallinger et al. 2008, p. 99–100.

[13] T0552/00.

[14] The overlap in this case represented only 10 % of the broad range of prior art; the prior art did not indicate any preferred size-related sub-range of the particles and the POSITA would probably end up with particles not in the size range of the patent.

overlapping range in various cases, which raises the question, whether this practice is the first step in creating a patent thicket.[15]

In cases when the prior art does not refer to size, it might destroy the novelty of a nano-scale invention, assuming that it contains an enabling disclosure. A nano-scale invention may still be novel despite of the fact that it is covered by the terms of a prior art document, if the POSITA cannot practice the invention at the nano scale without knowledge of the claimed invention or engaging in inventive activity. Nanotechnology is still a nascent and rather uncharted technology and the knowledge concerning it is constantly growing, thus non-size-related prior art may become ever more enabling prior art.

In the United States, the §102 of the Patent Act[16] precludes obtaining or enforcing patents covering an invention previously known or used by others. This paragraph pertains to novelty. If a printed prior art reference discloses within its four corners all aspects of a subsequently claimed invention, the reference anticipates the claimed invention. For example, in a patent application concerning forming self-aligned nano-electrodes[17], the applicant was able to overcome an anticipatory reference by demonstrating that it failed to clearly disclose one of the claimed elements, a transistor.[18]

2.2.2 Inventive step

Besides novelty, an invention must also involve an inventive step in order to be patentable. In other words, the invention must not be obvious to the POSITA, having regard to the state of the art. In nanotechnology inventions, mere downsizing is not necessarily enough to reach the requirements of an inventive step. In many fields downsizing can be considered as an obvious measure to take. One way to confer inventiveness on a nano-scale invention is the use of other processes to arrive at the nano-scale products. If the processes needed to produce nano-scale products are different from the processes used with bigger products, and those processes are not obvious to the POSITA, that may constitute an inventive step. Inventiveness can also be derived from other sources, such as a new unexpected function at the nano scale that solves a problem stated in the patent. Another way for nano-scale inventions to acquire inventiveness is that prejudice has to be overcome in order to arrive at a nano-scale invention. According to EPO, a prejudice is "a widely held but incorrect opinion of a technical fact"[19]. The idea of

[15] Schellekens 2010, p. 51-54.

[16] 35 U.S.C §102

[17] U.S. Patent No. 7,312,155 (Filed Apr. 7, 2004, issued Dec. 25, 2007). Available at http://www.patentstorm.us/patents/7312155.html.

[18] Troilo 2005, p. 37. See also Williamson & Carpenter 2010, p. 134.

[19] Schellekens 2010, p. 56.

prejudice is very strictly applied and it will become more difficult to use as knowledge of nanotechnology develops further.[20]

In the U.S. the required inventiveness of the patentable invention is expressed in 35 U.S.C. § 103. A patent may not be obtained, "if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains"[21]. The USPTO uses guidelines based on two U.S. Supreme Court decisions in order to determine whether an invention is obvious. The first case, *Graham v. John Deere Co.*, is from the year 1966. The Supreme Court established four factors for determining obviousness: 1) the scope and content of the relevant prior art; 2) the differences between the prior art and the claims at issue; 3) the level of ordinary skill in the pertinent art; and 4) secondary considerations such as commercial success, long felt but unsolved needs, and failure of others. Based on these four factors, the Court of Appeals for the Federal Circuit used the TSM test[22] for years. Forty years later the Supreme Court again addressed the issue of obviousness in *KSR Int'l Co. v. Teleflex, Inc.* The Court found that the TSM test was rigid, and while it didn't overrule the test, it stated that the TSM test is only one of many tests to determine obviousness. The Court found that a POSITA is also a person of ordinary creativity and thus in many cases where "familiar items may have obvious uses beyond their primary purposes - [and the POSITA]- will be able to fit the teachings of multiple patents together like pieces of a puzzle".[23]

2.2.3 *Industrial applicability*

According to the European Patent Convention, an invention must be industrially applicable in order to be patentable[24]. An invention is considered as susceptible of industrial application if it can be made or used in any kind of industry, including agriculture. This however does not mean that industrial applicability requires ability to make a product for the public at large. Basic materials may find application in industry through having a use as research tools. It has to be noted that this kind of research tool must, in order to be patentable, have a concrete use as a research instrument without the necessity to engage in further research. Another issue concerning nanotechnology inventions is that it is sometimes not yet possible to produce nanoscale substances in large amounts. That may cast doubt over the industrial applicability of a patent on a nano-scale substance, for it is difficult to build an industry on tiny quantities of a

[20] Schellekens 2010, p. 54–56. See also Kallinger et al. 2008, p. 100–101.

[21] 35 U.S.C. § 103(a)

[22] The TSM test held that obviousness rejections needed some evidence of teaching, suggestion, or motivation to combine the relevant prior art.

[23] Williamson & Carpenter 2010, p. 132-133.

[24] EPC Art. 52 and 57.

substance. For example, the production of carbon nanotubes at an industrial scale is still not completely solved. Distinctive to nanotechnology due to the size scale, is also the fact that it is still difficult to verify that nanotech inventions work as claimed by the patentee. Instruments to measure effects on a nano scale and even metrologies are often lacking. The disclosure of the invention has an important role as it has to be elaborate enough to convince the POSITA that the invention works as claimed. If the invention doesn't work, it has generally no practical use and therefore does not meet the requirement of industrial applicability.[25]

The requirement of industrial applicability is similar to the U.S. term of utility[26]. The invention defined by the claims of the patent has to have utility, which means it has to be operative and function for its intended purpose. While the utility requirement is not usually an issue in traditional inventions such as mechanical or electrical applications, it may pose a problem in an emerging field like nanotechnology. In emerging technologies the utility of an invention may not always be known at the time of conception or reduction to practice. In the interdisciplinary field of nanotechnology it is difficult to determine a good balance of claims in a patent application; claiming incredible uses of the invention may lead to the patent being denied on lack of utility and on the other hand unnecessarily limiting the claims not to cover anticipated improvements may render a patent useless.[27]

As previously stated, special characteristics in nanotechnology are its interdisciplinary nature and the fact that the technology is still in its infancy. The utility of the new inventions may not be known at the time of conception, which poses a challenge in patenting nanotechnology. Partly due to the lack of sufficient knowledge and partly due to companies intellectual property strategies, nanotechnology patents are broadly claimed; a "land-grab" mentality predominates in nanotechnology. These and other issues related to nanotechnology inventions are addressed in the next chapter.

3 Operational environment of nanotechnology patenting

3.1 Operational framework of nanotechnology patents

Nanotechnology is a branch of technology at its infancy and it typically requires high expertise and funding. It is not possible to do nano-scale research without requisite equipment and laboratory facilities. Although private corporations invest in nanotechnology research and patenting as well, unique to nanotechnology patents is that they are held in large proportion by

[25] Schellekens 2010, p. 56–58.

[26] It has to be noted, that the requirements are not congruent. The European patent law does not consider utility as a patentability criterion, which can be read in the decision T 0388/04.

[27] Troilo 2005, p. 37–38 and Halluin & Westin 2004, p. 235–236.

universities[28]. The amount of university filings in EPO applications has risen 600 % since the 1980s, and in nanotechnology and the life sciences universities file up to 50 % of all patent applications[29].

Universities collaborate with companies and industry. While the inventions resulted in academic research may not yet have commercial or industrial use themselves, private companies can carry on developing them into industrially applicable products. In addition, universities have top know-how and the advantage of research exemption[30] at their use. Private corporations have therefore a good reason to fund academic research.

Nanotechnology has grown explosively under the last years, and much of that growth is funded by government grants. Industry is another significant financier, for it sponsors certain research agreements.[31] Nanotechnological research is carried out in various universities throughout the world. As an emerging technology it offers scientists many interesting research subjects and huge potential for scientific breakthroughs.

> Over the last decades the universities' patenting activity has increased. The two main elements that lead to this development are the emergence of new technologies and the adoption of the Bayh-Dole Act in the U.S. in 1980[32].
>
> The Bayh-Dole Act, also known as University and Small Business Patent Procedures Act, gives U.S. universities, small businesses and non-profits intellectual property control of their inventions and other intellectual property that results from federal government funding. The Bayh-Dole Act encourages universities to collaborate with industry to promote the development and commercialization of the inventions made at universities using federal research funding. Universities have the right to elect title to federally funded inventions, and the obligation to file for patents on these inventions they elect to own.[33] The Act has said to have greatly influenced Europe's view on universities' obtaining of patents and some countries in Europe even have similar legislation in force today.[34]
>
> Research universities engage in the transfer of technology inter alia to facilitate the commercialization of university discoveries for the public good, to forge closer ties to

[28] Lemley 2005, p. 615.

[29] LaFlame 2010, p. 626.

[30] The research exemption excludes certain uses of patented subject matter from their ability to infringe a patent. However, the scope of the research exemption differs within several EPC jurisdictions.

[31] Shaddox 2006, p. 166.

[32] LaFlame 2010, p. 625–626.

[33] Berneman & Denis 2002, p. 228–229.

[34] LaFlame 2010, p. 626.

industry and to promote economic growth[35]. The above said and the fact that academic patenting could mean potential new jobs in the management of university intellectual property are used as justification for academic patenting and regional governments' support to it[36].[37]

3.2 Patenting building blocks

Partly due to legislation changes, and partly due to the increased magnitude of intellectual property rights around the world, patent applications are filed earlier and more often than ever. The case with a new technology like nanotechnology is that the basic ideas, the building blocks of nanotechnology, are patented at the outset[38].

Universities have patented building blocks of nanotechnology due to their role in basic research. Out of ten foundational nanotechnology inventions identified by Lemley[39], seven are owned by universities.[40] This is possible because universities still probably have the best requisites to do fundamental research on new technologies.

For one reason or another, most of the so called enabling technologies of the twentieth century, the computer, software, the Internet and biotechnology, were not patented from the very beginning of their rise. The core building blocks of these technologies ended up in the public domain through policy decision, shortsightedness, personal belief, government regulation or some other reason. In nanotechnology, on the contrary, both universities and companies are patenting early and often. Many of the most basic ideas in nanotechnology are already patented; patents have issued for example on carbon nanotubes, semiconducting nanocrystals, atomic force microscopes and a method of making self-assembling nanolayer. These however are not the only patented building blocks and probably more basic ideas in nanotechnology will end up patented. Patent applications can sometimes spend long times in the patent office, and because many of these applications will never be published, it is impossible to tell, which currently unpatented technologies will ultimately be patented.[41]

[35] Berneman & Denis 2002, p. 227.

[36] LaFlame 2010, p. 626.

[37] Academic patenting has also faced criticism: according to LaFlame some scholars see that fostering academic patents might lead to a lower "quality" of these patents and that the academic research might shift towards more “applied” science due to the incentives created by this fostering

[38] Lemley 2005, p. 605.

[39]Lemley lists patents on carbon nanotubes (3), semiconducting nanocrystals (2), light-emitting nanocrystals, metal oxide nanorods, atomic force microscopes, a method of making a self-assembling nanolayer, and a method of producing nanotubes through chemical vapor deposition.

[40] Lemley 2005, p. 614–616.

[41] Lemley 2005, p. 606–615.

Only a few of the basic building blocks are unpatented. Buckminsterfullerene[42] is probably the most well-known example. Buckminsterfullerene is composed of 60 or 70 carbon atoms shaped in a highly symmetrical spherical structure. Even though the substance in itself is unpatented, a huge number of patents have been issued on buckyball technology. From the classic buckyball shape the fullerene field has grown to a variety of carbon-based structures, including the above mentioned carbon nanotubes. The fullerenes are important, because unlike most carbon forms, they have the ability to enclose and incorporate other elements, including metals and noble gases. Thus fullerene structures have huge potential for manufacturing novel compounds and polymers for many different types of applications in a broad array of technology fields.[43]

It has to be noted that patent laws prohibit the patenting of abstract ideas, thus preventing early-stage patenting of broad concepts. Dr. Zekos sees the danger in patenting nanotechnology, which is still in its embryonic form, being the possible patenting of merely science and abstract ideas belonging to humanity. As mentioned above, many of the most basic ideas in nanotechnology are indeed already patented or may end up being patented.[44] The issue of broad claiming in nanotechnology patents is dealt with next.

3.3 Broad claiming and the "land grab" mentality in nanotechnology

Developing basic building blocks in nanotechnology is itself a complex and uncertain process and turning those building blocks into useable products takes considerable further research and time. Nanotechnology inventions require high investment in research and development. This and the long and doubtful process of innovating insinuate that nanotechnology patents should be reasonably broad, but not to the extent they prohibit further innovation.[45]

The temptation of claiming broadly and so receiving an issued patent that covers much more than the actual invention is understandable. The patent "land-grab" mentality means that corporate entities (and other potential patentees) seek and carve out far-reaching patent rights. Patentees often use the expedient of using broad and ambiguous terms in their patent claims to broaden the scope of protection for their invention. In some cases the specific types of nanoparticles, like quantum dots or nanotubes, are ambiguously described in the written description section of the patent instead of the actual patent claims. As an example of non-specific terminology is the use of the word "nanoparticle": it could refer to any shape nano-scale particle. Patents using such ambiguous terms are often subjected to claim interpretation to determine their true scope. Claim terms should be construed by first referring to intrinsic

[42] Buckminsterfullerene is named after the geodesic architect Buckminster Fuller. The substance is affectionately named "Buckyballs".

[43] Halluin & Westin 2004, p. 229–231.

[44] Zekos 2006, p. 310 and 361.

[45] Zekos 2006, p. 361.

evidence, which includes the claims, the specification, and the prosecution history of a patent application. If the intrinsic evidence is not enough to clear the meaning of a claim term, then extrinsic evidence, such as dictionaries and relevant technical treatises, may be consulted.[46]

Of course, by claiming broadly and using ambiguous terms in their patent applications, applicants take the risk of negative claim interpretation. Broad claiming in nanotechnology has lead to growing uncertainty amongst researchers, developers, policy-makers and investors regarding who really owns what particular element of technology. With focused claim drafting the patent owners may find it easier to convince investors and acquiring companies, who are wary of broad and possibly overlapping patents, of the defensibility and validity of their patents.[47] The far-reaching patent rights provided by early nanotechnology patents seem to overlap. This could lead to a vast amount of litigation in the future[48]. In the U.S., commentators blame the USPTO and its problems of the trend of uncertainty and patent overlaps[49]. The EPO and other patent authorities around the world face the same problems.

3.4 The challenges patent authorities encounter in nanotechnology

The amount of patent applications has surged, and the applications are more complex than ever. Distinctive to nanotechnology patent applications is that they are of multidisciplinary nature and their proper examination requires wide know-how of the examiners.

In Europe, EPO's workload has been said to have multiplied by 20 over the past 25 years. The patent filings have increased exponentially, but probably more problematic than that is the increase in the number of claims and pages in the average application. The average number of claims in an application has risen from 12 to 20 in two decades and the pages have increased over the same time period from 16 to 30. The applications especially in the fields of new technologies are increasingly complex and typically also have the most number of claims per application. The workload is only expected to increase in the future, mainly because of the improved integration of the European market for technology through the London Protocol or the European Patent Litigation Agreement, the potentially sharp increase in patent filings

[46] O'Neill et al. 2007, p. 30–33.

[47] O'Neill et al. 2007, p. 30, 39

[48] Litigation on overlapping patents in nanotechnology is not only a future scenario, but reality today (as shown on the before mentioned cases in this paper). The point is that the amount of litigation may grow, depending of course partly on the patent authorities' choices and decisions made concerning nanotechnology patents and licensing now and in the future.

[49] O'Neill et al. 2007, p. 30.

originating from fast developing countries and the arrival of new actors.[50] The described development has lead to pressure to increase productivity of the examiners at the EPO. Basically increasing productivity in this case means that examiners are spending less time on each application and thus the quantity of issued patents increases at the cost of quality.[51]

The EPO set up a Nanotechnology Working Group in 2003 to ensure that it was well-prepared for the impact of nanotechnology. The working group has called on internal and external expertise to develop a strategy for facing the patent challenges ahead. The most welcomed action taken by the EPO to tackle nanotechnology was the introduction of the "Y01N" tags to label nanotechnology in EPO databases. The interdisciplinary nature of nanotechnology made it difficult for anyone to retrieve existing patent documents and other literature on nanotechnology from the databases available before the new "Y01N" tags. The Y10N code is constantly updated and improved along with the progression of the technology.[52] The tagging system used in EPO helps both inventors and patent examiners in their search for prior art.

In the U.S. the USPTO has also improved the quality of examination of nanotechnology patent applications. The USPTO created a nanotechnology class[53] to organize most nanotechnology subject matter in a logical manner. Even though this significantly aides the patent examiners in their prior art search, it is still difficult to find relevant prior art. The USPTO has also utilized a Nanotechnology Customer Partnership program to help identify sources of prior art and establish technical training programs for examiners.[54]

Finding relevant prior art is in fact a very challenging task. Instrumental in examining prior art could be the Peer to Patent Project[55]. Noveck calls for creating a wiki-based "peer-review" system that will allow the expert community to provide relevant prior art for pending applications. The information would supplement the results found by the examiner and provided by the applicant. The system could response to difficulties third parties face in providing relevant prior

[50] For one more reason, see van Zeebroeck et al. 2008: "-- the size of patent applications is strongly affected by their geographical origin and technological area, with US drafting styles and biotechnologies leading the race. The strong effect of the filing route followed by applications prior to be filed at the EPO (and the well-known increasing success of the PCT option) suggests that the internationalization of patenting procedures and of technology markets encourages applicants to draft their applications only once according to the contingencies and modes of the largest market, namely the US, and to transfer their US-styled applications across the world, including the EPO."

[51] LaFlame 2010, p. 630–632.

[52] Nanotechnology in European patents - challenge and opportunity (Available at http://www.epo.org/news-issues/issues/nanotechnology.html)

[53] Class 977 contains 263 subclasses. Class 977 is a cross-reference classification, and prior to issuance a nanotechnology patent is first assigned a main classification in an area related to its specific technology, and then assigned a secondary nanotechnology classification to provide a supplemental search resource.

[54] Williamson & Carpenter 2010, p. 133.

[55] The Peer to Patent Project is based on Beth Noveck's 2002 paper "Peer to Patent": Collective Intelligence, Open Review and Patent Reform.

art to an examiner during patent examination, as well as the difficulties patent examiners face trying to take into account all relevant prior art. One advantage in this system is its cost-effectiveness: instead of wasting a huge amount of money in litigation, "bad" patents will be ferreted out expeditiously and with minimal costs. The USPTO has adopted a pilot program utilizing this proposed system for reviewing applications for Technology Center 2100, the chief group for software patents. The program has already led to communal prior art submissions against many big companies, like Yahoo and General Electric.[56]

Other issues complicating matters even more in both the U.S. and in Europe, are the facts that nanotechnology nomenclature is still quite diverse and nanotechnology standards are only beginning to be developed. Besides that, the patenting authorities employ thousands of people. The EPO is employing 7000 from over 30 countries[57] and the USPTO employs nearly 10 000[58]. This makes it challenging to provide the same level of education to everyone and maintain uniform practices in policymaking concerning, for example, the broadness of patent claims.

4 Challenges and approaches to possible solutions

4.1 Challenges

There are three main challenges in the field of nanotechnology: patent thickets caused by broad and overlapping patents, patent trolls and infringement actions. What makes infringement actions special in this field is the fact that when operating on such a small scale, detecting infringement activity is difficult.

The consequence of broad and overlapping nanotechnology patents being first filed and then granted is a patent thicket. A patent thicket is an unintentional formation of overlapping patent rights that belong to different owners. Patent thickets require that those seeking to commercialize new technology obtain licenses from multiple patentees. Patent thickets have the potential of preventing all parties from making a product that encompasses numerous patented technologies.[59] As said, patent thickets are unwanted, because they typically stifle competition in market and furthermore impede innovation.

A nanotechnology advisory firm called LuxResearch consults clients for investment in nanotechnology. The firm has developed the LuxReport, a report on nanotechnology patents. The report analyzed over one thousand patents related to the building blocks of

[56] Duane 2008, p. 70–72.

[57] The EPO, available at http://www.epo.org/about-us/jobs/why/who.html. Accessed at 10.3.2010.

[58] The USPTO 2011-2015 Strategic Human Capital Plan, p.24. Available at http://www.uspto.gov/about/stratplan/USPTO_2011-2015_Strategic_Human_Capital_Plan.pdf. Accessed at 10.3.2010.

[59] Paredes 2006, p. 492–493.

nanotechnology. The report stated that many of the issued patents overlap, to the extent of making a potential patent thicket.[60]

Nanotechnology seems to follow similar paths to the radio industry in its infancy. The early years of radio industry in the 1920's were privately funded and there was extensive patenting among a diverse group of unaffiliated private entities. The diverse group of investors, each of whom were keen on exploiting their patents for maximum advantage, owning the key patents in the industry lead to rife patent litigation and patent blocking. In cases where two patents, owned by competing entities, were essential to practice a particular innovation, the patent battles resulted in deadlock. Such situations also halted progress, because in the radio industry one innovation builds on others and the end product is the result of many related technologies. Despite the reluctance of cross-licensing between key position corporations, finally some cross-licensing agreements on patents had to be arranged. It has been stated that the development in the radio industry was forestalled by an overarching unwillingness to cross-license patents, and it is hard to object to that statement.[61]

In the radio industry the seminal inventions were privately funded and privately owned and had strong immaterial property protection. In comparison nanotechnology is both privately and publicly financed, but has likewise strong IP protection. As a result of the Bayh-Dole Act though, in U.S. the publicly funded nanotechnology research will end up privately owned. This means that nanotechnology industry is in fact in a very similar state as the radio industry once was.[62]

The development of a nanotechnology patent thicket could impede the licensing process required for further innovation. In nanotechnology, like in the radio industry, it is often necessary to obtain licenses from many different patent owners to enable the production of new technology. The accumulated transaction costs of all the required licenses may become prohibitive for the licensee. It has been marked that, in the field of nanotechnology, patent holders are not likely to collaborate voluntarily in order to form patent pools and circumnavigate these patent thicket licensing problems. Most of the nanotechnology research is already funded, so the inventors don't have the need to pool patents. They rather keep their patents and licenses exclusive in order to gain greater profits in the future. Other reasons are for example the fact that there has been little demonstrated need for pooling and nanotechnology as a multidisciplinary field makes it likely for researchers specializing in one area to find it difficult to compare the values of patents from other branches of science. In

[60] Paredes 2006, p. 491.

[61] Sabety 2005, p. 495–497

[62] Sabety 2005, p. 507.

addition to the above-mentioned, nanotechnology is still in its infancy and as such an uncertain investment for financiers.[63]

Although thousands of nanotechnology patents have been issued and even more have entered the application process in the United States, there is still very little nanotechnology-specific infringement litigation that would have reached judgment. Especially in common law countries ample case law would provide useful guidelines on the validity of nanotechnology patents. Considering the pace of nanotechnology development and innovations, infringing patents and applications are bound to have come up, so why is there still no significant nanotechnology-specific infringement case law? The obvious reason is the expense of litigation. Also many innovators are in a situation where they simply lack standing. This leads to those innovators attempting to license "bad" patents rather than contest them. One factor deterring patent litigation is the assumption of symmetry: if a competitor sues you for infringement you can sue them back.[64] The following two examples will shed little light on this issue.

In the U.S. the first nanotechnology patent case in federal circuit was the *In re Kumar* case. The central question in the case was the overlapping size of nanoparticles used in polishing applications. Although the court disposed of the case on procedural grounds, the unanimous opinion touches upon a number of important issues for future nanotech patent cases. Then again, this was not a case involving litigation between two companies regarding infringement of a nanotech patent, but rather a determination by the PTO.[65] Another example of a nanotechnology specific patent litigation is *Cabot Microelectronics'* decision to pursue legal action against *DuPont Air Products NanoMaterials* (DA NanoMaterials) and *Korea's Cheil Industries*:

> Cabot claimed DA NanoMaterials is manufacturing and marketing slurries that infringe on its patents. Cabot made this decision at the turn of year 2006/2007. After this a long process followed. DA NanoMaterials brought a non-infringement lawsuit against Cabot and both parties were to submit pretrial filings by January 15, 2010. Finally, a jury in the United States District Court for the District of Arizona rendered a verdict according to which DA NanoMaterials' products do not infringe Cabot's patents.

Even without knowing the exact legal and other expenses both parties had to carry during litigation, the process was undoubtedly remarkably costly.[66]

[63] Tullis 2005, p. 295–297.

[64] Tullis 2005, p. 298–299. See also Lemley 2008, p. 615.

[65] Baluch et al. 2005, p. 342–344.

[66] Online news concerning the case are available at: http://www.nanotechbuzz.com/50226711/cabot_alleges_nanotechnology_patent_infringement.php, http://www.azonano.com/news.asp?newsID=14832, http://www.azonano.com/news.asp?NewsID=15188 and http://www.azonano.com/news.asp?newsID=18478. Accessed at 7.4.2011.

Nanotechnology is a difficult branch of technology from patent owner's and licensee's point of view, when they are considering the policing and enforcing nanotechnology patent rights against possible infringers. The exceptionally small scale makes it hard to analyze, observe and police the infringing activity of nanotechnology. Furthermore, a vast number of new innovations and improvements to existing technology are occurring almost daily across multiple disciplines. Thus the nature of nanotechnology as a small-scale multidisciplinary branch of science makes it difficult to determine whether a third party is infringing.[67] Zekos has stated that because of this difficulty, nanotechnology industry will follow the footsteps of biotechnology: to avoid a patent thicket at the research stage it will not limit the scope or issuance of patents, but merely ignore them.[68]

As mentioned before, the patent authorities are having a hard time reviewing nanotechnology patent applications thoroughly, partly because of the amount of the applications and partly because of the multidisciplinary nature of nanotechnology. This results in "bad" patents being issued, which in turn leads to increased and costly litigation, a burden on invention because of fear of potential infringement, and the rise of patent trolls.[69]

Patent trolls are companies or persons that use their patents against one or more alleged infringers in a manner considered unduly aggressive or opportunistic. Often these patent trolls have no intention of manufacturing or marketing the patented inventions themselves.

> Among some industry representatives universities are considered to be patent trolls: universities don't need a license to other people's patent rights and thus have no interest in cross-licensing, so they are only interested in money[70].

Related to patent trolls is the term warehousing. In other words, these companies warehouse patent rights to extract cash from others that are found to be infringing these rights. In some cases the mere threat of costly litigation results in payment of tribute. Part of the problem is the patents resulting from publicly funded research. Universities should avoid warehousing patent rights as an investment and instead use their patents that have resulted from publicly funded research as tools to provide a nascent company with a competitive position that can attract capital to build a business.[71]

[67] Sutton et al. 2009, p. 180.

[68] Zekos 2006, p. 363.

[69] Duane 2008, p. 67.

[70] Lemley 2008, p. 615–616.

[71] Sabety 2005, p. 509–510. See also Duane 2008, p. 68–69.

4.2 Possible solutions

A resolution to patent thicket could be found in licensing, but it has been argued that limiting the scope of overlapping claims is at least equally important[72]. When considering licensing nanotechnology, probably most of the questions unique to nanotechnology are related to size, but what the licensees should consider more, is the intellectual property matters.

In the nanotechnology context the licensees should investigate intellectual property matters in detail. Often licensees do a comprehensive market survey and financial analysis and investigate carefully the technical aspects of the subject of the license but do not give the intellectual property the attention it deserves. As mentioned before, nanotechnology is a field of broad and overlapping patents. That is why it is important to include into the licensing due diligence report a review of the quality of the patents, with extra attention to the scope of the claims and the possibility for competitors to design around the technology.[73]

As mentioned, the development of nanotechnology patent thicket could impede the licensing process required for further innovation. At this point one option could be compulsory licensing. Compulsory licensing means that government forces the patent holder to grant use to the state or others. The TRIPS agreement[74] sets out specific provisions that shall be followed if a compulsory license is issued, and the requirements of such issues. Article 31 of the TRIPS Agreement permits World Trade Organization members to grant compulsory patent licenses under the limited circumstances of national emergency, antitrust violations, and public noncommercial use.[75]

On one hand, compulsory licensing can be seen as a solution to certain problems in the field of nanotechnology, but on the other hand it can also be seen as a scheme that stifles innovation and investment. The only two statutory compulsory licensing provisions in the U.S. are for inventions related to atomic energy and air pollution control[76]. Developing downstream products comprises high risks and development costs, which makes proper patent protection highly important for companies. One aspect of this is the venture capitalists' eagerness to invest in start-up companies: it decreases if there's a risk that government shatters the patent barriers that protect their investments. Another issue is the decrease of public disclosure of technological process, when companies rely rather on trade secrets than patents to protect their

[72] Burk and Lemley 2003, p. 1614.

[73] Shaddox 2006, p. 165–167.

[74] The Agreement on Trade-Related Aspects of Intellectual Property Rights

[75] Tullis 2005, p. 293–297 and 311.

[76] According to Lemley (2008), some have even suggested that all publicly funded research should be subject to compulsory licensing. The opinion reflects the fear that universities might treat their licensing offices as revenue generation devices, which might lead to university patent policies that are not often consonant with the ultimate public interest.

inventions.[77] Compulsory licensing is widely criticized and rarely used and thus it may not be the answer to solving problems caused by the patent thicket in the field of nanotechnology.

It has been argued that limiting the scope of overlapping claims are at least equally important as licensing when trying to find a resolution to patent thicket. One tool to narrow broad claims that comprise these overlapping patent rights could be the written description requirement. One purpose of written description requirement is to ensure that the inventor actually has invented what the patent application claims; to obtain a valid patent an applicant must include in his or her application a specification adequately disclosing the invention and how to make and use it. The requirement protects against overbroad claim amendments by requiring patent applicants to provide a description sufficient to show that they are in possession of the invention. Thus the written description requirement derives in part from considerations of patent breadth. The assessment whether the written description sufficiently supports a patent's claims is made through the eyes of the POSITA. It is considered probable that the third parties are likely to perceive what the POSITA is likely to understand.[78]

According to Paredes, the written description requirement can be used to prevent or even clear the patent thicket in nanotechnology. He states that "each legal principle under the written description requirement should be examined and applied appropriately to each nanomaterial with broad, overlapping patents". Also the strong presumption of compliance with the written description requirement should be inapplicable to new technologies.[79]

4.3 Recommendations

As mentioned earlier, broad and overlapping patent claims lead to patent thickets and at worse to patent blocks, if patent owners are not willing to cooperate with others. To prevent possible deadlock situations, cross-licensing and patent pools should be used more in the field of nanotechnology. Patent owners and licensees should also cooperate more to prevent infringement actions.

A cross license is an agreement between two or more parties that grants each the right to practice the other's patents. Despite the fact that the term 'cross licensing' implies that neither party pays monetary royalties to the other party, cross licenses may or may not involve fixed fees or running royalties, which can run in one direction or in both. Cross licenses may also involve various geographic or field-of-use restrictions. It is common that cross licenses involve some but not all relevant patents held by either party.[80] Parties are often symmetric in a sense that they

[77] Miller 2005, p. 79–80.

[78] Paredes 2006, p. 493–496.

[79] Paredes 2006, p. 512.

[80] Shapiro 2001, p. 127.

both are usually companies and have certain essential patents in a certain field of technology. This symmetry also means that usually when a competitor sues a company, the company can sue them back[81]. Universities, as mentioned before, don't need a license to other parties' patents due to research exemption. This has lead to some commercial parties claiming that universities are patent trolls who only want to gain profit by licensing their own patents.

In certain situations cross-licensing is also a means to eliminate or at least minimize costly legal battles; cross-licensing can offer a viable alternative to litigation for companies whose technologies have an overlapping scope. Parties should be encouraged to grant cross licenses when in this situation of similar or overlapping scopes. Covenants not to sue in cross-license agreements can decrease the costs associated with fighting infringement suits. Cross-licensing may also be a feasible strategy for late-comers looking to enter a technical area where there are already existing players. Usually late-comers are in a defendant position because the existing players have the basic patent rights of the technical area in question. However, if a late-comer enters the market with a patent portfolio that fences in an existing player's technology, the late-comer may be able to force the existing player into a cross-license agreement in order to maintain its possibilities of expanding its technology outwards. The terms of a cross license in this situation may well be advantageous to the late-comer because of the late-comer's superior bargaining rights. In nanotechnology these situations occur for example in the area of nanotube technology, which is an area currently experiencing increased cross-licensing.[82]

By definition, a patent pool is a consortium of at least two companies agreeing to cross-license patents relating to a particular technology. Under a patent pool, an entire group of patents is licensed in a package, usually to anyone willing to pay the associated royalties. [83] Under a package license, two or more patent holders agree to the terms on which they will jointly license their complementary patents and divide up the proceeds.

Patent pools are a form of self-regulation. Pooling patents has its pros and cons. Pros of self-regulation are among other things the use of top-level expertise when making the regulation and also increased commitment to the regulation. According to some studies the parties involved in making the rules of a regulation are usually more willing to accept and conform it. Self-regulation is also more adaptable and cost efficient than government based regulation. It is said that self-regulation improves the equality of private parties in comparison to government officials. The criticism of self-regulation sums up in its inefficiency, possibly low sanctioning and the rise of free rider mentality. It has also been stated that self-regulation concentrates on the private interest at the expense of the public interest.[84]

[81] Lemley 2008, p. 615.

[82] Sutton et al. 2009, p. 179.

[83] Shapiro 2001, p. 127.

[84] Vuorinen 2008, p. 49–50.

Patent pools bind only their member patent owners and licensors. One of the most important provisions in patent pools is the obligation to license certain key patents to the pool. Pooling the building block patents of nanotechnology could lead to both increased licensing in the field and broader access to technology. Pooling is a good option when compared to compulsory licensing. Especially in the U.S. the government intervention is traditionally seen as detrimental to competition and to free market economy. The attitude towards compulsory licensing is not too approving in other parts of the world either. Self-regulation, such as patent pools, is said to restrain the authorities' interference and to provide the rise of field-specific appreciation[85]. Thus patent pools could be one answer to dealing with the patent thicket problem. As mentioned many times above, nanotechnology is at its infancy. This basically means that the patent thicket will probably thicken and become a bigger issue in few years because of the vastly growing amount of patent applications in the field. Forming patent pools seems to be a rational measure to take to avoid, among others, government interference and costly infringement litigations.

Noticing infringement in nanotechnology, as stated above, is quite challenging. Cooperation between licensor and the licensee is one means to increase possibilities of detecting infringement actions early on. Mutual cooperation provisions can facilitate some of the burden faced by licensors in enforcing and policing their patent rights. Mutual cooperation provisions demand that both parties to the agreement cooperate to protect each other's patent rights. These provisions may require that both the licensor and the licensee participate in gathering evidence and pursuing court action in the event of infringement. This can lead to the identification of infringing activity early on, before any significant financial or other harm comes to either party. Furthermore, mutual cooperation in a patent infringement action can lead to better chances of success in proving cause of action.[86]

5 Conclusion

Nanotechnology is one of the rising fields in technology of our age. Its special characteristics are its size and multidisciplinary nature. Nanotechnology is still at its infancy and has huge potential. Some nanotech related inventions are already a part of our daily lives and in the future innovations of this field will become more and more frequently used in everyday life.

Nanotechnology poses many questions. Nowadays it is clear that nanotechnology inventions are generally patentable. Patentability criteria apply to nanotechnology the same way as to innovations from other fields of technology. The most notable issue to consider in nanotech patent applications is often related to size: whether the innovation in question is novel and entails an inventive step compared to similar inventions that operate on a different size scale. It

[85] Vuorinen 2008, p. 50.

[86] Sutton et al. 2009, p. 180.

is also clear that a naturally occurring substance or a new found property of such substance can not be patented as such, but products or processes that arise from human effort are inventions and thus patentable.

The authorities in both Europe and the U.S. have faced same problems as the amount of patent applications filed in the field of nanotechnology has grown vastly. Measures, like creating a labeling system for nanotechnology inventions or educating the staff are taken, but there's still more to do. The patent authorities should be encouraged to find and use new, innovative methods in examining patent applications. One example introduced in this paper is the Peer to Patent Project. As the wise men have said; problems can't be solved using the same way of thinking used when they were created[87]. Noveck's wiki-based "peer-review" system is a modern creation that would not have been feasible a few decades ago, but fits well in the information society of today.

Problematic in nanotechnology patenting is the fact that so many overlapping patents have already issued and there are probably more to come. This forms an undesirable patent thicket. As possible solutions to problems caused by patent thicket and blocking patents, voluntary licensing, both in the form of simple cross-licensing and creating patent pools, are introduced. Patentees should be encouraged to license more and to cooperate more. Licensors and licensees should work together in order to stop infringement activity.

It seems that there is no need to change patenting legislation because of nanotechnology. Patent laws offer enough room to patent nanotechnological inventions. In the future, and already today, more attention should be paid to the scope of claims in nanotechnology patent applications and creating nanotechnology standards as well as a clear nomenclature.

[87] A quote from Albert Einstein: "We can't solve problems by using the same kind of thinking we used when we created them."

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Abbreviations

EPO	European Patent Office
PHOSITA	Person having ordinary skill in the art
TRIPS	The Agreement on Trade-Related Aspects of Intellectual Property Rights