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Nanotechnology under the Magnifying Lens from a European and U.S. Perspective:

General Patent Statistics, Non-Obviousness Versus Inventive Step, and Two Case Studies in CNT Commercialization

Luca Escoffier

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Abstract

In this article, Luca Escoffier first provides a definition of nanotechnology and some commented statistics about the patenting of nanotechnology innovations through the PCT route, and then analyzes the current jurisprudence as to the inventiveness/non-obviousness requirement for nano-related inventions in the U.S. and Europe.

He also provides examples of international IP issues involved in commercializing carbon nanotubes through two case studies. The first case study provides an insightful comparison between the United States Patent and Trademark Office and the European Patent Office as to the prosecution of the same technology in the field of carbon nanotubes. The prosecution history of a particular patent application reveals how a patentee can obtain patent protection in one jurisdiction while encountering difficulties in another jurisdiction. In the second case study, the author offers a reasoned opinion on a recent license agreement that could impact the commercialization of carbon nanotubes.

Keywords

Nanotechnology, statistics, IP, CNT, USA, Europe, regulatory, patents.

Disclaimer

This article does not employ proprietary information but instead uses publicly available data. As to the first case study, the author neither intends to provide commentary on the intellectual property strategy of the subject company at hand nor on the internal policy and procedures of the European Patent Office or the U.S. Patent & Trademark Office. Rather, the article aims to provide the reader with a picture of the development of an IP portfolio in the nanotech sector before two different patent offices. As to the second case study, the author does not intend to provide commentary on the IP or business strategies of the companies at stake. Rather, the article aims to provide the reader with some comments on a recent agreement that could dramatically boost the commercialization of carbon nanotubes. It must be stressed that the author has not attempted to exactly reflect the actual magnitude of the patent portfolio and the patent families of the companies at stake. Same proviso applies to the statistical considerations made on the basis of WIPO's datasets. The paper is based on data and information up until April, and June 2009.

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INTRODUCTION

First, this article tries to offer to the reader the necessary basic information to understand what nanotechnology is, and what its most common present and future applications are. Some interesting figures as to nanotechnology patenting will also be provided with a reasoned commentary. The article then will focus on one of the patentability requirements, inventive step (in EU) or non-obviousness (U.S.), which will be analyzed in detail with reference to the most current case law.

Second, an insightful comparison between the United States Patent and Trademark Office (PTO), and the European Patent Office (EPO) as to the prosecution of nanotechnology-related innovations is carried out to understand whether there are differences as to their patentability before the two offices[i]. In this regard, specific consideration will be given to the inventiveness of nanotechnology-inventions, that is, to one of the necessary requirements that an invention has to meet to be patentable.

Companies face challenges in prosecuting patent applications in multiple jurisdictions. An invention might well lead to the issuance of a patent in relatively short time by a patent office in one jurisdiction; but that very same invention might face an entirely different situation in other jurisdictions. It is not clear whether this anomaly results more frequently from the nature of nanotechnology. According to statements from the United States Patent and Trademark Office ("U.S. PTO") and the European Patent Office ("EPO"), however, there are no unique hurdles to overcome when evaluating nanotechnology-related inventions.

The first case study in this article highlights one example of how a patentee can have success in prosecuting a nanomaterial-related invention in the U.S., but not in Europe. In addition to challenges involved in prosecuting patents, companies seeking to commercialize nanotechnology also face patent disputes with other companies. Several commentators have predicted that companies working with carbon nanotubes will be involved in protracted conflicts and cross-licensing arrangements.

The second case study focuses on the agreements that have been recently executed between Hyperion Catalysis International Inc. ("Hyperion"), a U.S. company, and Showa Denko K.K. ("SDK"), a large Japanese company. A review of patent figures can shed some light on the scope and implications of the agreements.

Some conclusions are then drawn to summarize the findings of the study, and due consideration is given to the importance of the figures provided, as they can show how we are facing a paradigm shift in patent activities[ii].

I. A BRIEF INTRODUCTION TO NANOTECHNOLOGY AND ITS APPLICATIONS

Nanotechnology is not just a simple word that we can find in, by now, thousands of textbooks and novels[iii]. Nanotechnology is a revolution in terms of thinking and implications that will utterly revolutionize the way we live. If we look up this not-so-fully-understood word in the dictionary, we discover that it is defined as:

> *the art of manipulating materials on an atomic or molecular scale especially to build microscopic devices (as robots).*

So, since the very beginning of our article we start with a doubt, from this very vague definition it seems that nanotechnology is every manipulation of the matter occurring at a small scale. To have a clearer idea though, it is necessary to look at the definition provided by the National Nanotechnology Initiative (NNI)[iv]. In this case the term is described as follows:

> *nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale. [] Unusual physical, chemical, and biological properties can emerge in materials at the nanoscale [].*

From this standpoint it is now possible to understand more deeply all the facets of this multidisciplinary field of technology. Since in one micron there are 1,000 nanometers, it is possible to infer that nanotechnology, *lato sensu*, is the technology applied within the micron size, but *stricto sensu*, and for our purposes it has to be considered as defining the technology within the 0-100 nanometers range, and this is because of the intrinsic properties displayed by the elements at stake. Finding the exact terms to describe the topic of this article is not a meaningless exercise at all. Indeed, when talking about the inventions conceived in this sub-world where there is quite a space for the researcher's imagination, there is room for patenting even for subject matter already known to the public, and part of the prior art. In fact, this is possible when novel solutions are found to overcome technical hurdles not resolved yet. Definitions are also crucial for those involved in the field of nanotechnology, and patents when retrieving and examining nanotechnology-related inventions[v], which is not a trivial task, and it is fundamental to correctly categorize and compare the claimed inventions, also for the patent offices themselves.

As to the current and potential applications of nanotechnology-enabled devices or nanomaterials, there are way too many examples, and that is why I decided to pick up only a piece of news published last week[vi]. So, for example, on 23 June 2009 QD Soleil™, a division of Nanosys Inc.,[vii]announced[viii]that the PTO has allowed the company's patent claims based on the use of nanostructures for solar concentrators which magnify the sun's rays on a small area of highly efficient solar cells. QD Soleil uses its quantum dot technology to efficiently capture and concentrate light[ix].

II. PATENT STATISTICS IN NANOTECHNOLOGY

Personally, I think that providing some figures about nanotechnology patenting can be a useful tool for the reader. Unfortunately, there are many articles in which nanotechnology patenting is of course measured in terms of patents or applications, but the numbers are always pretty confusing from one article to another as everyone uses a different approach, different datasets and therefore there is no homogeneousness in this regard[x]. I am pretty aware of the inaccuracies that my research could have generated, especially for the number of applications that are maybe counted twice due to several codes that are used in the applications[xi], but these drawbacks are common to all the other similar studies, as they all use the same databases.

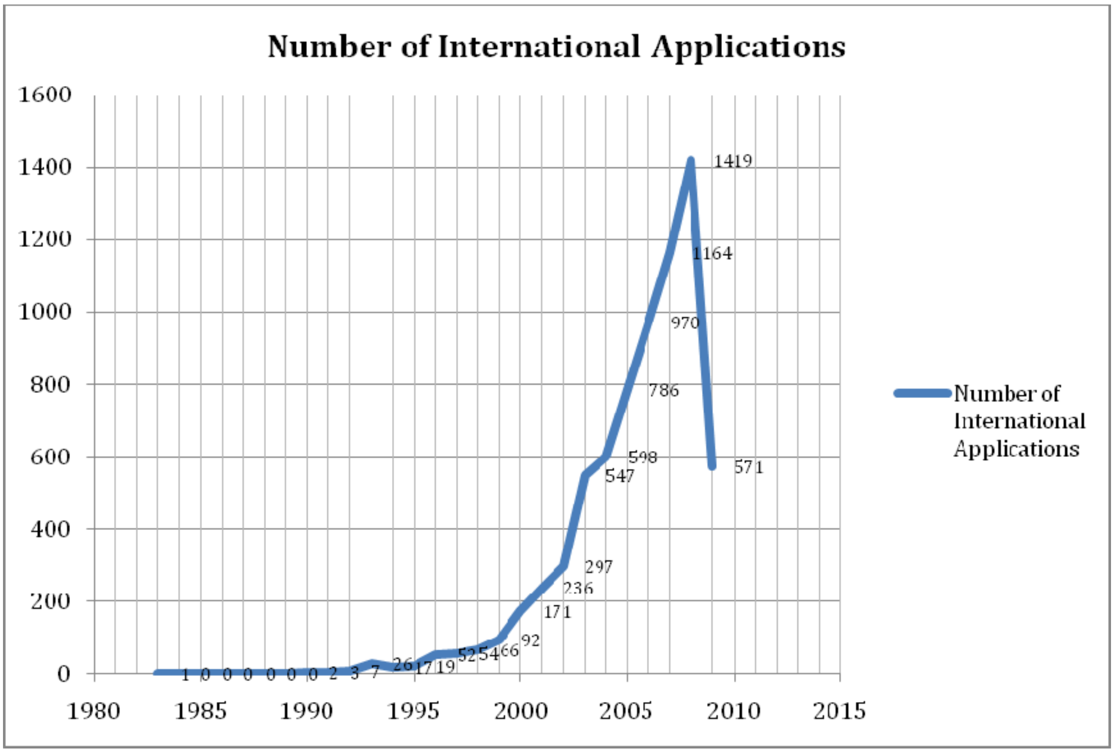

Figure 1: nanotechnology patent filings (the results mirror the number of documents containing the word "nano" in their Title) - Source: Patentscope® as of June 15th, 2009

This first plot I drafted represents the number of published international patent applications filed, through the PCT route, and published since 1983 until June 15, 2009. It is obvious that the data of 2009 are not in line with the exponential increase if we assume that by the end of the year we could have a number that is twice as much the one that is now represented. In fact, ca. 1200 applications would be less than 1419, the number recorded as of 2008. The reason in reality is not that obscure. In fact, it is not an inflection of the technology pace but rather a change of mind, a paradigm shift that will be more persistent in the years to come. We can add something more. More and more companies are benefiting from the nanoscale intrinsic qualities of materials, but they start now being a bit skeptical as to the appropriateness of using the word "nano" in their marketing and patenting strategies. In fact, there is a palpable trend at the industry level to start avoiding any mention as to the presence of nanoparticles in the sold compounds, especially in the case of cosmetics, since the real effects of those products are still unknown, [xii] and entrepreneurs do not want to run the risk of having in their hands products that can adversely affect their businesses solely for their names[xiii].

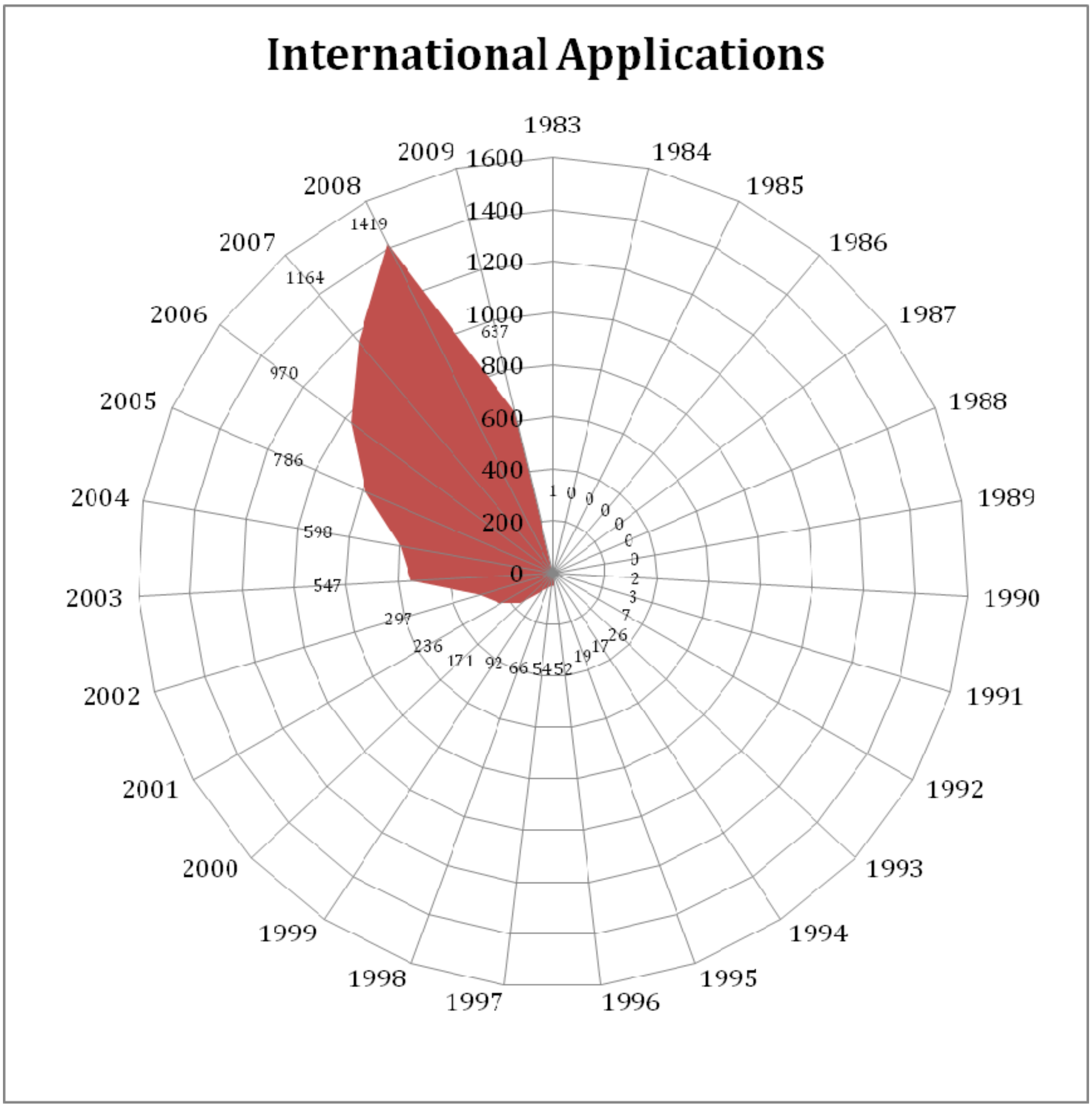

Figure 2: nanotechnology patent filings (the results mirror the number of documents containing the word "nano" in their Title) - Source: Patentscope® as of June 15th, 2009

The above radar chart reproduces the results contained in *Figure 1* and shows in a more intuitive way the exponential increase in the number of applications over the years. I figured that the number of applications could differ according to the part of a patent in which I would have performed a search using some filters, and this assumption turned out to be correct. In the radar chart below, the search has been performed by selecting the documents containing the term “nano” in their Title, and Abstract. Not surprisingly, the number of was slightly inferior to the one displayed in *Figure 2*, 1056 applications v. 1164 for 2007 and 1301 v. 1419 for 2008.

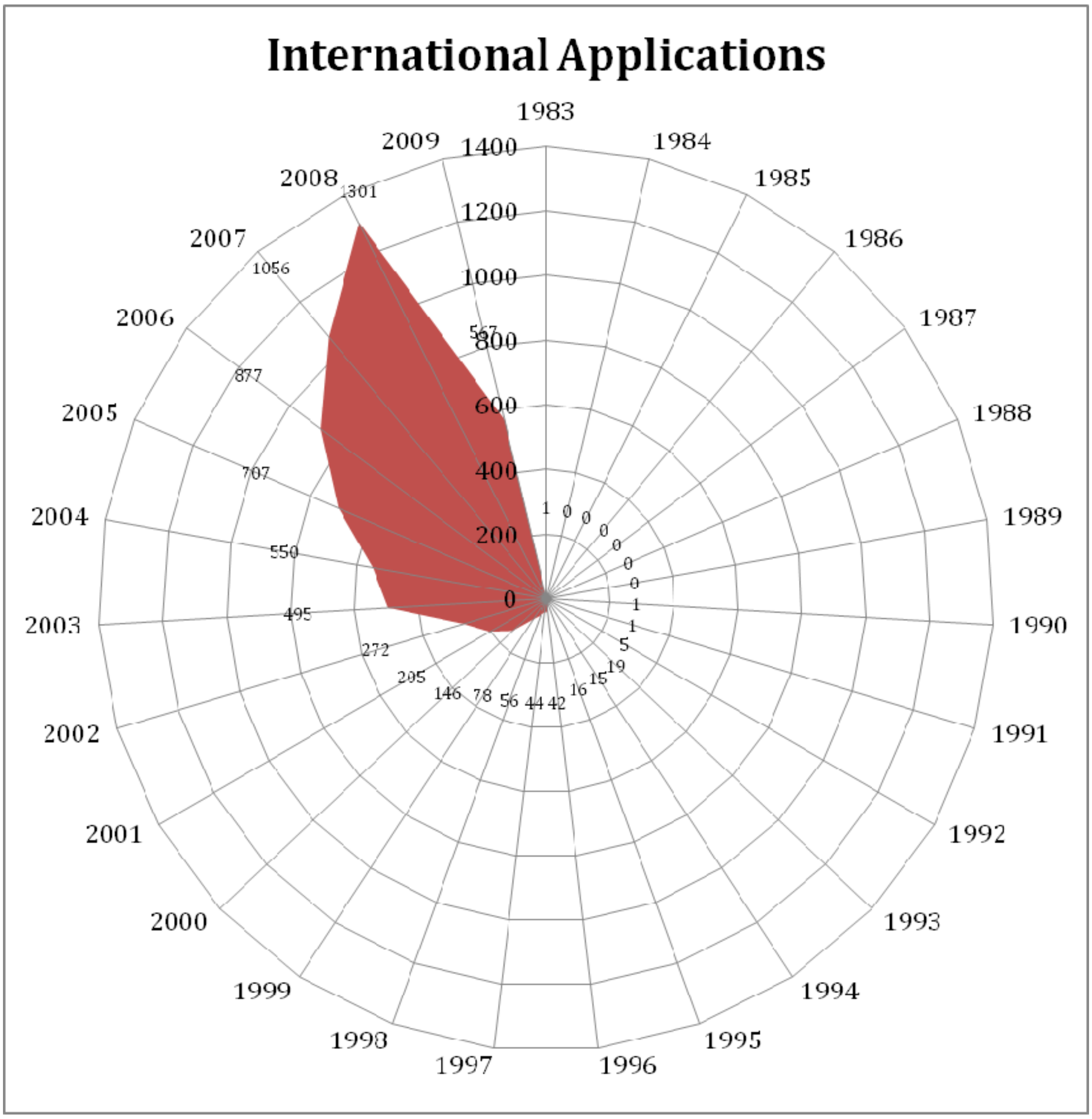

Figure 3: nanotechnology patent filings (the results mirror the number of documents containing the word “nano” in their Title and Abstract) - Source: Patentscope® as of June 15th, 2009

In the radar chart here below we find the results of the search performed by looking for documents containing the term “nano” in their Title, Abstract and Claim(s). Predictably, the figures are lower if compared to the numbers of the two previous charts as the Claim(s) constitutes an additional filter for the applications displaying “nano” in their Title and Abstract.

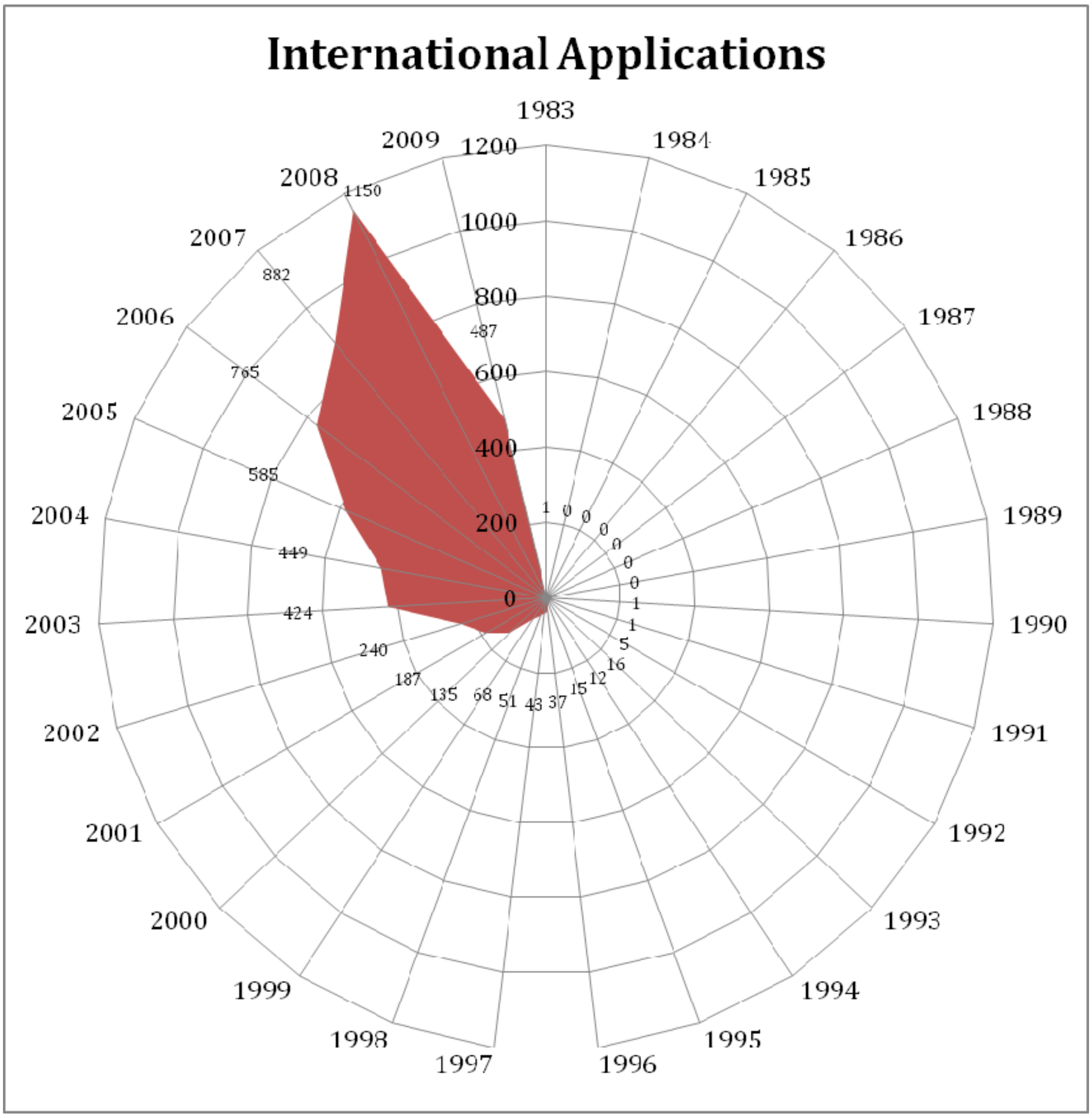

Figure 4 :nanotechnology patent filings (the results mirror the number of documents containing the word “nano” in their Title, Abstract, and Claim(s)) - Source: Patentscope® as of June 15th, 2009

The really interesting results of my study, though, come when talking about the applications containing the term “nano” in their Abstract, and Claim. The last radar chart clearly shows that the difference is material with 1502 applications in 2007, and 1914 in 2008 as opposed to the 1164 and 1419 displayed in *Figure 2*, therefore we are talking of about 30% less applications labeled as pertaining to a nano-scale innovation. At this point it is possible to make two mutually exclusive considerations. The numbers of applications in *Figure 5* is higher because applicants do not want to "show" so easily that they are dealing with nanotechnology to potential competitors or, as I think more probable, because the current trend to avoid future regulatory hurdles is to avoid the labeling of a claimed invention as "nano". This, in fact, can still "allow" applicants to argue before regulatory agencies that the product is not different from known the prior art, while the terminology used in the claims - before a patent office - can actually help them qualify the claimed invention as novel, and inventive, and thus patentable.

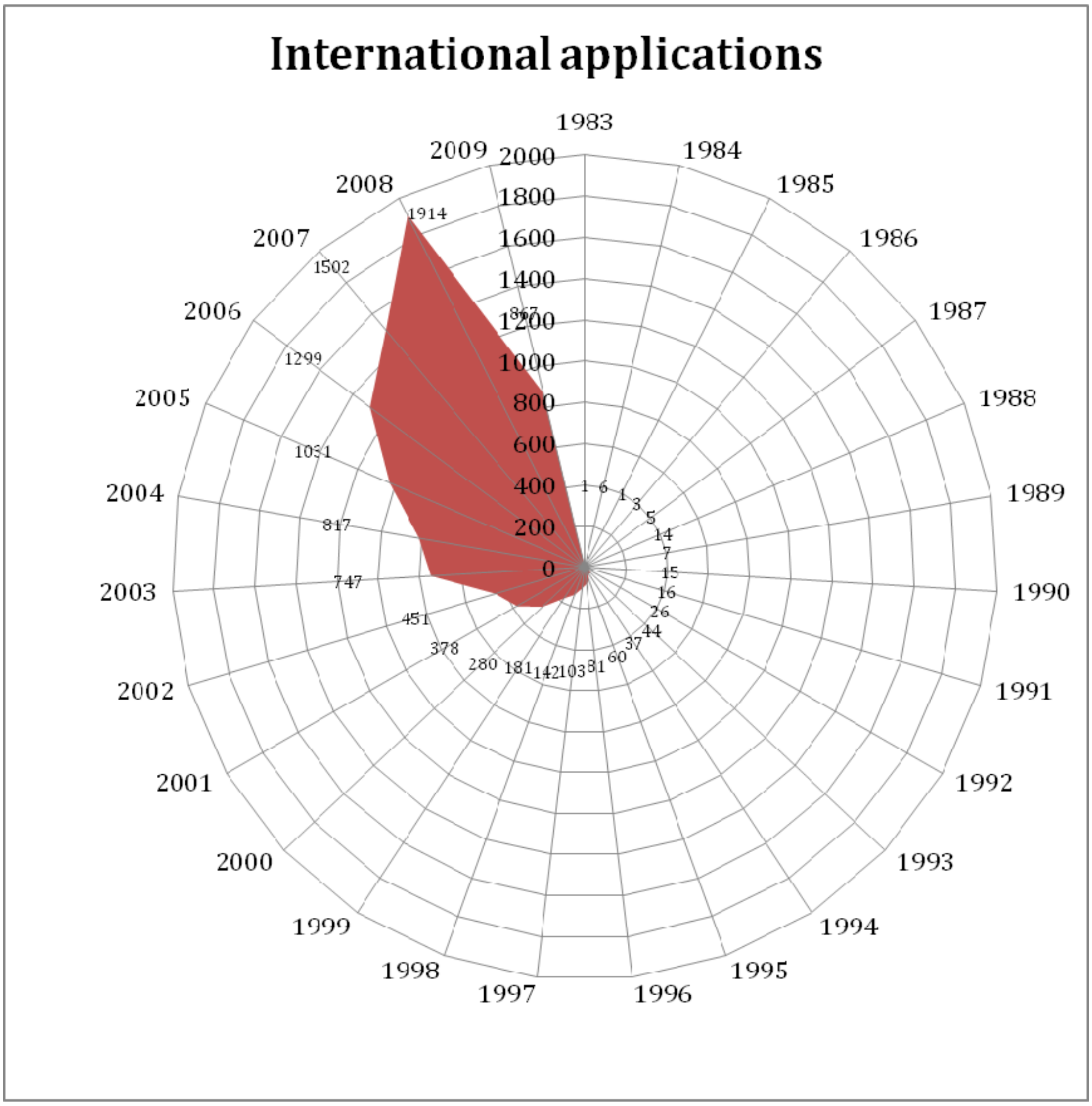

Figure 5: nanotechnology patent filings (the results mirror the number of documents containing the word "nano" in their Abstract, and Claim(s)) - Source: Patentscope® as of June 15th, 2009

The series of pie charts reproduced from now onwards are mirroring the number of international applications – always according to the multipronged test – by country of origin. This search has also provided interesting results.

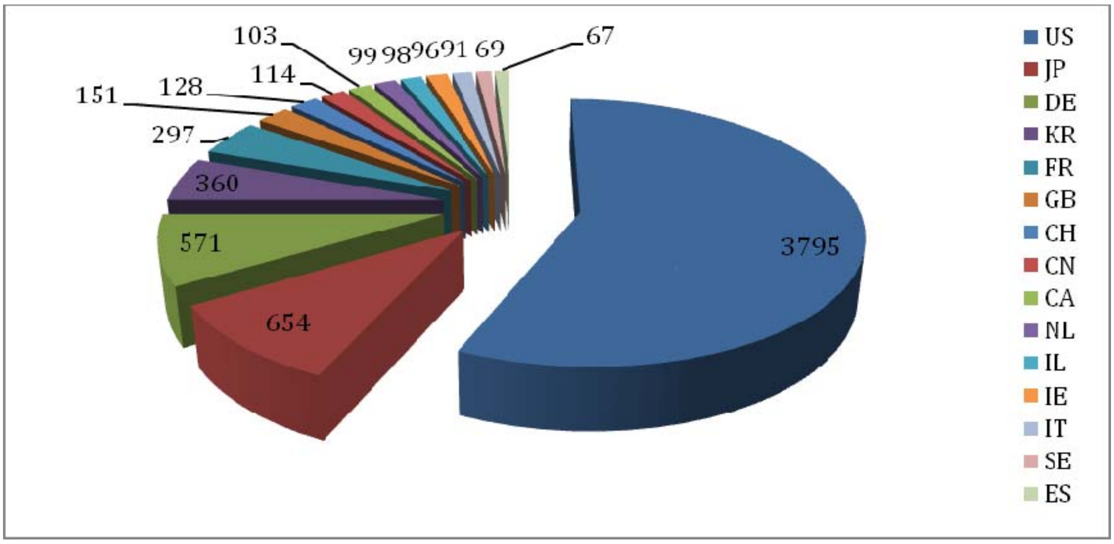

Figure 6: nanotechnology patent filings by country of origin (the results mirror the number of documents containing the word "nano" in their Title) - Source: Patentscope® as of June 15th, 2009

The first pie shows the supremacy of the U.S. in terms of patent filings as far as applications having the word "nano" in their Title are concerned. The numbers are stunning, the ratio with Japan, the second "filer", is sixfold: 3795 applications v. 654.

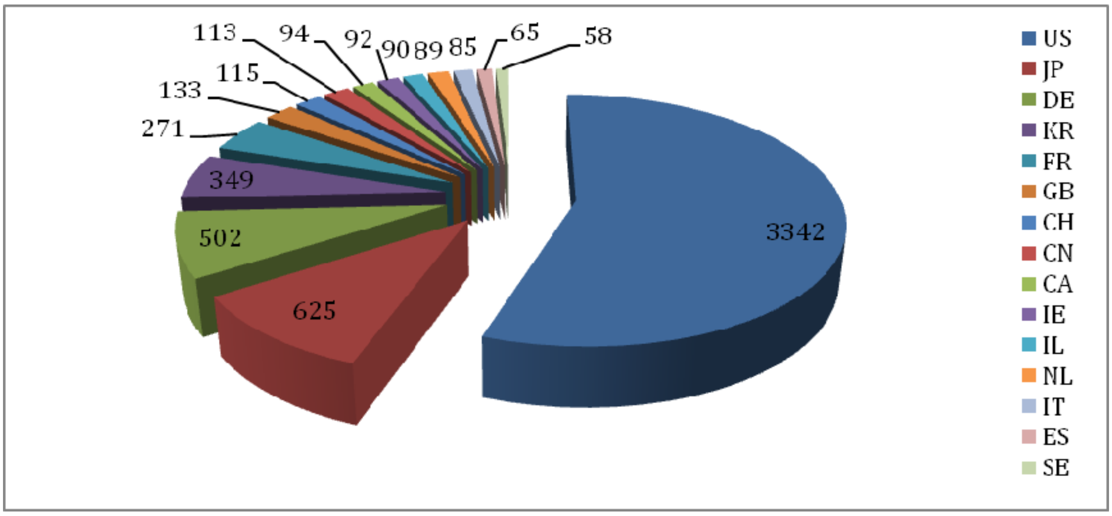

Figure 7: nanotechnology patent filings by country of origin (the results mirror the number of documents containing the word "nano" in their Title, and Abstract) - Source: Patentscope® as of June 15th, 2009

Predictably enough, *Figure* 7 shows more or less the same proportions as adding the filter of the Abstract narrows down the numbers but the countries keep their ranking, The unique exception we can find pertains to Japan that in the next chart (the one showing the applications applying the Title, Abstract, and Claim(s) filter) drifts to number eight. This is pretty interesting as it shows that there is a considerable tendency in labeling inventions as "nano" when they are probably not strictly related to this field.

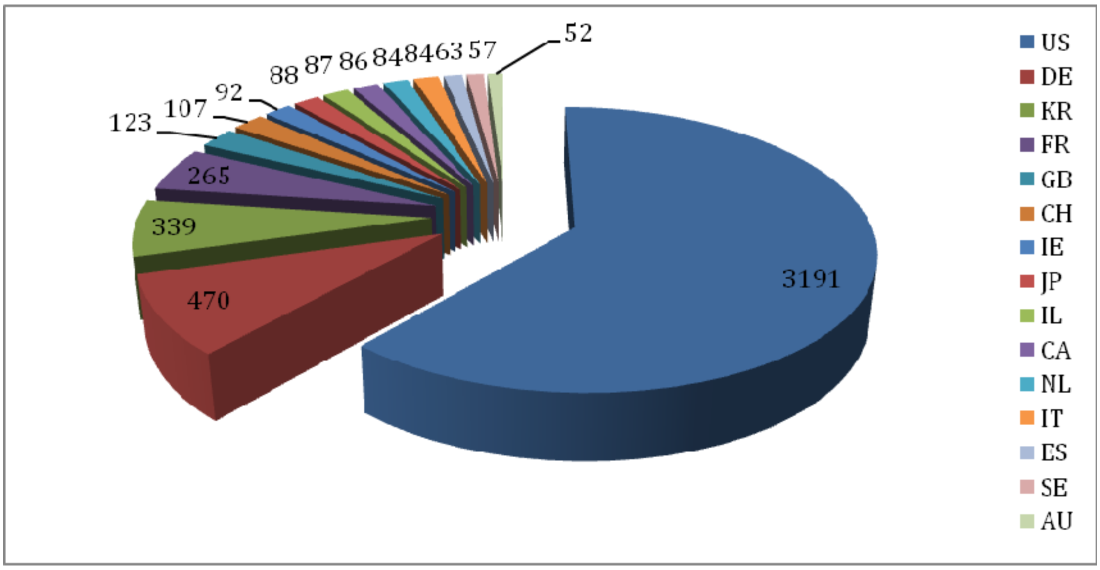

Figure 8: nanotechnology patent filings by country of origin (the results mirror the number of documents containing the word "nano" in their Title, Abstract, and Claim(s)) - Source: Patentscope® as of June 15th, 2009

A confirmation of the previous assumption comes from the last chart in which the Abstract, and Claim(s) filter is used. In fact, U.S., Germany, Korea, and France maintain their position in the ranking while Japan drops to the tenth position. The numbers are stunning for the first four countries, and it shows than in all of them the increase in the number of applications compared to the chart represented in *Figure* 6 is between 20 % and almost 50 % (in the case of U.S., and Germany). What will be interesting to see going further with the results is that within the (probably) increased tendency not to label a claimed invention as pertaining to the nano world, there is a quite unique characteristic, especially in the U.S., which confirms, I guess, my previous assumptions. In fact, the applicants with the highest number of applications containing the word nano in their Title are U.S. universities, which, on the one hand, transfer very actively their inventions, and therefore need to make them more appealing (maybe using "nano" to entice potential partners), while, on the other hand, they do not run any regulatory risk as they are not involved in the regulatory process, which is taken care of by the potential assignee/licensee. These assumptions maybe just conjectures or be true, this is something we still do not know for now.

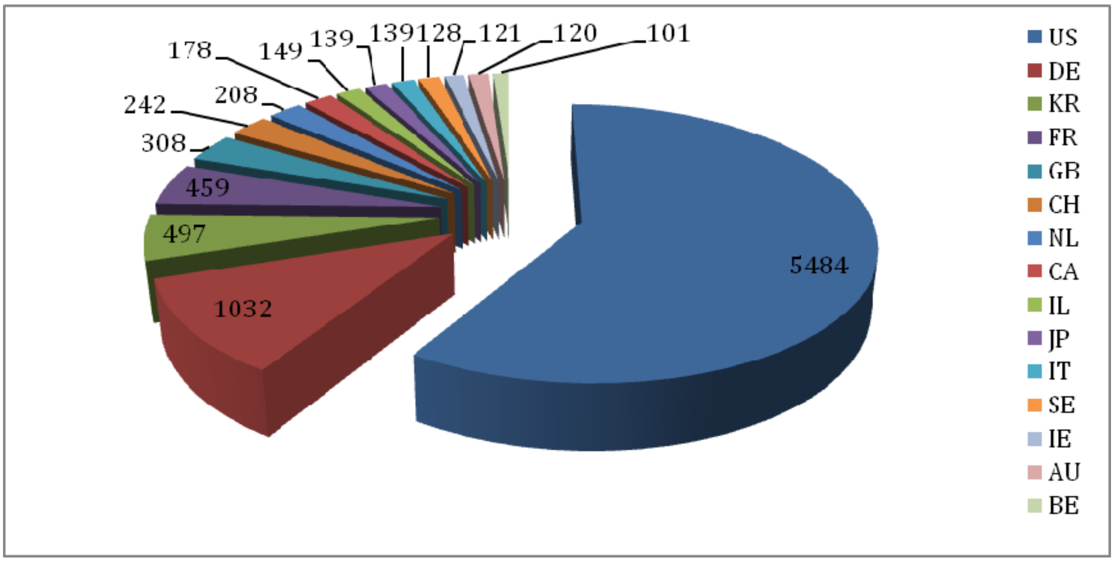

Figure 9: nanotechnology patent filings by country of origin (the results mirror the number of documents containing the word "nano" in their Abstract, and Claim(s)) - Source: Patentscope® as of June 15th, 2009

The above pie charts are pretty indicative of the major role still played by the U.S. in the nanotechnology race. With the parameters used for the search, the datasets almost reflect more or less the general data concerning the countries with the highest numbers of total applications. In fact, the first three top filers are the U.S., Japan and Germany, respectively. So, there is apparently no major difference with general patent rankings[xiv] with the only exception of an exchange of positions between the U.S. and Japan and the better role played by Ireland and Israel, both known for their R&D commitment, and endeavors. The datasets that have been used for plotting the chart of *Figure* 10 here below are different from those on which I performed my search, but they provide a useful overview of the number of applications that have been filed in the period 2001-2005 by country of origin and technical field. Unfortunately, the field of technology used by WIPO is way broader and encompasses also micro-technologies in which, as it is well known, Japan firms play a dominant role.

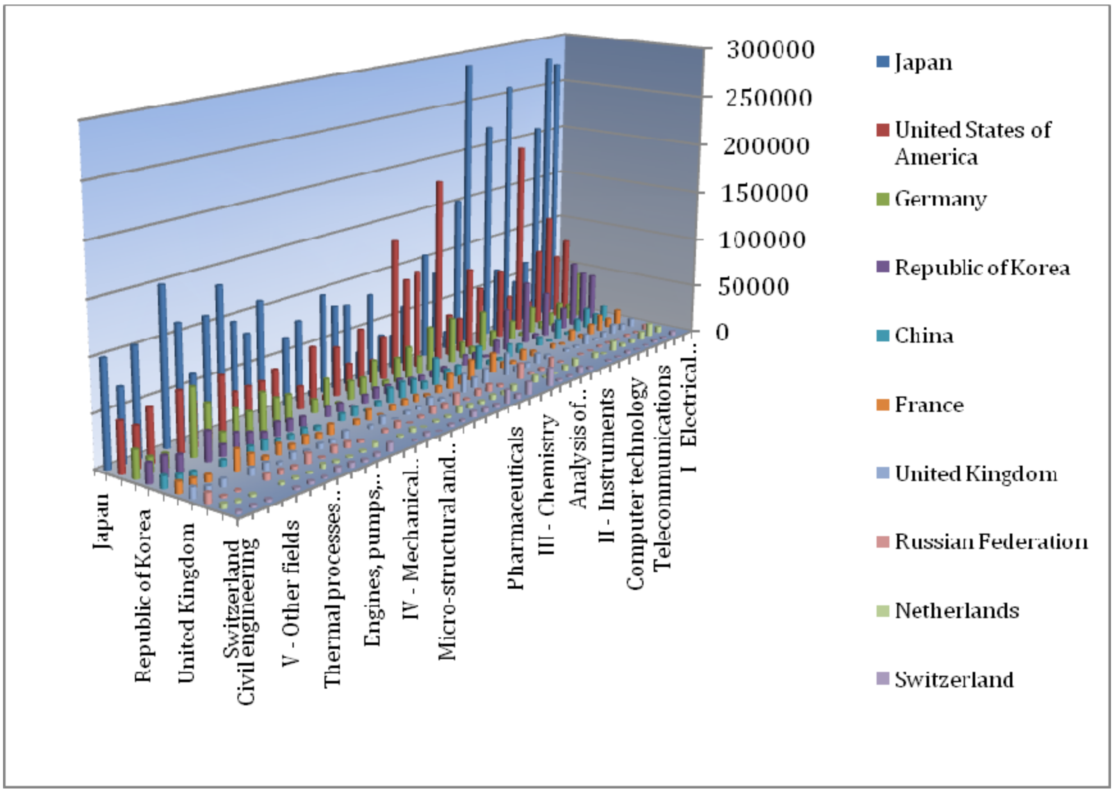

Figure 10: overall patent filings by country of origin and technical field 2001-2005 average[xv] - Source: WIPO Patent Statistics as of June 5th, 2009

Figure 11 shows the supremacy of Japan over the U.S. and China gets the forth position in the ranking doing better than Korea and France.

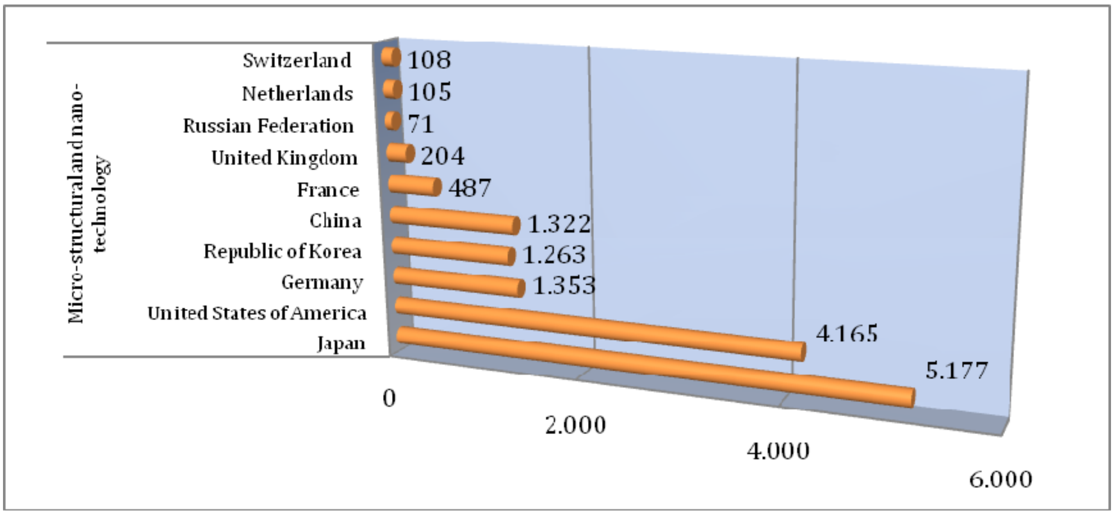

Figure 11: patent filings by country of origin in micro-structural and nanotechnology 2001-2005 average[xvi] - Source: WIPO Patent Statistics as of June 5th, 20009

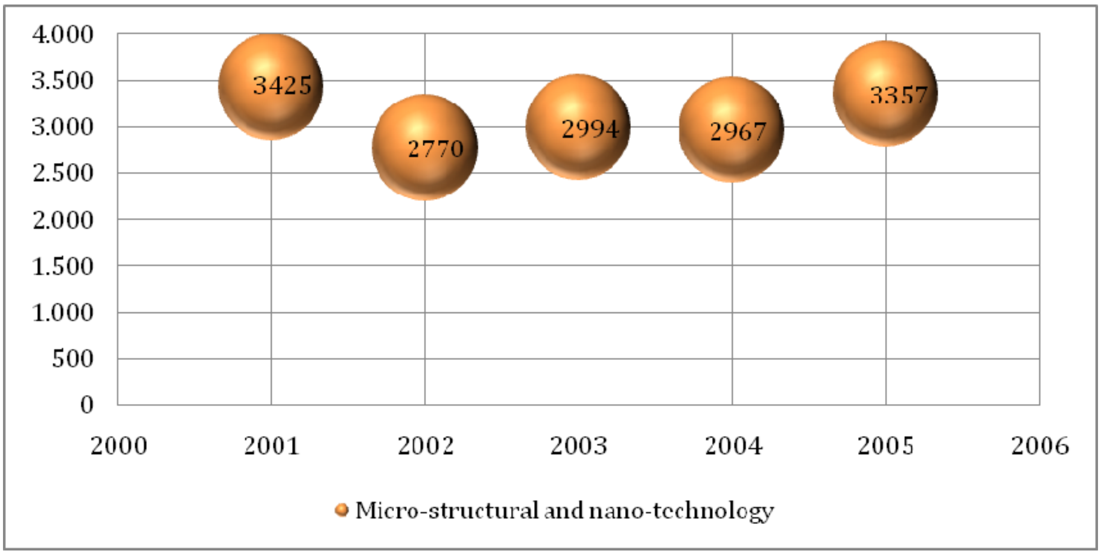

Figure 12: patent filings in micro-structural and nanotechnology 2001-2005 average[xvii] *- Source: WIPO Patent Statistics as of June 5th, 20009*

In the last chart I plotted (*Figure* 12) from WIPO datasets based on the 2001-2005 average, there is a constant number of applications, which is probably due to the complementarities between micro, and nanotechnologies over the years. In fact, I guess, the decrease of “micro” could have been leveled by an increase in nano-related applications.

The other radar chart here below, which reproduces the number of applications per applicant/assignee, sorted by using the Title filter, is also pretty interesting as the top filers are three U.S. universities; the University of California, Rice University, and the MIT. Again, this is not an irrefutable datum as I extrapolated the number of applications, and the relevant applicants just by using the word “nano”, so, it might well be that the actual data and rankings could be slightly different from the plot. Interestingly enough, though, from what we see, we can infer that top U.S. universities are playing a key role in the nanotechnology race[xviii].

As of today, MIT has 45 available technologies since 1999[xix], so, the number I extrapolated for the plot could be quite accurate since the analysis carried out through Patentscope® refers to a much greater period (i.e. from 1983 to date), and the University of California is now offering[xx] "only" 25 available nanotechnology inventions out of 164, so, probably this figure is the symptom of more fertile commercialization of the innovations at stake.

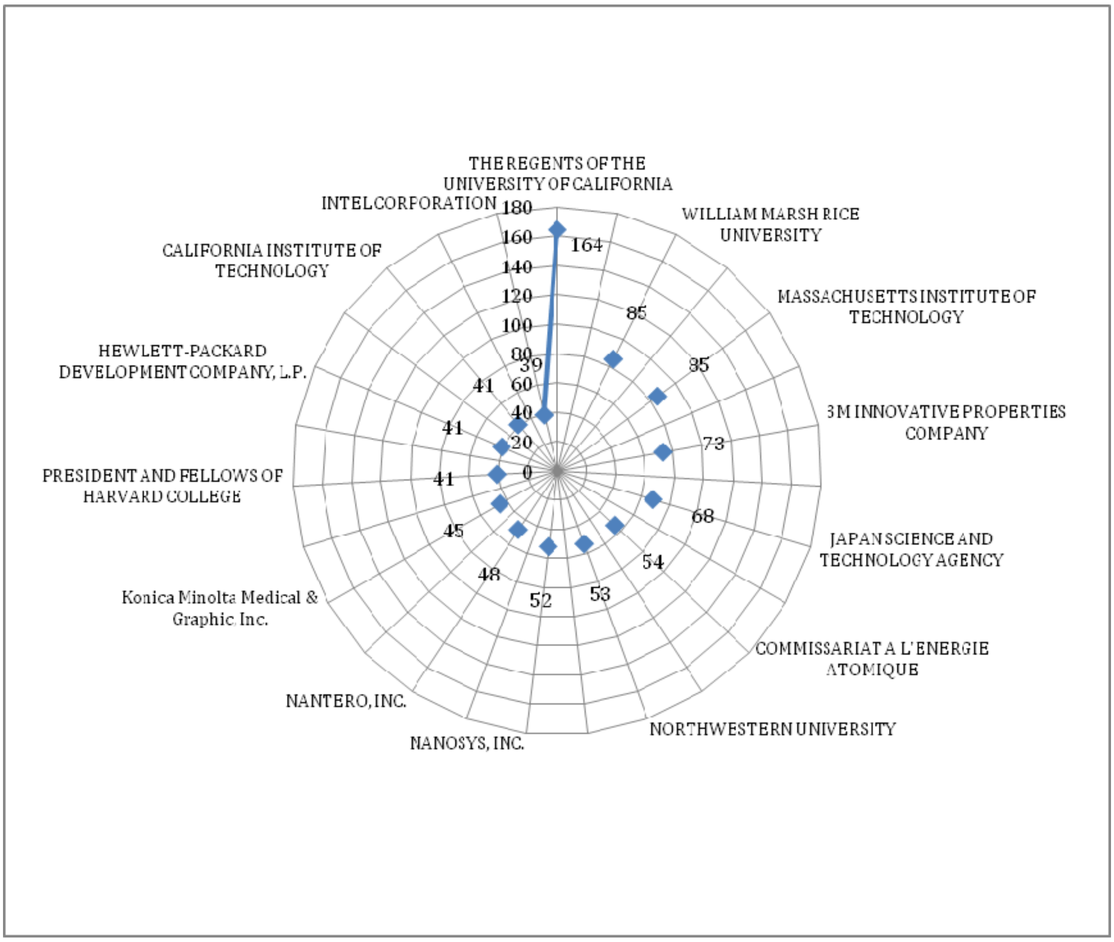

Figure 13: nanotechnology patent filings by country of origin (the results mirror the number of documents containing the word "nano" in their Title) - Source: Patentscope® as of June 15th, 2009

The charts of *Figure* 14, and 15 do not show substantial differences with the numbers contained in the above chart, but they confirm the idea that universities in the U.S. are pretty active with technology transfer activities, and probably patents labeled as "nano" can be more appealing nowadays. It is also true, though, that universities, especially in the U.S., are very active in nanotechnology research, which is very much related to basic research, and the money fuelling this sector is definitely substantial. So, the two factors combined make the MIT, Rice, and the University of California constantly on the podium in the three charts.

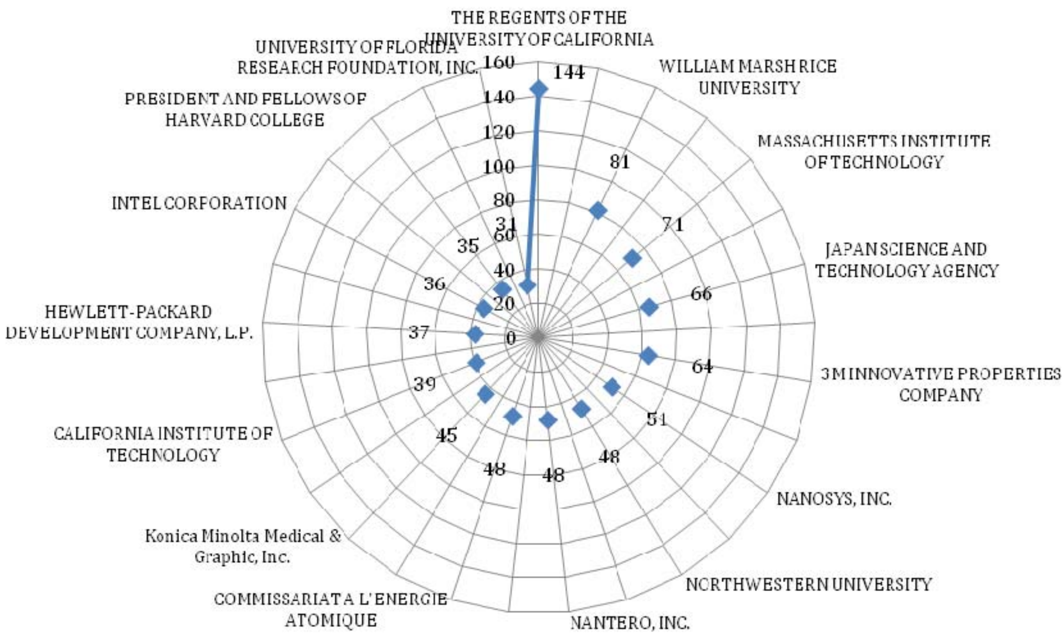

Figure 14: nanotechnology patent filings by country of origin (the results mirror the number of documents containing the word "nano" in their Title, and Abstract) - Source: Patentscope® as of June 15th, 2009

As to the other positions in the charts using the first three filters (i.e. 1) Title, 2) Title-Abstract, 3) Title, Abstract, Claim(s)), there is no substantial difference after the fourth position of the ranking and the same actors usually gain or loose some positions depending on the type of filter that has been used. What is really interesting to observe is the radar chart of *Figure* 15, though. In fact, predictably, in the Abstract-Claim(s) search, many companies not present in the previous searches appeared.

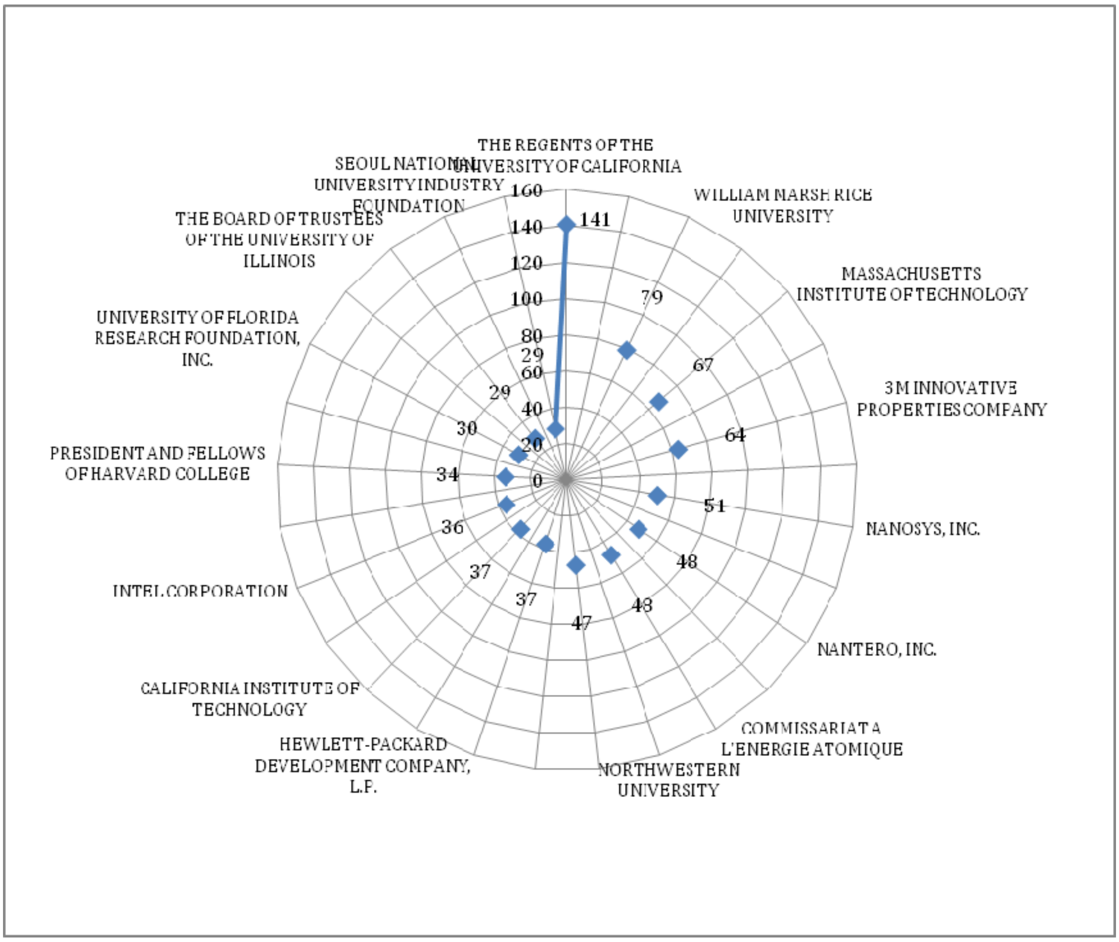

Figure 15: nanotechnology patent filings by country of origin (the results mirror the number of documents containing the word "nano" in their Title, Abstract, and Claim(s)) - Source: Patentscope® as of June 15th, 2009

3M is able to climb the rankings and get the second position and Philips, Procter & Gamble, Du Pont, and GE come out for the first time showing that they probably have no interest in labeling the claimed inventions as "nano", as they are going to use them directly in-house, and are not particularly interested in trading them. Another worthy consideration regards the Japan Science and Technology Agency, in fact, the Japanese research entity disappears in the last charts (*Figure* 15 and 16) moving from 66 patent applications (see *Figure* 14) to less than 29 by applying the Title, Abstract, and Claim(s) filter, and less than 48 by applying the Abstract, and Claim(s) filter. This could be the symptom of an aggressive marketing of products that in actuality do not pertain necessarily to the nano world. In fact, the Agency is pretty active as to the commercialization of its inventions[xxi].

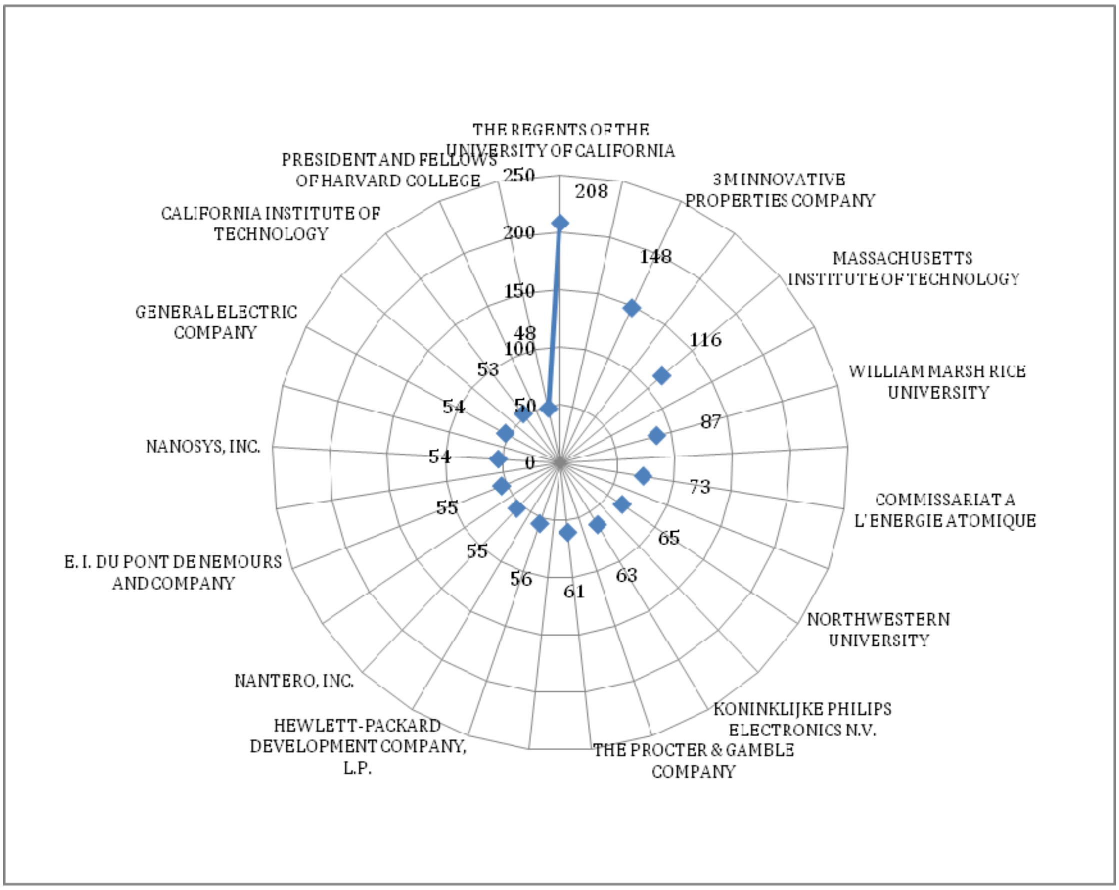

Figure 16: nanotechnology patent filings by country of origin (the results mirror the number of documents containing the word "nano" in their Abstract, and Claim(s)) - Source: Patentscope® as of June 15th, 2009

From the chart here below (showing the results of a search performed with the Title filter), it is interesting to notice how the applications retrieved during the search are spread across several subclasses, and thus confirming the interdisciplinary nature of nanotechnology. Specifically, code A61K, comprising preparations for medical and related purposes[xxii], is the field with the highest number of applications, followed by semiconductor devices[xxiii] and non-metallic elements, and compounds thereof.

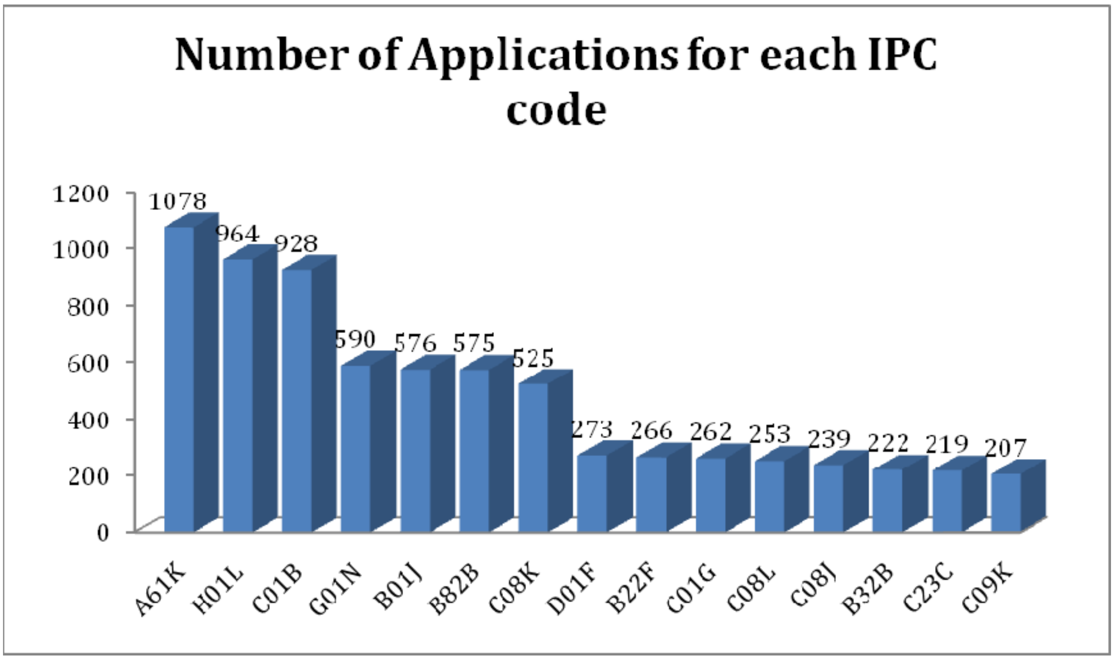

Figure 17: number of applications assigned to each IPC code - Source: Patentscope® as of June 15th, 2009

The Table here below, containing the same data of the bar chart of *Figure* 17, shows in detail the number of applications attached to each IPC subclass, and the kind of technology linked to said subclasses.

International Patent Classification	Number of applications	Technology
A61K	1078	PREPARATIONS FOR MEDICAL, DENTAL, OR TOILET PURPOSES
H01L	964	SEMICONDUCTOR DEVICES; ELECTRIC SOLID STATE DEVICES NOT OTHERWISE PROVIDED FOR
C01B	928	NON-METALLIC ELEMENTS; COMPOUNDS THEREOF
G01N	590	INVESTIGATING OR ANALYSING MATERIALS BY DETERMINING THEIR CHEMICAL OR PHYSICAL PROPERTIES
B01J	576	CHEMICAL OR PHYSICAL PROCESSES, e.g. CATALYSIS, COLLOID CHEMISTRY; THEIR RELEVANT APPARATUS
B82B	575	NANO-STRUCTURES; MANUFACTURE OR TREATMENT THEREOF
C08K	525	USE OF INORGANIC OR NON-MACROMOLECULAR ORGANIC SUBSTANCES AS COMPOUNDING INGREDIENTS
D01F	273	CHEMICAL FEATURES IN THE MANUFACTURE OF ARTIFICIAL FILAMENTS, THREADS, FIBRES, BRISTLES, OR RIBBONS; APPARATUS SPECIALLY ADAPTED FOR THE MANUFACTURE OF CARBON FILAMENTS
B22F	266	WORKING METALLIC POWDER; MANUFACTURE OF ARTICLES FROM METALLIC POWDER; MAKING METALLIC POWDER

C01G	262	COMPOUNDS CONTAINING METALS NOT COVERED BY SUBCLASSES C01D OR C01F
C08L	253	COMPOSITIONS OF MACROMOLECULAR COMPOUNDS
C08J	239	WORKING-UP; GENERAL PROCESSES OF COMPOUNDING; AFTER- TREATMENT NOT COVERED BY SUBCLASSES C08B, C08C, C08F, C08G or C08H
B32B	222	LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM
C23C	219	COATING METALLIC MATERIAL; COATING MATERIAL WITH METALLIC MATERIAL; SURFACE TREATMENT OF METALLIC MATERIAL BY DIFFUSION INTO THE SURFACE, BY CHEMICAL CONVERSION OR SUBSTITUTION; COATING BY VACUUM EVAPORATION, BY SPUTTERING, BY ION IMPLANTATION OR BY CHEMICAL VAPOUR DEPOSITION, IN GENERAL
C09K	207	MATERIALS FOR APPLICATIONS NOT OTHERWISE PROVIDED FOR; APPLICATIONS OF MATERIALS NOT OTHERWISE PROVIDED FOR

Figure 18: number of applications retrieved per each IPC sub-class. Source, Patentscope® as of June 15th 2009

Eventually, the last chart here below shows the number of applications linked to the B82B[xxiv] subclass. The overall number of application is 880, and 575 of them contain the word "nano" in their title. This is pretty much indicative of the confidence that the applicants possessed at the time of the filing about this wording. A closer look at the chart reveals, though, that the same problem affecting overall applications in nanotechnology is also concerning B82B-related applications in recent years. In fact, even if the data refer just to first half of 2009, the figures do not reflect the exponential increase that the number of applications has experienced so far. The reason probably in this case is even more related to the "nano syndrome"[xxv] as probably applicants start fearing to have an invention formally related to nanotechnology, either through the patent classification or the title they choose for the invention when filing the application.

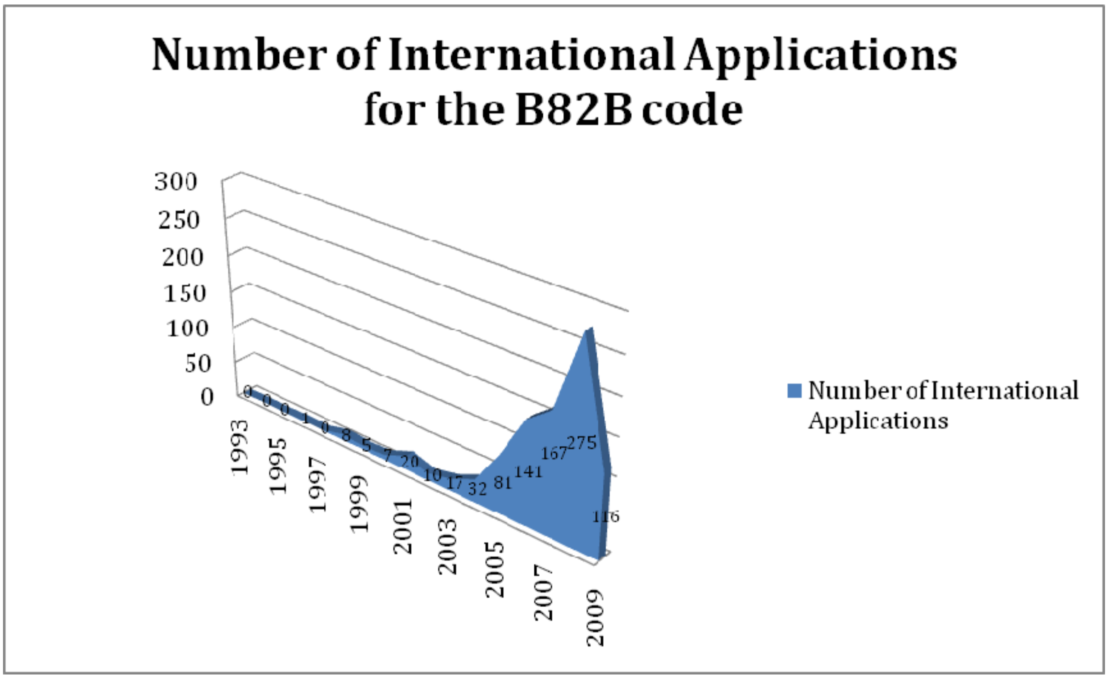

Figure 19: number of applications for the B82B code - Source: Patentscope® as of June 15th, 2009

Interestingly enough, the study I carried out generated similar results to the ones represented in a recent report of the U.K. Intellectual Property Office entitled "UK innovation nanotechnology patent landscape analysis"[xxvi]. In fact, the first three subclasses I found being the more prominent are also those with the highest number of patent applications in the mentioned study, that is, A61K, H01L, and C01B. In the British study there is also a chart showing an evident decline of the applications in the last two years that can be attributable for sure to delays in the publication and processing, but also, as I have already mentioned, to the now widespread understanding that "nano" can be more a hassle than a real advantage for the applicants. Moreover, the British study shows that 67% of the applications is linked to commercial organizations. This figure, though, does not compromise my findings as the top filers in my case are public institutions and universities mainly from the U.S., and Japan, which are number one and two, respectively, in terms of patent activity linked to nanotechnology, while Great Britain is ranked number six (see *Figure* 11). Actually, the British report is pretty useful as it shows that in countries where academic and governmental patenting activities are not that as common as in the U.S. and Japan, the percentages are more likely to be exactly the opposite showing a clear higher trend of patent activity from commercial enterprises. Eventually, another interesting document to compare is an OECD study of 2007[xxvii]. In said document even though the overall number of nanotechnology patents slightly differs from my findings, Japan and the U.S. are by far the top filers, and electronics, medicine, and nanomaterials are, once again, the three major areas of interest for patent applicants as diffusely shown above.

III. NOVELTY V. NON-OBVIOUSNESS

Inventions can be patented worldwide in exchange of the technical information necessary to reproduce the subject matter of a patent. This *quid pro quo* between the inventor and each patent office allows third parties to know the invention in exchange of a temporally limited monopoly granted to the patentee. The disclosure has a twofold significance: first, it is the consideration given towards to the legal monopoly conferred by a patent; second, it is necessary for third parties in order to know the actual state of technology and, indirectly, avoid infringing on the issued patent.

There are requirements that the invention has to possess and others that the patent application has to meet. An invention in the U.S. has to be novel, non-obvious, and useful. In Europe the invention must be novel, realize an inventive step, and be industrially applicable. Let us consider for our purpose those requirements as interchangeable. Talking about the disclosure contained in the patent application then, the invention must be sufficiently disclosed in order to enable a person skilled in the relevant art to perform the invention. Just one invention can be the subject matter of a patent application and its boundaries are determined by the claims. This article is concerned just with the second of the requirements that the invention has to possess, the inventive step (before the EPO) or non-obviousness (before the PTO). I will deal with the two definitions separately as I will first mention the case law of the PTO[xxviii], the Court of Appeals for the Federal Circuit, and the Supreme Court for the U.S., and then the one of the EPO and its Boards of appeal for Europe.

1. Nanotechnology inventions and non-obviousness in the U.S.

In the U.S., an invention to be patentable has to be nonobvious, according to 35 U.S.C. § 103[xxix]. Non-obviousness is usually ascertained according to the "teaching-suggestion-motivation" (TSM) test to check whether there are prior teachings or suggestions that render the claimed invention obvious to try. Said rules (also called the Graham factors) for determining obviousness under 35 U.S.C. 103 are stated in *Graham v. John Deere Co.*[xxx]. The factual inquiries suggested by the Court to determine obviousness are:

- ascertaining the scope and content of the prior art and the level of ordinary skill in the art;
- ascertaining the differences between the claimed invention and the prior art; and
- considering the objective evidence of non-obviousness.

Objective evidence, also referred to as "secondary considerations," may well include features as commercial success, long-felt and unsolved needs, failure of others, and unexpected results. The Graham factors were reaffirmed by the Supreme Court in its determination of obviousness in *KSR International Co. v. Teleflex Inc.*[xxxi] (KSR). As stated by the Supreme Court in KSR[xxxii], the Graham factors continue to apply to the inquiry as to the determination of obviousness but the following errors must be avoided:

- holding that "courts and patent examiners should look only to the problem the patentee was trying to solve"[xxxiii];
- assuming "that a person of ordinary skill attempting to solve a problem will be led only to those elements of prior art designed to solve the same problem"[xxxiv];
- concluding "that a patent claim cannot be proved obvious merely by showing that the combination of elements was "obvious to try"[xxxv]; and
- applying rigid "preventative rules that deny factfinders recourse to common sense"[xxxvi].

The Supreme Court in KSR affirmed that the analysis supporting a rejection for obviousness should be made explicit and quoting *In re* Kahn[xxxvii], held that obviousness cannot be sustained by mere conclusory allegations[xxxviii].

Usually, nanotechnology inventions take advantage of the peculiar characteristic of the nanoscale and differ from already known bulk materials "solely" for their different size. Theoretically, thus, if the "mere" difference consists of a reduced size of the known material, the claimed invention should be obvious to try, but other considerations at this point come into play. In fact, most of the times the nanoscale material is obtained through a series of steps that employs processes that are indeed patentable as they overcome technical hurdles for which no solution in the prior art was known. I came across several decisions concerning nanotechnology-related applications that were the subject matter of appeals before the Board of Appeal and Interferences of the PTO. One of those cases is *Ex parte* Kaminis et al.[xxxix] in which the appellants' invention was directed to:

> *a method for forming at least one nanopore useful for forming a mold for deposition of a material or for aligning molecule(s) in fabricating electronic devices.*

The examiner found several prior references to show unpatentability of the invention, and essentially determined that would have been obvious for one of ordinary skills to try the claimed invention[xl].

Appellants, on the contrary, contended that the mentioned teachings did not suggest a method for the formation of nanopores. Ultimately, the Board, though, affirmed the examiner's rejection as the size of the particles was suggested by the mentioned prior art references as the author of one of them suggested the desirability of smaller particles than microspheres to obtain nanopores. From this decision we can infer, though, that if the prior references would have not suggested the use of smaller particles, the method for forming the nanopores could have been deemed patentable indeed. Moreover, by combining another reference, the examiner determined that would have been obvious of using the etching technique that was disclosed therein. Interestingly enough, the Board, to corroborate its decision, quoted KSR by stating that "a combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results"[xli].

Another interesting case to look at, at the Federal Circuit level, is *In Re* Kumar[xlii], where the controversial claims were 1 and 19[xliii]. The examiner raised two grounds of rejection for being the invention allegedly anticipated, and unpatentable over prior art references. The major issues in the case were calculations made *sua sponte* by the PTO (and not during the prosecution by the examiner), which did not allow the applicant to rebut. The Federal Circuit then, even if indirectly, because the reason for appealing was chiefly procedural, stated that to render a later invention unpatentable for obviousness in a case of overlapping sizes of nanoparticles, the prior art must enable a person of ordinary skill in the field to make and use the later invention not being the overlapping *per se* a bar toward the patentability of the claimed invention[xliv]. Eventually, one of the most recent cases that shed further light on nanotechnology patenting is Procter and Gamble Company (P&G) v. Teva Pharmaceuticals USA, Inc. (Teva)[xlv]. In this case the Federal Circuit, applying KSR's teaching, affirmed that "it remains necessary to identify some reason that would have led a chemist to modify a known compound in a particular manner to establish *prima facie* obviousness of a new claimed compound"[xlvi]. The Court then added that the patentee, if challenged for obviousness, may rebut relying on unexpected results by demonstrating "that the claimed invention exhibits some superior property or advantage that a person of ordinary skill in the relevant art would have found surprising or unexpected"[xlvii]. Very peculiar to nanotechnology and nanomaterials in particular is the other consideration made by the Court whereby to decide whether a claimed invention was obvious in light of the prior art, a court must determine whether, at the time of invention, a person having ordinary skill in the art would have had a "reason to attempt to make the composition" and "a reasonable expectation of success in doing so." [xlviii] The Court then relied on secondary considerations of non-obviousness including the commercial success of the claimed invention, and its satisfaction of long-felt need[xlix], and eventually held that the district court correctly found that secondary considerations supported a finding of non-obviousness.

2. Nanotechnology inventions and the inventive step before the EPO

As to the approach followed by the EPO to determine the presence of an inventive step, according to Article 56[l] of the European Patent Convention (EPC), an invention cannot be patented if it is obvious to a person skilled in the art. At first sight, in the wording of § 103 there is almost no difference with the one of the EPC. In fact, they both predicate the unpatentability of inventions that are obvious to try for a person skilled in the art. According to the EPO practice, an invention involves an inventive step, if having regard to the current state of technology, it solves a technical problem. To assess the inventive step, then, EPO Boards of appeal embrace the problem-and-solution approach[li] whereby the steps to follow are:

- identifying the closest prior art;
- assessing the technical effects of the claimed invention towards the closest prior art;
- defining the technical problem to be resolved by the claimed invention; and
- assessing whether for a person skilled in the art the established closest prior art would have suggested the technical effects of the claimed invention to obtain the technical results of the claimed invention.

This principle is stipulated in order to avoid any *ex post facto* analysis as the problem, and the relevant solution have to be present and understandable from the patent application. There are several cases I came across that are relevant for my inquiry. As to the prior art that can be relevant to assess the inventive step, for example, the Boards have continuously stressed that the closest prior art has to disclose subject matter conceived for the same purpose or at least aiming at the same results of the claimed invention and having the fundamental characteristics in common[lii]. It is also true, though, that the Boards also considered the joint interpretation of different documents as possible as long as the findings of the two or more documents are not contradictory[liii]. Moreover, it has been held that even if the life of a document can be relevant, there was no plausible reason to disregard it[liv]. As to the problem to be solved, then, it has been repeatedly stated than obviousness is at hand when there was a reasonable expectation of success[lv], but this cannot be confused with the understandable hope to succeed of a scientist[lvi] though. The assessment of non-obviouness in nanotechnology, most of the times, will result in an appraisal consisting of combining already existing inventions and data at times, especially for methods conceived to achieve materials at the nanoscale. In this regard the EPO case law clarified that to ascertain the inventive step in the solution of the technical problem in a combination invention the decisive criterion to follow is not to ascertain if the individual elements of the combination where part of the prior art but if a skilled person would have thought possible combine them to solve the technical problem[lvii]. This should clearly allow the patentability of novel and inventive methods to manufacture even known materials at the nanoscale.

Also before the EPO there are secondary indicia in the assessment of the inventive step that can help the examiner during the patent prosecution. It has to be stressed, though, that those auxiliary considerations are seen as merely ancillary by the EPO case law[lviii]. Among those secondary considerations we can enumerate the age of the prior art documents at stake[lix], the satisfaction of long-felt needs[lx], and the conception of surprising effects[lxi].

IV. CARBON NANOTUBES: AN OVERVIEW

CNTs are materials made of carbon that can allegedly even occur spontaneously in nature,[lxii] and even though the early conception of man-made CNTs dates back to many years ago, the real commercial exploitation started in early 1980s with pioneering companies such as Hyperion. Carbon nanotubes are commonly divided in two categories, single-walled carbon nanotubes ("SWCNTs"), and multi-walled carbon nanotubes ("MWCNTs").[lxiii]

Structurally, MWCNTs are multi-layered tubular shapes with interesting features that can be appealing to many sectors of industry. The major qualities of such materials are their electrical and thermal conductivity and the mechanical strength which potentially offer endless applications ranging from sporting goods, to textiles, and aerospace, just to mention a few. The automotive industry is also among the sectors benefiting from MWCNTs; in fact, they are employed for structurally stronger and lighter components. As to the global patent landscape for CNTs, an exhaustive presentation from Young-Jae Lee shows all the sectors of their potential application, and provides a detailed breakdown of patenting activities around the world.[lxiv]

1. First Case Study: Prosecuting a CNT Patent in the U.S. and Europe

Several patent offices have already dealt with the issues surrounding the retrieval and examination of nanotechnology-related inventions. The EPO, for example, decided to adopt a new system by utilizing the “YO1N” tag to embrace nanotechnology-related documents in EPO databases both pertaining to patent and non-patent literature. EPO examiners, for example, use this tag to carry out prior art searches when dealing with nanotechnology-related inventions.[lxv]

The U.S. PTO, in order to tackle the same issue (that is, the retrieval of documents pertaining to nanotechnology, and therefore linked to different branches of science and technology), created a classification system to help those interested in such matter, search and examine nanotechnology patents through the adoption of a new cross-reference digest, designated class 977/dig.1, entitled “Nanotechnology.” This digest functions as a collection of issued U.S. patents and published patent applications.[lxvi]

Notwithstanding these efforts, companies seeking to obtain patent protection on the same invention in different jurisdictions may face very different obstacles. A study of the prosecution history of U.S. Patent No. 6,988,925[lxvii] (“‘925 Patent”), assigned to Eikos Inc. and entitled, “Method for Patterning Carbon Nanotube Coating and Carbon Nanotube Wiring,” reveals how a patentee can face different challenges prosecuting the same patent application in different jurisdictions. The ‘925 Patent claims methods for patterning carbon nanotube films.

1.1 The U.S. PTO

The ‘925 Patent is the result of a patent application filed on May 21, 2003, and the invention claimed priority to two U.S. provisional applications both filed on May 21, 2002. During the prosecution of the patent application, consisting of 41 claims, the U.S. PTO, on June 16, 2004, required the restriction of the two different inventions contained therein under 35 U.S.C. § 121.

According to the U.S. PTO, claims 1-11 were drawn to a carbon nanotube wiring, whereas claims 12-41 were drawn to a method for patterning a carbon nanotube; and the inventions were therefore classified in two different classes. According to the U.S. PTO, the inventions were distinct; and, therefore, a restriction for examination purposes was considered proper even though the requirement could be traversed.[lxviii] On July 29, 2004, Eikos replied that the burden to impose a restriction has not been met by the U.S. PTO. Eikos then asked for a withdrawal of the restriction and examination of all claim groups and provisionally elected claims 12-41 with traverse. On October 18, 2004, the examiner replied in the next office action that the traversal of the applicant was not persuasive because the two group claims showed separate classifications, status in the art, and separate field of search for the inventions. The examiner also made the requirement final by allowing claims 12-41.[lxix] The examiner then, in accordance with the practice under *Ex parte Quayle*, closed the prosecution on the merits and gave the applicant a limited period to amend minor formal matters in the application.

On April 20, 2005, Eikos amended the claims as requested and asked for the issuance of a notice of allowance[lxx] by the U.S. PTO. On August 11, 2005, the PTO mailed the notice of allowance to the applicant. In the meantime, the applicant received the supplementary European search report ("SERP"), dated May 25, 2005, of the corresponding application with a supplementary reference and mailed a supplemental information disclosure statement[lxxi] to the examiner which considered it as properly submitted by the applicant. Eventually, the patent issued on January 24, 2006.

1.2 The EPO

The invention of the '925 Patent was also the subject matter of a PCT patent application that was filed on May 21, 2003 which designated several countries and regional offices as the EPO. On December 4, 2003, the international search was completed; and its publication occurred on March 18, 2004. Afterward, an international preliminary examination report ("IPER")[lxxii] was demanded according to the PCT procedure and was carried out by the U.S. PTO as authorized international preliminary examination authority. The IPER was received by the EPO in late 2004. The IPER stated that the requirements of novelty, inventive step and industrial applicability of the invention were met, with the exception of some claims mainly related to the 1-11 claim group, which lacked novelty and inventive step. In fact, some of the claims (i.e., claims 1, 3, 6-9 and 11) were deemed anticipated by a previous U.S. patent, and others (i.e., claims 2, 4-5, and 10) were deemed lacking inventive step as being obvious in light of other patent literature. As a matter of fact, both patents are cited references in the '925 Patent.

The applicant, after the international search, slightly amended the claims as originally filed by omitting certain dependent claims, which were incorporated in only one dependent claim.[lxxiii] On May 17, 2005, the EPO completed the SERP[lxxiv] and then transmitted it to the applicant. In the SERP, the EPO considered a new document relevant to claim 1; and this new document was a scientific article dating back to 1999. The EPO then asked the applicant to declare whether there was a desire to proceed with the application because, as it noted, the request for examination was filed before the transmission of the supplementary European search report. The other available documents then show that Eikos paid the renewal fees for 2006 and 2007 and in July 2008 the EPO sent a notice drawing attention to Rule 51(2) EPC and Article 2, no. 5 of the Rules relating to fees as the renewal fee was not paid by the due date, and it invited Eikos to pay the renewal fees plus the additional fee for belated payment. In January 2009, the EPO sent another notice announcing the loss of rights pursuant to Rule 112(1) as the application has been deemed withdrawn as per Rule 86(1) EPC,[lxxv] due the lack of payment of the renewal and additional fees. There are some means of redress to keep an application alive; but, as of the date of this writing, the author does not know whether they have been used or not.

This being said, from the available data, it is not possible to infer why the application has been withdrawn; but the case in question clearly exemplifies how cumbersome an international prosecution can be, particularly since the U.S. patent issued in early 2006.

2. Second Case Study: Cross-License Of CNT Intellectual Property

In addition to challenges involved in patent prosecution, companies involved in nanomaterials in general, and carbon nanotubes in particular, are likely to face the prospect of needing to address potential patent infringement issues. Indeed, a number of commentators have predicted that large number of broad and overlapping patents would result in patent disputes and cross-licensing arrangements. At the end of January 2009, the closing of the cross-license negotiations between Hyperion and SDK were formally announced. The excerpt from SDK's website contained the following statement:

> *SDK has concluded a patent cross-license agreement and a supply agreement with Hyperion Catalysis International, Inc., which owns many key patents pertaining to materials and applications in the area of carbon nanotubes, including for resin composites.. . .The companies have agreed*

to work together in certain defined areas. The arrangement will help SDK and Hyperion—the world leaders in carbon nanotube commercial production technology and quality design—to maintain and grow their leading positions in the promising composite market. The two companies are also pursuing possible joint R&D programs.[lxxvi]

A similar statement was officially made by Hyperion:

Hyperion Catalysis International, Inc. (Hyperion) has concluded a patent license agreement and a supply agreement with Showa Denko K.K. (SDK) of Japan. In exchange for certain payments, royalties and other consideration, the patent license agreement provides that SDK will be able to sell carbon nanotube-based products for use within a defined field in plastics under Hyperion's extensive patent portfolio. The supply agreement provides that SDK will purchase Hyperion's FIBRIL™ carbon nanotube-based products for resale along with its own line of carbon nanotube-based products. These license and supply agreements will help SDK and Hyperion, the world leaders in carbon nanotube commercial production technology and quality design, to continue and grow their leading positions in the production, distribution and marketing of carbon nanotube-based products. The two companies have also identified other areas of mutual interest and have initiated discussions regarding possible joint R&D projects.[lxxvii]

Overall, the two statements reflect more or less the same content, that is, that SDK licensed (or both companies partly cross-licensed) some patented (or patent pending) technologies related to CNTs, and that Hyperion will also act as supplier of the famous "FIBRIL" CNTs. It is also clear that some R&D collaboration might be pursued by the parties.

Hyperion is a company that was founded in 1982 to develop novel forms and morphologies of carbon. Hyperion's top technology consists of MWCNTs trademarked as "FIBRIL." Since the very origins of CNTs' development, and commercialization, in the early 1980s, Hyperion has devoted substantial resources to improving their technologies. Hyperion now provides its customers with FIBRIL nanotubes in different plastics, and those composites are mainly employed for automotive and electronics applications, but further are in development. The composites will likely pave the way to other markets as well. Hyperion has been manufacturing and selling its FIBRIL carbon nanotubes for a wide range of applications since 1983. FIBRIL nanotubes are deployed to impart electrical conductivity and other benefits that are related to their unique structure. Other emerging applications for MWCNTs seem to be in the sectors of displays, batteries and fuel cells.

SDK is a large Japanese company that began developing VGCF in 1982 with Professor Endo, who is among the pioneers of CNTs. The company then started a 20-ton-per-year commercial plant in 1996, and expanded its capacity to 100 tons per year in 2007 to cope with the high demand for VGCF for use in lithium ion batteries to enhance their durability. Notably, the company started the construction of a 400-ton-a-year VGCF-X[lxxviii] plant in March 2009. From a technical standpoint, VGCF-X has enhanced electrical conductivity and dispersibility. A very small amount can give stable conductivity to resins, and it is expected that VGCF-X could find application in plastic cases for semiconductor/hard disk media parts. In fact, with recent developments in those fields, said cases may be required especially to prevent contamination. The table here below shows SDK's carbon nanotubes lineup with its newcomer, VGCF-X, and it lists their major features.

Table 1: SDK Carbon Nanotube Products

	VGCF-X	VGCF	VGCF-S
Diameter (nm)	15-20	150	80
Length (µm)	3	10	10
Applications	Resin composites	Additive in lithium ion batteries	Rubber/resin composites

Characteristics	Stable conductivity with addition of a small amount	Enhanced durability of batteries	Increased durability of composites and high electrical conductivity

Figure 20 Table showing the different properties - Source: SDK's Carbon Nanotube Lineup[lxxix]

Since the precise terms of the licence agreement at stake were not disclosed by the parties, one can only imagine what could be the maximum extent of such agreement. Based on a search of patents filed with the U.S. PTO, 53 patent applications assigned to Hyperion were filed between 2002 and 2008. Out of those, 20 of the patent applications contain the terms "carbon nanotubes" in their title. As to the issued patents, then, the number of patents assigned to Hyperion is 79, and 5 contain the terms "carbon nanotubes" in their title. The patents issued range in dates between 1987, and 2009. The overall number of patents recorded containing the terms "carbon nanotubes" as of April 5, 2009 equals 326.

From a purely statistical comparison and without examining in detail the content and claims of the patents, it is clear that the patent landscape of carbon nanotubes is predominantly in the hands of a fairly small number of companies; and Hyperion definitely plays a substantial role in that small number of companies. SDK, on the other hand, is the assignee of one patent concerning a "method for producing carbon nanotubes", which issued in 2002. It should be noted, though, that SDK is the assignee before the U.S. PTO of 722 patents ranging in its fields of interest. Such data, however, also does not include the number of potential patents assigned to the subsidiaries of SDK. At any rate, this first figure gives a clear idea of the immense patent portfolio of SDK, and also suggests that probably the (cross-) license agreement between SDK and Hyperion may include the vast Hyperion patent portfolio and some key patents among those owned by SDK. Finally, the search conducted may be somewhat under-inclusive; CNTs are sometimes referred to simply as "carbon fibers" in the patent literature.

The agreement between Hyperion and SDK, then, seems to be a complementary tool that could allow a pioneer of advanced materials like Hyperion, and an undisputed leader in the chemical sector like SDK, to exploit the potential of CNTs and could pave the way for potential R&D collaborative projects. In fact, since CNTs have seemingly endless applications in the long-term, Hyperion may have decided to license out its patent portfolio (or part of it) to a company like SDK that operates in many promising fields for CNTs, such as hard drives and electronics.

V. CONCLUSIONS

Some conclusions as to the peculiar role played by inventions at the nanoscale are mandatory. First, from the data shown above, it is clear that we are observing a paradigm shift in terms of where the patenting activity mainly takes place. In fact, the role played by public institutions and universities is absolutely not comparable to other fields of technology where downstream inventions (the absolute majority) are conceived by entrepreneurial entities, as the latter are the ones spending more resources in R&D and because they are also more involved in applied and not basic research as opposed to universities and public research organizations.

Second, it appears from the most relevant decisions at the administrative and judicial level in the US and Europe that nanotechnology inventions might well overcome obviousness objections, as it happens already for other inventions, as long as the applicant is able to show that the achieved results go beyond the known prior art and tackle technical problems that were not solved yet. Therefore, in the vast majority of cases, especially for inventions employing the bottom-up approach[lxxx], the applicant will be able to rebut a *prima facie* case of obviousness, in particular when overlapping sizes of the particles are at stake, by demonstrating that a technical and not obvious problem has been overcome to achieve the claimed results.

From the first case study examined above, it is easily inferable that, for the time being, it is still fairly difficult for a company to seek the international protection of its innovative ideas in the short term. It is not clear if this difficulty is causally related to the different procedures applied by the patent offices involved in the prosecution, but it is something that has to be taken into due account when trying to develop a vast IP portfolio in various geographical regions. Building an international IP portfolio and the international prosecution of patent applications can take a considerably long time. Given the difficulties, the applicant should think of different strategies for the countries or regions in which the applications are still under examination, even for meeting marketing purposes. Prosecuting patents in multiple jurisdictions presents some issues that are not necessarily unique to the field of nanotechnology, even though some argue that the prosecution of nanotechnology-related patent applications can last quite longer than inventions in other fields due to nanotechnology's interdisciplinary nature and higher complexity.

Ultimately, in the international context, the most relevant consideration to any company involved with international patent prosecution should be whether other forms of protection for inventions, such as trade secrets—where feasible and appropriate—are more effective than international patent prosecution. This might be surely the case when dealing with inventions doomed to obsolescence. However, it is possible that opting for trade secrets protection could provide a more viable means in the nanotechnology sector than in others due to the difficulties that some competitors might encounter in attempting to copy nanotechnologies without having the necessary skills at their disposal.

As to the second case study, the agreement between Hyperion and SDK, other lessons emerge. Commenting on an event that is not fully known by the public is not an easy task. In the case of the agreement between SDK and Hyperion, the strategic value of the agreement is more readily ascertainable, especially for the objective exploitation of the products and processes conceived by Hyperion in more than 20 years since its inception. What is also clear from the agreement (to the extent of my understanding of it) is that a small company, if committed on having a solid patent portfolio and management, can succeed in enticing bigger entities willing to work together and exploit novel and useful innovations from products and processes incorporating CNTs. Moreover, Hyperion will not only gain royalties and other consideration from the agreement,[lxxxi] but it will also have the chance to collaborate with SDK on R&D projects that might ultimately be beneficial for both parties.

Finally, new engineered nanomaterials such as carbon nanotubes can be subject in the near future to strict regulatory provisions that can hinder their commercialization. Therefore, when a patent license agreement is entered into by companies, it is likely that they consider many regulatory issues in addition to the IP issues that are inherent to any such arrangement, especially when the license covers multiple jurisdictions that can have different regulations in force.

ENDNOTES

[i] In carrying out this research, judicial determinations have been taken into account too.

[ii] In fact, as mentioned in several studies, nanotechnology inventions are primarily conceived, at least up to now, by institutions carrying out basic research that is giving birth to upstream innovations.

[iii] There are 13,592 inventoried and on sale books on Amazon.com concerning Nanotechnology as of June 30, 2009. At any rate, two must-have books to understand what the future of nanotechnology is likely to be are:

- Ray Kurzweil, *The Singularity is Near: When Humans Transcend Biology*, Penguin Books, 2006;
- Eric K. Drexler, *Engines of Creation The Coming Era of Nanotechnology*, Anchor Books, New York, 1986.

[iv] The full definition is available from the NNI website at http://www.nano.gov/html/facts/whatIsNano.html (last visited June 30, 2009).

[v] The EPO, for example, adopted a new system by utilizing the "YO1N" tag to embrace nanotechnology-related documents in EPO databases both pertaining to patent and non-patent literature. EPO examiners, for example, use this tag to carry out prior art searches when dealing with nanotechnology-related inventions. Similarly, the PTO created a classification system to help those interested in searching and examining nanotechnology patents through the adoption of a new cross-reference digest, designated class 977/dig.1, entitled "Nanotechnology".

[vi] For a current and updated overview of the "nano" products already on the market, visit the Inventory of the Project on Emerging Nanotechnologies at http://www.nanotechproject.org/inventories/consumer/ (last visited June 30, 2009). Moreover, for a very recent update of other several nanotechnology applications and opportunities, see the presentations (both made at the "NC nanotechnology commercialization conference" on 25 march 2009) of Matthew M. Nordan, *The nanotechnology opportunity: comparing nanotech with life sciences and IT*, available at http://www.ncscitech.com/ncncc/Slides/Nordan.pdf and Russel J. Mumper and Michael Jay, *Nano-bio tutorial*, available at http://www.ncscitech.com/ncncc/Slides/Mumper-Jay.pdf (both last visited 30 June 2009).

[vii] To check Nanosys's major nanotechnology applications, see http://www.nanosysinc.com/app/index.html (last visited 30 June 2009).

[viii] The original press release is retrievable from http://www.qdsoleil.com/PR-3.php (last visited 30 June 2009).

[ix] Another interesting example of nanotechnology application is the one proposed by Solar Gard is the Ultra Performance window film, which is made using nano-particle coating, in which millions of nanoscopic particles work together to intercept infrared radiation from the sun. As a result, Solar Grad claims that 99 per cent of all damaging UVA and UVB light is blocked, and up to half of all solar energy is rejected, keeping the car cooler. For more info and applications of thin films, see http://solargard.com (last visited 30 June 2009).

[x]The approach I followed to plot the following charts is the following. I truncated the word "nanotechnology", and used the keyword "nano" in the search engine of Patentscope®, which is WIPO's search engine containing data concerning international applications from 1978 to date. The findings of my research are series of datasets that reflect all the international applications bearing the word "nano" in their title both as autonomous item and as part of a longer word.

[xi] At any rate, the major remarks when considering the following graphs and charts, are the following:

- "Publication year" is the year of the PCT international publication;
- "Country of origin" is the country of residence of the first named applicant or assignee of the PCT international application. Where residence applicant's is not give, the address or country of filing are used instead;

- "Applicant/Assignee" is the first named applicant of the PCT international application. Note that alternative spelling of names is not fully corrected, so the same applicant may appear more than once with different variations of spelling;
- The IPC subclass is the first four characters of the IPC classification of each PCT international application. As an international application often has multiple IPC symbols, the same application may be counted under several IPC subclasses.

[xii] There are several studies dealing with the opportunities and risks of nanotechnology. An interesting and recent one is the report published by the Investor Environmental Health Network on *Eight Accounting Loopholes--Lessons from Nanomaterials and Asbestos.* A synopsis of the eight loopholes identified by this study, are the following :

"SHORTSIGHTEDNESS. Taking the short view and thereby effectively avoiding disclosure or estimation of potential longer term liabilities.

CONCEALED SCIENCE. Concealing emerging science that forewarns of potential liabilities in the future.

THE KNOWN MINIMUM. Disclosing only the "known minimum" of potential liabilities, even though a more realistic assessment might be so much larger that it would indicate the potential for a total wipe out of shareholder value.

PRIVILEGING SECRECY. "Privileging" concealment, by using attorney-client privileges as a shield against generating a public estimate of liability for investors.

INCONSISTENT ESTIMATES. Providing inconsistent liability estimates to insurers and investors, with larger estimates of liabilities typically provided to insurers than to investors.

HIDDEN ASSUMPTIONS. Using hidden assumptions to minimize estimates of liability.

MISSING BENCHMARKS. Refusing to benchmark liabilities against other companies whose published litigation results may demonstrate realistic estimates of liability.

RISK-FREE PROXIES. Refusing to allow shareholders to place on the annual proxy ballot questions requesting disclosure of specific risks of concern to investors." For further details see the IEHN webpage at http://www.iehn.org/publications.reports.eightloopholes.php (last visited, June 30, 2009). Copy of the Report can be downloaded at http://www.iehn.org/documents/EightLoopholes.pdf (last visited, June 30, 2009).

[xiii] I was personally involved during the MIT Enterprise Forum of the Northwest for the *Global Broadcast Series: Extreme Science and its Entrepreneurial Opportunities* (occurred on 8 June 2009 in Seattle) in a conversation with three entrepreneurs with discordant views on how the term "nano" is and should be perceived by the public. Overall, I think that nowadays there are three approaches in this regard:

- there are companies which prefer not to disclose the employment of nanomaterials to avoid competitors be attracted;
- there are companies that bet on the advent and success of nanotechnology and speak about "nano" even when they actually deal with "micro";
- eventually, there are companies that are now scared of using the term "nano" as there are some fears that nanotechnology can be the next asbestos and therefore they consider not that appropriate to sit on a potential bomb.

On this last topic, *see* the recent article of Caroline Scott-Thomas, available at http://www.foodnavigator-usa.com/Financial-Industry/Nanotechnology-The-new-asbestos, and the report mentioned *supra* note 11.

[xiv] Cfr. *infra* Figure 10.

[xv] Please note that the International Patent Classification (IPC) symbols assigned to the patent document are linked to the fields of technology by a concordance, and since a patent application may be assigned multiple IPC symbols, the sum of patent filings by fields of technology is higher than the actual total number of patent filings.

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[xviii] See on this the article authored by Behfar Bastani et al., *Technology Transfer in Nanotechnology: Licensing Intellectual Property From Universities to Industry*, 1 Nanotech. L. & Bus. 166 (2004). In this article an overview of university tech transfer is presented together with considerations as to the groundbreaking inventions in nanotechnology generated by universities.

[xix] This reference has been obtained by using the search engine of the MIT for available technologies by using the word "nano" in their titles.

[xx] This reference has been obtained by using the search engine of the MIT for available technologies by using the word "nano" in their titles. There are 40 technologies containing the term "nano", and 110 according to the advanced search by selecting the topic "nanotechnology".

[xxi] See the website of J-Store, one of the databases managed by the JST, available at http://jstore.jst.go.jp/EN/ (last visited, June 30, 2009).

[xxii] Please note that, according to the IPC, "this subclass covers the following subject matter, whether set forth as a composition (mixture), process of preparing the composition or process of treating using the composition:

(a) Drug or other biological compositions which are capable of:

- preventing, alleviating, treating or curing abnormal or pathological conditions of the living body by such means as destroying a parasitic organism, or limiting the effect of the disease or abnormality by chemically altering the physiology of the host or parasite (biocides A01N 25/00 to A01N 65/00);
- maintaining, increasing, decreasing, limiting, or destroying a physiological body function, e.g. vitamin compositions, sex sterilants, fertility inhibitors, growth promotors, or the like (sex sterilants for invertebrates, e.g. insects, A01N; plant growth regulators A01N 25/00 to A01N 65/00);
- diagnosing a physiological condition or state by an in vivo test, e.g. X-ray contrast or skin patch test compositions (measuring or testing processes involving enzymes or micro-organisms C12Q; in vitro testing of biological material, e.g. blood, urine, G01N, e.g. G01N 33/48);

(b) Body treating compositions generally intended for deodorising, protecting, adorning or grooming a body, e.g. cosmetics, dentifrices, tooth filling materials.

Attention is drawn to the definitions of groups of chemical elements following the title of section C.

In this subclass, in the absence of an indication to the contrary, classification is made in the last appropriate place. Therapeutic activity of medicinal preparations is further classified in subclass A61P."

[xxiii] H01L refers in particular to: "conveying systems for semiconductor wafers B65G 49/07; use of semiconductor devices for measuring G01; details of scanning-probe apparatus, in general G12B 21/00; resistors in general H01C; magnets, inductors, transformers H01F; capacitors in general H01G; electrolytic devices H01G 9/00; batteries, accumulators H01M; waveguides, resonators, or lines of the waveguide type H01P; line connectors, current collectors H01R; stimulated-emission devices H01S; electromechanical resonators H03H; loudspeakers, microphones, gramophone pick-ups or like acoustic electromechanical transducers H04R; electric light sources in general H05B; printed circuits, hybrid circuits, casings or constructional details of electrical apparatus, manufacture of assemblages of electrical components H05K; use of semiconductor devices in circuits having a particular application, see the subclass for the application."

[xxiv] This subclass covers:

"A. Infinitesimally minute arrangements of matter having particularly shaped configurations (i.e., nano-structural assemblages), that are distinctive from both naturally occurring and chemically produced chemical or biological arrangements composed of similar matter, and include at least one essential integral element that

(1) consist solely of an atom, a molecule, or an atomically precise limited collection of either atoms or molecules (i.e., the collection in its entirety would be undetectable by any optical microscope) and
(2) is formed by having its atoms, molecules, or limited collections individually manipulated as discrete units during the manufacture of its arrangement.

B. An essential integral element per se of nano-structural assemblages when they have specialized structural features limiting them to use with these assemblages.

C. The manufacture or treatment of the above nano-structural assemblages when the manufacturing or treating creates a structural feature thereof and utilizes either

(1) processes having one or more steps with specialized features directly related to the infinitesimal minuteness of their final products or

(2) apparatus specially adapted for performing at least one step in such processes."
For other further information, see the WIPO webpage dedicated to the B82B subclass at http://wipo.int/ief-projects/d008/d008-a06_uspr.doc (last visited June 30 2009).

[xxv] See what has been extensively said on this *supra* notes 12, and 13.

[xxvi] See the report at http://mnt.globalwatchonline.com/epicentric_portal/binary/com.epicentric.contentmanagement.servlet.ContentDeliveryServlet/MNT/Knowledge%2520Centre/IPONanotechnologPatents2009.pdf (last visited June 30, 2009). For this project the EPO database, EPODOC, was interrogated. All data reported therein relates specifically to nanotechnology related patent activity in the UK, unless otherwise stated.

[xxvii] See the report entitled *Capturing nanotechnology current state of development via analysis of patents*, available at http://oecd.org/dataoecd/6/9/38780655.pdf (last visited June 30, 2009). This analysis aimed at evaluating current inventive activities in nanotechnologies based on the analysis of patent applications filed with the EPO. The main findings of the study were the following: nanotechnology is a multifaceted technology; the majority of nanotechnologies, are seemingly conceived by a top-down process; another group of nanotechnologies, that will probably blossom later on, is developed by a bottom-up process.

[xxviii] For a general overview of nanotechnology patenting, see Vivek Koppikar et al., *Current Trends in Nanotech Patents: A View From Inside the Patent Office*, 1 NANOTECH. L. & BUS. 24 (2004).

[xxix] 35 U.S.C. § 103(a) reads as follows: "A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, 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. Patentability shall not be negatived by the manner in which the invention was made".

[xxx] See 383 U.S. 1, 148 USPQ 459 (1966).

[xxxi] See 550 U.S., 398, 82 USPQ2d, 1391 (2007).

[xxxii] The Supreme Court has utilized the Graham factors in each of its obviousness decisions since Graham. See *Sakraida v. Ag Pro, Inc*., 425 U.S. 273, 189 USPQ 449, rehearing denied, 426 U.S. 955 (1976); *Dann v. Johnston*, 425 U.S. 219, 189 USPQ 257 (1976); and *Anderson's-Black Rock, Inc. v. Pavement Salvage Co*., 396 U.S. 57, 163 USPQ 673 (1969).

[xxxiii] See *supra* note 31.

[xxxiv] *Id*.

[xxxv] *Id.*

[xxxvi] *Id.*

[xxxvii] See 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006).

[xxxviii] Exemplary rationales that may support a conclusion of obviousness may comprise the following:

- "combining prior art elements according to known methods to yield a predictable result;
- simple substitution of one known element for another to obtain a predictable result;
- choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention."

These, and additional rationales to support obviousness of a claimed invention are described, and extensively commented in the Examination Guidelines of the Manual of Patent Examining Procedure and available at http://www.uspto.gov/web/offices/pac/mpep/documents/2100_2141.htm#sect2141 (last visited June 30, 2009).

[xxxix] For further details, see *Ex parte* Kaminis et al. (08/03/2007).

[xl] The examiner determined that "to employ such nanoparticles as the etch mask in Kikuchi and to use reactive ion etching during the etching of Kikuchi for forming a pillar underneath each particle etch mask as taught by Deckman to be known techniques for masking using particle masks and for etching using reactive ions to obtain the expected results associated therewith."

[xli] See *supra* note 39 at 7.

[xlii] For further details, see In re Kumar, 418 F.3d 1361, 1365 (Fed. Cir. 2005), apparently, the first reported case concerning nanotechnology inventions tried before the Court of Appeals of the Federal Circuit.

[xliii] The claims in question read as follows:

"1. A collection of particles comprising aluminum oxide, the collection of particles having an average diameter of primary particles from about 5 nm to about 500 nm and less than about one in 106 particles have a diameter greater than about three times the average diameter of the collection of particles.

19. A collection of particles comprising aluminum oxide, the collection of particles having an average diameter from about 5 nm to about 500 nm and a distribution of particle sizes such that at least about 95 percent of the particles have a diameter greater than about 40 percent of the average diameter and less than about 160 percent of the average diameter.

[xliv] See in this regard the interesting article authored by Andrew S. Baluch et al., *In re Kumar: The First Nanotech Patent Case in the Federal Circuit*, 2 NANOTECH. L. & BUS. 342 (2005).

[xlv] See no. 2008-1404, -1405, -1406, slip op. (Fed. Cir. May 13, 2009).

P&G sued Teva for infringement of the one patent after Teva notified P&G that it planned to market a generic equivalent of Actonel®. Specifically, P&G alleged that Teva's proposed drug infringed several claims of the patent. Teva argued that the patent was invalid as obvious in light of an expired P&G's expired U.S. Patent and alternately invalid for obviousness-type double patenting.

[xlvi] Id. at 5, quoting Takeda Chem. Indus., Ltd. v. Alphapharm Pty., Ltd., 492 F.3d 1350, 1357 (Fed. Cir. 2007).

[xlvii] Id. at 5, quoting In re Soni, 54 F.3d 746, 750 (Fed. Cir. 1995).

[xlviii] Id. at 6, quoting PharmaStem Therapeutics, Inc. v. ViaCell, Inc., 491 F.3d 1342, 1360 (Fed. Cir. 2007).

[xlix] Id. at 12, quoting B.F. Goodrich Co. v. Aircraft Braking Sys. Corp., 72 F.3d 1577, 1582 (Fed. Cir. 1996).

[l] Article 56 EPC reads as follows:

"An invention shall be considered as involving an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art. If the state of the art also includes documents within the meaning of Article 54, paragraph 3, these documents are not to be considered in deciding whether there has been an inventive step".

[li] Usually, the problem-and-solution approach is considered as residing in the Implementing Regulations, whereby according to Rule 27(1)(c) the description must:

"disclose the invention, as claimed, in such terms that the technical problem (even if not expressly stated as such) and its solution can be understood, and state any advantageous effects of the invention with reference to the background art."

[lii] See T606/89, T834/91, T298/93, T59/96, and T650/01.

[liii] See T487/95.

[liv] See T153/97. In this case the document at stake had more than 30 years. It has to be stressed then, that also at the national level in Europe this principle is quite accepted. In fact, in Italy, in the case *Candy Elettrodomestici S.r.l. v. BSH Bosch Und Siemens Hausgerate GmbH*, RCLIP- IT-5/2008 (the RCLIP reference concerns cases that are summarized and edited by the Research Center for the Legal System of Intellectual Property of Waseda University in conjunction with the Center for Advanced Study and Research in Intellectual Property of the University of Washington) the Supreme Court of Cassation held that the reasoning of the Court of Appeal was legitimate in considering the relevant prior art, and there was no rule, of law or logic, imposing not to consider old documents as relevant prior art. The RCLIP summary is retrievable at http://www.21coe-win-cls.org/rclip/db/search_detail.php?cfid=2229 (last visited June 30, 2009).

[lv] See T149/93.

[lvi] See T296/93 in which the Board considered the hope to succeed a mere wish whereas the reasonable expectation to succeed is inferable from available facts.

[lvii] See, among others, T388/89, and 869/96.

[lviii] See T1072/92.

[lix] See T79/82 in which the age of the documents cited have been considered relevant in assessing the protraction of an unsolved problem.

[lx] See T349/95.

[lxi] See T181/82.

[lxii] For a complete presentation of the patent landscape in the carbon nanotubes' world, please consider the interesting article of Oscar M. Dunens et al., *Inconsistencies in the Carbon Nanotube Patent Space: A Scientific Perspective*, 1 NANOTECH. L. & BUS. 25, 25-40 (2008).

[lxiii] For a profound overview of the potential applications of MWCNTs, please refer to the document entitled *Applications and benefits of multi-walled carbon nanotubes*, available on the website of the European Chemical Industry Council at http://www.cefic.org/Files/Downloads/Benefits%20of%20Carbon%20Nanotubes.pdf (last visited Apr. 20, 2009).

[lxiv] The presentation, comparing data from KIPO, JPO, USPTO, and EPO is titled, *Patent Analysis for Preparation, and Application of Carbon Nanotubes*, and it is available at http://www.kosef.re.kr/community/suica/upload/300/927/4.pdf (last visited Apr. 20, 2009).

[lxv] For a brief overview by the author regarding nanotechnology in U.S. and Europe, *see* Luca Escoffier, *Nanotechnology: The Revolutionary Technology Seen from the U.S. and European Perspective*, DYNAMICS OF MARKETS AND INSTITUTIONS IN EUROPE INTELLECTUAL PROPERTY RIGHTS 3-6 (Working Paper Series No. 14, Aug. 2006), *available at* http://ipr.dime-eu.org/files/active/0/IPR-WORKING-PAPER-14_Escoffier.pdf (last visited Apr. 20, 2009). Moreover, for a general outlook of nanotechnology patenting and funding in Japan drafted by the same author, *see* Luca Escoffier, *A Brief Review of Nanotechnology Funding and Patenting in Japan*, 4 NANOTECH. L. & BUS. 101 (2007). To learn more about the challenges and opportunities in nanotechnology before the EPO *see* Christian Kallinger et al., *Patenting Nanotechnology: A European Patent Office Perspective*, 5 NANOTECH. L. & BUS. 95 (2008).

[lxvi] More information on the continuing effort to improve the search and examination of nanotechnology-related patent documents and the U.S. PTO Class 977 cross-reference art collection is available at http://www.uspto.gov/web/patents/biochempharm/crossref.htm (last visited Apr. 20, 2009).

[lxvii] The full text of the '925 Patent is available at http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=7&f=G&l=50&co1=AND&d=PTXT&s1=eikos.ASNM.&OS=AN/eikos&RS=AN/eikos (last visited Apr. 20, 2009).

[lxviii] When the initial requirement imposed by the office is traversed, it should be reconsidered. If, upon reconsideration, the examiner is still of the opinion that restriction is proper, it should be repeated and made final in the next office action.

[lxix] The total number of claims of the '925 Patent, therefore, is thirty (30), all drawn to a method for patterning a carbon nanotube.

[lxx] If, on examination, it appears that the applicant is entitled to a patent, a notice of allowance is sent to the applicant and specifies a sum constituting the issue fee which must be paid to avoid abandonment of the application. The sum specified in the notice of allowance may also include the publication fee.

[lxxi] Information disclosure statements are not permitted in provisional applications. Conversely, in non-provisional applications, applicants and other individuals substantively involved have a duty to submit to the U.S. PTO information which is material to patentability. Moreover, applicants and other individuals substantively involved might want to submit information to the U.S. PTO for other reasons (e.g., to make sure that the examiner has the chance to consider the same information that was considered by these another patent office in a counterpart or related patent application filed in another country or region). The procedures for submitting an information disclosure statement are designed to encourage individuals to submit information to the U.S. PTO promptly. Said rules provide certainty for the public by clearly defining the requirements for submitting information disclosure statements to the U.S. PTO so that the Office will consider information contained therein before a patent is granted. In fact, the examiner has the obligation to consider the information submitted. There is no requirement that the information must be prior art references in order to be considered. The examiner's initials placed adjacent to the citations on the form mean that the information has been considered by the examiner.

[lxxii] According to Article 33 of the Patent Cooperation Treaty, the objective of the international preliminary examination is to formulate a preliminary and non-binding opinion on the questions of whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), and to be industrially applicable. The international preliminary examination shall take into consideration all the documents cited in the international search report. It may take into consideration any additional documents considered to be relevant in the particular case.

[lxxiii] At this point, the patent application consists of 29 claims. Claims 1-11 are drawn to a carbon nanotube wiring, whereas claims 12-41 are drawn to a method for patterning a carbon nanotube.

[lxxiv] Supplementary European search reports are drawn up for international applications for which the patent office of the U.S., Japan, China, Australia, Russia or Korea was the international searching authority. No precise limits at present are set for these supplementary searches since the documentation and search practice of these international searching authorities have not been fully harmonized with respect to the EPO. As a general rule, the EPO avoids any superfluous work and duplication of work and relies on the efficiency and quality of the international searches.

[lxxv] Article 86(1) EPC provides that "renewal fees shall be paid to the European Patent Office in accordance with the Implementing Regulations in respect of European patent applications. These fees shall be due in respect of the third year and each subsequent year, calculated from the date of filing of the application".

[lxxvi] The complete press release from SDK on the agreement reached with Hyperion can be found on SDK's website at http://www.sdk.co.jp/aa/english/news/2009/aanw_09_1006.html (last visited Apr. 20, 2009).

[lxxvii] The original press release of Hyperion can be found on Business Wire's website at http://www.businesswire.com/portal/site/home/permalink/?ndmViewId=news_view&newsId=20090126005857&newsLang=en (last visited Apr. 20, 2009).

[lxxviii] See *supra* note 76.

[lxxix] See http://www.sdk.co.jp/aa/english/news/2009/aanw_09_1006.html (last visited June 30, 2009).

[lxxx] Nanotechnology inventions are conceived, in general terms, either through the bottom-up or top-down approach. The former consists of mainly creating novel compounds at the atomic and molecular level whereas the latter employs systems that reduce the size of a bulk material.

[lxxxi] See *supra* note 77.