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NANOTECHNOLOGY PATENT LAW: A CASE STUDY OF THE UNITED STATES AND EUROPEAN PATENT APPLICATIONS

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By Michael Costello-Caulkins[1]

As nanotechnology moves from research development to commercial development, applicants are seeking patents outside the United States and in European markets in greater numbers. As a consequence, understanding the challenges of international prosecution is of growing importance to nanotechnology companies. One way to understand these challenges is to look at how jurisdictions are treating patents. This article focuses on four case studies of nanotechnology patent applications filed in the United States and Europe. Ultimately, the European applications were abandoned earlier in prosecution and in greater numbers than the US applications and, where patents issued in both jurisdictions, the European patents contained narrower claims. This is attributable to different prior art relied on by the European Patent Office, which read on more claims and required additional claim limitations than the US prior art. To provide context to the case study a definition of nanotechnology, a comparison of the patent laws, and a summary of previous scholarship are also discussed.

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INTRODUCTION

Nanotechnology has become increasingly relevant across a wide range of fields.[2] For example, nanotechnology is critical to the mRNA COVID-19 vaccine developed by Moderna, Inc.[3] The mRNA technology "employs nanoparticles-based drug release approaches"[4] that allow for improved penetration into tissues and low toxicity to the body.[5] Additionally, major manufacturing hurdles have been overcome in the creation of a 16-bit microprocessor comprising carbon nanotube transistors which are ten times as energy efficient as silicon transistors.[6] It is safe to say that nanotechnology is a rapidly growing technological area. As a result, there are a growing number of patent applications being filed.[7]

In 2020, about three percent of the total patent applications filed at the United States Patent and Trademark Office ("USPTO") and the European Patent Office ("EPO") were related to nanotechnology.[8] In terms of granted patents and published patent applications, a total of 22,462 and 5,292 nanotechnology patents were issued by the USPTO and EPO respectively.[9] The EPO's nanotechnology patents account for 23.6% of the USPTO's patents, showing a sizable increase compared to 2016 (i.e., 18%).[10] This growth reveals "the considerable attention of countries and companies all over the world to the EU's nanotechnology markets compared to the US ones."[11]

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[2] *Benefits and Applications*, NANO.GOV: NATIONAL NANOTECHNOLOGY INITIATIVE, https://www.nano.gov/you/nanotechnology-benefits.
[3] *Technology Against COVID-19: Nano Insights into Prevention, Diagnosis, and Treatment*, STATNANO, https://statnano.com/technology-against-covid-19-nano-insights.
[4] *Id.*
[5] *Lipid Nanoparticles*, PRECISION NANOSYSTEMS, https://www.precisionnanosystems.com/workflows/formulations/lipid-nanoparticles.
[6] Becky Ham, *Carbon nanotube transistors make the leap from lab to factory floor*, MIT NEWS: ON CAMPUS AND AROUND THE WORLD (June 1, 2020), https://news.mit.edu/2020/carbon-nanotube-transistors-factory-0601.
[7] *A Statistical Look at USPTO Nanotechnology Patents Published in 2020*, STATNANO (Jan. 26, 2021), https://statnano.com/news/68609/A-Statistical-Look-at-USPTO-Nanotechnology-Patents-Published-in-2020.
[8] *Id.*
[9] *2020's Statistical Review of Top Countries in Holding Nanotechnology Patents*, STATNANO (Feb. 1, 2021), https://statnano.com/news/68635/2020's-Statistical-Review-of-Top-Countries-in-Holding-Nanotechnology-Patents.
[10] *Id.*
[11] *Id.*

As the EU's nanotechnology market continues to grow, it is important for US companies considering patent protection in Europe to understand the challenges of pursuing an international patent portfolio. To highlight how European patent law differs from United States law in regard to nanotechnology, this paper presents four case studies of nanotechnology patent applications. More specifically, I identify four pairs of "matched USPTO-EPO patent application twins"[12] and analyze their prosecution histories. Each of the pairs refers to early nanotechnology patents that sought to protect the basic ideas of the technology,[13] which highlight some of the issues unique to the field. To the same end, this article presents a definition of nanotechnology, a comparison of US and European patent law, and a summary of the relevant scholarship.

Based on the EPO's greater understanding of the issues affecting nanotechnology patents and better reputation, I hypothesize that the European patent applications will issue into patents at a lower rate than the US applications and contain narrower claims. The results of the four case studies largely confirm my hypothesis. I find that it is much harder to get a nanotechnology patent in Europe than it is in the US, in part, because the EPO relies on better prior art than the USPTO.

I. DEFINING NANOTECHNOLOGY

Nanotechnology involves science at the nanometer scale.[14] A nanometer is a unit of measure that is one billionth of a meter and materials at this size have unique properties that are governed less by the traditional laws of physics and more by the behavior of individual atoms and molecules.[15] This can be quite different than the behavior exhibited by the same material in bulk. For instance, aluminum in bulk is stable but at the nanoscale it is combustible.[16] Gold also undergoes a

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[12] Colleen Chien, *Comparative Patent Quality*, 50 ARIZ. ST. L.J. 71, 102 (2018).

[13] *See* discussion *infra* Section IV.

[14] *What It Is and How It Works*, NANO.GOV: NATIONAL NANOTECHNOLOGY INITIATIVE, https://www.nano.gov/nanotech-101/what.

[15] Mark A. Lemley, *Patenting Nanotechnology*, 58 STAN. L. REV. 601, 602 (2005) (discussing how the characteristics of nanoscale materials lie "between the classical large-molecule level to which traditional physics and chemistry apply and the atomic level in which the bizarre rules of quantum mechanics take effect"); *Ten Things You Should Know About Nanotechnology*, NANOWERK, https://www.nanowerk.com/nanotechnology/ten_things_you_should_know_3.php [hereinafter *Ten Things*].

[16] *Ten Things*, *supra* note 15.

transformation as it gets smaller and smaller, eventually turning to liquid at room temperature.[17]

Patent offices have defined nanotechnology accordingly. Both the USPTO and EPO have designated nanotechnology with its own class designation: class 977 and B82Y, respectively.[18] With regard to size, the USPTO defines a nanostructure as having at least one physical dimension of approximately 1-100 nanometers.[19] Similarly, the EPO states that a nanostructure must have "at least one nanosized functional component," where "nanosized" relates to a dimension below 100 nanometers.[20] With regard to properties, both offices state in similar terms that the nanostructure must have a special property that is uniquely attributable to the nanoscale.[21]

II. UNITED STATES & EUROPEAN PATENT SYSTEMS

Before looking at the data, it is important to understand the patent system in each region. Specifically, it is important to understand the difference in legal standards and evidentiary processes, with a focus on which regime encourages a more rigorous examination. This paper touches on provisions that were particularly relevant in the prosecution of these patents: novelty and non-obviousness. It is worth noting the patents in this paper were all filed before March 16, 2013, so the pre-AIA provisions of the US Code are applicable.

A. Novelty

With regard to novelty, 35 US Code Section 102 governs, and section (a) says that an invention is not novel if it is known or used in the US, or if it is published anywhere in the US or a foreign country.[22] Case law has defined a published reference as one that has been disseminated or made available so persons interested and ordinarily skilled in the subject matter can locate it.[23] Case law has also defined

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[17] *Id.*

[18] *Class 977 Nanotechnology*, USPTO, https://www.uspto.gov/web/patents/classification/uspc977/defs977.htm [hereinafter *USPTO*]; *Nanotechnology*, EUROPEAN PATENT OFFICE: NEWS & EVENTS, https://www.epo.org/news-events/in-focus/classification/nanotechnology.html.

[19] *USPTO*, *supra* note 18.

[20] COOPERATIVE PATENT CLASSIFICATION, DEFINITION: B82Y (2017).

[21] *Id.*; *USPTO*, *supra* note 18.

[22] Melanie J. Howlett & Andrew F. Christie, *An Analysis of the Approach of the European, Japanese and United States Patent Office to Patenting Partial DNA Sequences (ESTS)*, 34 INT'L REV. INDUS. PROP. & COPYRIGHT 581, 591 (2003).

[23] *Id.*

"known or used" as that which is accessible to the public, with no deliberate attempt to keep it secret.[24]

In Europe, novelty is governed by Article 54 of the European Patent Convention ("EPC").[25] Article 54 mandates that "an invention shall be considered to be new if it does not form part of the state of the art."[26] The state of the art comprises "everything made available to the public by means of a written or oral description, by use or in any other way, before the date of the filing of the European patent application."[27] Lack of novelty can be evident from explicit statements in the document, or it can be implicit, "such that a skilled person would inevitably arrive at the claimed invention by following the teaching of the prior document."[28]

In practice, there are two key differences between the novelty requirements. First, Europe follows the principle of absolute novelty, meaning a patent application must be filed before the occurrence of any activity that would constitute prior art.[29] In the US, there is a one-year grace period from initial public disclosure or commercial use in which an inventor can file a patent application and still obtain a valid patent.[30] Second, Europe follows a policy of qualified public use, where the public disclosure actually has to enable someone to figure out what the invention is.[31] In the US, neither public disclosure nor commercial use has to be enabling.[32]

B. Non-obviousness

In the US, non-obviousness is covered in 35 US Code Section 103.[33] Section 103 states that a patent will be rejected when the collective prior art suggests to a person skilled in the art that the patent's claim was obvious.[34] Non-obviousness analysis is fact dependent and requires comparing the claimed subject matter as a

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[24] *Id.*
[25] European Patent Convention art. 54, Oct. 5, 1973, 1065 U.N.T.S. 272.
[26] *Id.*
[27] *Id.*
[28] Howlett & Christie, *supra* note 22, at 588.
[29] Jeffrey M. Kaden, *Patent Protection and the Novelty Requirement*, GOTTLIEB, RACKMAN & REISMAN, P.C., https://grr.com/publications/patent-protection-novelty-requirement/.
[30] *Id.*
[31] Andre Marais, Schwegman Lundberg & Woessner, US vs EP Patent Consideration: A Practical Guide to the Differences, Presentation at Santa Clara School of Law (Oct. 6, 2020).
[32] *Id.*
[33] 35 U.S.C. § 102 (2015).
[34] *Id.*

whole to the prior art.[35] To establish a prima facie case of obviousness an examiner can show three things: (1) a suggestion or motivation in the prior art to modify the reference; (2) a reasonable expectation of success in combining or modifying the prior art to arrive at the claimed invention; and (3) prior art references that suggest all of the claim limitations.[36] Importantly, obviousness is judged by the hypothetical person of ordinary skill right before the invention was made.[37]

Under the EPC, Article 56 states that an invention has an inventive step, if "having regard to the state of the art, it is not obvious to a person skilled in the art."[38] This is evaluated using a "problem-solution" approach which involves three steps: (1) determining the closest prior art; (2) establishing the technical problem to be solved in the present application; and (3) considering whether the present invention, beginning with the closest prior art and the technical problem, would have been obvious to a person skilled in the art.[39] Obvious is defined as "not going beyond the normal progress of technology but rather following plainly or logically from that prior art."[40] Importantly, the closest prior art must be in the same technical field and must address the same problem as the present invention.[41]

In practice, the European "problem-solution" approach requires an examiner to strike out all non-technical language in the claims and any claim element that appears in the prior art.[42] If what remains is a technical solution to a technical problem, an inventive step exists.[43] This inquiry resembles an eligible subject matter evaluation and is quite different than the US approach, which focuses primarily on whether the combination of prior art is obvious and contains every claim element.[44]

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[35] Howlett & Christie, *supra* note 22, at 592.
[36] *Id.*
[37] *Id.*; Tom Irving, *Obviousness: Overcoming Obviousness Rejections by Attacking the Prima Facie Case*, LEXIS PRACTICE ADVISOR 2, https://www.finnegan.com/images/content/2/5/v2/255327/PUBLISHED-Lexis-Practice-Advisor-Obviousness-Overcoming-Obvi.pdf.
[38] European Patent Convention art. 56, Oct. 5, 1973, 1065 U.N.T.S. 273.
[39] Howlett & Christie, *supra* note 22, at 589.
[40] *Id.* at 590.
[41] *Id.* at 589–90.
[42] Andre Marais, Schwegman Lundberg & Woessner, US vs EP Patent Consideration: A Practical Guide to the Differences, Presentation at Santa Clara University School of Law (Oct. 6, 2020).
[43] *Id.*
[44] *Id.*

III. RELEVANT SCHOLARSHIP

There are a couple areas of patent scholarship that are applicable to this case study. The first has to do with patenting nanotechnology and the second, more generally, compares obtaining patent rights in the US and Europe. Scholarship on patenting nanotechnology tends to be region specific, with the exception of a single case study that compared the prosecution of a nanotechnology patent application in the US and Europe.[45] This section briefly summarizes the prior art and provides a prediction about the results of this case study.

The first area of relevant patent scholarship looks at nanotechnology patents. Most authors focus on subject matter of early nano patents, the cross disciplinary nature of nano patents,[46] and novelty concerns with miniaturizing prior inventions.[47] In both the US and Europe, the basic ideas, or "building blocks," of nanotechnology were patented.[48] For example, in the US, patents have issued on carbon nanotubes, semiconducting and light emitting nanocrystals, nanorods, and methods for making nanotubes and nanocrystals.[49] This is the first area of technology in almost one hundred years in which the building

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[45] Luca Escoffier, *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* (Stanford – Vienna Transatlantic Technology Law Forum Working Paper Series, Paper No. 3, 2009), https://law.stanford.edu/wp-content/uploads/sites/default/files/publication/205107/doc/slspublic/escoffier_wp3.pdf.

[46] For scholarship on the subject matter and cross disciplinary nature of nano patents *see* Lemley, *supra* note 15, at 606–14; Amit Makker, *The Nanotechnology Patent Thicket and the Path to Commercialization*, 84 S. CAL. L. REV. 1163 (2011); Maurice H.M. Schellekens, *Patenting Nanotechnology in Europe: Making a Good Start? An Analysis of Issues in Law and Regulation*, 9 (TILT Law & Tech., Working Paper No. 008/2008, 2008), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1139080.

[47] *See* Emily M. Morris, *The Irrelevance of Nanotechnology Patents*, 49 CONN. L. REV. 499 (Dec. 2016); Jordan Paradise, *Claiming Nanotechnology: Improving USPTO Efforts at Classification of Emerging Nano-Enabled Pharmaceutical Technologies*, 10 NW. J. TECH. & INTELL. PROP. 169, 175 (2012); Andrew Wasson, *Protecting the Next Small Thing: Nanotechnology and the Reverse Doctrine of Equivalent*, 2004 DUKE L. & TECH. REV. 10 (2004); Christopher Anderson, *Small Can be Inventive: The Patentability of Nanoscale Reproductions of Macroscale Machines*, 9 Wm. & Mary Bus. L. Rev. 295 (Nov. 2017).

[48] Lemley, *supra* note 15, at 606–14.

[49] *Id.*

blocks were patented from the beginning.[50] In fields like computer hardware, the internet, and biotechnology, early research was conducted by the US government or the US government compelled companies and universities to license their patents.[51] Nanotechnology has not been subject to the same government-mandated licenses or policies against university patenting and, as a result, patenting occurred early.[52] The European Commission has expressed concern that "nanotechnology is raising fundamental questions as to what should, and should not be patentable, e.g., on the level of individual molecules."[53] Additionally, the EPO has worked on instruments to monitor nanotechnology patents to prevent over patenting.[54]

Scholarship also focuses on the cross-disciplinary structure of nanotechnology.[55] Particularly, patents on the basic ideas can affect multiple fields ranging from biomedicine to telecommunications.[56] Patentees will consequently have rights in several industries, and expertise in each industry will be required to commercialize each patent.[57] This has raised practical concerns in Europe such as what disciplines should the person skilled in the art have.[58] One commentator has suggested defining a person skilled in the art as a team of people, each skilled in a discipline that could be used by the invention.[59]

Nanotechnology patents also raise the unique issue whether macroscale devices can be prior art for nanoscale inventions. When considered broadly, courts have found that a patent covers the same invention independent of its size.[60] But nanotechnology is fundamentally different in that its material properties are not present at the macroscale.[61] One case in particular has dealt with issues regarding the size range of nanotechnology, finding that a nanotechnology patent can infringe a non-nanotechnology patent where the two patents

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[50] *Id.*
[51] *Id.*
[52] *Id.*
[53] Schellekens, *supra* note 46.
[54] *Id.* at 7.
[55] *See* Lemley, *supra* note 15, at 614; Makker, *supra* note 46; Schellekens, *supra* note 46.
[56] Lemley, *supra* note 15.
[57] Makker, *supra* note 46, at 1173.
[58] Schellekens, *supra* note 46.
[59] *Id.*
[60] Anderson, *supra* note 47, at 287.
[61] *Id.*

specify particles with overlapping size ranges.[62] In contrast, when faced with situations where a nano-patent overlaps with ranges mentioned in the prior art, the EPO's Technical Board of Appeal has noted that the prior art was not novelty destroying because the prior art did not provide specific examples in the overlapping part of the range.[63]

One case study has compared the prosecution of a nanotechnology patent in the US and Europe.[64] The patent pertained to patterning carbon nanotubes and was subject to two office actions in the US where the examiner had the applicant restrict the patent to one of two enclosed inventions and make minor formal amendments to the application.[65] The applicant submitted a supplemental European search report to the examiner, which was acknowledged, but had no effect on the outcome of the application.[66] The application eventually issued as a patent.[67] In Europe, the application was found to lack novelty and inventive step based on two patents that were cited references in the US patent.[68] The applicants slightly amended the claims but after the EPO considered a new, non-patent reference relevant, that was cited in the supplemental European search report, the application was abandoned.[69] The author concluded the case study "exemplifies how cumbersome an international prosecution can be."[70]

More generally, the EPO has long held a reputation as the "gold standard" among patent offices in terms of patent quality.[71] This is because the EPO makes upfront investment in prosecution, regularly relies on non-patent references, and caps application continuations following rejections.[72] By contrast, the USPTO is not held in as high regard in terms of patent quality, in part, because their continuation policy allows applicants to continue prosecuting applications despite final rejection.[73] The USPTO also falls behind the EPO in several key metrics. For example, the EPO spends thirty hours examining a patent

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[62] Paradise, *supra* note 47 (discussing Elan Pharma Int'l Ltd. v. Abraxis Bioscience Inc., No. 06-438 GMS, 2007 WL 6382930 (D. Del. Dec. 17, 2007)).
[63] Schellekens, *supra* note 46.
[64] Escoffier, *supra* note 45.
[65] *Id.* at 28.
[66] *Id.* at 29.
[67] *Id.*
[68] *Id.*
[69] *Id.* at 30.
[70] Escoffier, *supra* note 45, at 30.
[71] Chien, *supra* note 12, at 74.
[72] *Id.* at 101–20.
[73] *Id.* at 106.

compared to the USPTO's thirteen hours.[74] Additionally, the EPO typically applies a team of three examiners to a patent, whereas the USPTO applies one primary examiner.[75] In sum, the EPO invests heavily in getting patent quality right at early stages of prosecution, which, not surprisingly, leads to higher rates of abandonment when compared to the USPTO.[76]

For several reasons, the US patent applications in this case study should issue into patents at a higher rate than the European applications, and in cases where applications issue in both jurisdictions, contain broader claims. The EPO not only appears to have a greater understanding of the unique issues affecting nanotechnology patents,[77] but their reputation as a better patent office[78] would make it more difficult for applicants to obtain a patent. Additionally, the previous nano patent case study suggests that nano patents are more difficult to obtain in Europe than in the US.[79]

IV. THE CASE STUDY

Comparative studies of patent law are not new. Many studies have been done comparing the law between regions,[80] but few studies have been conducted at the case study level. In addition, nanotechnology has been studied for a long time,[81] but the study of nanotechnology patents is less prevalent. To understand the differences in patent law between the US and Europe with respect to nanotechnology, this section analyzes four pairs of nanotechnology patent applications. I initially searched for "building-block" patents

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[74] *Id.* at 111.
[75] *Id.*
[76] *Id.* at 107.
[77] Schellekens, *supra* note 46, at 7, 9.
[78] Chien, *supra* note 12, at 74.
[79] Escoffier, *supra* note 45, at 30.
[80] Chien, *supra* note 12; Paul H. Jensen et al., Disharmony in International Patent Office Decisions, 15 FED. CIR.B.J. 679, 679–82 (2006); Alfons Palangkaraya et al., Misclassification Between Patent Offices: Evidence from a Matched Sample of Patent Applications, 93 REV. ECON. & STAT. 1063, 1063–64 (2011); Elizabeth Webster et al., Characteristics of International Patent Application Outcomes, 95 ECON. LETTERS 362, 367–68 (2007).
[81] *See* Samer Bayda et al., *The History of Nanoscience and Nanotechnology: From Chemical-Physical Applications to Nanomedicine*, MOLECULES (Dec. 27, 2019), https://www.mdpi.com/1420-3049/25/1/112 (Richard Feynman introduced the concept of nanotechnology in 1959 during the annual meeting of the American Physical Society).

and found ten,[82] however, only three had European counterparts and, of those three, only two had US file wrappers that were published online.[83] To find a larger sample of accessible EPO/USPTO patent applications, I searched for similar applications using Google Patents and identified nine matched pairs of EPO/USPTO patent applications.[84] Notably, five of these pairs contained abandoned European patent applications,[85] and one contained an abandoned US application.[86] For this study, I selected one of the pairs containing an abandoned European application,[87] the one pair containing an abandoned US application,[88] and one pair where both the US and European applications issued into patents.[89] In summary, these applications cover fundamental nanotechnology inventions chosen for their significance in the field, in addition to the fact that patent protection was sought both in the US and Europe.

A. Case 1: US 7,425,368 & WO 2006/023697

US patent 7,425,368 started as a provisional application filed on August 20, 2004.[90] The invention contained 19 claims and described a polymer infused with nano particles which created a fiber with

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[82] Lemley, *supra* note 15, at 613–14 (citing ten patents on the basic ideas in nanotechnology like carbon nanotubes, semiconducting nanocrystals, and metal oxide nanorods).

[83] Patent applications filed before June 20, 2003, were not scanned into the Image File Wrapper system and so were not available online in public PAIR after they published. MPEP § 1730 (II)(B)(1)(d) (8th ed. Rev. 7, Sept. 2008).

[84] The nine US patent applications identified using Google Patents include U.S. Patent Application Serial No. 11/179,102 (filed July 15, 2005); U.S. Patent Application Serial No. 10/470,517 (filed July 29, 2003); U.S. Patent Application Serial No. 10/090,223 (filed Mar. 4, 2002); U.S. Patent Application Serial No. 10/549,950 (filed Mar. 19, 2004); U.S. Patent Application Serial No. 10/976,179 (filed Oct. 29, 2004); U.S. Patent Application Serial No.10/977,363 (filed Oct. 29, 2004); U.S. Patent Application Serial No. 11/120,729 (file May 3, 2005); U.S. Patent Application Serial No. 13/392,124 (filed Aug. 25, 2010); U.S. Patent Application Serial No. 09/133.948 (filed Aug. 14, 1998).

[85] U.S. Patent Application Serial No. 11/179,102 (filed July 15, 2005); U.S. Patent Application Serial No. 10/470,517 (filed July 29, 2003); U.S. Patent Application Serial No. 10/549,950 (filed Mar. 19, 2004); U.S. Patent Application Serial No. 11/120,729 (file May 3, 2005); U.S. Patent Application Serial No. 09/133.948 (filed Aug. 14, 1998).

[86] U.S. Patent Application Serial No. 13/392,124 (filed Aug. 25, 2010).

[87] U.S. Patent Application Serial No. 11/179,102 (filed July 15, 2005).

[88] U.S. Patent Application Serial No. 13/392,124 (filed Aug. 25, 2010).

[89] U.S. Patent Application Serial No.10/977,363 (filed Oct. 29, 2004).

[90] U.S. Patent No. 7,425,368 at [22].

improved axial strength.[91] On December 14, 2007, the USPTO required the patent to be restricted to one of the two inventions enclosed.[92] Specifically, claims 1-14 of the application were drawn to the fiber, while claims 15-19 were drawn to a method for making the fiber.[93] On January 18, 2008, the applicants replied electing to restrict the invention to the claims drawn to the fiber.[94]

On January 31, 2008, the USPTO sent an Office Action concerning the restricted claims.[95] According to the USPTO, claims 1-4 and 6-14 were indefinite and claims 1-4, 6, 8-9, and 13-14 lacked novelty pursuant to US Code Section 102.[96] On April 21, 2008, the applicants replied by amending claim 1, cancelling claims 4, 10, 12, and 14, and rewriting claim 11 in independent form.[97] On September 5, 2008, the USPTO sent a notice of allowance stating that the amended application was acceptable,[98] and on September 16, 2008, a patent was issued.[99]

The applicants also filed a PCT application on August 19, 2005.[100] The EPO conducted an international prior art search which published on February 3, 2006.[101] A year later, an international preliminary report on patentability indicated claims 1-14 lacked novelty and an inventive step.[102] The last document available shows

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[91] U.S. Patent Application Serial No. 11/179,102 (filed July 15, 2005).
[92] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, REQUIREMENT FOR RESTRICTION/ELECTION (Dec. 14, 2007).
[93] *Id.*
[94] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, AMENDMENT/REQUEST FOR RECONSIDERATION AFTER NONFINAL REJECTION (Jan. 18, 2008).
[95] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, NONFINAL REJECTION (Jan. 31, 2008).
[96] *Id.*
[97] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Apr. 21, 2008).
[98] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, NOTICE OF ALLOWANCE AND FEES DUE (Sept. 5, 2008).
[99] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, ISSUE NOTIFICATION (Sept. 16, 2008).
[100] World Intellectual Property Organization (WIPO), *Filler-Enhanced Polymeric Fibers with Improved Mechanical Properties and Method for Making*, WO 2006/034697 (filed on Aug. 19, 2005).
[101] European Patent Office (EPO), *International Search Report*, File No. 05791549.8 (Feb. 3, 2006).
[102] *Id.*

that in April 2007, the EPO sent a notice announcing the loss of rights due to lack of payment.[103]

To summarize, the US application issued into a patent[104] and the EU application was abandoned.[105] There were several differences between the prosecution of the two applications. The first is that the USPTO relied exclusively on US patent material,[106] while the EPO relied on a combination of US and foreign patent material.[107] Notably, shown in Table 1, none of the references relied on by the patent offices overlapped. This had a big impact on the perceived validity of the applications.

Reference Type	USPTO	EPO
US Patent Documents	US-6,979,709 US-6,852,410 US-6,900264 US-2002/0127162 US-2005/0049355 US-2006/0188718 US-2007/0116631	US-5,512,368
Foreign Patent Documents	-	EP-1,449,942 WO-03/020638 WO-03/069032 WO-03/033785

Table 1: References Cited by the USPTO[108] and EPO[109]

For example, in the US, the examiner stated the fiber disclosed in US-2005/0049355 possessed the same enhanced mechanical properties as the fiber disclosed in nine of the applicant's claims.[110] In

[103] European Patent Office (EPO), *Application Deemed to be Withdrawn*, File No. 05791549.8 (Apr. 27, 2007).
[104] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, ISSUE NOTIFICATION (Sept. 16, 2008).
[105] European Patent Office (EPO), *Application Deemed to be Withdrawn*, File No. 05791549.8 (Apr. 27, 2007).
[106] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, LIST OF REFERENCES CITED BY APPLICANT AND CONSIDERED BY EXAMINER (Jan. 29, 2008); U.S. PATENT & TRADEMARK OFFICE, FILE NO. 11179102, LIST OF REFERENCES CITED BY EXAMINER (Jan. 31, 2008).
[107] European Patent Office (EPO), *International Search Report*, File No. 05791549.8 (Feb. 3, 2006).
[108] LIST OF REFERENCES CITED BY APPLICANT, *supra* note 106; LIST OF REFERENCES CITED BY EXAMINER, *supra* note 106.
[109] *International Search Report*, *supra* note 107.
[110] NONFINAL REJECTION, *supra* note 95.

response, the applicant's amended independent claim 1 to specify a unique structural identity and composition, shown in Table 2.[111]

Claim 1: Amended
Filler-enhanced polymeric fiber comprising: a polymer fiber: and high aspect ratio filler particles dispersed within the polymeric fiber and in intimate contact during processing with the polymeric fiber, the filler particles, having an interfiber spacing of less than 350 nanometers, serving as templates to orient the molecular structure of the polymer fiber to enhance fiber mechanical properties.[112]

Table 2: Amendments to Claim 1 of the US Application

In contrast, the EPO found that WO-03/020638 disclosed essentially the same fiber disclosed in claim 1 of the application.[113] The EPO went on to indicate the remaining thirteen dependent claims did not contain features that imparted novelty or an inventive step.[114]

Ultimately, the different references led the USPTO and EPO to different conclusions about the applications. The EPO indicated early in prosecution that every claim directed to the fiber either lacked novelty or an inventive step, limiting the applicant's path forward.[115] Relying on a different set of references, the USPTO indicated some, but not all, of the claims in the application were obvious, allowing the applicants to cure their claims through amendment.[116]

B. Case 2: US 7,465,871 & EP 1,812,974

US Patent 7,465,871 started as a patent application filed on October 29, 2004.[117] The application consisted of 65 claims that were directed towards a composite made of a semiconductor material infused with nanoparticles.[118] On December 2, 2005, the USPTO sent a notice requiring applicants to restrict the invention to one of two

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[111] APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT, *supra* note 97.
[112] *Id.*
[113] European Patent Office (EPO), *Copy of the International Preliminary Report on Patentability*, File No. 05800694.1 (Apr. 3, 2007).
[114] *Id.*
[115] *Id.*
[116] APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT, *supra* note 97.
[117] U.S. Patent No. 7,465,871 at [22] (filed Oct. 29, 2004).
[118] U.S. Patent Application Serial No. 10/977,363 (filed Oct. 29, 2004).

inventions enclosed in the patent.[119] The USPTO stated that claims 1-56 were drawn to the composite material, while claims 57-65 were drawn to a method of manufacturing the composite.[120] On January 27, 2006, the applicants replied electing to restrict the invention to the composite.[121]

On May 23, 2006, the USPTO sent an Office Action concerning the remaining claims.[122] The USPTO found that certain claims were not novel, and a combination of references rendered additional claims obvious.[123] On September 22, 2006, the applicants replied amending claims 1, 32, 38, 41, 53, 56, and adding a new claim.[124] On June 1, 2007, the USPTO sent a second Office Action stating claims 1-11, 15-25, 27-31, 38-43, 52, 53, 56, and 66 were not novel in light of new prior art.[125] On October 10, 2007, the applicants replied with a declaration that one of the references was authored by the co-inventors,[126] prompting the USPTO to withdraw their rejection of claims 15-16, 22, 24-25, 27-28, 52-53, and 66.[127]

On April 8, 2008, the applicants amended claim 1, canceled claims 38-43 and 56, and added claims 70-160.[128] On June 18, 2008, the USPTO withdrew their rejection of claim 1 but rejected claims 106-109, 128-131, 139-142, and 150-153.[129] On July 3, 2008, the applicants replied cancelling the rejected claims.[130] On October 10, 2008, the

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[119] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, REQUIREMENT FOR RESTRICTION/*ELECTION* (Dec. 2, 2005).
[120] *Id.*
[121] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, AMENDMENT/REQUEST FOR RECONSIDERATION AFTER NONFINAL REJECTION (Jan. 27, 2006).
[122] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, NONFINAL REJECTION (May 23, 2006).
[123] *Id.*
[124] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Sept. 22, 2006).
[125] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, NONFINAL REJECTION (June 1, 2007).
[126] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Oct. 10, 2007).
[127] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, FINAL REJECTION (Dec. 27, 2007).
[128] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Apr. 8, 2008).
[129] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, NONFINAL REJECTION (June 18, 2008).
[130] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (July 3, 2008).

USPTO sent a notice of allowance and on December 16, 2008 a patent was issued.[131]

The applicants also filed a PCT application on October 31, 2005.[132] The EPO conducted an international prior art search which published on May 16, 2007.[133] An IPR followed on February 12, 2008, indicating the claims defined three different inventions and that claims 1-15, 20-30, and 37-41 were not novel.[134] On June 24, 2009, the applicants replied electing to restrict the application to one of the inventions, and amended claim 1.[135] On February 14, 2014, the EPO sent a notice that the application still was not in conformity with the EPC.[136] On June 16, 2014, the applicants replied with a second amendment to claim 1 and canceled another claim.[137] Satisfied with the applicant's amendments, the EPO issued a patent on July 16, 2015.[138]

To summarize, both applications issued into patents.[139] The USPTO relied on a combination of US patent material and non-patent references,[140] whereas the EPO relied on US and foreign patent material and non-patent references.[141] Notably, three of the references

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[131] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, ISSUE NOTIFICATION (Dec. 16, 2008).

[132] World Intellectual Property Organization (WIPO), *Nanocomposites with High Termoelectric Figures of Merit*, WO 2006/127923 (filed on Oct. 31, 2005).

[133] European Patent Office (EPO), *Copy of the International Search Report*, File No. 05858279.2 (May 16, 2007).

[134] European Patent Office (EPO), *Copy of the International Preliminary Report on Patentability*, File No. 05858279.2 (Feb. 12, 2008).

[135] European Patent Office (EPO), *Reply to Communication from the Examining Division*, File No. 05858279.2 (June 24, 2009).

[136] European Patent Office (EPO), *Communication from the Examining Division*, File No. 05858279.2 (Feb. 14, 2014).

[137] European Patent Office (EPO), *Reply to Communication from the Examining Division*, File No. 05858279.2 (June 16, 2014).

[138] European Patent Office (EPO), *Communication About Intention to Grant a European Patent*, File No. 05858279.2 (Nov. 4, 2014).

[139] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, ISSUE NOTIFICATION (Dec. 16, 2008); European Patent Office (EPO), *Communication About Intention to Grant a European Patent*, File No. 05858279.2 (Nov. 4, 2014).

[140] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, LIST OF REFERENCES CITED BY EXAMINER (May 23, 2006); U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, LIST OF REFERENCES CITED BY EXAMINER (June 1, 2007); U.S. PATENT & TRADEMARK OFFICE, FILE NO. 10977363, LIST OF REFERENCES CITED BY EXAMINER (Dec. 27, 2007).

[141] European Patent Office (EPO), *Copy of the International Search Report*, File No. 05858279.2 (May 16, 2007).

relied on by the patent offices overlapped, shown in Table 3. This led the applicants to pursue similar prosecution strategies in both jurisdictions.

Reference Type	USPTO	EPO
US Patent Documents	US-6,060,656 US-6,444,896 US-2003/0099279 US-6,858,154	US-6,060,656 US-6,444,896 US-2003/0099279 US-2002/170590
Foreign Patent Documents		WO 2004/055912 EP-1,187,230
Non-Patent Documents	J.M. Essik et al. (1989) J.M. Essik et al. (1996)	Harris T et al. Ronggui Yang et al. Zhao X et al. Hohyun Lee et al. Sconwille N et al.

Table 3: References Cited by the USPTO[142] and EPO[143]

For example, both patent offices rejected independent claim 1 in view of US-2003/0099279.[144] In response, the applicants amended claim 1 by adding that the nano particles were dispersed *randomly* relative to one another,[145] as indicated in Table 4.

[142] LIST OF REFERENCES CITED BY EXAMINER (May 23, 2006), *supra* note 140; LIST OF REFERENCES CITED BY EXAMINER (June 1, 2007), *supra* note 140; LIST OF REFERENCES CITED BY EXAMINER (Dec. 27, 2007), *supra* note 140.
[143] *Copy of the International Search Report*, *supra* note 141.
[144] NONFINAL REJECTION, *supra* note 122; European Patent Office (EPO), *Communication from the Examining Division*, File No. 05858279.2 (Feb. 13, 2009).
[145] APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT, *supra* note 124; *Reply to Communication from the Examining Division*, *supra* note 135.

US Claim 1: Amended	EU Claim 1: Amended
A thermoelectric nanocomposite semiconductor composition, comprising: a semiconductor host material, and a plurality of nano-sized inclusions distributed randomly within said host material, said inclusions being formed of a semiconductor inclusion material, wherein said host material comprises dopants, and wherein the conduction band-edge offset or a valence band-edge offset between said host material and the inclusion material at an interface of the two materials is less than about 5kT,wherein k is the Boltzman constant and T is an average temperature of said nano composite composition.[146]	A thermoelectric nanocomposite semiconductor composition, comprising: a semiconductor host material, and a plurality of nano-sized inclusions distributed randomly within said host material, said inclusions being formed of a semiconductor inclusion material, wherein the host material comprises a plurality of nano-sized structures formed of a semiconductor material different than said semiconductor inclusion material, and wherein the conduction bad-edge offset or a valence band-edge offset between said host material and the inclusion material at an interface of the two materials is less than about 5kbT, where kb is the Boltzman constant and T is an average temperature of said nanocomposite composition.[147]

Table 4: Amendments Made to the US and EU Applications

The additional amendments in the EU application were prompted by US-2003/0099279 and two non-patent references unique to the EU prosecution.[148] For example, the EPO stated the references taught a composite where the nanoparticles were made from the same material.[149] To overcome this, the applicants amended claim 1 to specify the host material and nanoparticles were made from different

[146] APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT, *supra* note 124; APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT *supra* note 128.
[147] *Reply to Communication from the Examining Division*, *supra* note 135; *Reply to Communication from the Examining Division*, *supra* note 137.
[148] *Id.*
[149] *Id.*

materials,[150] shown in Table 4. In contrast, the applicants in the US combined the limitation from claim 15 with claim 1, after the USPTO indicated claim 1 shared the same materials and properties with another US patent reference.[151]

Ultimately, the outcomes of the applications were similar in both jurisdictions. Both patents issued and similar prior art sets allowed the applicants to make similar amendments in some respects. However, the US patent contains broader claims than the EU patent because the non-patent references cited by the EPO required the applicants to make additional amendments to the EU application.

C. Case 3: US 2012/0208002 & EP 2,470,472

On August 25, 2010, the applicants filed a PCT application directed to a ceramic composite material consisting of aligned nanotubes that improved thermal conductivity.[152] The EPO conducted an international prior art search which published on November 10, 2010.[153] An IPR followed on February 28, 2012, and stated that each claim lacked an inventive step.[154] On March 19, 2012, the applicants amended claim 9 and 14 and canceled claims 19-22.[155] On June 23, 2016, the EPO sent a notice that the application did not meet the patentability requirements of the EPC for the reasons stated in the IPR.[156] On November 3, 2016, the applicants replied that the claims did not lack inventive step for the reasons summarized in Table 5.

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[150] *Id.*

[151] APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT, *supra* note 128.

[152] World Intellectual Property Organization (WIPO), *Composite Materials Containing Aligned Nanotubes and the Production Thereof*, WO 2011/024000 (filed on Aug. 25, 2010).

[153] European Patent Office (EPO), *International Search Report*, File No. 10752912.5 (Nov. 10, 2010).

[154] European Patent Office (EPO), *International Preliminary Report on Patentability*, File No. 10752912.5 (Feb. 28, 2012).

[155] European Patent Office (EPO), *Amended Claims with Annotations*, File No. 10752912.5 (Mar. 19, 2012).

[156] European Patent Office (EPO), *Communication from the Examining Division*, File No. 10752912.5 (June 23, 2016).

Inventive Step Argument	EPO Response
The thermal conductivity of the material claimed in the invention was significantly higher than that of the material specified in the prior art[157]	The use of aligned nanotubes was in reach of the skilled person in light of the prior art[158]
The references were not an appropriate starting point for assessing inventive step because the references were not concerned with the same technical problem as the invention[159]	The subject matter of claims 1-10 could be considered new and inventive but some additional objections needed to be overcome[160]

Table 5: Applicant's Inventive Steps Arguments and the EPO Response

Among the additional objections that need to be overcome were that claim 1 was overly broad.[161] The applicant's narrowed claim 1, and the EPO subsequently granted the patent on May 3, 2020.[162] The applicants also submitted a US patent application on May 7, 2012.[163] The USPTO required the application to be restricted to one invention because claims 1-9 and 11-13 were drawn to a method of forming the ceramic composite while claims 14-21 were drawn to the ceramic composite itself.[164] On April 25, 2013, the applicants replied electing to restrict the invention to the method of forming the ceramic

[157] European Patent Office (EPO), *Reply to Communication from the Examining Division*, File No. 10752912.5 (Nov. 3, 2016).
[158] European Patent Office (EPO), *Communication from the Examining Division*, File No. 10752912.5 (May 10, 2017).
[159] European Patent Office (EPO), *Amended Claims with Annotations*, File No. 10752912.5 (Feb. 15, 2018).
[160] European Patent Office (EPO), *Result of Consultation by Telephone/in Person*, File No. 10752912.5 (Feb. 28, 2018).
[161] *Id.*
[162] European Patent Office (EPO), *Decision to Grant a European Patent*, File No. 10752912.5 (May 3, 2020).
[163] U.S. Patent Application Serial No. 13/392,124 (filed May 7, 2012).
[164] *Id.*

composite.[165] On August 6, 2013, the USPTO sent its first Office Action stating that claims 1-5, 7-9, and 11-13 were obvious in light of two of the prior art references.[166] The applicants responded arguing the invention was nonobvious, shown in Table 6.

Nonobvious Argument	PTO Response
Fibers disclosed in the prior art were much larger than the nanotubes disclosed in the invention[167]	The fibers in the references could be smaller than those argued by applicant[168]
The invention taught dipping an array of nanotubes in a solution whereas one reference taught pouring a ceramic solution on an array[169]	Applicants attacked references individually when the rejection was based on obviousness[170]

Table 6: Applicant's Nonobviousness Arguments and the USPTO Response

Both arguments were rejected by the USPTO, prompting the applicants to submit amendments to claim 1.[171] On March 1, 2016, the PTO sent their final Office Action stating claim 1 was obvious in light of new prior art.[172] The next and last available document shows that in October 2016, the USPTO sent a notice to the applicants that they failed to reply to the Office Action.[173]

To summarize, the EU application issued into a patent[174] whereas the US application was abandoned.[175] The USPTO relied on

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[165] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, RESPONSE TO ELECTION/RESTRICTION FILED (Apr. 25, 2013).
[166] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, NONFINAL REJECTION (Aug. 6, 2013).
[167] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, AMENDMENT/REQUEST FOR RECONSIDERATION AFTER NONFINAL REJECTION (Dec. 5, 2013).
[168] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, FINAL REJECTION (Dec. 23, 2013).
[169] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Dec. 23, 2013).
[170] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, NONFINAL REJECTION (Oct. 9, 2014).
[171] FINAL REJECTION, *supra* note 168; NONFINAL REJECTION, *supra* note 170.
[172] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, FINAL REJECTION (Mar. 1, 2016).
[173] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, ABANDONMENT (Oct. 25, 2016).
[174] *Decision to Grant a European Patent*, *supra* note 162.
[175] ABANDONMENT, *supra* note 173.

three US patents, three US patent applications, one foreign patent, and four non-patent references.[176] The EPO relied on one international patent application and four non-patent references.[177] None of the references relied on by the patent offices overlapped, as indicate in Table 8. Again, this had a big impact on the perceived validity of the applications.

Reference Type	USPTO	EPO
US Patent Documents	US-6,277,440 US-6,831,017 US-2004/0032637 US-2007/0257212 US-6,350,488 B1	-
Foreign Patent Documents	TW-200633946	WO-2006/080936
Non-Patent Documents	Satishkumar et al. Garcia et al. Fan et al. Liu et al.	Cho et al. Z. F. Ren et al. A. Chandrashekar et al. A. Peigney et al.

Table 8: References Cited by the USPTO[178] and EPO[179]

For example, both applicants amended claim 1 to specify the array of substantially aligned nanotubes were *carbon* nanotubes,[180] as shown in Table 9. Additionally, both applicants amended claim 1 to specify that the ceramic matrix material is in the form of a *sol*.[181]

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[176] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, LIST OF REFERENCES CITED BY EXAMINER (Aug. 6, 2013); U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, LIST OF REFERENCES CITED BY EXAMINER (Feb. 27, 2015); U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, LIST OF REFERENCES CITED BY EXAMINER (Mar. 1, 2016).

[177] European Patent Office (EPO), *International Search Report*, File No. 10752912.5 (Aug. 8, 2013).

[178] LIST OF REFERENCES CITED BY EXAMINER (Aug. 6, 2013), *supra* note 176; LIST OF REFERENCES CITED BY EXAMINER (Feb. 27, 2015), *supra* note 176; LIST OF REFERENCES CITED BY EXAMINER (Mar. 1, 2016), *supra* note 176.

[179] *International Search Report*, *supra* note 177.

[180] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Feb. 9, 2015); European Patent Office (EPO), *Reply to Communication from the Examining Division*, File No. 10752912.5 (Sept. 19, 2019).

[181] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Jan. 22, 2016); *Reply to Communication from the Examining Division*, *supra* note 180.

EU Claim 1: Amended	US Claim 1: Amended
A method of forming a composite material comprising nanotube oriented in a matrix comprising a ceramic material, the method comprising the steps of: providing an array of substantially aligned nanotubes, wherein the nanotubes comprise carbon nanotubes; providing a ceramic matrix material in the form of a solution; applying the solution to the nanotubes; allowing the solution to infiltrate into the array of nanotubes; and sintering the ceramic matrix material to form the composite material; wherein the nanotubes are substantially aligned in the ceramic matrix, wherein the ceramic matrix is formed by a sol-gel process.[182]	A method of forming a composite material comprising nanotube oriented in a matrix comprising a ceramic material, the method comprising the steps of: providing an array of substantially aligned nanotubes, wherein the nanotubes are carbon nanotubes; providing a ceramic matrix material in the form of a solution; applying the solution to the nanotubes; allowing the solution to infiltrate into the array of nanotubes; and sintering the ceramic matrix material to form the composite material; wherein the nanotubes are substantially aligned in the ceramic matrix, wherein the step of applying the solution to the nanotubes comprises dipping the array of nanotubes in the solution and the solution infiltrates into the array of nanotubes by capillary action; wherein the solution of the ceramic matrix material is provided in the form of a sol, and wherein the sol is a colloidal suspension having a particle size of 1 to 10 nm.[183]

Table 9: Amendments Made to the US and EU Applications

However, the additional US patent material and non-patent references relied on by the USPTO rendered the applicant's claims obvious in the eyes of the examiner.[184] The US applicants did not argue the prior art was not analogous to the invention, which was a successful argument at the EPO.[185] Rather, the US applicants made new

[182] APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Feb. 9, 2015), *supra* note 180; APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Jan. 22, 2016), *supra* note 181.
[183] *Reply to Communication from the Examining Division*, *supra* note 180.
[184] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, FINAL REJECTION (Mar. 1, 2016).
[185] *Amended Claims with Annotations*, *supra* note 159.

arguments and amendments without countering the points made by the examiner—a strategy that was ineffective.[186]

Ultimately, the applicants made similar amendments during prosecution, but the different prior art relied on by the patent offices and nonobvious arguments made by the applicants resulted in different outcomes for the applications. In this case, the patent and non-patent references relied on by the USPTO prevented the US applicants from successfully amending their claims, as the applicants did in the EU.

D. Case 4: US 6,346,189 & WO 00/09443

US Patent 6,346,189 was one of the "building block" patents[187] and described "Carbon Nanotube Structures Made Using Catalyst Islands."[188] The US patent issued before the USPTO began publishing prosecution history, so it was not possible to compare the US prosecution with the EU prosecution. However, the European prosecution history was published and revealed the application was abandoned.[189] Previous scholars would suggest the EPO's investment in getting patent quality right at early stages of prosecution gave the applicant a good indication of the likely outcome of their application.[190] In this case, the international prior art search found a US patent and two international patent applications, listed in Table 10, that were relevant to every claim in the patent.[191]

Reference Type	**EPO**
US Patent Documents	US-5,780,101
Foreign Patent Documents	WO-95/10481 WO-98/05920
Non-Patent Documents	Hongjie Dai et al.

Table 10: References Cited by the EPO[192]

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[186] U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (July 27, 2015); U.S. PATENT & TRADEMARK OFFICE, FILE NO. 13392124, APPLICANT ARGUMENTS/REMARKS MADE IN AN AMENDMENT (Jan. 22, 2016).
[187] Lemley, *supra* note 15, at 613.
[188] U.S. Patent No. 6,346,189.
[189] European Patent Office (EPO), *Matter Concerning the Application*, File No. 99932269.6 (Sept. 17, 2001).
[190] *See* Chien, *supra* note 12, at 107.
[191] European Patent Office (EPO), *Copy of the International Search Report*, File No. 99932269.2 (Oct. 21, 1999).
[192] *Id.*

Notably, each of references in the international prior art search are also cited as references in the US patent.[193] Without analyzing the US prosecution, it is not clear whether the references affected the outcome of the prosecution. It is possible the references were included in the US patent without affecting the scope of the claims, like in the previous nanotechnology patent study.[194]

CONCLUSION

The results from the three case studies largely confirm the prediction that US nano patent applications would issue into patents at a higher rate than the European Applications. In one study, the EPO relied on different prior art references than the USPTO and indicated to the applicants early that every claim in the application lacked novelty and an inventive step.[195] Also as predicted, the EU patents contained narrower claims.[196] While the patent offices relied on several common references, the unique references found by the EPO forced additional amendments in the EU applications.[197] This could be explained by the EPO's reputation as a better patent office.[198] It follows that if the EPO applies more examiners and time to each application, one result would be higher quality prior art references. With this in mind, nanotechnology companies should be prepared for different treatment at the EPO than at the USPTO, and, where applications issue into patents, different patent scopes.

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[193] '189 Patent at [56].
[194] Escoffier, *supra* note 45, at 29.
[195] *See* discussion *supra* Section IV.A.
[196] *See supra* Table 4.
[197] *See Reply to Communication from the Examining Division*, *supra* note 137.
[198] Chien, *supra* note 12, at 74.