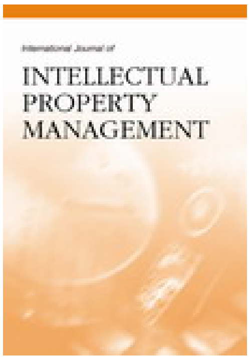

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A framework of evolution and potential impact of nanotechnology in USPTO: the SWOT analysis

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Abstract: Being an emerging technology, nanotechnology provides the most promising tools that impact market growth and our daily lives. However, commercialisation remains a challenge due to ambiguously broad claims of nanotechnology patents. The broadness of the claims of nanotechnology patents is attributed to the absence of prior art and R&D in this domain. Nanotechnology patents fail to get IP protection despite fulfilling the necessary conditions of patentability, and patent protections. Considering these loopholes, the main impetus of the current review is the analysis of the patents granted in nanotechnology and its associated domains, by USPTO during a definite span of 2016–2021. Notably, 50.62% of nanotechnology patent's share in USPTO belongs to US investors and companies, indicating a kind of 'home advantage'. Considering all the stats and facts, the assessment of USPTO nanotechnology patents might help to guide policies and strategic recommendations. Alongside, the SWOT analysis of nanotechnology patents of USPTO predicts the unseen future threats and opportunities, and measures to prevent technological weakness, enhancing development.

Keywords: cooperative patent classification; CPC; nanotechnology; patent; R&D; SWOT; USA; United States Patent and Trademark Office; USPTO.

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1 Introduction

The advancement of nanotechnology in the naive domains can have a driving influence on global patent organisations. The bombarded growth of patent publications in the United States Patent and Trademark Office (USPTO) shows the impact of patents on academicians and industries (Kashyap et al., 2020). As nanotechnology is the most rapidly evolving technology in the contemporary world, because of huge investments by both governmental and private organisations, at the nanoscale (Huang et al., 2010). These patents which are granted by the USA's federal agency, i.e., USPTO, protect the claims in the USA and its associated territories only, for 20 years from the date of filing the patent (Bawa, 2007). The patent office of the USA has published immense sum of nanotechnology patents during 2016–2021 and had undergone remarkable but sudden growth. After 1980s, the number of patent application and granted patent paced up with a boom (Arundel and Kabla, 1998; Kortum and Lerner, 1999; Marinova, 2002). It is notable to mention that the growth was four-fold during the span from 2001–2010 (Singh, 2017). Nanotechnology would probably have a deep horizontal impact on almost all kinds of industries including societal, economic (Link and Gorsuch, 2018) human health, environmental and strategic industries, and have the potential to revolutionise various sectors well (Bowman and Hodge, 2006; Woodson and Duy, 2015). After observing its huge potential, various nations had prioritised funding in R&D for nanotechnology, leading to its escalated growth (Huang et al., 2010). The government of USA adopted nanotechnology as a priority and funded its research as top priority (Link and Gorsuch, 2018) under its national nanotechnology initiative (NNI) (Jia, 2005; Marinova, 2002; Robles-Belmont and Vinck, 2011; Woodson and Duy, 2015) recently, which acted as a driving force behind huge nanotechnology patent applications. Nanotechnology has the huge potential to change our world at almost the same pace as of computer revolution. The USA NNI initiative provides a basic framework for the future of nanotechnology (Chachibaia, 2014).

USA's NNI had explained and defined nanotechnology indicating its flawed patent classification framework (Bawa, 2007), which need to be resolved. The USA took the lead in nanotechnology-related expenditures in 2016, and countries like South Korea, Germany, Japan, etc. follows the USA (Calipinar and Ulas, 2019). Furthermore, the USA remained the leader in nanotechnology research and related publications, allocating its nanotechnology funding to a diverse range of institutes (Huang et al., 2010). US universities are the pioneer in applying for patents (Calipinar and Ulas, 2019). As per the new definition proposed by International Standard Organisation (ISO/TS18110), any patent is said to be a nanotechnology patent when it has minimum of one claim/about/related to nanotechnology or a code related to it as per international patent classification (IPC) ('Nanotechnology published patent applications in USPTO (Patent)'2020). Government and regulators count on ISO, a hierarchical categorisation framework (Leitch et al., 2012) for maintaining better standards (Calipinar and Ulas, 2019), such standardisation facilitates quick and secure development and growth of the latest technologies, within certain regulatory frameworks (Bowman and Hodge, 2006). The BCC research's report namely, nanotechnology: a realistic market assessment, predicted nanotechnology market growth globally to $64.2 billion by 2019 (McWilliams, 2014). While according to Scitechnol, the global nano market expected growth by 2024 is predicted to exceed a net value of approximately $124 billion US dollars (Adiguzel, 2019).

The salient purpose of patents is to motivate the pioneer researchers to explain their innovative ideas so that other researchers can learn from the previous work that had been done in their domain to contribute to the economic drive (Anuar et al., 2013; Ouellette, 2012; Pearce, 2013; Pal et al., 2007). Patents offer some plausible credible insights as to what we were seeing in our research. It reflects the latest technological advancement and global competitiveness of a particular field (Young-Ki et al., 2016; Zheng et al., 2013). Also, the protocols are described in detail in the patents that are not found in other published literature; it shows that the way new technology is explained is much more authentic and reproducible in patent documents than in a scientific paper as academic researchers deliberately remove crucial steps for reproducing data that they cannot hide out in patent applications (Faunce and Watal, 2010). The patents provide useful information or measure the performance of countries in innovation. On account of its data richness, availability and importance in research and development, the use of patents is highly recommended by scholars (Tseng et al., 2013; Uzma, 2016). However, not all the patent documents are valuable as they are not applied (Youtie and Shapira, 2008). Therefore, patent documents are intensively used to describe a nation's innovation strength in different areas of technology and to map technological trajectories.

Information on the number of patents published reveals trends of technological progression and is good indicator of technology growth which can be applied for the market growth.

The USPTO along with European Patent Office (EPO) are the leaders of patent offices (Chen et al., 2008; Kashyap et al., 2020) due to huge number of patents and their importance. The USA particularly attracts innovators and entrepreneurs on virtue of its large size and technological advancements. Consequently, USPTO receives largest number of foreign applications (Archibugi, 1992), with approximately 50% of US patents are granted to foreigners (Marinova, 2002; Zheng et al., 2013). However, the remaining 50% of US patents are owned by US itself (Barpujari, 2010). As per IP laws, if any aspirant nation wants to lead in naïve technologies, its intellectual property rights (IPR) must be protected and its presence in the USPTO must be significant (Vizcaíno-González, 2020). USPTO covers most of the world's patents in nanotechnology. Thus, to gain a global insight on trends in nanotechnology patents, we have analysed patents granted by USPTO. In the present study, the quantitative analysis of patent data of nanotechnology from USPTO has been done, during 2016–2021. The analysis indicates the accelerated growth of nano-patent during that time and the global advancement in the field of nanotechnology.

Usually, more than 50% of patent applications in a patent office come from their own country (Chen et al., 2008), reflecting a significant 'home advantage'. Along with that, Patent application and grants followed a rapid increase after 1980s (Marinova, 2002) and the number of nanotech patents is on rise in USPTO with passing time (Pearce, 2012). This boom in patenting depicts the beliefs to entrepreneurs, industrialists, policymakers, etc. that patents are conducive to economic and social progress.

Data on the count of patents published reveals the trends of progression, which can later be transformed into commercial and economic benefits. Based on USPTO data, the analysis of strength (S), weakness (W), opportunities (O), and threats (T) in nano-patents was also done using the SWOT model. SWOT is a strategic planning tool and methodology that is used to gain an insight into the unpredictable future threats and weaknesses of the technology, and to find methods for its prevention.

2 Methodology and tools

The primary impetus of our analysis is to forecast US patent activity in the field of Nanotechnology and provide to an end-user the future directions of research and innovation. To reach this goal, a related nanotechnology patent search via patent database 'lens' was run (https://www.lens.org/), which is an open cyber-infrastructure to make the innovation and R&D system transparent, more efficient, fair, and inclusive. Patent Lens is an open, no-cost, reliable tool that aims to bridge academic research, with IP, and Industry, etc. The patent data sets are consisting of many countries. However, in the present work, US patent datasets were used. In addition to the patent data in various countries lens also covers over 14 million USPTO assignments via free and private accounts.

For analysis of US patents having quantum of information, the latest cooperative patent classification (CPC) is used in the present analysis for processing the searches. The CPC is a further extension of IPC and managed by EPO and USPTO, collectively. CPC has nine divisions/sections, A-H and Y, which are further classified into classes, sub-classes, groups, and sub-groups. There are approximately 25,000 classification entries according to the EPO. The classification-based patent searches are the most accurate and authentic as far as a wide range of searches is concerned. In the present study, primarily B82 CPC is used and the related patent data is obtained. The same class and US patent in the lens were found 64,085 on the day of analysis, i.e., 13 August 2021. The whole data is further refined with the date range from July 1, 2016, and July 31, 2021, and 5273 results were obtained, which are further refined with the status of grant and 2027 US granted patents were further considered and analysis was performed.

The queries were selected based on the latest work progress on CPC and to the best of our knowledge; such type of work for this field is neither applied nor explored. A command Lens was made to lens for applying queries in front pages of the patent text, wherein the CPC is mentioned. However, in the present analysis, we have restricted the patent analysis to the granted US patents based on CPC only for the said duration as cited above.

Besides, Table 2 consists of the top most patents associated with nanotechnology in USPTO. The commercialisation value of these patents is mentioned in terms of various indexes alongside indicating their monetary values. These indexes are internally developed tools by United Patents (i.e., a member-based organisation which deters faulty patents in any specific technology field) (2021a). It includes advanced patent IndeX (APIX), broadness indeX (BRIX), citation indeX (CITX), portfolio value IndeX (PVIX), ReNew IndeX (RNIX) and SaVe IndeX (SVIX). The above indexes are delineated in the section below.

1. APIX: a measure of patent's validity, by rating the survival probability of patent using administrative patent review (PTAB). The APIX score is given from AA, A, B, C, D, etc. where AA is most likely and D is less likely to survive a PTAB challenge (Pandey et al., 2021; Advanced Patent Index, 2021).
2. BRIX: the patent broadness value is determined using unique claims language in CPC. AA denotes the broadest claims while D means the narrowest (Pandey et al., 2021; BRIX, 2021).
3. CITX: it is similar to APIX and measures patent value. It holds the fact that the market value of patents is highly correlated with its forward citations. Where D denotes the lowest CITX rating and AA is the highest (Pandey et al., 2021; CITX, 2021).
4. PVIX: it measures the patent's portfolio value and calculates the score based on family score, market score and reputation score. The patents with similar kinds of technological descriptions belong to one family. Each patent family has a separate PVIX score (i.e., the sum of individual scores of patents). It analyses the technological as well as the geographical impact of patents (Pandey et al., 2021; PVIX, 2021).
5. RNIX: it is the difference between PVIX – SVIX, as it analyses the patent value with the cost of patents fees remaining. A negative value means the cost still has to be paid on renewal fee is more than the patent value of the family, i.e., SVIX > PVIX while for a positive value PVIX > SVIX (Pandey et al., 2021; SVIX, 2021).

6 SVIX: it analyses the unique patent families to determine the annuity payment that has to be paid over the life of the patent family. A higher SVIX score means higher payments are required (Pandey et al., 2021; RNIX, 2021).

3 Data and discussion

3.1 Patent counts per year and with the earliest priority

Patent registrations mean a date on which a patent application is filed, is not the same as the patent issue date. Patent application date is accepted as the more accurate measure of patent activity (Marinova, 2002). There is a significant lag between the date of application and the date of patent issue (in some cases up to ten years); it usually takes around two to three years for a patent application to get approval by USPTO (Marinova, 2002; Zhang et al., 2017). Thus, the patent count of last 2 to 3 years of sample period is eventually high than their current numbers. The number of publications per year is depicted in Figure 1(a). It is observed that the number of patents in nanotechnology was higher in 2017, i.e., 2146 patents.

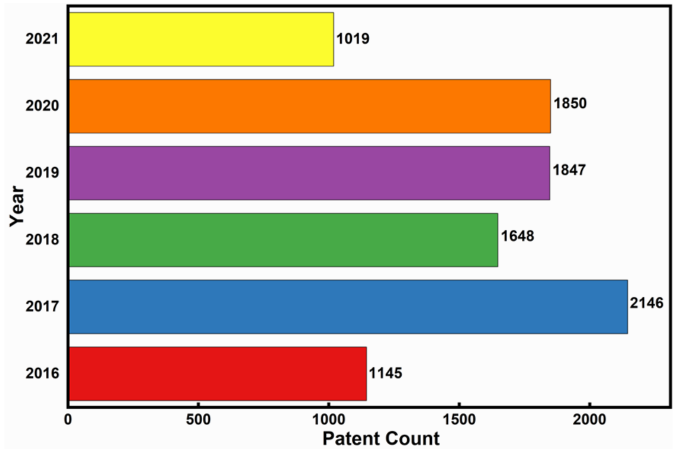
Furthermore, Figure 1(b) indicates the patent filing trend, with the earliest priority. During the year 2016, the patent count is showing an inverse relationship; the 414 patents got the earliest priority but the number of the patent filed was 90. The filing count shows an abrupt increase from the year 2016 to 2017 to 2018, i.e., almost six and eight times respectively. But the earliest priority got decreased. From the year 2018 onwards, the earliest priority kept decreasing abruptly and remains only 19 counts till the year 2020. Thus, indicating the abrupt growth of nanotechnology patents, however, the published count was still quite significant.

3.1.1 Top applicants

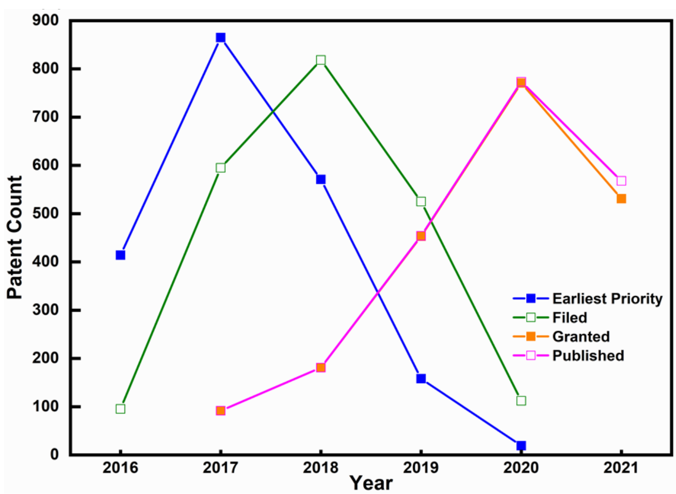
The USA is the top ranker with a share of about 50.62% of all nanotechnology patents in USPTO (‘Top Ten Countries in Nanotechnology Patents in 2017’). China and the UK rank second and third, respectively with a great difference following the USA. China took the previously obtained second place of South Korea with significant growth in the number of nanotechnology patents. Enhanced number of patents from China and the UK are due to the negative growth of South Korea and Japan’s nanotechnology patents.

The top ten applicants of nanotechnology patents are shown in Figure 2(b); which makes up most of the nanotechnology patents in USPTO. The top applicant is IBM with 357 patents during 2016–2021, which stabilised the dominance of the USA in nano patents. These top ten applicants contribute the majority share of all the nanotechnology patents. While Taiwan’s Taiwan Semiconductor Mfg. Co Ltd. and South Korea, Samsung Electronics Co. Ltd. have maintained their spots.

Figure 1 Nanotechnology patent publication status, (a) number of publications per year, (b) patent filing trend with the earliest priority and grant status (see online version for colours)



(a)

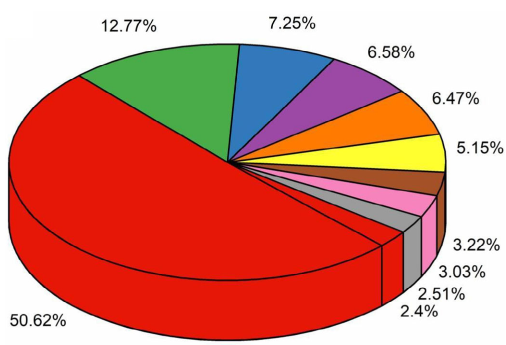


(b)

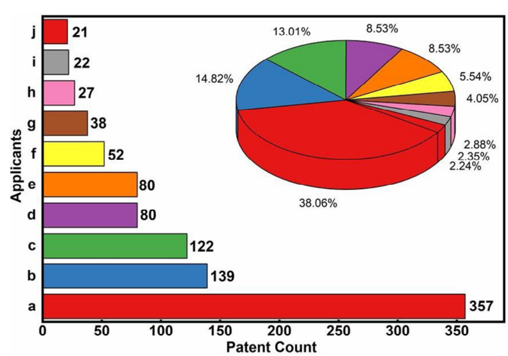
3.1.2 Top CPC classes

Figure 3 shows the CPC classes which are most innovative and have the most patent published. Any patent which has even a single claim regarding nanotechnology is categorised under 'B82' (nanotechnology) in CPC is fully dedicated for nanotechnology patents, which is a subclass under 'B' (performing operations; transporting), and 'B82Y' deals with 'Specific uses or applications of nanostructures; measurement or analysis of NANOSTRUCTURES and manufacture or treatment of nanostructures. 'H' (electricity) categories and subclass 'H01' (basic electric elements), i.e., 'H01L' [semiconductor devices; electric solid-state devices not otherwise provided for (use of semiconductor devices for measuring G01; resistors in general H01C; magnets, inductors, transformers)] and ‘H01L29’ (semiconductor devices adapted for rectifying, amplifying, oscillating or switching, or capacitors or resistors with at least one potential-jump barrier or surface barrier, e.g., PN junction depletion layer or carrier concentration layer; details of semiconductor bodies or electrodes thereof; multistep manufacturing process thereof) have some component related to nanotechnology which interconnects the field of electricity with nanotechnology (Leitch et al., 2012), posing certain interdisciplinary technological advancements of nanostructures in electronics as well. The top three CPC classes are under group-B (performing operations, transporting) in B82Y while the next 6 belong to electricity, indicating the role of nanotechnology in the current advancement in the field of electrical devices.

Figure 2 (a) Top countries with nanotechnology patents where more than 50% of the patents belong to USPTO, (b) Top applicants of nanotechnology-based patents in USPTO [(a) IBM, (b) Taiwan SMCL, (c) Samsung ECL, (d) Hon Hai Prec ICL, (e) Univ. Tsinghua, f. Global foundries INC, (g) Intel Corp, (h) Univ. King Saud, (i) Imec Vzw, (j) Applied Materials Inc.) (SMCL-Taiwan Semiconductor Mfg. Co. Ltd., ECL-Samsung Electronics Co. Ltd., ICL-Hon Hai Prec Ind Co. Ltd.] (see online version for colours)



(a)



(b)

According to IPC, most of the nanotechnology patents are published under section ‘B’ (performing operations; transporting), ‘H’ (electricity), ‘C’ (Chemistry, metallurgy), and ‘G’ (Physics) (Chen et al., 2008). While as described in Table 1; CPC is a more detailed version of IPC, was jointly propounded by USPTO and EPO. It has nine sections, which categorises the broad areas to which a particular patent belongs (Anuar et al., 2013).

Figure 3 Top most CPC classes related to nanotechnology patents [(a) B82Y10/00, (b) B82Y40/00, (c) B82Y30/00, (d) H01L29/775, (e) H01L29/673, (f) H01L29/66439, (g) H01L29/42392, (h) H01L29/78696, (i) H01L29/66545, (j) B82Y20/00) (see online version for colours)

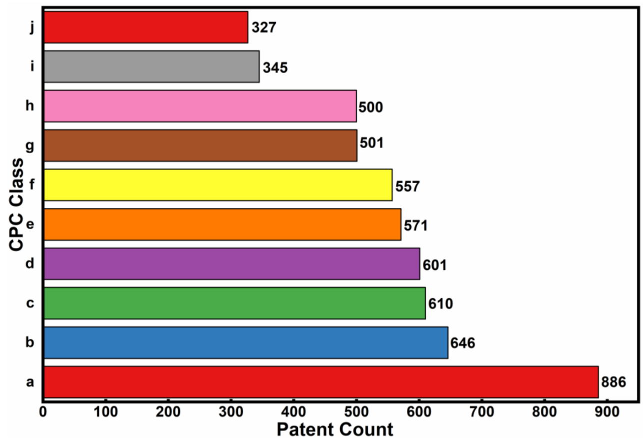


Table 1 Nanotechnology related sections of IPC classes and their field of operation

Sr.	*Scheme*	*Description*	*Classes*	*Subclasses*
1	B	Performing operations; transporting	B82 (Nanotechnology)	B82B (nanostructures formed by atomic manipulations: manufacture and treatment)
				B82Y (specific applications of nanostructures, uses, analysis, manufacture and treatment)
2	H	Electricity	H01 (Basic electric elements)	H01L (semiconductor devices; electric solid-state devices not otherwise provided for)
				H01C (Resistors)
3	C	Chemistry, metallurgy	------------	---------------
4	G	Physics	-------------	--------------

3.1.3 Top citation count applicant and claim basis

Table 2 describes 'citation count' shows the number of the citation with publishing year. A patent from Global Foundries Inc. titled 'methods of forming nanosheet transistor with dielectric isolation of source-drain regions and related structure' (Aamer, 2015) (US 9,947,804 B1) got maximum citations. Followed by a patent from Nanoclear Tech Inc. titled 'property control of multifunctional surfaces' (US 10,017,384 B1). Maximum of four patents from Global Foundries Inc. are in the top ten highest citation lists, showing its fast work and high patent filing, followed by IBM which has three patents in the top ten. The first patent having the maximum number of citations, i.e., 32 titled 'Methods of forming nanosheet transistor with dielectric isolation of source-drain regions and related structure' has only 14 claims which are related to the integrated circuit (IC), design and structure with bottom dielectric isolation like mechanism. Another patent from Nanoclear Tech Inc. titled property control of multifunctional surfaces has 26 claims related to surface modification of product via non-bonded interactions, to achieve desired physical and chemical properties using nanomaterials coatings. The third patent of IBM titled 'inner spacer for nanosheet transistors' has around 19 claims related to a method of fabrication of semiconductor devices and FET. Hence, the trend of claims and citations is quite inconsistent. It indicates the claims and citation do not correlate with each other. Quantity is not enough to indicate the hold of a nation in the nanotechnology arena, quality is much needed. Quality is measured by the citation (i.e., the number of times a patent is cited by other researchers), which showcases the influence of a country in the field of nanotechnology. US patents are with the highest number of citations which indicates their quality, influence, and hold in nanotechnology (Youtie et al., 2008).

Table 2 The top most patents (as per the citation count) associated with nanotechnology in USPTO, along with their quality indexes

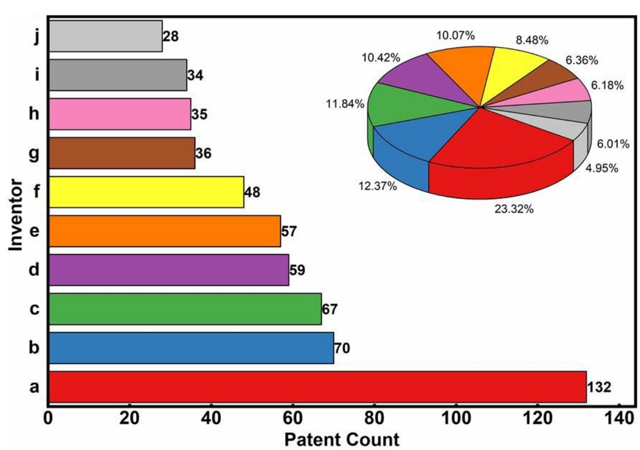
Patent no.	*Title*	*Citation*	*Claims summary*	*Reason of inclusion*
US 9,947,804 B1	Methods of forming nanosheet transistor with dielectric isolation of source-drain regions and related structure.	32	Related to the IC, their design and structure based on electrically isolated stacked nano-sheet Field effect transistor (FET) with bottom dielectric isolation like mechanism.	APIX: AA CITX: D BRIX: C PVIX: 66.3, RNIX: 65.58, SVIX: 0.71
US 10,017,384 B1	of multifunctional surfaces	27	Related to surface modification of product via non-bonded interactions, to achieve desired physical and chemical properties using nanomaterials coatings.	APIX: AA CITX: D BRIX: B, PVIX: 63.06, RNIX: 62.29 SVIX: 0.75
US 9923055 B1	Inner spacer for nanosheet transistors	27	Related to a method of fabrication of semiconductor devices and FET	APIX: A, CITX: D, BRIX:C, PVIX: 61.24, RNIX: 60.53
US 9847390 B1	Self-aligned wrap-around contacts for nanosheet devices	24	Etch stopped layer wrapped around on nanosheet transistor for forming a source/drain region, covered by sacrificial layer, followed by the dielectric layer	APIX: B, CITX: D, BRIX: A, PVIX: 60.26, RNIX: 59.92, SVIX: 0.33
US 10103736 B1	Four-input Josephson gates	23	Reciprocal quantum logic (RQL) gate circuit to receive and store positive single flux quantum (SFQ) pulses, utilising four logic loops.	APIX: A, CITX: D, BRIX: B PVIX: 60.15, RNIX: 58.88 SVIX: 1.26
US 9984936 B1	Methods of forming an isolated nano-sheet transistor device and the resulting device.	22	Formation of the sacrificial gate over a semiconductor stacked substrate making a source/ drain region for deposition of the conformal layer.	APIX: AA, CITX: D, BRIX:C, PVIX: 59.56, RNIX: 59.17 SVIX: 0.38

More the claims a patent has the more protection it provides for any infringement of the rights of the patentee. More claims do not necessarily mean it will provide more citations to a patent. It only indicates the amount of protection a patent will provide. Most of the other highly cited patents have claims related to the variability of semiconductor devices, FET and different methods and materials used to make those devices and different nano-sheet stackings. Six out of the top ten patents are related to nano-sheet and its stacking and usage in transistor devices (1, 3, 4, 6, 8, and 10). Only one applicant has a patent related to carbon allotropes whose claims are completely varied from the other nine highly cited patents (7). The claims of these highly cited patents indicate the trends of nanotechnology during 2016–2021 which are mostly related to semiconductor materials and nanosheet stacking (Herr and Herr, 2016) and variable orientations to place them.

3.1.4 Top ten inventors

Figure 4 shows the top inventors in the nanotechnology domain during 2016–2021, Cheng Kangguo is the top inventor with the highest patent count of 132. But he is associated with top applicant Global Foundries Inc. and top second IBM; Xie Ruilong is the second most active inventor who is also associated with Global Foundries Inc. as well as with IBM. While 3rd and 4th inventors are Fan Shou-shan and Lee Choonghyun, respectively. Cheng Kangguo has replaced Fan Shou-shan from being the top inventor till 2019 while Fan Shou-shan took the fourth position. Two prominent inventors Cheng Kangguo and Xie Ruilong belonging to two major applicants Global Foundries Inc. and IBM mark the dominance of these organisations and inventors in the field of nanotechnology associated with US patents.

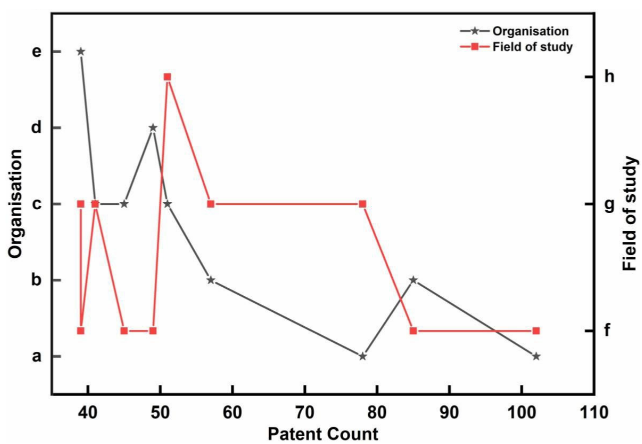
Figure 4 Top ten inventors in the field of nanotechnology in USPTO [(a) Cheng Kangguo, (b) Xie Ruilong, (c) Fan Shou-Sshan, (d) Lee Choonghyun, (e) Reznicek Alexander, (f) Li Juntao, (g) Jiang Kai-Li, (h) Zhang Jingyun, (i) Ando Takashi, (j) Frougier Julien) (see online version for colours)



3.2 SWOT analysis of the data

SWOT technique analyses the internal and external factors that define the potential of emerging technology (here we did a SWOT analysis of USPTO patents of nanotechnology) to affect future technologies, market flow, and global economic trends. SWOT is a kind of foresight module element to analyse the current status of nanotechnology which predicts the qualitative commercial potential of nanotechnology (Malanowski and Zweck, 2007). The Strength and weaknesses of nanotechnology are the internal factors however; the opportunity and threats are decided by the external agencies that cannot be controlled by the pros and cons of the nanotechnology itself, predicting the future trends of the nanotechnology (De Groot and Loeffler, 2005). SWOT matrix helps to bridge the loopholes emerging between the future researches and the conventional market research, in the emerging state of a new technology trend. As nanotechnology is in its naive/ infant stage of evolution, we did the SWOT analysis.

Figure 5 Shows the top most organisations with most numbers of patents granted and their field of study [(a) Chinese Academy of Science, (b) MIT, (c) Harvard University, (d) IBM, (e) Stanford University, (f) material science, (g) nanotechnology, (h) biology] (see online version for colours)



- Strength (S): it is measured by the increasing number of patents granted, accelerated patent filing, quality of patents, number of claims a patent is having, R&D, and innovation of nano-patents. The US being the top ranker have about 50.62% share of all nanotechnology patents in USPTO. Nations like China and the UK follow the USA. More patents granted indicate the fast growth of nanotechnology in these developed countries. It also shows that the industries of developed countries have an upper edge in USPTO counts overdeveloping ones except for China. CPC classifications say the B class has more innovation which is related to R&D in transportation and performing operations. Maximum of four patents from Global Foundries Inc. are in the top ten highest citation lists, showing its fast work dominance, and high patent filing. Thus, indicating the strength in this field (Chen et al., 2008). Alongside, three patents from IBM are in the top ten highly cited lists, giving tough competition to Global Foundries Inc.

- Weakness (W): more the number of claims a patent has the more protection it provides for any infringement of the rights of the patentee. But sometimes it poses big problems due to the fallacious nature of claims. Also, the extensive patenting is rapidly increasing the cost while slowing down the development of this evolving area as downstream experimentation and innovation usually infringe the previously existing broad patent claims, due to the immaturity of the nano field. Which need to be relaxed for its rapid growth (Pearce, 2012). Broad claims with patenting on basic inventions are making nanotechnology patenting more troublesome (Barpujari, 2010; Singh, 2017). The current data from 2016-2021 indicates the lag timing between patent application and grant by USPTO, which needs to get fasters and smoothers to encourage new innovators to apply for patents to save their IPR and remains relevant as far as technology is concerned (Anuar et al., 2013).
- Opportunities (O): the USPTO has more patents belonging to developed nations, which signifies the competitiveness and speed of these countries in R&D in nanotechnology. The patent-related activities cause immediate growth in market flow (Marinova, 2002). Although, the growth of patents granted was fluctuating but was quite significant. This indicates the future opportunities in emerging domains of nanotechnologies in developed countries like the USA, UK, Japan, South Korea, etc while China is an exception from the developing world. The countries, which are not at all in the race of filing patents in nanotechnology and have their research and innovation have great opportunities to patent and monetise the patents and keep their significance in the competitive world.
- Threats (T): even though the data shows more than 50% of patents of USPTO belong to the USA indicating a home advantage. But the rapid growth of Chinese enterprises and the United kingdom's dominance and Japanese industries might pose challenges for American enterprises. Also, the other contemporary technologies i.e., the complementary assets accumulate competitors and might exert fierce influence in the similar hot emerging R&D field of nanotechnology (Fernández-Ribas, 2010).

4 Conclusions

Nanotechnology is the emerging future technology as it is green technology; needs very few resources. Hence, it will pose a major impact on the environment and the economy. As per the data collected and the information that has been gathered an analysis via SWOT matrix tool was done which indicates the elements of foresight module for the growth of nanotechnology in the USA. The annual trend of the patent filed and the patent granted during the span indicates the growth and need for nanotechnology. US government has taken various initiatives to ignite innovative growth, which has accelerated the growth of patents, indicating the industrial competitiveness and development of nanotechnology. Also, a major difference in the count of the patent filed and granted was seen, which might have been less due to the administrative delays. As patents can determine the industrial competitiveness, innovation, commercial and academic developments as well. More the enforced claims a patent has the more protection it provides for any infringement of the rights of the patentee. The study finally concludes with certain recommendations to help reconcile the urgency to prioritise funding in certain domains over the others. The patent regime also protects the public interests and ensures its accessibility must not be blocked due to malignant claims.

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