Chapter 3:

Literature Review
3.1 Literature Review

Nanotechnology is application of nanoscience which is rich branch of science which has input from all discipline of science i.e. from physics, chemistry, electronics, biology and engineering. Nanotechnology is understanding and control of matter at dimension of roughly 1 to 100 nanometre where unique phenomenon enables novel application.

Commercialisation of Nanotechnology is one of most significant aspect of world economy and will impact each and every industry. This has given tremendous rise in number of publications and patent filings estimated to 19 percent compound annual growth rate (CAGR). Market research estimated nanotechnology product of worth $254 billion incorporated by 2009 and it is forecasted to raise $2.5 trillion globally by 2015. Nanomaterial has impacted major industries and thus this has lead to commercialisation of nanotechnology in electronics, manufacturing medical, pharmaceutical, oil and gas, aerospace, automotive, construction, energy and environment.

3.2 Origin of Nanotechnology

The basics of nanotechnology was first highlighted by the physicist Richard Feynman in his seminal talk on December 29th 1959 at the annual meeting of American Physical Society, at California Institute of Technology entitled “There is plenty of room at the bottom”. In this talk he anticipated the possibility of controlling matter at a very small scale and thus introduced the scientific community to a new field of enquiry and thus paved a way for Nanotechnology. He was felicitated by noble prize for the same. This was first published in February 1960 issue of Caltech’s Engineering and Science, which owns the copyright. It has been made available on the web [http://www.zyvex.com/nanotech/feynman.html](http://www.zyvex.com/nanotech/feynman.html) with their kind permission.

The term Nanotechnology was first time introduced by in 1974 by Norio Tangichi from the Tokyo University of Science, while the basic idea of this technology was explored in greater detail by Eric Drexler in his much-cited book “Engines of Creation – The Coming Era of Nanotechnology” from 1986.

Davis Baird & Ashley Shew of Department of Philosophy, University of South Carolina in their article “Probing the history of Scanning Tunnelling Microscopy published in Discovering the Nanoscale”, Amsterdam: IOS Press, 2004 described
brief history of the development of scanning tunnelling microscopy (STM). These microscopes, developed in 1981 by Gerd Binnig and Heinrich Rohrer (Nobel prize 1986), are capable of imaging and manipulating at an atomic level. These put way forward for nanotechnology. Fullerenes (C60) were discovered in 1985 by Richard Smalley, Harry Kroto and Robert Curl who won the 1996 Nobel Prize in chemistry. Fullerenes are any molecule composed entirely of carbon in the form of a hollow sphere. A C60 fullerene is a fullerene made up of 60 carbon atoms with a cage-like fused-ring structure that resembles a soccer ball.

Gerd Binning examined the use of atomic force between atoms rather than tunnelling current, to move the scanning tip over solid’s surface. Binning shared his ideas with Christopher Gerber of IBM Zurich and Calvin Quate of Stanford, and soon they had produced a prototype of a new type of scanner, the atomic force microscope (AFM), which started a new field of microscopy. The AFM made it possible for the first time to image materials that are not electrically conductive.

K. Eric Drexler is said to be “The founding Father of Nanotechnology”. In 1981 he introduced concept in his seminal paper in the Proceeding of the National Academy of Science; which established fundamental principles of molecular engineering and designed development paths toward advanced nanotechnology. In 1986 book published by him with title, Engines of Creation: The coming Era of Nanotechnology, he introduced a common man to fundamental technology objectives: using machine that works at the molecular scale to structure matter from the bottom up. Drexler’s research in this field has been the basis for numerous journal articles and a comprehensive, physics-based analysis in Nanosystems: Molecular Machinery, Manufacturing, and Computation. In his publications and lectures, Dr. Drexler describes the implementation and applications of advanced nanotechnologies and shows how they can be used solve, not merely delay, large-scale problems such as global warming. He gave future vision of potential feasibility of molecular manufacturing and possibility that nanotechnology may be able to be used to build virtually anything, arrange atoms in almost ‘any reasonable arrangement’ and self-replicating ‘nanobots’ can be considered.

P.M. Ajayan, J.C. Charlier and A. G. Rinzler in their article Carbon nanotubes: From macromolecules to nanotechnology discussed the discovery of nanotubes which happened in 1991 when Dr. Sumio Iijima of NEC corporation found
these tiny needles on electrodes used to prepare fullerene. The development of nanotechnology and nanoelectronics based on nanotubes is certainly most promising event in nanotechnology principles.

Final report prepared for the Department of Innovation, Industry, Science and Research by Ms Kate Seear, Alan Petersen and Dr Diana Bowman from Monash University Victoria, Australia with title, “The Social and Economic Impacts of Nanotechnologies: A Literature Review” find out the various commentary on nanotechnology origin, historical context, social and economic impact and Australian context. This report says that there has been a sharp increase in commentaries on the social and economic impacts of nanotechnology in recent years. The risk and regulation of nanotechnology is the central outcome of discussion of maximum papers. There are uncertainties about the applications and impact of nanotechnology in term of social and economic aspects, long term risk and public response to the innovative nature of nanotechnology. The huge gap exists in existing and desired further research and analysis. There was huge scope for further detailed analysis of literature. The economic crisis of 2008-09 has impacted investment in Australia and other countries. The future literature is optimistic about future of nanotechnology.

3.3 Challenges of nanotechnology commercialisation

Dr. Madhuri Sharon (MD) Adjunct Professor (Mumbai University) in her article “Nanotechnology Commercialisation in Indian scenario“, tries to highlight the advantages and problems linked with commercialisation of nanotechnology in Asia and especially in India. Problem faced by nano technocrats in research and development and setting industry are discussed and also strategies for reducing the barriers to commercialisation are being suggested. The paper says that commercialisation has already started with launch of few products and also some upcoming products are on the way. Inception, running, funding, growth and problems are the area of research of nanotechnology commercialisation. According to author the major problems are limited market for nanomaterial, underestimating the difficulties in commercialisation, huge fund requirement. The major barriers are scientist are interested in publishing paper rather than scaling it up commercial application, getting patent faster clearance, lenient Indian standard hampering export ,lack of standards in nanotechnology standards in India. These problems and barriers are common faced across all over world including India.
The article published in Science and Public Policy Advance Access on May 22, 2013, "Emerging technologies in India: development, debates and silences about nanotechnology by Koen Beumer and Sujit Bhattacharya, this paper outlines the developments, discussions, and silences concerning nanotechnology in India. Quantum analysis was made based on research paper and patent details retrieved from science citation index- expanded (SCI-E) accessed web of science. Patent data from Delphion database, Indian Patent office was used. Newspaper clipping service called Indian business insight database product was used. EBSCOHOST was used to derive the data. The analysis says that the nanotechnology development in India is dominated by Government initiatives. Government investments led to a steady rise in global publication rankings, scientific collaborations and the number of institutions involved. This growth is mainly rooted in fundamental research and public research institutes. Industry involvement and patenting activity are at a nascent stage and developing slowly. Issues that were raised in the Indian context relate to funding, capacity, commercialisation, regulation of risks, and the distribution of benefits. Nanotechnology is positively viewed across the board, with notable silences on ethical issues and the relation to the public. In India companies want ready to use technology instead of investing on R&D. There is huge scope for nanotechnology in India.

Tetsuya Kirihata, Associate Professor at Kyoto University, and Visiting Associate Prof., Nara Institute of Science and Technology, published a article “The Challenges and issues with Nanotechnology at the product development stage”. In this article he tries to study issues and challenges faced by the manufacturer at product development stage to nanotechnology commercialisation in Japan. A questionnaire was designed and conducted with 329 respondents out of which 132 respondent at Osaka Science and Technology Centre Kansai nanotechnology promotion conference. Process for commercialisation is divided into three stages: basic research stage, product development stage and commercialisation stage. This paper reveals that “funding”, “external collaboration”, and “extracting visions and conceptualizing market needs” are the main challenges at the product development stage of nanotechnology business. Major problem faced by all manufacturers is that of funding. Nanotechnology R&D is quiet expensive as compared to other upcoming industries. The other major challenge faced is availability of skilled human resource. Public support is most important to overcome all this challenges.
Mangesh Nandagopal, Kaushik Gala and V.Premnath from National Chemical Laboratory, Pune presented their paper “Improving technology commercialisation at research institutes: Practical insights from NCL Innovation”, at Innovation Educators Conference (IEC) at Indian School of Business, Hyderabad. They highlight the problem faced by the researchers and scientists as well as research institutes in translating technology into product and services. It tries to resolve practical issue faced by researchers in multipronged approach to increase technology productivity. National Chemical Laboratory (NCL), Pune is one of the flagship laboratory of CSIR with around 200 researchers, 500 students and 800 project assistant. NCL has being leading many agro chemical based industries. NCL is looking for entry in public-private, public-public partnership to jointly develop and commercialise its technology. The major problem of commercialisation is week knowledge of input technology. To get bureaucratic free mindset investors investing in creating a cadre of high quality technology managers who create facilitating mechanism and help to define problems and also work toward it creating the atmosphere conductive for it. The authors says that mindset of researcher that they cannot be entrepreneur need to be hanged and also funding for basis start up of technology is required.

Laura Mazzola from Excelling Life Sciences, California, USA chairman of forum on NanoBio Convergence in her article “Commercializing Nanotechnology” highlights the initial commercial efforts in life sciences utilising nanotechnology. Author discusses the challenges in commercialisation of nanotechnology in the field of biotechnology. Selected companies and their focus area of biotechnology using nanotechnology are being discussed. Various funding program by the universities through Government agencies has been found out. Also the area where nanotechnology can impact has been discussed in the article. The major challenge to commercialisation of nanotechnology will be to identify a market for the tools nanotechnology can provide. The another major challenge is to develop application that will leverage a nanotechnology based aspect. Basic field of biotechnology where nanotechnology has been applied as bio analysis, drug delivery and therapeutics, biosensors and medical devices has been explained. Author recommends that many applications of nanotechnology at the conceptual level which will need huge R&D before being utilised for production. This article gives good insight to us about how nanotechnology
is being used in biotechnology for exploring the field and how various Government agencies, universities and economic centre are funding for it.

Marina Fiedler from University of Passau and Isabell M.Welpe from Technical University of Munich, Germany in their article, ”Antecedents of cooperative commercialisation strategies of nanotechnology firms” published in Research Policy focus on antecedent for cooperative behaviour in commercialisation of nanotechnology for small and medium enterprises (SME) and large firms which is to be examined .They tried to study relationship between intellectual property rights protection for small and medium cooperative commercialisation strategy. Hypothesis are developed and tested using sample survey design and data collection .Data of pretested survey of small ,medium and large nanotechnology firms of Germany (96 large and 336 small and medium sized firms)were surveyed. The survey finding says that nanotechnology help to make miniaturisation possible .New products and attributes to the application of nanotechnology are possible. Improved possibilities for analytical measurement in nanometre .Lot of tools and process which were micro system or microtech are now grouped as nanotechnology thus firm expert in micro technology are leading in nanotechnology. The research paper successfully discovered the cooperative behaviour in commercialisation of nanotechnology for small and medium firms in antecedent while that of large firms is associated with acquisition of other firm intellectual property rights.

A report on study of two Universities The Pennsylvania State University and The University at Albany in New York State has been published with title ”Mitigation of barrier to commercialisation of nanotechnology : An overview of two successful University – Based initiatives”. These two universities have significant contribution in the nanotechnology. They are profiled as role model for other research institution who invested in R&D and commercialisation project. The two nanotechnology centre of the both above universities are being highlighted and detailed study being made on the barrier to the commercialisation of nanotechnology. National Nanotechnology Initiative (NNI) provides support for utilization of nanotechnology by funding, making trade mark offer. At The Pennsylvania State University Nanofabrication facility (nanofab) is a complete open access to National Nanotechnology Initiative (NNI). Centre for Nanoscale Science and Engineering
(CNSE) at The University at Albany in New York States centrepiece at institute of commercialisation of nanotechnology.

Anthony Waitz and Wasiq Bokhari in their paper “Nanotechnology Commercialisation Best Practices”, tries to find out some key factors for success of commercialisation of nanotechnology. They find out how common strategies help companies to gain venture capital while some different strategies that companies used which were struggling with funding. The consultant from Quantum Insight has been in touch with more than hundred of new companies in the field of nanotechnology. The large number of example are being studied and discussed of companies that are pure nanotech start-ups and other small tech start up. Intellectual Property right and patent filling is most important issue of any nanotech start up. Involvement of inventor is most important for any invention to be utilised. Spin out, independent entrepreneur are the way of nano start up. Well disciplinary team, multidisciplinary skill sets needed to accomplish business goal. The common sources of funding are friend, family, angels, venture capital, Government and corporate partners. The common practices for getting funding is to write good proposal, experience team, focused efforts and to avoid pitfalls are avoiding wrong investors, lack of technical understanding is the lack of business understanding by venture capital and getting government grants. Common strategies of funding are partnering with large corporation spin off technologies from common underlying technologies. The single most important success factor is that having a management team that have strong target market knowledge.

Elicia Maine, Academic Director, Management of Technological MBA, Beedie School of business, Simon Fraser University, in their paper “Scientist-Entrepreneurs as a catalyst of nanotechnology commercialisation”, tries to find out of constraint of commercialisation of nanotechnology. The author suggests some possible way out for resolving this constraint. Scientist and Entrepreneurs should have developed knowledge about principles and practices of entrepreneurship, patent processes and considering partner for alliance. They should instantly commercialize a lower risk substitute application and at last should employ a hybrid organisational structure in joint venture. Author made observation on the employees of firm of Nanogram Corporation, Nanogram Devices, Neophotonic Corporation and Kainos Energy Corporation. They found the above factors to promote nanotechnology commercialisation and the scientists and entrepreneur will serve as catalyst for this
commercialisation as the span for research and final outcome of nanotechnology is quite unpredictable and heavily expensive.

Vincent Mangematin from France and Steve Walsh from University of New Mexico try to poke how future of nanotechnology will move toward nanotechnology leading to application with higher value such as nanobiotechnology, nanoenergy, nanomaterial etc. The objective of authors is to present a state of art synthesis of current thinking about the management of nanotechnology. Nanotechnology based solution promises to transform nearly every aspect of life. It took decade to generate significant public investment. Nanotechnology will be critical to 21st century scientific advancement. It will lead to technological development leading to product innovation and social innovation. Scientific convergence appears to be slower than the integration of nanotechnology in existing or new product or processes. Nanotechnology is general purpose technology (GPT) which helps in creating new ways and new devices to improve the quality of life. The regulation and acceptance of nanotechnology remain important issue of further study. The further research need to be done in the direction of resolving challenges faced and future ahead of nanotechnology.

Cheol-Ju Lee and SuKap Lee from KEIT (Korea Evaluation Institute of Industrial Technology), Myung S.Jhon from Mellon University, Pittersburgh and Juneseuk Shin from Sungkyunkwan University in their paper “Factor influencing nanotechnology commercialisation: An empirical analysis of nanotechnology firms in South Korea”, tries to find out key factor of nanotechnology commercialisation. The purpose is to quantitatively analyze the key factors that influence the commercialisation of nanotechnology and related sales of nanotechnology. The authors collect data from 206 Korean nanotechnology based companies. Utilisation of these potentially toxic materials makes commercialisation difficult even if products are not toxic it is difficult to determine. The barriers to nanotechnology commercialisation can be low industrial investment and patent productivity. As per 2004 data Government funding for nanotechnology R&D in South Korean rank fourth across globe. Environment friendly nanotechnology based product manufacturing firms more likely to enter commercialisation better than other firms. Regression analysis is used based on various data point collected and different results were derived. Government support for nanotechnology R&D in the area of energy and environment field together with
clarification on toxicity related issue will achieve two goals. Stable long term accumulation of technology and surveys of public acceptance for technology needs to be carried out.

Jye-Chyi Lu from Georgia Institute of Technology, Atlanta, Shuen-Lin Jeng, National Cheng Kung University, Tainan and Kaibo Wang, Tsinghua University, Beijing in their article, “A Review of Statistical Methods for quality improvement and control in Nanotechnology” published in Journal of Quality Technology discuss the use of statistical method which helped rapid development of nanotechnology in term of data collection, treatment effect and quality control. The article include experimental design, uncertainty modelling, process optimization and monitoring are area in which future research is to be carried out. Encompassing nanoscale science engineering and technology, nanotechnology involves imaging measures modelling and manipulating matter at length scale. The four generations of nanotechnology are discussed in the article. Various features of statistical procedure are highlighted. Author has suggested measures for better quality improvement and control in nanotechnology. The physical and chemical properties varies at nanoscale than a material and this has impacted the statistical process control and analogue process control technology in nanotechnology application are confronted with new data type

Article with title,“ Mitigation of Barriers to Commercialisation of Nanotechnology: An Overview of Two Successful University-Based Initiatives” says that Nanotechnology do not create products, we make them better. The potential of nanotechnology is undoubtedly going to impact various aspects of human life and society. However, considerations and factors, such as long time between nanotechnology research and development of commercial products, large capital investment needed for a viable commercial venture, and financial/operational risks associated with commercial applications of nanotechnology, have impeded rapid adoption of this technology in the commercial domain. Substantial government funding, and involvement of academic institutions and research laboratories are viewed as an essential response to these barriers. In this article The Pennsylvania State University and The University at Albany in New York State which have made very significant contributions in the arena of nanotechnology commercialisation has been studied. The seriousness of the interest of the Federal government in the research, development and commercialisation of nanotechnology is evidenced by the allocation
of more than $3 billion since 2003 for programs in this arena. It has been mentioned that the Federal government investment in nanotechnology may be exceeded in magnitude by the Federal funding for NASA programs only. Commercialisation of such advanced functional materials and products requires that they can be produced in a predictable, reliable way, and in sufficient quantities. Until this is achieved, production will be limited to academia and R&D departments within industry. Study emphasizes the role of academia in maintaining the momentum that is required for timely commercialisation of nanotechnology. Albany NanoTech, CNSE at the University at Albany and Nanofab at the Pennsylvania State University have already confirmed that academic institutions can be very effective in facilitating, promoting and sustaining the commercialisation of nanotechnology. Even after the nanotechnology industry attains maturity, progressive entities like Albany NanoTech and Nanofab will be needed to sustain the R&D activities, and nanotechnology workforce education and training.

Mazumder S, Sarkar D from Department of Chemical Engineering, BITS, Pillani and Puri IK from McMaster University, Hamilton, Canada, in their article, “Nanotechnology Commercialisation: Prospects in India” published in Journal of Materials Science & Nanotechnology explain the potential of India in commercialisation of nanotechnology. It is an interdisciplinary technology which manipulates and creates matter to nanometre scale materials and objects. Since from last few year, nanotechnology have innovated applications for agriculture, healthcare and medicine, biotechnology, energy and environment, materials science, electronics, information technology, telecommunication and manufacturing. Huge investment has being made by Government and private investors and venture capitalists emerging nanotechnologies. This article reviews the commercialisation of nanotechnology by considering the strategies of large corporations and start-up firms and determines the major challenges faced by them for adopting and diffusion of nanotechnology. In India the research is not linked with commercialisation or commercial viable production. This can be overcome by improving and enhancing IP protection, regulations and ethical guidelines. The focus on infrastructure development, education, skilled workforce is must for faster growth of nanotechnology. Risk and safety studies are also required to ensure public acceptance. Government agencies need coordination in their efforts to promote the commercialisation of nanotechnology. More study need to be carried out for ethical issues, public perception and acceptance for nanotechnology and
regulation issues. Author suggests that future generation of scientists and engineers will be available by integrating nanoscience and nanotechnology into the academic curriculum.

Dr. Vinita Vishwakarma, Scientist from Centre for Nanoscience and Nanotechnology of Sathyabama University, Chennai in her article, “The role of nanotechnology R&D institutes to enhance competitiveness of small and medium enterprises” highlights how nanotechnology is going impact every aspect of our industry by means of small and medium enterprises and thus speed up commercialisation. Small and medium scale industries need to incorporate nanotech-based value added products which can improve their growth of business and technology. The only way out for this is collaboration of R&D institutes with small and medium enterprises to promote commercialisation of nanotechnology. Nanotech can serve as catalyst and help them to breakeven faster and sustain the economical growth. This will help to raise standard of living with financial stability and thus boost the global economy. SME need to capitalize this cutting edge technology. Research need to be applied base and beneficial for SME. Awareness need to be created among SMEs and monitor the application of nanotechnology to promote faster commercialisation. The increasing population has made resources to extinct and thus environmentally acceptable methods are required and this leads to research to be done keeping industrial demand in mind. Industrial professional should give their inputs to research so that it will consider all aspects of SMEs like production, material management and supply chain management. The SMEs to be successful must be tech savvy. The shift is required from fundamental academic research to application oriented. The nanotechnology has potential and possibilities of many new materials and devices with huge applications. Many business houses sponsoring research to patent them or identify as it will benefit in future.

Dr. Blessie A. Basilia from Industrial Technology Development Institute, Bicutan, Philippines in her article, “Development of nanotechnology competency for small and medium scale enterprises in the Philippines” published in Techmonitor magazine tries to highlight the importance of nanotechnology for developing countries with reference to Philippines. Nanotechnology can play a key role in the developing countries for research to be prioritised in the areas which require pressing need such as energy, environment and agricultural productivity. Universities and research institute
have recognised the importance and initiated applied research to serve their requirement. The Philippines government’s Department of Science and Technology has establishing a national centre for advanced materials characterization with advanced facilities which will be used for development of nano-based products for the electronics and semiconductor sector and other industries. The development of nanotechnology will lead to advancement of technological capabilities. The establishment of ADMATEL (Advanced Device and Materials Testing Laboratory) in the Philippines has improved product quality and services, and build competency on new and advanced technologies such as nanotechnology. This new facility seeks to raise our technological competence and technological sophistication to the next level at regional and global level.

Dr. Shin-ichi Kamei from Mitsubishi Research Institute, Inc and Mr. Tohru Kobayashi from Policy Alternative Research Institute, University of Tokyo, Japan in their article, “Strategy for new industry creation in the nanotechnology field” tries to put up nanotechnology as means of next level of commercialisation and thus industrialisation. Nanotechnology will play a key role to bring new industries in Japan and worldwide. It is responsibility of Government and existing industries to promote the faster pace of commercialisation of nanotechnology. There need to be integration in applied and basic research and face to face meeting to be held between researcher and industries. This article reviews Japanese experiences: an introduction of technology road-mapping approach, an evaluation of economic impact of nanotechnology and a publicizing of its result, and a formulation of private consortium. For Asia to be developed as next centre of world economy and R&D Asian nation has worked on innovative technology like nanotechnology. These countries compete against each other but at the same time they collaborate with each other for a common cause for eg. Asian Nano Forum, Asian Productivity Organisation. Asian Nano Forum (established in 2004), consists of 15 Asian countries, hosts international conferences and working groups on policy, R&D or commercialisation of nanotechnology. Asian Productivity Organization, consists of nine Asian countries, convene study meetings for exchanging information and discussion on commercialisation. We must note that such cooperation is important to enhance commercialisation of nanotechnology.

H. Purushotham, Head, Centre for Knowledge Management of Nanoscience and Technology Advanced Centre for Powder Metallurgy and New Materials (ARCI),
Hyderabad in his article, “Transfer of nanotechnologies from R&D institutions to SMEs in India Opportunities and Challenges” highlights how small and medium enterprises (SME) utilizes the process of transferring technology from public funded R&D institution. To nullify their size disadvantage and overcome diseconomies of scale, SMEs usually adopt the technology transfer from public funded R&D institutions. These relationship need to be strengthened to leverage the mutual strengths. There is huge gap between public funded R&D institution and industry. He also discusses the efforts of Government of India to promote nanotechnology with the help of case studies. As a result of vision of initial formulators like Dr. Kalam, and Dr. C. N. R. Rao of nanotechnology development policy India has critical infrastructure, human resource and corporate involved in R&D and commercialisation of nanotechnology. Nanotechnology research in India has maintained global competitiveness by achieving seventh position among the top ten countries of the World. Considering the pace of growth of nanotechnology in various fields it will be dominant player in global economy in coming years.

As Prof. C. N. R. Rao says, “India can’t afford to miss the revolution in nanotechnology. We should not be at the receiving end when the world is driven by nanotechnology.” What is required at this juncture is the continued and strong government policy support to leverage the investments already made in creation of R&D infrastructure. Careful and selected further investments in nanotechnology can catalyze country’s economic development.

Dr. R. A. Mashelkar, former Director General of the Council of Scientific and Industrial Research (CSIR) said, “Besides technological innovation, innovations in policy are also needed to make benefits of science reach the poor”. Nanotechnology provides huge cost effective benefits to the society but the Government need to play key role for strong promotion of public and private partnership, institute and industry collaboration.

Ronald D. McNeil, Dean, Jung Lowe, J. D., Ted Mastroianni, MPA, Dyanne Ferk, Boston, Massachusetts, Associate Dean of Business Management, University of Illinois – Springfield in their final report prepared for U.S. Department Of Commerce Technology Administration with title, “Barriers to Nanotechnology Commercialisation” highlights the barriers to commercialisation depending on primary data collected by the researchers from round table, tapes, site visits and respondent
interviews. This is a summary of document and outcome of U.S national study to identify and resolve issues regarding commercialisation of nanotechnology. It recognises the key strengths and recommends solution to overcome them. The findings are evaluated and comparison to related information is done. This survey identifies current key strength of nanotechnology. Major barrier and other casual factors are suggested for policy action and further study. The upcoming applications of nanotechnology and revolutionary products are significant. The critical barriers for nanotechnology pointed out in survey are long time gap between research and commercialisation, Gap between researchers and applied scientists, short of funding and lack of understanding the gap between researcher and scientists, time to patent, uncertainty and lack of clarity about regulation and regulator. The report suggests certain measures to reduce and eliminate these barriers. According to researchers Government and industry must do funding for research as well as product development on priority. Market research must be done to identify the need and supply of nanotechnology based products. Regulations and tax laws should be designed so as to increase and motivate new start ups and SMEs. Tax incentives will boost the efforts. There need to be uniformity and clarity in regulator and regulation to promote nanotechnology commercialisation.

Dr. Angela Hullmann, European Commission, DG Research, Unit “Nano S&T - Convergent Science and Technologies” in their report

3.4 Social Aspects of nanotechnology

Annual Report 2012-13 published by Government of India, Department of Science & Technology and Ministry of Science & Technology highlights the upcoming technology including nanotechnology and their potential to impact the India economically, socially and every aspect of life. This report highlights the citation and publications published and patents done in India. This report focuses on initiatives of Government to promote upcoming technologies like building up infrastructure, developing skilled workforce, Engineers and managers. Report tries to highlight the applications of nanotechnology in various sector and its possibilities to turn around the Indian economy.

CREST OMC Working Group report on Internationalisation of R&D – Facing the Challenge of Globalisation: Approaches to a Proactive International Policy in S&T

This report gives an overview of the existing cooperation in science and technology with India at EU, Member States and Associated Country level. It is one of three country reports (Russia, India and Brazil) prepared in the frame of the work of the CREST OMC Working Group on ‘Internationalisation of R&D - Facing the Challenge of Globalisation: Approaches to a Proactive International Policy in S&T’.

Australian Institute of Commercialisation in their report, “Enabling Technologies roadmap study for the Department of Innovation, Industry, Science and Research” highlights the upcoming technology and which are on verge of commercialisation. These are Biotechnology, Nanotechnology and synthetic Biology. The report discusses in detail the opportunities available and the barrier and threat in the commercialisation of these technologies. This report gives an overview of how important are these technologies are important and going to impact every aspect of economy. The report says that nanotechnology is going to impact various industries due to its multidisciplinary nature and promises a bright future ahead.

Robert Doubleday from Department of Geography, University of reflexivity: Alternative framings of the public dimensions of nanotechnology” argues that public policy and processes are having narrow focus on the environmental and health risks of nanoparticles and public projects are having limitations towards adoption of nanotechnology as a focus of deliberation. The objective is to explore how social aspects of nanotechnology have emerged as public issue, public engagement project framed in term of nanotechnology and rational for social science research on nanotechnology. The experience of author at academic nanoscience laboratory during a two years collaborative project on social dimension of nanotechnology helps him to study. Author found out that during first phase nanotechnology begins to emerge on policy and public agendas. During second phase more voices are raised and more detailed assessment projects are initiated. During third phase debate about public issue raised about nanotechnology are increasingly institutionalised through public bodies and the debate become globalised. Maximum research should be carried out on risk associated with nanoparticle. The six projects concluded with common finding are as follow
1) Expectation of benefits 2) scepticism of current regulation 3) concern over direction of technological development 4) eagerness to see more open debate.

He concludes that social science can be source of converting science and technology more reflexive and suggest modest ways that research can support discussion of public dimension of nanotechnology. Public opinion should be involved and discussion on nanotechnology future should be done. In this dimension social scientist like author play a prominent role. Topic of nanotechnology itself is a limited framing of such critical reflexion project, the initial public engagement project received here suggest more fruitful laboratory practise and particular vision of science and technology that such arrangement produces.

Xuan Liu, Department of Management Science and Engineering, School of Business, East China University of Science and Technology, Shanghai Siddharth Kaza, Department of Computer and Information Sciences, Towson University, Towson, Pengzhu Zhang, Department of Management Information Systems, Shanghai Jiao Tong University, Shanghai, Hsinchun Chen, Department of Management Information Systems, University of Arizona, Tucson collectively in their article titled “Determining Inventor Status and Its Effect on Knowledge Diffusion: A Study on Nanotechnology Literature From China, Russia, and India”, discuss data from the most productive and high impact institutions in China (Chinese Academy of Sciences), Russia (Russian Academy of Sciences), and India (Indian Institutes of Technology). The objective of this research was to understand knowledge diffusion within science and technology oriented research organisations. The purpose is to identify most prolific researchers and to determine collaborative research impact. Data is used from Thomas Reuter’s Scientific Citation Index (SCI). Keyword searching method is used. Authors are in position to work towards prestigious position in knowledge network to play important role in organisation knowledge evolution. Knowledge diffusion has impact of boundaries. The success of togetherness measures of prestige shows that nanotechnology community and possibly scientific community at large would benefit by economy collaboration between diverse parts of discipline.

Philip Shapira, Jan Youtie and Luciana Kay from Georgia Institute of Technology, Atlanta, USA, published their online article “National innovation systems and the globalization of nanotechnology innovation”. The authors tries to examine how corporate are being involved in nanotechnology innovation. They
tried to measure this using publication and patent application. It tries to examine the level to which the character and structure of corporate nanotechnology activity by country reflects in patent and publication. Data source used is secondary data. Text mixing software and appropriate hardware is utilised to analyse the data which is huge. Boolean search approach is used to identify and collect the data related to patent and research publication related to nanotechnology. The outcome of this analysis is that The USA, Japan, Germany are the leading and there is substantially higher shift is evident in the countries other than these leaders. There are huge collaborations at international level among the corporate. The countries with more multinational corporations or more dynamic and collaborative firms are more likely to shift from R&D to technological application in nanotechnology. Corporate plays a major role in globalisation of a nanotechnology commercialisation which is impacted by National Innovation System.

Vesna Milanovic and Andrea Bucalina from Megatrend University, Belgrade in their paper “Position of the countries in Nanotechnology and Global competitiveness “, tries to find out position and place of the countries on global level with respect to nanotechnology competitiveness. All secondary data is used to collect details from the external sources that are publicly available like various official reports published by Government, Universities etc. The positions of counties are classified on the basis of nanotechnology activity and power of technology development. These countries are classified as leaders, challengers, niche and follower. Competitiveness is compared on the basis positions of countries in year 2005 and 2009. The position of India in term of level of technological activity is improved while the power of technological development has being lowered similar to other countries.

Ndeke Musee, Alan C. Brent and Peter J. Ashton from Graduate School of Technological Management, University of Pretoria, South Africa in their article “A South African research agenda to investigate the potential, environmental, health and safety risks of nanotechnology”, map out a research agenda that provide a basis for systematic risk assessment research human capital development and the establishment of scientific research infrastructure to support environmental, health and safety (EHS) risk research related to nanotechnology in South Africa. The present risk assessment tool used for macroscale materials are inadequate to deal with material having nanoscale dimensions. Information on material is scarce on environmental, health and safety. Absence of single index to measure the toxicity of nanomaterial is
hurdle. There is lack of universal nanotechnology nomenclature. There is no cost effective monitoring system for nanomaterial and nanotechnology. Systematic human health and risk of nanomaterial is not assessable. A team of scientific regulators and industry as well as other stake holder be constituted to refine and define the highest priority areas of research that supports risk management decision for nanomaterial in South Africa at national level.

Gurulingappa Pattan and Gautam Kaul from Department of Biochemistry, National dairy Research Institute, Karnal, Haryana, in their article “Health Hazards associated with Nanomaterial”, published in Toxicology and Industrial Health tries to point out hazard and stress on assessing the toxicity associated with nanomaterial and nanoparticle. Their objective is to present a variety of hazards for human health and environment. They discuss various experiment carried out by various scientists lead to diagnosis of impact of nanomaterial on different parts of human body. Nanomaterial includes nanoparticle, nanofibre and nanotubes, composite material and nanostructred surfaces. The outcome of different experiments of different nanomaterials on various human body organs has been found out. Same nanomaterial with different size and different dosages has variable impact on human body. This studies carried has conflicting results regarding magnitude and mechanism of nanomaterial toxicity. Detailed investigation is required for study of nanomaterial toxicity and database need to be created. This vast paper tries to touch base large number of nanomaterial studies but do not give information about these toxicity in detail. Open discussion need to be carried on broader societal impact and urgent toxicological oversight action.

Mithali C. Roco from National Science Foundation, Arlington, Barbara Harthorn, University of California, David Guston, Arizon State University and Philip Shapira from Georgia Institute of Technology, Atlanta in their article “Innovative and responsible Governance of nanotechnology for societal development”, published in Journal of Nanoparticle Research. The author tries to outline Governance principle and method specific for field of nanotechnology. This article outlines advancement of nanotechnology in last decade, the current status and vision for commercialisation for next decade. The secondary data is utilised as well international study and survey input from 35 countries is used. Nanotechnology is multidisciplinary technology impacting various fields and expected to reach mass usage
by 2020. The developments of nanotechnology with governance for societal benefit is a challenge with many facet ranging from fostering research and innovation to addressing ethical concern and long term human development aspects. The major challenges to be tackled for commercialisation of nanotechnology are to developing the multidisciplinary knowledge foundation, establishing the innovation chain from discovery to societal use, establishing an international common language, developing nanotools, people and organisation to responsibly take advantage benefits of new technology on verge of commercialisation. Research and advancement of nanotechnology applications has created many opportunities for society to engage and a strong understanding of dynamic of emergent public perception and public opinion about nanotechnology need to be developed. It is vital to combine economic support with meaningful incentives and framework to ensure responsible development that besides technological business goals also address societal goals to reach nanotechnology’s full potential over next decade. Nanotechnology will be responsible for science, engineering and socio-political project. A strong focus is required in next decade on improving anticipatory and participatory Governance for nanotechnology that integrate the four basic functions of being transformative responsible inclusive and visionary. There should be increased international exchange based on mutual benefit to address opportunities for global R&D collaboration and competition. A common factors observed across all countries is focus on R&D as well as on developing governance framework for regulation of nanotechnology industry.

Ms. Sona Vikas from Ansal Institute of Management, Gurgaon, in her article, "Industrial Relation In BRIC (Brazil, Russia, India, China) Nations: A Study" published in Asia Pacific Journal of Research in Business Management tries to study the industrial relation between BRIC nation. Article tries to study historical background and way forward. The authors highlights the role of the government in handling the industrial relation issues and the significance of harmonious relationship among these BRIC nation.

There is huge scope for development of nanotechnology among BRIC nations.

K. Eric Drexler from Foresight Institute in his article, "Nanotechnology: From Feyman to Funding" tries to understand ideas and terminology showing how deep polarization has developed in the community. The confusion developed and misdirected argument that hinder public discussion both of current
research objectives and of long term benefits and risks. Feyman vision gave rise to National Nanotech Initiative (NNI). It leads to development of tiny robots called assembler. Feyman Thesis implies the feasibility of nanoreplicator. At same time these nanorobots are difficult to deliver by technologist. These may suppress nanotechnology research and development. This article is outcome of confusion between two thesis, one thesis of Feyman says of nanoreplicator and nanorobots while other questions its existence and if it exist then there control will be great issue ahead.

Shyam Ramani from Netherland, Nupur Chowdari from school of Management and Governance, Netherland, Roger Coronini from France and Susan Reid from Williams School of Business, Canada in their paper, “On India’s plunge into Nanotechnology: What are good ways to catch-up?” focuses how developing countries like India is moving ahead in nanotechnology race. The scientific and technological capabilities have moved upstream and regulatory capabilities are being strengthened. The achievements of Indian nanotechnology firms are noteworthy as compared to other international leaders with respect to higher investment done by them in nanotechnology. This paper tries to point out role of public and private investments in NST (nanoscience and/or Nanotechnology). Investment in nanotechnology in India has gradually increasing compared to other platform technology. There is argument that it will be not making sense to catch up with other developing countries in term of regulation or market design. The author suggests that mixed strategy need to be implemented with public investment for private economic growth.

R. Chidambaram, Padma Vibhushan award winner and a scientist who has chaired various senior Government technical head position in his invited paper, ”Research and Innovation: An Indian Perspective” says that if high growth ort term, in a developing country be maintained for country like India than strong foundation of research to be laid down along with higher rate of innovation capacity. Focus need to be given on attracting talented young people towards careers in science and technology and encouraging international collaborations. India is gaining a stronger foothold on position better than other world economies. The main driver of global manufacturing competitiveness is talent driven innovation which include nanotechnology as a key technology. India can become developed country and global leader provided it support research and innovation in technology like nanotechnology.
David C. Mowery from University of California, Berkeley, USA, in his article, "Nanotechnology and the US national innovation system: continuity and change", challenges the post academic nature of US universities' involvement with nanotechnology R&D and federal funding for nanotechnology. US innovation system includes the institutions performing R&D and source of funding for such R&D as well as intellectual property right and regulation policy. All these affect the technology development and advancement. US federal Government funding program for nanotechnology NNI (National Nanotechnology Initiative) represent significant break with philosophy of supporting R&D. The significant difference in nanotechnology and IT related innovations is transformation of intellectual property rights environment. Patent has been obtained by academic as well as industry.

Allianz in his paper, “Small sizes that matter: Opportunities and risks of Nanotechnologies Focuses on the economic potential and potential safety risk, including human and environmental, associated with nanotechnology from the perspective of the insurance industry. He acknowledges the uncertainties associated with nanotechnology and the difficulties that this creates for the insurance industry when attempting to calculate potential risks. He advocates for a risk management approach to nanotechnology in order to ensure that the many benefits of the technology may be realised. It is recommended to increase funding for basic research into toxicity and exposure as a way to address the current uncertainties.

Anderson A., Petersen, A., Wilkinson, C. and Allan, S. in their paper titled, “Nanotechnology, Risk and Communication” analyse the role of the news media in framing debates about the ethical, social and economic risks associated with nanotechnology discuss the role of media to build a public opinion of nanotechnology. News Media in the initial phase (primarily US and UK news media) has tended to emphasise the potentially revolutionary aspects of nanotechnology and beneficial applications. Argument given by media is that an earlier news framing is important for building agenda for public debate. The author analyse the empirical data to provide insight how science journalists including other media interaction can help to shape the public opinion on nanotechnology issues.

Bowman, D.M. and Hodge, G.A. in their paper, “A Small Matter of Regulation: An International Review of Nanotechnology Regulation” presents an overview of the
emerging regulatory debate for nanotechnology. It also examines the regulatory frameworks for nanotechnology within the US, Japan, the UK and Australia, and how multilateral bodies are handling the challenges posed by the nanotechnology and does a analysis of it. Authors find that while existing regulatory frameworks are applicable to nanotechnology-products and processes, these framework need to be amended in order to address health and safety concerns. They suggest that such regulatory responses will include both ‘soft’ and ‘hard’ approaches. Argument exists for regulatory challenges associated with nanotechnology, active coordination between existing national and international bodies, as well as NGOs, is required in order to actively manage potential risks posed by the technology.

Cobb, M. And Macoubrie, J. in their survey report title, “Public Perceptions about nanotechnology: Risks, Benefits and Trust” assess views on nanotechnology and its application and risks associated with it. It was first national US survey which was carried out and it represent to know the risk perception for nanotechnology. The survey highlights that people’s perceptions of nanotechnology are positive and the expected benefits are to be more prevalent than risks. Respondents’ preferred potential benefits of nanotechnology were in field of medicine, while their greatest fears with the potential loss of privacy as a outcome of new surveillance devices. There is lack of trust in business leaders to minimise health related risks.

Ebeling M. in his article, “Mediating uncertainty: Communicating the Financial Risks of Nanotechnologies gives critical overview of the communication of financial risks and benefits associated with nanotechnology. Author says that financial and associated risks of nanotechnology tend to be underestimated or overlooked in news media. Article expresses concerns that there may be too much ‘hype’ associated with nanotechnology. Evidence appears to be emerging that some within industry recognise the possible existence of nano ‘hype’ on markets.

ETC Group in their article, “The Potential Impacts of Nano-Scale Technologies on Commodity Markets” studies the implications of commodity dependency of developing countries. They examined the potential consequences of nanotechnology for commodity dependent developing nations, with reference to the impact on agriculture, mining and related sectors. It is difficult to predict the definite consequences of nanotechnology upon workers and developing nations with any clarity. Nanotechnology tends to be likely to have a ‘disruptive’ potential. It is not possible to
predict and conclude that whether nanotechnology will have a positive or negative impact for commodity-dependent developing nations. It appears that developing nations are especially vulnerable to nanotechnology. Developing nations have a poor infrastructure available to deal with social and economic disruptions and public awareness and engagement issues. The paper also deals about impact upon employment and economic conditions of commodity-rich developed nations.

ETC Group in their other paper, “Nanotech’s “Second Nature Patents: Implications for the Global South” examine in depth nanotechnology-patent framework, and the implications thereof, especially for developing countries (the ‘global South’). It is observed that developed counties have taken lead over monopoly of nanotechnology-patents, and thus this prevent developing countries from being benefitted by the nanotechnology as compared to developed nations. The paper analyses and gives recommendations which are designed to help developing countries benefit from nanotechnology-patents.

Lux Research in their report published in 2006 with title, “Nanotech Battles worth Fighting” examines the nanotechnology-patent landscape, including a comprehensive analysis of filled and granted US patents on eight nanomaterial platforms. The paper highlights the significant patenting activity occurring within the US, and the increasing sophistication of the patents. Emerging patent-thickets around key materials will have significant implications for organisations, and if left unaddressed, has the potential to hinder innovation. Patent office needs the necessary expertise to speed up the patent examination process.

Mehta, M in his article, “Privacy vs Surveillance: How to avoid a nanopanoptic Future” studies the possible privacy dimensions of nanotechnology. Author warns against possible incursions upon individual privacy and the use of nanotechnology for surveillance of individuals and populations in future. He suggests to establish new regulatory agencies, tighten privacy legislation, introduces ethical codes of conduct in industry to address nanopanopticism, public engagement, education of scientists.

Renn, O. And Roco, M.C. in their article, “Nanotechnology and the need for risk governance” outline the general risks posed by the four generations of nanotechnology and articulates how current risk governance structures are inadequate for dealing with these risks. The article recognises the uniqueness in nature of nanotechnology and a risk governance framework developed by International Risk
Governance Council is discussed. This framework helps in managing the potential risks of the technology, both in the short and longer term. They point out what actions need to be taken by which stakeholders, and steps on how the framework may be implemented.

Royal Society-Royal Academy of Engineering in their detailed report, “Nanoscience and Nanotechnologies: Opportunities and Uncertainties” examines current and future developments in nanosciences and nanotechnology and the various impacts of these developments. It is concluded that whilst nanotechnology offer benefits both now and into the future, there is a need for public debate on a range of issues associated with their development. There is a need for more research to address uncertainties associated with the health and environmental effects of nanoparticles, in particular. The report acknowledges that the UK’s existing regulatory frameworks were sufficiently broad to generally address nanotechnology. They noted that amendments to regulatory instruments would be required in order to effectively regulate different facets of the technology. The regulatory framework governing chemicals was identified as one regime that would require amendment in order to address the current gaps. They explicitly rejected the calls at that time for a moratorium.

Sparrow R in their article, “Negotiating the Nanodivides” provides an overview of possible dimensions of the nano-divide. He argues that there are four likely dimensions of the nano-divide: involving divides on the basis of access to nanotechnology, profit from nanotechnology, benefit from and control of nanotechnology. The technology does not necessarily create new divisions between and within nations but are instead shaped by existing inequalities and divisions. The author suggests restricting or delaying access to nanotechnology that are likely to only result in ‘substantial positional goods’ for the developed nations.

Swiss Re a reinsurer company in their research report, “Nanotechnology: Small Matter, many unknowns” provides an overview of the potential benefits of innovative nature and risks associated with nanotechnology. The report discusses the risk with reference to the scientific uncertainties associated with it and also the implications of the technology for the insurance industry. The research highlights a range of potential risks to human and environmental health and safety, and draws the analogy between nanotubes and asbestos in relation to toxicity and exposure. A conclusion is made out of study that it is not possible for the insurance industry to perform risk assessments of
nanotechnology and the risk associated with applications of nanotechnology. The insurance industry is going to have to face the uncertainties of nanotechnological risks for a long time to come. Swiss-Re advocates risk management, underpinned by a ‘better safe than sorry’ approach, as well as a multi-party approach to addressing the uncertainties.

Toumey C. in his paper, “Privacy in the Shadow of Nanotechnology” does a critical analysis of the treatment of privacy and surveillance issues in the literature. The author shares some concerns with earlier literatures regarding privacy and the potential for certain applications to reconfigure relations between citizens and the State. However there may also be potentially beneficial implications for citizens’ privacy e.g. for individuals with Alzheimer’s disease. The paper raises concerns about technologies impacting upon privacy and eroding individual rights are not new, nor confined to nanotechnology. There is a potential for nanotechnology to intrude into our privacy in ways both positive and negative.

Wood, S. et al in his earlier report, “The Social and Economic Challenges of Nanotechnology” present a detailed report by examining literature on the social and economic dimensions of nanotechnology. He identifies four overarching themes in the literature. These are positive view about the outcomes of nanotechnology that may be generated for society, a negative view about the outcomes of nanotechnology that might generate for society, a concerns about barriers to developing technology and issues of public acceptance, and the need for regulation of nanotechnology due to the uncertainties associated with its impacts on humanity and the environment. The paper recommendations include: the need for more inter-disciplinary research in the field and international comparisons of regulation.

Wood, S. et al publish another paper, “Nanotechnology, From the Science to the Social: The Social, Ethical and Economic Aspects of the Debate”. This is a follow-up to the Wood et al. 2003 report examining literature on the social, ethical and economic impacts of nanotechnology. The extent of polarisation identified in the earlier literature and reported in their 2003 report had subsided to a large extent, and had instead been replaced by ‘more moderate views’ of the implications of nanotechnology. Developments after the Wood et al (2003) Report include that the debate had become ‘less dominated by radical visions’, but that the literature continues to be discussion
based. ‘Utopian’ and ‘dystopian’ perspectives on nanotechnology can still be located but more complex issues and levels of analysis are emerging.

### 3.5 Applications of Nanotechnology

Praniti Srivastava, Rishabha Malviya, Koushal Dhamija, Sumedha Gupta and Pramod Kumar Sharma from Department of Pharmaceutical Technology, Meerut Institute of Engineering and Technology, Meerut, in their review article “Nanotechnology :Application and Market” published in Drug Invention Today focuses on application of nanotechnology in medical science i.e. nanomedicine. The article says that nanotechnology along biotechnology and bioinformatics constitute the basis of 21st century. They highlight the potential of market for nanomedicine. The nanotechnology can be used in detection as a sensor, implant to replace or damaged body parts, delivery of therapeutic and as drug target device. The market value of nano medicine product is going to increase. Nanotechnology major impact will be in medical science and in every aspect of medical field. Large number of patent and product are on the verse of commercialisation and thus they are going to give better returns.

R. kalpana Shastry, H.B.Rashmi, N.H.Rao and S.M. Ilyas from National Academy of Agriculture Research, Hyderabad in their article “Integrating nanotechnology into agri-food systems research in India: A conceptual framework” published in Technological Forecasting & Social Change tries to find out implication of current trends in nanotechnology for agriculture sector in India. They tried to develop a database technology o map research theme of nanotechnology to agrifood thematic area. They first identified and relate to nano research and agrifood thematic areas, designing the database structure for bibliography and patent database storage, designing the bibliography search strategy and lastly patent search strategy. The tools used are preliminary survey and assessments of literature, interview and survey with researcher to collect data are being collected. A database technology based process methodology to search, assemble and characterize available bibliography and patent information in nano research areas and map them to identified research thematic areas across the agricultural value chain is being developed. A detailed database technology based process methodology has been developed which is useful to identify the agriculture research thematic areas across the agriculture value chain developed. It is useful extract the information regarding any bibliographic and patent related to implementation in agriculture field.
Behfar Bastani and Dennis Fernandez from Fernandez & associates in their article “Intellectual Property Rights in Nanotechnology”, discuss the area in which intellectual property rights can be applied and also some challenges and issues surrounding the acquisition of intellectual property rights in nanotechnology are also presented. Type of intellectual properties protections are Patent, Copyrights, Trade Secrets, Trademarks and Mask works. Once a Product or service is developed issued patent and trademarks protect the technology and associated names and symbol. The first one to patent will have the best chance of using the broadest patents. The patenting is different for nanotechnology as nanotechnology is multidiscipline. There is lack of focused expertise combined with understaffed state of the USPTO is likely to result in improper rejection of patent and overbroad patent giving the owner excessive control ov a particular area.

Dr. Seema Singh, Associate Professor in Economics, Delhi Technological University, Delhi in her article ”Achieving Second Green Revolution through Nanotechnology in India”, published in Agriculture Situation in India discuss the feasibility of second Green Revolution through nanotechnology in India. It also focuses on myriad agriculture application of nanotechnology which can be effectively increase production. Also nanotechnological application in agriculture in India and challenges associated with it are also to be found. Nanotechnology has feasibility of achieving second green revolution in India through its application in agriculture. It can be discussed as catalyst to initiate second green revolution in India. Various aspects like use in irrigation fertilizers etc is being discussed. Planning commission of India has recommended that nanotechnology research and development should become area of investment. Nanosensor, nanorobots and other nanotechnology application can bring a good impact in agriculture. Nanotechnology can be grouped into two categories namely environmental health and safety applications and societal dimensions of nanotechnology. Channel of communication need to be established with relevant stake holder in term of proximity, information and taking their feedback

Mary Page Bailey in her article, “Grappling with Graphene: The race to commercialisation” published in Chemical Engineering highlights about graphene and its properties and application which seems to be endless. Graphene is single atom that allotrope which has enabled us miracle material. These article highlights commercialisation power of grapheme. Large numbers of application are coming up in
future in next 5 to 15 years. This is magical material which has great use and large application and can be used for large impact for society. They Emphasize the importance of mindfulness in quest of commercialisation these unique grapheme nanomaterial.

Sumio Iijima from Meijo University, Japan in his article, “Carbon nanotubes: past, present, and future” discuss the carbon nanotube and their application. Carbon nanotubes have tremendous interest from both academic to industry and fields ranging from condensed-matter physics to chemistry. This paper highlights earlier studies and then recent developments in nanotubes. It also touches possible applications and ambitious studies carried out of nanotubes.

Chetan Anjwala from Jodhpur Pharmacy college, Jodhpur University, Girish Jani from College of Pharmacy, Silvassa and S. M. Vijeyndra Swami from Bhagwan Mahavir College of Pharmacy from Surat in their article, “Current Trends of Nanotechnology for cancer Therapy” published in International journal of pharmaceutical sciences and Nanotechnology discusses the emergence of nanoparticulate as new generation of treatment for cancer. It has potential to overcome many biological, biophysics and biomedical barriers against standard process. The drug targeted to be delivered at the tumour tissue is a most important and challenge for the present pharmaceutics and medical science in the treatment of cancer. With the development of nanotechnology, nanomaterial is a promising approach for treating cancer because of their small size and modification capacity. In the article several promising application of medical science based on nanotechnology and nanobiotechnology are discussed.

Michael A. Janse, Alexei A. Andreev, Daniel B. Wolfe, Misti Ushio and Douglas W. Jamison from Harris & Harris Group, Inc in their research article Harris & Harris Group’s Approach for Investing in Nanotech for Electronics Companies discusses their investment thesis which is driven by four ideas. First says nanotechnology is means of reducing manufacturing cost and increase the performance of electronic component. New capability of component is possible due to nanoelectronics. Due to this improved performance of these components has helped to improve the performance of nanotechnology enabled electronic product company. Finally quantum computing are enabled by nanoscale phenomenon. These features
have helped to identify nanotech companies and lead to commercialisation of nanotechnology.

Susan Cozzens, Ogundiran Soumonni, and Thomas Woodson from Technology Policy and Assessment Centre, School of Public Policy, Georgia Institute of Technology and Rodrigo Cortes from Universidad de Talca, Chile in their article, “Nanotechnology and the Millennium Development Goals: Water, Energy, and Agri-food” examine the subsequent development of several applications of nanotechnology. Database used for analysis was publication data on nanotechnology to describe the trajectories of nanoapplication in water, energy, and agri-food. These three areas ranked at the top of the list by researchers and also world economy. Nanotechnology is an emerging technological area which is a dominant research topic of BRICs countries. These countries are focusing more than affluent countries in more practical applications areas of water, energy, and agri-food. This paper put up supporting data and analysis that shows nanotechnology as one of important key driver in basic research areas.

Jonas Berggren in his master’s thesis carried out at the Department of Physics Division of Solid State Physics with title, “Fundamentals and Limits of DNA Nanotechnology” has shown in this report that DNA nanostructures are suitable as scaffolds for proteins, FRET- and SERS active molecules, quantum dots, carbon nanotubes etc. The fabrication of a biochip for fast DNA sequencing is the ultimate goal for the other field of research has been presented here. This can be realized if single molecular spectroscopy methods using fluorescent, SERS, or FRET molecular probes must be integrated to work in an environment where DNA is stretched through nanochannelling techniques. It might be possible in the future to combine DNA self assembly and DNA computing to such that the assembly itself is regulated through a DNA computing circuit. A thesis presents a short overview of DNA switching mechanisms.