NANOTECHNOLOGY IN TURKEY

R&D INFRASTRUCTURE AND CLUSTER ACTIVITIES IN NANOTECHNOLOGY



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NANOTECHNOLOGY AT A GLANCE

Nanotechnology is defined as the science, engineering, and technology which is conducted at the nanoscale level, i.e. about 1 to 100 nanometers. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. Scientists and engineers are finding a wide variety of ways to deliberately make materials at the nanoscale to utilize the advantage of their enhanced properties such as improvisation in control of light spectrum, high strength, light weight and higher chemical reactivity than their larger-scale counterparts. Visualization, manipulation and modeling of atoms, molecules and macro molecular structure to create unique desired structures is performed in nanotechnological research for generating nanocomponents with enhanced properties and functionalities. ¹

The global nanotechnology market has shown impressive growth owing to factors, like increase in government and private sector funding for R&D, partnerships & strategic alliances between countries, and increased in demand for smaller and more powerful devices at affordable prices. Nanotechnology has made major breakthrough in the healthcare industry with its application for the diagnosis and treatment of chronic diseases like cancer, heart ailments, etc. Further, significant developments are also achieved in other sectors such as electronics, agriculture, and energy.

The modern drivers of the world nanomaterials market are as follows: increase in the market penetration of existing materials, decrease in the prices of nanomaterials, improving materials' properties, expending R&D activities related to the new materials, increase in public and private expenditure towards nanotechnology research, growing support of the government institutions, rapid new materials and applications' development [1-3], effective functioning the partnerships and strategic alliances of domestic and foreign companies and organizations, increasing number and collaboration among industry players including growing international research and production cooperation in nanotechnology industry. 2

The global nanotechnology market should reach \$90.5 billion by 2021 from 39.2 billion in 2016 at a compound annual growth rate (CAGR) of 18.2%, from 2016 to 2021. There are two main sub topic in nanotechnology market: Nanomaterials and nanodevices. The nanomaterials market hould reach \$77.3 billion by 2021 from \$32.5 billion in 2016 at a CAGR of 18.9%, from 2016 to 2021 and the nanodevices market should reach \$195.9 million by 2021 from \$56.5 million in 2016 at a CAGR of 28.2%, from 2016 to 2021.³

In terms of patents owned, research universities and technology companies from Asia dominates the market. As seen on figure 1 below, more than 75% of the universities, research institutions or companies with the highest number of patents owned are originally located in Asia.





NUMBER OF PATENTS

Figure 1: Top patent owners according to patent numbers published in the field of nanotechnology - Global



TURKISH NANOTECHNOLOGY

INFRASTRUCTURE



As the Turkish government sees nanotechnology as important, its Ministry of Science, Industry and Technology published a national nanotechnology strategy in 2014. The strategy focuses on improving the R&D infrastructure in nanotechnology and the use of nanotechnology by small and medium-sized enterprises (SME). Nanotechnology is relatively well funded by the Turkish government. Research centres for nanotechnology have received the majority of funding in order to establish national R&D centres of excellence.⁴

The following research centres have received funding from the Turkish government via Ministry of Development funds:

Gebze Technical University Nanotechnology Research Center	Testing, Analysis and R&D services
Bilkent University National Nanotechnology Research Center (UNAM)	Offers access to research infrastructure for researchers
Istanbul Technical University ITUnano Nanotechnlogy Research Center	Nanomaterial production and synthesis
Cumhuriyet University Nanophotonics Application and Research Center	Production of optoelectronic devices, LED, laser, detector, sensor, solar batteries with epitaxial crystal magnification and characterisation.
Sabancı University Nanotechnology Research & Application Center (SU-NUM)	SUNUM is one of the leading nanotechnology research centers in Turkey. It has strategic research alliances and forms precompetitive consortiums as well as collaborations with many national or inter- national universities, research centres, companies and professional unions. Its focus areas are food & agriculture, structural materials, biotechnology, energy, environment, water and defence.
Middle East Technical University METU Center	Focuses on semiconductor nanostructures for nanophotonics and nanoelectronics, magneti nanoaprticles, heterogeneous catalysis, and molecular biology and biotechnology.
Anadolu University Ceramic Research Center	First example of a successfull precompetitive research consortium. It is now a university-/industry-owned corportation which provides the industry with access to better infrastructure and technical support.
TÜBİTAK MAM Materials Institute	As part of the National Sciencce Council TUBİTAK, MAM co-organised a technology matchmaking mission for thin-film photovoltaics in June 2016
Koç University Surface Science and Technology Center	An interdisciplinary research centre combining nanotechnology, polymer science, ceramics, composites, biomaterials, microelectronics and device manufacturing. The centre condusct research into surface chemistry, surface physics and surface engineering. Applitcations are in the field of materials, opties & photonics as well as microelectromechanical systems (MEMS) & devices.

As we examine the academia in the field of nanotechnology in Turkey, we can observe that three major research universities, Bilkent, ITU and METU lead in terms of web of science documents and times cited. Bilkent, with the boosting effect of UNAM, one of the most advanced national research infrastructures in the country is the leading university with a number of 8287 citation counts and 464 generated documents in the field. The difference between the documents are rather small with 80 difference with METU and 180 with ITU while the difference in times citied is more than 2500 and 4500 respectively.







While Bilkent University seems to be leading on developing the literature in Turkey, it is not the same in terms of creating patents in the field. Istanbul Technical University, on the other hand, is topping that list with a total of eight patents in nanotechnology. Sabanci and Ozyegin Universities are on second and third spot with a number of four patents each.

Start-ups that are active in the field of nanotechnology are quite successful in terms of new product development and revenues in the world. In Turkish start-up ecosystem, nanotechnology start-ups are located in different technoparks and play active roles in different accelerator programmes. While the development of these start-ups is rather slow, there are some companies that show promising potential and rewarded with investment from national and international venture capital companies. Most active university technoparks in terms of start-up hosting are Yıldız Technical University, Bilkent University and Istanbul Technical University with a number of four start-up companies located in their premises.



Figure 2: Top Universities in Turkey according to academic papers in the field of nanotechnology, (data source: https://incites.thomsonreuters.com)



Figure 3: Top Universities according to patent numbers in the field of nanotechnology (Data source: Turkish Patent Institute)



N A N O TECHNOLOGY CLUSTER

Turkey started to work on its cluster activities in nanotechnology with a series of sectoral meetings in 2015. The cluster was formed by TÜBİTAK Marmara Research Center in November 2016 with the aim of creating an effective and long-lasting platform for collaboration as well as coordination among all advanced materials and nanotechnology projects. Subsequently, the Nanotechnology Cluster Collaboration Protocol was signed in January 2017.

With a vision of establishing a skilled organisation that can promote precompetitive collaboration in advanced technology, the cluster has seven main objectives: to increase the infrastructure in the field of nanotechnology, to increase industry-university-R&D centre collaboration, to increase sectoral applications in nanotechnology, to increase production capacity, to increase the global market share of Turkish nanotechnology, to increase the development process and manufacture of high-tech products, and finally to increase the compatibility of Turkish products in the market.

The core objectives of the Nanotechnology Cluster are based on the following four pillars.

COLLABORATION ACTIVITIES

Establish effective collaboration channels between the companies, research centres and universities in order to facilitate the achievement of their technical and non-technical goals; a) b) enhance the impact of such achievements during and after the

project lifetime.

AWARENESS-RAISING AND NETWORKING

Increase the visibility and impact of the cluster projects as well as their research achievements with regard to the industry, contracting parties and other stakeholders, establishing appropriate networks and alliances with such organisations.

EXPLOITATION

Strengthen the role of industrial partners, especially SMEs, in speeding up the exploitation of research results deriving from the cluster projects. Identify new technology, market needs and trends. Develop a market-driven value chain approach with a set of tech and non-tech actions that will also lead to business and market roadmaps.

3

COORDINATION AND SUPPORT SERVICES

Create the necessary infrastructure. Identify gaps in research and work towards their solution. Develop a roadmap that could be used as a starting point for potential projects.







NATIONAL AMBITION

Nanotechnology is defined as "priority technology area" by the government in the 10th Development Plan of Turkey. In addition, the National Nanotechnology R&D and Innovation Strategy Document and Action Plan (2015-2019) contains the following important remarks and suggestions about the general situation in nanotechnology:

1. Technical and R&D infrastructure needs to be improved in order to succeed in the global integration of nanotechnology.

2. Employment and financial infrastructure needs to be improved in order to increase the production capacity of nanotechnology.

 Collaboration between the state, the universities and the industry needs to be improved in order to achieve "nanotechnology togetherness".
Nanotechnology roadmaps and strategies for different sectors need to be prepared.

The cluster organises joint projects, trainings, supporting events such as conferences or workshops and other promotional activities aimed at the successful development of high-tech products and processes.

In order to achieve the aforementioned nanotechnology togetherness, TÜBİTAK has organised a series of meetings with potential members of the cluster. Email groups have been formed to increase communication between the parties. After the last of these meetings and workshops, sectoral roadmaps and strategies will be prepared and target projects will be determined. The Nanotechnology Cluster prepared its Strategic Aims & Action Plan (2018-2023) in 2016, with the support of TÜBİTAK MAM. This plan was compiled from different governmental strategy documents such as the Turkey Vision Report (2023), National Nanotechnology R&D and Innovation Strategy Document and Action Plan (2015-2019), 9th Development Plan Strategy Document (2007-2013), 10th Development Plan Strategy Document (2013-2018), National Science & Technology Policies Strategy Document (2003-2023) and the National Industry Strategy.

The Nanotechnology Cluster focuses on the seven cities which have the most industry-focused zones, the most government investments in nanotechnology and the most companies in fields affected by nanotechnology developments. These cities are Düzce, Ankara, Kocaeli, Bilecik, Bursa, İstanbul and İzmir. The favourable position of the area benefits the cluster in terms of national and international logistics such as the easy access to sea, land and air transport, the proximity to national producers of raw materials and the presence of free zones for easy access to raw materials imported from abroad.⁵

The cities in the cluster area are the largest industrial cities in Turkey. For example, 41% of the automotive industry and 27% of the chemical industry in Turkey is situated in Kocaeli. This city realised 16.9 million dollars of imports and 42.9 million dollars of exports in the year 2015. With a variety of organised industrial zones (OIZ), free zones and technoparks in the area, Kocaeli's industry keeps growing systematically. In the year 2016, the city of Bursa also achieved 13 million dollars of imports out of a 142.6-million total import for Turkey. In the same year, the turnover of the capital city Ankara in the defence industry reached 6 billion dollars.





FOREIGN POLICY & INNOVATION/R&D JPPOIUNIIES FOR THE NETHERLANDS

In order to achieve its aims as listed in the previous sections, the cluster seeks to expand its reach both in Turkey with more members and abroad with effective collaborations. The collaborations can be established both as project-oriented partnerships and in the context of Horizon 2020 partnerships.

In May 2017, the cluster applied for the Bronze Label of the European Cluster Excellence Initiative (ECEI). In order to achieve ECEI certification, the cluster seeks to establish international collaborations with different institutions including TNO and NanoNextNL from the Netherlands. Other target institutions are the Catalan Technical Textile Cluster and the Slovakian Research Academy (SAS).

The aforementioned potential collaborations should be developed in several target sectors of the cluster. While the main supporting sectors for nanotechnology in Turkey are chemistry and machinery, the Nanotechnology Cluster aims to "maximise the impact of the cluster projects on the defence, energy, textile, automotive, building, health and food industries"

EDUCATION & LABOUR MARKETS

The cluster's member universities host around 20 educational programmes at all levels (Master's and PhD). Affiliated companies and institutions conducted nearly 80 seminars, 40 business meetings, 100 business trips as well as 7 matchmaking events between 2012 and 2017. The cluster also performs well in academic publishing. Researchers from cluster members such as TÜBİTAK MAM, TÜBİTAK UME, Middle East Technical University, İstanbul Technical University, Gebze Technical University, Uludağ University, İstanbul University and Sabancı University published 130 national and 500 international academic studies from 2012 to 2017.⁶



The Nanotechnology Cluster's partners are companies, R&D centres, universities and chambers of industry. It currently has "48 partners that signed the "Nanotechnology Cluster Collaboration Agreement", of which 72% are large enterprises or SMEs.

In the cluster's target region, most SMEs focus on the chemistry and automotive industries. Increasing the R&D activities in these industries with a view to high-tech applications such as nanotechnology will increase the success of the SMEs (for example, there are projects focusing on light-weight vehicles and vehicle parts).⁷





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