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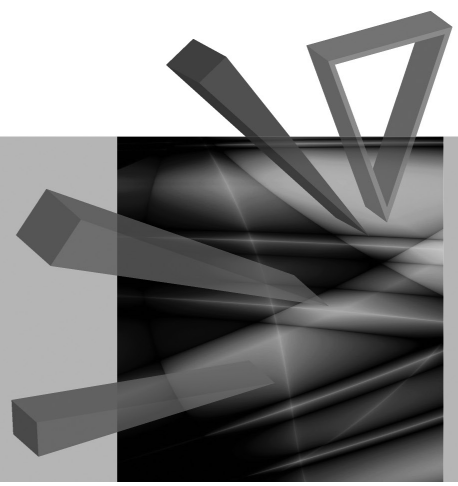
295

Clusters, Networks and Markets in the Asia-Pacific Region



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KNOWLEDGE CLUSTER INITIATIVES BY MEXT[1] – CASE OF TOKAI REGION NANOTECHNOLOGY MANUFACTURING CLUSTER IN JAPAN[2]

Abstract: Knowledge Cluster Initiative by MEXT provides support facilities and promotes local outward-oriented initiatives of industry-academia-government collaboration in order to internationalize cluster structures and boost technological revolution. Tokai Region Cluster is an interesting example of intensive spillovers among private and public actors integrated around common vision of progress.

Keywords: knowledge cluster initiative, Tokai Region.

1. Introduction

Linking cluster initiatives with the concept of knowledge-based economy has become the core issue of Japanese cluster policy by Ministry of Education, Culture, Sports, Science and Technology (MEXT). Between 1996 and 2015 four Basic Plans of Science and Technology were designed and implemented in order to reach four different stages of transformation of cluster policy:

– First Basic Plan of Science and Technology (Financial Years 1996–2000) – Foundation of Regional R&D;
– Second Basic Plan of Science and Technology (Financial Years 2001–2005) – Start of the Cluster Policy;
– Third Basic Plan of Science and Technology (Financial Years 2006–2010) – Implementation of Cluster Policy;
– Fourth Basic Plan of Science and Technology (Financial Years 2011–2015) – Development of Cluster Policy.

[1] Ministry of Education, Culture, Sports, Science and Technology in Japan.

[2] Article based on empirical data collected by author during research made in Tokyo and Nagoya, Japan, between 6th and 21st October 2012 under research project no. 2011/01/B/HS4/00639 entitled "Clusters as innovation carrier of enterprises and regions. Verification and implementation of Asian models in terms of the Polish economy", funded by National Science Centre, Poland.

The aim of the article is to present empirical dimension of MEXT cluster policy, focused on promotion and formation of regional knowledge-based clusters, initiated under second stage of cluster policy.

Tokai Region Nanotechnology Manufacturing Cluster is a great example of The Second Stage Knowledge Cluster Initiative, challenging energy conservation, environment preservation, renewable energy, global competitiveness and paradigm shift in industrial sector. Tokai Region, covering Aichi, Gifu, Mie Prefectures and Nagoya City, is a leading Japanese automobile, aircraft, machinery and their parts centre, accumulating nearly 10% of Japanese GDP.

According to MEXT, enhancing industry-academia-government collaboration at the regional level should induce both development of world-class clusters (Knowledge Cluster Initiative) and small clusters based on regional strengths (City Area Program).

2. Cluster structures

Clusters are, according to M.E. Porter, the exemplification of a typical paradox that "the competitive advantage in the global economy is based increasingly on local resources, such as knowledge, relationships and motivations that are not available for distant competitors."[3] He defined clusters as a geographical concentration of interconnected companies, specialized suppliers, service providers, businesses operating in related sectors, as well as related institutions (such as financial, training, research, standardization institutions and trade associations), in specific areas, while competing and cooperating with each other. Thus, a departure from the traditional understanding of the role of location,[4] on the one hand, reflects significant changes in the field of technology and competition, on the other – points to the serious implications in the acquisition of resources on a global scale. It turns out that the cluster structures may become, when reaching an appropriate critical mass, an instrument of competition policy under the dynamic knowledge-based economy.[5]

Modern theoretical approaches move away from a Marshall's industrial district for the extended manufacturing cluster model based on SMEs, while taking into account the growth of service clusters, operating in high-technology sectors, increasing importance of TNCs, network-affiliated international companies, and finally – the contribution of public and private institutions.[6]

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[3] M.E. Porter, Clusters and the new economics of competition, *Harvard Business Review* 1998, November–December, Reprint No. 98609, p. 78.

[4] M.E. Porter, Location, competition, and economic development: Local clusters in a global economy, *Economic Development Quarterly* 2000, vol. 14, no. 1, pp. 15–34.

[5] According to M.E. Porter, clusters affect competition in three ways: by increasing business productivity, by stimulating innovation, by determining future productivity growth and initiating the process of creating new businesses to strengthen the cluster (based on: M.E. Porter, Clusters and the new economics… of Competition, p. 80).

[6] OECD, *Competitive Regional Clusters. National Policy Approaches*, OECD Reviews of Regional Innovation, Paris 2007, pp. 25, 26.

Organisation for Economic Cooperation and Development (OECD) argues in its report on the issue of competitive regional clusters that "countries are seeking ways to strengthen or develop the potential enabling a concentration of innovative companies associated with the structures of the knowledge economy [...] clusters are considered as effective and pragmatic instrument of managing resources and building partnerships."[7] OECD, conducting research dedicated to critical for knowledge-based economy innovation clusters, indicates the role of both business entities as "knowledge-generating agents and consumers,"[8] while distinguishing traditional and modern concept of cluster (Table 1).

Table 1. Characteristics of traditional and knowledge cluster

Item	Traditional	Knowledge
Phase of life	mature sectors, shaped concentration	young sectors, new concentrations
Type of relationships/ transactions	long-term relationships, shaped by locally oriented supply chains	temporary coalitions for joint R&D activities induced by the market
Innovation activities	gradual innovations, absorption of technologies	technological innovations

Source: own study based on: European Commission and Enterprise Directorate-General, *Regional Clusters in Europe: Observatory of European SMEs*, no. 3, Brussels 2002.

The increase of cluster structures associated with knowledge-based economy will generate significant multiplier effects, encouraged increasingly by external location determinants and structural transformation of the regions (very often specific agglomerations), resulting in the intensification of R&D activities.[9]

3. Overview of MEXT's cluster policy

Ministry of Education, Culture, Sports, Science and Technology, when designing cluster policy, complement activities of Ministry of Economy, Trade and Industry (METI).[10] While METI is oriented on support for the commercialization of research

[7] OECD, *Competitive Regional Clusters*…, p. 11; J.L. Furman, M.E. Porter and S. Stern point to cluster structures environment as one of the key components of the innovation potential of the country, next to the institutional, resource and political frameworks (based on: J.L. Furman, M.E. Porter, S. Stern, The determinants of national innovative capacity, *Research Policy* 2002, vol. 31, p. 905).

[8] See also: OECD, *Boosting Innovation: The Cluster Approach*, OECD Publications, Paris 1999; OECD, *Innovative Clusters: Drivers of National Innovation Systems*, OECD Publications, Paris 2001.

[9] For further studies see: P. Dicken, *Global Shift: Transforming the World Economy*, Paul Chapman, London 2003; S. Bobowski, M. Haberla, *Networked clusters in the context of knowledge-seeking strategy of international business*, [in:] B. Skulska, A.H. Jankowiak (Eds.) *Innovation Sources of Economies in Eastern Asia*, Research Papers of Wrocław University of Economics No. 256, Publishing House of Wrocław University of Economics, Wrocław 2012, pp. 121–131.

[10] However, some interviewees admitted that the distribution of competences among MEXT and METI is, to some extent, fluid and smooth.

results and development of sales channels, MEXT is focused on support for the formation of intellectual assets and for the development of human resources.

Knowledge Cluster Initiative by MEXT is a component of Regional Innovation Program, initiated till the end of 2010, in parallel with Third Basic Plan of Science and Technology (see Table 2 for details).

Table 2. Transformation of cluster policy by MEXT, 1996–2015

First Basic Plan of Science and Technology	1996–2000
Foundation of Regional R&D	– increasing public awareness of S&T, promoting basic and pioneering R&D, and constructing S&T-related facilities – creating and expanding various research systems
Second Basic Plan of Science and Technology	2001–2005
Start of the Cluster Policy	– formation of regional knowledge-based clusters – implementation of S&T policies in regions through fostering and providing expert human resources, enhancing coordination, and promoting interregional technological transfers, further promoting industry-academia-government collaboration in the region
Third Basic Plan of Science and Technology	2006–2010
Implementation of Cluster Policy	– formation of regional clusters through selective support to regions that have the potential to develop as world-class clusters – developing small clusters with strengths that utilize regional characteristics
Fourth Basic Plan of Science and Technology	2011–2015
Development of Cluster Policy	– building of regional innovation systems enabling local communities to independently develop STI activities that capitalize on their strengths – providing well-performed local clusters with governmental support in networking, fostering and securing of human resources, intellectual property activities concerning R&D and the promotion of R&D

Source: based on documentation provided by MEXT, Tokyo, during empirical research made by the author in October 2012.

When analysing the evolution of MEXT cluster policy through the years, it should be noted that governmental policy has been more and more closely linked with decentralization of development policies, in order to combine local assets and advantages with strategic goals of sustainable growth and societal development boosted by innovations.

Moreover, regionally designed innovation policies within the framework of MEXT policy were proposed to reorient and activate local capabilities for devel-

opment. Therefore, decentralization might be found as relative when recognizing direct linkages between local initiatives, their performance and significance, and governmental support, based on top-down system of evaluation and selection.

4. Cluster concept by MEXT

MEXT perceive cluster as a network among industry, academia and government focused on generating and promoting innovative chain reactions (Figure 1). According to MEXT, cluster structure should be based on tight collaboration and frequent communication among the participants, provide various new technological "seeds," while attracting external human resources, companies, information and capital.

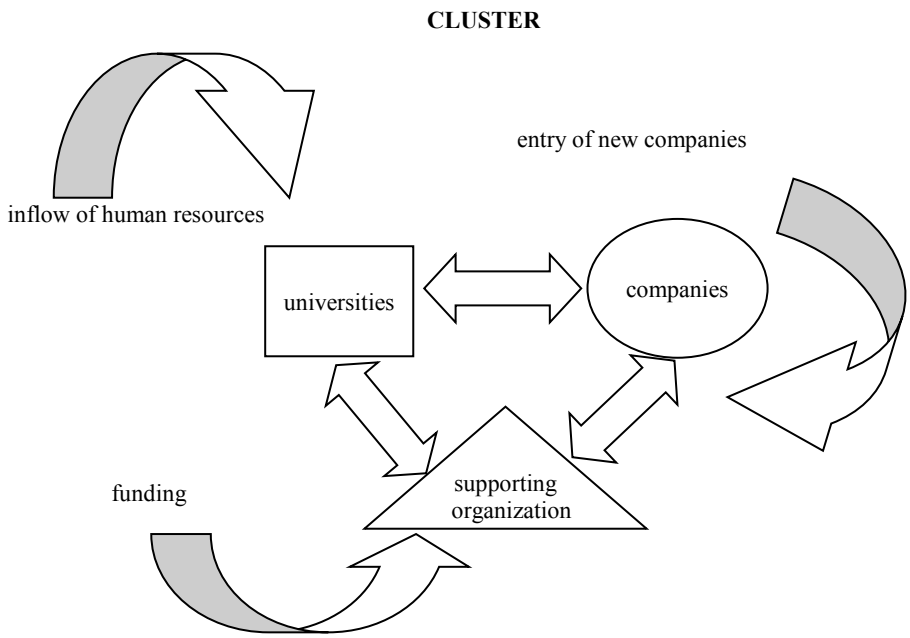


Figure 1. Cluster concept by MEXT

Source: own study by the author.

5. Regional Innovation Cluster Program

Knowledge Cluster Initiative, supporting the formation of world-class clusters, is expected to encourage and deepen regional independence of innovation policies. Local governments are expected to design core organizations responsible for collaboration with universities, companies and other relevant organizations to initiate

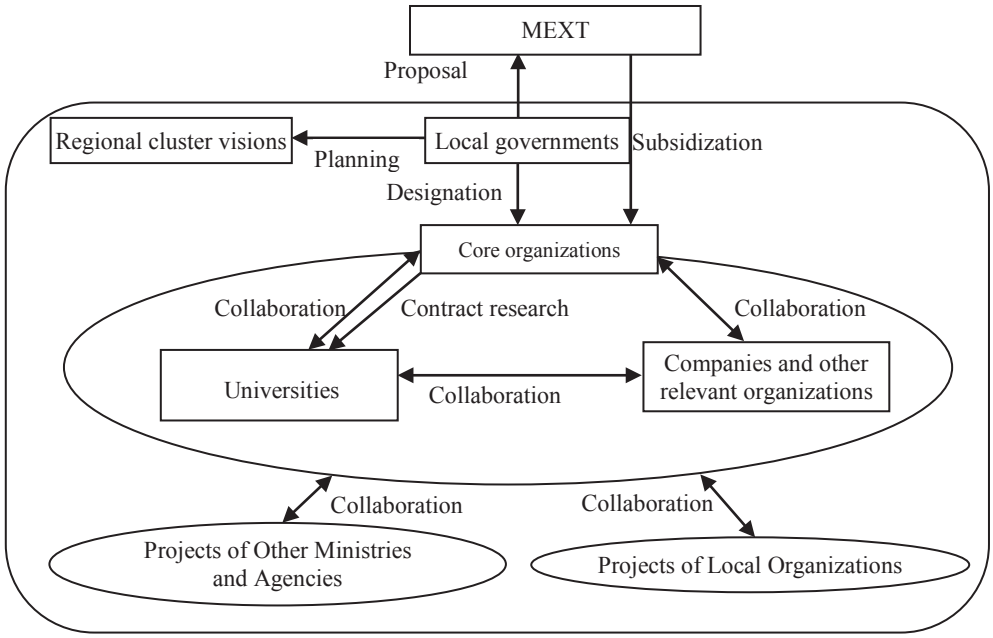


Figure 2. Regional Innovation Cluster Program

Source: based on documentation provided by MEXT, Tokyo, during empirical research made by the author in October 2012.

joint research projects, while being provided with projects of other ministries and agencies, i.e. R&D projects undertaken by METI or Japan Science and Technology Agency (JST), and local organizations, i.e. business groups and universities. Core organizations take the responsibility for realization of regionally designed cluster vision while local government submit his vision to MEXT for evaluation to get subsidies (Figure 2).

6. Quantitative results of Knowledge Cluster Initiatives

According to data provided by MEXT, between 2002 and 2012 127 projects within 75 regions were implemented, inducing investments of 120 billion JPY (1.2 billion EUR).

Majority of cluster initiatives has been concentrated around life sciences (e.g. Kansai Area Cluster, Kansai Science City and Surrounding, Takamatsu, Tokushima, Ehime Nanyo, Central Oita, Toyama Ishikiwa, Niigata, Central Akita, Hirosaki, Sapporo, Tokachi, Fukushima, Okinawa Coastal, Hiroshima, Yamaguchi, Kurume, Nagasaki, Toyohashi), nanotechnology/materials (e.g. Tokai Region, Kyoto, Hamamatsu, Yamagata Yonezawa, Fukui Central, Onoda and Shimonoseki, Fukuoka

Chikushi, Kumamoto, Ehime Eastern, Centrai of Osaka, Osaka Izumi), production engineering (e.g. Southern Okayama, Osaka East, Matsuyama, Harima, Southern Ishikawa, Nagaoka, Utsunomiya and Central Tochigi, Yokohama Inland, Western Tono), environment (e.g. Fukui Wakasa, Shinjiko and Nakaumi, Fukuoka Chikushi, Saga Ariake Sea Coastal, Southern Kumamoto, Miyakonojo Basin, Yoneshiro-river Basin, Kasumigaura Southern Coastal City, Kanto Plain Saitarna, East Kanagawa, Shonan and Central Kanagawa, Yamanashi Kuninaka, Tokai Region), energy (e.g. Fukui Wakasa, Fukuoka Chikushi, Hachinohe, Kasumigaura Southern Coastal City, Yamanshi Kuninaka) and IT (e.g. Fukuoka Kitakyushu Iizuka, Osaka Izumi, Southern Ishikawa, Sapporo, Mutsu-Ogawara, Sendai, Tsukuba Science City, Hamamatsu, Southern Gifu)[11] sector.

In financial years 2002–2011, according to calculations, 3064 domestic and 647 international patents were provided, 3501 domestic and 8320 international articles were published, 2238 ideas were commercialized/incorporated, while the sale of related products reached approximately 56.7 billion JPY (2.3 billion EUR). When comparing with City Area Program under Regional Innovation Cluster Program, presented achievements do confirm the primacy of outward orientation and globalization of Japanese clusters over local orientation, assuming creation of new businesses and R&D businesses that utilize unique regional resources within small to medium-size clusters.

Tokai Region provides interesting findings and characteristics of The Second Stage Knowledge Cluster Initiative, aiming at global expansion within nanotechnology manufacturing.

7. Tokai Region Nanotechnology Manufacturing Cluster

Cluster Program of Tokai Region was built on two pillars:

1) R&D on advanced nano-manufacturing technology for environment friendly materials and devices;

2) sustainable innovation cluster, assuming efficient industry-government-academia network, knowledge exchange networking (needs/seeds), between academia and industry, while providing facility support through government policy.

Tokai Region Cluster is a very well organized and promoted project, with Nagoya Industries Promotion Corporation, core agency located in Aichi Prefecture and R&D foundation from Gifu Prefecture cooperating under Knowledge Cluster Initiative Headquarter (Figure 3).

Research themes are directly correlated, transferring services and technologies (see Table 3 for details).

[11] Data provided by MEXT during empirical research made by the author in October 2012.

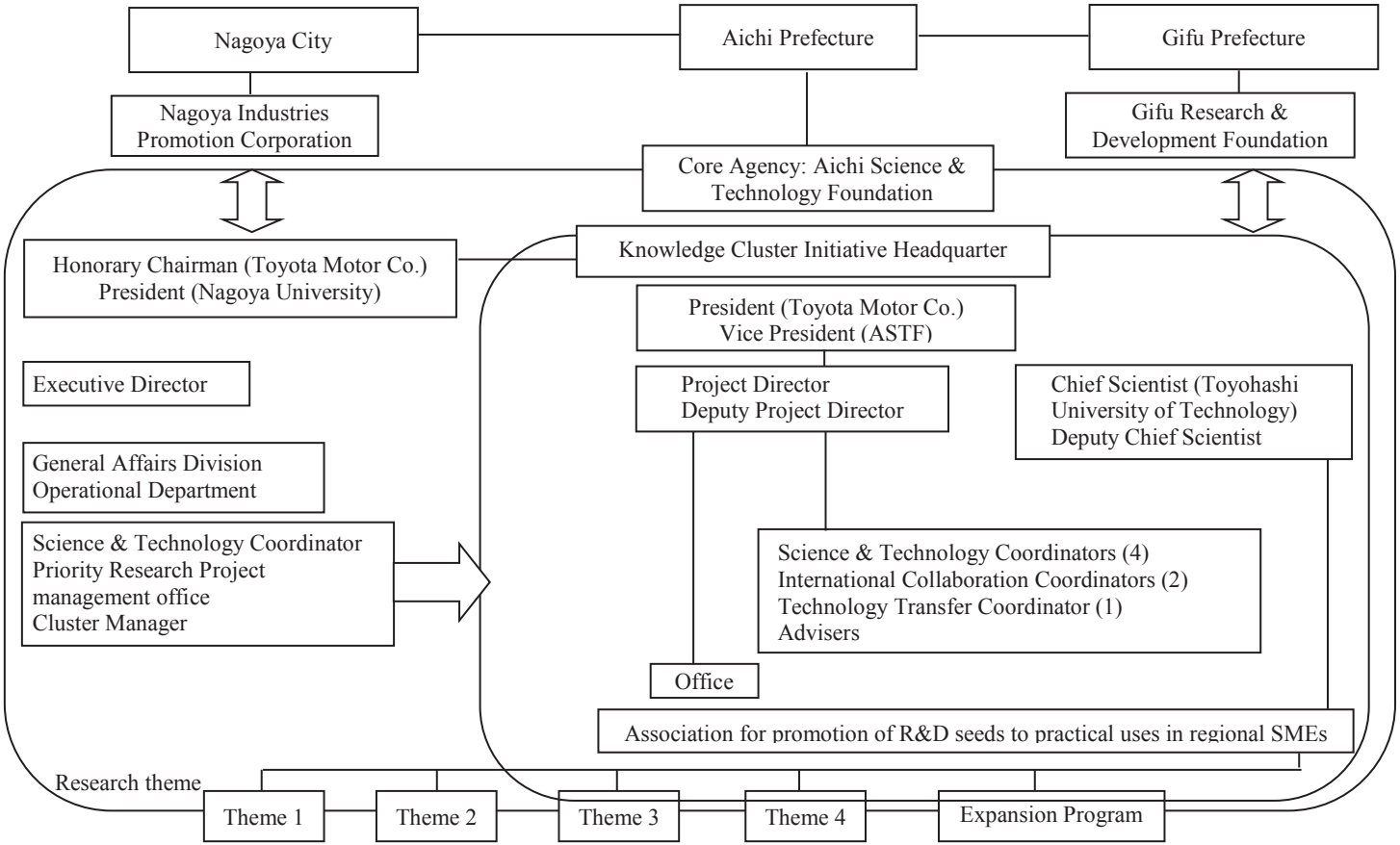


Figure 3. Organization of Tokai Region Cluster Project Promotion

Source: based on documentation provided by Tokai Region Cluster Headquarters and Aichi Science & Technology Foundation, Nagoya, during empirical research made by author in October 2012.

Table 3. Overview of research themes by Tokai Region Cluster

Research Theme	Objectives
Research Theme 1	Development of advanced plasma nanotechnology Total plasma control with plasma nanoscience – High-density radical source – Plasma measurement – Plasma control technology – Atmospheric plasma and liquid plasma technology
Research Theme 2	Development of advanced nanomaterials through surface functionality Development of nanomaterials with novel surface functions – Nano-carbon materials (solution plasma application) – Ceramic materials – Organic/inorganic hybrid nanomaterials
Research Theme 3	Development of highly-efficient optical, power materials and devices Development of GaN/Si semiconductors and device application – Large diameter GaN/Si substrates – InGaN nanostructure materials – Device process technology
Research Theme 4	Development of nanocomposites based on surface & interface engineering – Precision machine tools for CRRP – Environment-friendly nanocomposites
Expansion Program	Construction of Advanced Plasma Nanotechnology Research Foundation – Development of high performance plasma processing technology (international collaboration researches) – International Symposium on Advanced Plasma Science and its Applications (ISPlasma)

Source: based on documentation provided by Tokai Region Cluster Headquarters and Aichi Science & Technology Foundation, Nagoya, during empirical research made by author in October 2012.

Research conducted under Theme 1 provides plasma diagnostics and plasma surface treatment to Theme 2, plasma MBE (Molecular Beam Epitaxy) and plasma etching to Theme 3, Theme 2 exchange surface & interface technology with Theme 4, while Expansion Program induce international collaboration within Theme 1 and Theme 3.

8. R&D management in Tokai Region Cluster

According to the concept by Dr. H. Schmidt, there are five R&D phases of potential interactions and contributions of academia and industry:
– basic study,
– elemental technology development,
– product development,
– mass-production technology, and
– business.

Although, transfers of basic research results from academia to the industry in the business phase are forbidden, knowledge might be exchanged among industry and academia in the first four phases, while technology transfer from academia to industry should take place in the mass-production technology phase.

Nagoya Model provides a set of definitions of each R&D phase (see Table 4 for details).

Table 4. R&D phases according to Nagoya Model

R&D phase		Definition
Fundamental Research for Application		Research to yield Innovative Technical Seeds which can be used by Industry
Applied Research	Unit Technology	Incubation of the Seeds for Specified Product Target and the Auxiliary Technologies
	Product Development	Integration of the Unit Technologies to complete Product Target, and Prototype Production
	Mass Production Technology	Mass Production Technology Development of Product Target (infrastructure for trial production)
Business		Business Model Product Commercialization

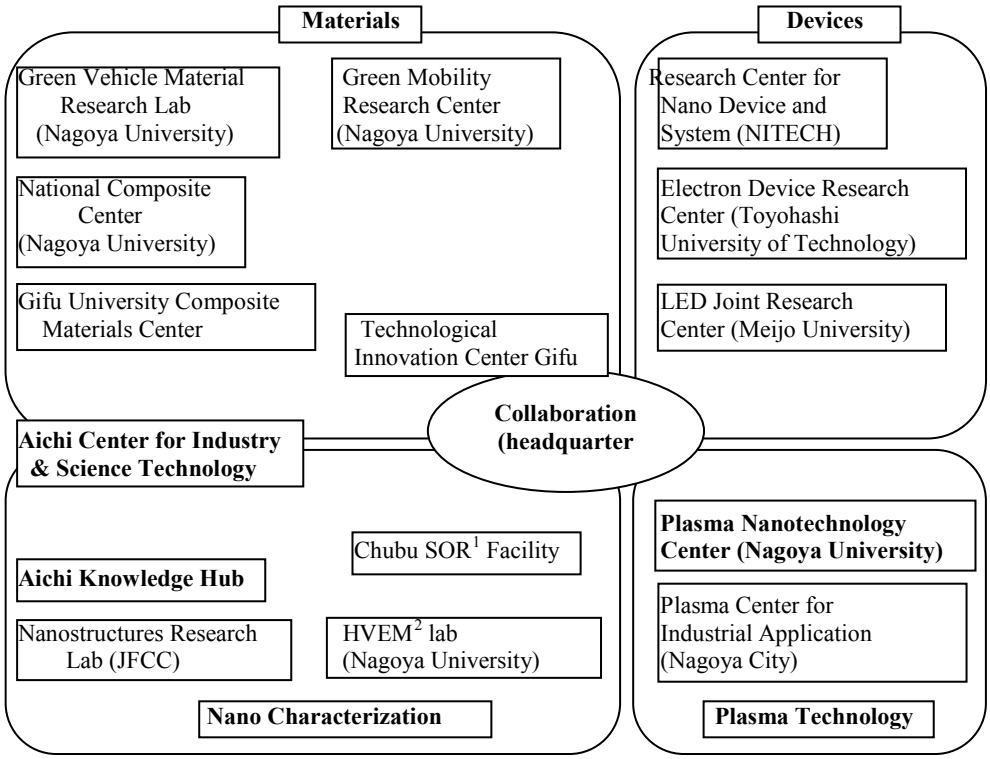
Source: based on documentation provided by Tokai Region Cluster Headquarters and Aichi Science & Technology Foundation, Nagoya, during empirical research made by author in October 2012.

Referring to Schmidt concept, research units operating within Tokai Region Cluster, i.e. Nagoya University and Toyohashi University of Technology, should be oriented on applicable studies to be potentially used by industry, subordinate applied research to complete product target and support prototype production through knowledge exchange. Mass production technologies, developed within academia, are to be transferred to industry in the 4th R&D phase, while inflow of knowledge from academia to industry in the last phase – product commercialization – is uncertain.

Tokai Region Cluster has developed various platforms and organizations for technology transfer (Figure 4).

Different research institutes, laboratories and universities are concentrated around knowledge hubs and centers coordinated by Tokai Region Cluster Headquarters within four dimensions: Materials, Devices, Nano Characterization and Plasma Technology.

Foreign partners in plasma technologies are engaged within International Plasma CoE Network – Plasma Nanotechnology Center located at the Nagoya University cooperates closely with research units from South Korea, United States, Australia, Germany, France, Ireland, Netherlands, United Kingdom and Italy.



[1] Synchroton Radiation; [2] High Voltage Electron Microscope.

Figure 4. R&D platforms and organization for technology transfer within Tokai Region Cluster

Source: based on documentation provided by Tokai Region Cluster Headquarters and Aichi Science & Technology Foundation, Nagoya, during empirical research made by the author in October 2012.

International collaboration is combined with intensive regional activities supported by local governments:

1. Installments of Regional Innovation Facilities
– Aichi Center for Industry and Science Technology,
– Technological Innovation Center Gifu,
– Plasma Science for Industrial Application.

2. Theme-based Workshops such as seminars of the Cluster Achievements and the related Topics, the Schooling and the Coaching
– Plasma Application Monozukuri (PLAM) Workshop,
– Highly Functional Nanomaterial Workshop,
– Nitride Semiconductor Application Workshop,
– Aircraft Material and Process Workshop.

3. Support of Public R&D, Technology Transfer to the Regional SMEs
– Projects for Utilization and Promotion of the Achievements of the Tokai Cluster,
– R&D Projects for Industrial Application of Plasma Technology,
– Joint Industry-Academia-Government Research Projects.

Therefore, management within Tokai Region Cluster might be studied through the prism of plan-do-check-adjust (PDCA) cycle, because every implemented action and executed task is preceded by brainstorm session, inputs consideration, objectives planning, followed by evaluation, data analysis and recommendations formulation. Local governments take the responsibility for visualization of cluster initiative outcomes and effective utilization of regional activities. Finally, R&D processes are managed using multiphase Nagoya Model. Various Innovation Platforms and Organizations are designed in the form of networks to locate R&D facilities near industries.

9. Tokai Region Cluster results

Regional Cluster Initiative have already resulted in a few successful R&D results within Theme 1, 2, 3 and 4 (see Table 5 for details).

Table 5. Tokai Region Cluster – R&D results

R&D Objective	R&D Results
Research Theme 1: Development of Advanced Plasma Nanotechnology	
Precise control of plasma and construction of plasma science	Element technologies for an autonomous control of plasma nano-process Effectiveness of the autonomous control of plasma nano etching Scientific researches of radical species in plasma lead to plasma process optimization
Research Theme 2: Development of Advanced Nanomaterials through Surface Functionality	
R&D of advanced functional materials through surface modification	Stable growth discharge plasma in solutions Expansion of the SP technology Reaction promotion, cluster formation, and surface modification Nanoparticles as electrode catalysts in metal-air battery and H2-fuel cell
Research Theme 3: Development of highly-efficient optical, power Materials and Devices	
GaN/Si heteroepi semiconductors and power device applications	MOCVD equipment for large-diameter GaN/Si substrate High quality 6 inch GaN/Si leads to low cost and high performance power devices All Japan power device R&D centre in Nagoya Institute of Technology
Research Theme 4: Development of Nanocomposites based on Surface & Interface engineering	
Development of new carbon-fiber-reinforced plastic (CFRP) and ultra-precision machine tools	By the centrifugal sintering casting method, abrasive grains functionally graded grinding wheels with 20 mm were successfully fabricated and the gyro-driving grinding wheel machine, which can make high quality holes on CFRP by using the unique technique, was developed

Source: based on documentation provided by Tokai Region Cluster Headquarters and Aichi Science & Technology Foundation, Nagoya, during empirical research made by author in October 2012.

Four separate research fields, led by specialists from Nagoya University and Nagoya Institute of Technology, should encourage the advancement of plasma nanotechnology and utilization of nanomaterial and device technologies at key junctures, promote the use of environment-friendly advanced materials and processing technologies by regional SMEs.

Meanwhile, Expansion Program is expected to reinforce personnel development and international collaboration, to promote international industry collaboration, research seminars aimed at smooth transfer of research achievements within academia-industry-government network.

Since 2009 five annual International Symposiums on Advanced Plasma Science and its Applications for Nitrides and Nanomaterials (ISPlasma) were organized in order to create a world leading international foundation for advanced plasma nanotechnology science. In March 2010 Tokai Region Cluster Headquarters have concluded a partnership agreement with the research and development foundation MINATEC, located in France – world leader in the field of nanotechnology.

According to the roadmap provided by Tokai Region Cluster Headquarters R&D activities within optical/power device components, fundamental plasma nanotechnology, nanomaterials and processing, conducted through the network of five industry-academia-government partnership centrer and six collaboration centrer, should contribute to development of next-generation industries, offering green vehicles, aircrafts, environment-friendly materials and processing, medical devices and environmental conservation, etc.

10. Conclusions

Knowledge Cluster Initiative by MEXT combine clustering with the concept of knowledge-based economy, seeking for effective frameworks of future growth strategy. R&D management in terms of Nagoya Model, visualization of outcomes and actions according to PDCA cycle, accompanied by utilization of regional advantages, result, in case of Tokai Region Cluster, in significant achievements within plasma technology, GaN/Si Epi technology and ultra-precision machines. Expansion of network type innovation platform involving international partners may increasingly strengthen global performance of Japanese economy.

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INICJATYWA KLASTRA WIEDZY MEXT – PRZYKŁAD KLASTRA NANOTECHNOLOGICZNEGO REGIONU TOKAI W JAPONII

Streszczenie: Inicjatywa Klastra Wiedzy MEXT przewiduje wsparcie rzeczowe i promocyjne lokalnych inicjatyw współpracy przemysłu, środowiska nauki i rządu na potrzeby umiędzynarodowienia struktur klastrowych i dynamizacji rewolucji technologicznej. Klaster regionu Tokai stanowi interesujący przykład intensywnych interakcji aktorów prywatnych i publicznych zintegrowanych wokół wspólnej wizji postępu.

Słowa kluczowe: inicjatywa klastra wiedzy, region Tokai.