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| Textversion | author  |

# Collaborative Promotion of Nanotechnology Researches in

## Kyoto Area

The technology, which can control materials and processes at the nano-scale precision, "nanotechnology", has been utilized for a long time in Kyoto, an old capital of Japan. Kyoto is well known not only as a traditional and cultural town but also as one of the most innovative towns in Japan, and has produced many world-wide technology-based start-up (venture) companies, such as Kyocera, Nintendo, Omron, Murata MFG, Rohm, Horiba MFG, Nichicon and more. In these two features of tradition and innovation, there exists potentially a close correlation. Loads or emperor in the capital had gathered the highest level of technologies at their times and created various kinds of artistic works and buildings. Namely, the concentration of high-technology as well as the creation of new technologies are essential to built new industry as well as to keep the activity of the principal towns.

One of typical nano-scale products produced from such the circumstances may be the golden foils with uniform thickness of several hundreds nano-meter. Many travellers from the world visit the golden pagoda (Rokuonji Temple), located in Kyoto, all the walls of which are shining and covered with golden foils, not composed of golden brocks, as shown in Figure 1. The foils are very uniform and extremely thin as several hundreds nanometer. Such the foil fabrication technics, which are believed to been developed first in ancient Egypt period, can be classified as one of nowadays nanotechnologies, and have been utilized and improved by using modern technologies to form printed substrates of cell phones and PC as well as touch panels. Thus, the nanotechnology as modern high-tech, which has a long history and created traditional arts, is now essential technologies to produce recent advanced materials and devices.

Since the nanotechnology is basic and wide-range research area, various

aspects and relations are involved to promote the research as well as the creation of advanced industrial products. Here, in this article, several activities in nanotechnology research and development fields conducted in the Kyoto area are introduced as follows.

## **FUSION IN NANOTECH RESEARCH –INTECH RESEARCH CENTER-**

Academic research area included in and related to nanotechnology are broad and the collaboration (fusion) is essential to promote timely novel achievements. In universities, there are very many researches specialized in various different fields such as physics, chemistry, biology, as well as electrical, mechanical and material engineering, but their interactive works have been seldom conducted by research groups covering over three or four research categories.

The Int'tech center at a graduate school of engineering in Kyoto university may be one of such formations, as illustrated in Figure 2. An "int" in the new word of "Int'tech" is derived from a prefix in the words of "international", "interdepartment", "interdisciplinary", and "intelligent". This center is composed of several advanced institutes such as the department of nano-technology, the members of which are the professors and researches belonged to various related and different research fields, forming several specific groups, as shown in Figure 3.

The university provides laboratory spaces included with clean rooms, but the maintenance fee should be paid by the constituting members. By forming such interdisciplinary members, novel researches areas such as molecular electronics, fusion of chemistry and electronics, can be promoted first with a large viewpoints. This system was established about 10 years ago, and is still active even now with a little systematic changes. Actually, this system has been useful to work together not only with various research groups in the university but also with academia/industry collaborative groups, and further to propose and get a large scale of governmental research funds.

## **ACADEMIA-INDUSTRY COLLABORATION R&D PROGRAM**

In order to develop advanced materials and devices such as organic EL (electro luminescent) display and solar cells, it is necessary to integrate many knowledge and researchers, and Kyoto university-“Strategic Alliance Program” was one of such academia-industry collaboration research project, the outline is shown in Figure 4. The project was conducted by gathering many researchers over 150, specialized in molecular design, synthesis, fabrication process, device evaluation, and not only from universities but also from industries. The industrial companies involved were Hitachi Electric, NTT, Mitsubishi Chemical, Pioneer, and Rohm, which are the companies of different categories and form unique and vertical integration. This five-years project with about 15M\$ research fund offered from these companies have produced successful results for making high efficient organic EL devices and higher conversion rate solar cells, and many intellectual patents over 130. One of unique results produced firstly by such the combination was a flexible substrate for EL display, which is the transparent and thermally stable one, composed of natural origin bio nano-fibers and plastic, as shown in Figure 5.

## **FORMATION OF NANOTECH RESEARCH NETWORK**

In June of 2002, the Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) was commenced to support researchers working in nanotechnology. Since the nanotechnology is a multidisciplinary field expanding over a wide range of technologies, the Nano-technology Support Project aimed to support researchers by making use of high-quality and high-performance facilities in well-established 14 research centers in Japan and also by consulting on technical issues. From 2008, this program was transferred to the second stage and concentrated to 7 major groups, and Kyoto university was selected as one of such the seven centers. The supporting system is not limited within one university or institute, and

actually Kyoto university has promoted the project cooperatively with the neighboring two universities.

### **CLUSTER PROJECT IN ENVIRONMENTAL NANOTECHNOLOGY AREA**

Researches in nanotechnology are expected to produce novel materials high-performance devices, and further new industries as a whole. Therefore, many nations in the world have promoted actively the research and development of science and technology in nanotechnology area, and afford lot of research funds. As one of such the project, Japanese government has promoted so-called high-tech “cluster project”, by which local regions form the innovative areas (cluster) by the collaboration of academia, industry, and local governments so as to produce constantly advanced technological products, as illustrated in Figure 6.

Kyoto area has proposed the nanotechnologies, as such the advanced technology, to be developed in the area, and been selected from the national government as one of such the cluster areas. At the first period of from 2001 to 2007, the Kyoto Cluster project had conducted mostly fundamental researches in nanotechnology area and developed many new functional materials, evaluation systems, and high-efficient sensors with the total fund of about 30 M\$. Now, as the second stage starting from 2008 for 5years with the total budget of about 40 M\$, Kyoto area has focused the objectives of the nanotech-research and development so as to solve the environmental issues, by creating new eco-materials and energy-saving devices. By collaborating with academia and industrial researches, many products have been produced and been now close to commercial.

### **LOW CARBON RESEARCH NETWORK JAPAN (LCNET)**

In order to facilitate the “Green Nanotechnology” which contribute to reduce the amount of carbon dioxide emission using nanotechnology, a network of 3 core facilities and 15 research satellite facilities shown in Figure 7 was established in Japan in March 2011 with budget of 175 M\$ from MEXT. At Kyoto University, as one of core facilities, a center for micro/nano fabrication and device was established with budget of 50 M\$ and start to provide its service to provide the most advanced research environments to research

scientists and industrial engineers conducting the research for green nanotechnology together with other two core facilities, a center for materials research (at National Institute for Material Sciences) and a center for advanced characterization and analysis (at the University of Tokyo).

## INTERNATIONAL AND YANG-RESEARCHERS FORSTER PROGRAMS

As the nature of nanotechnology, new academic fields as well as novel social areas will be produced especially with the fusion of different categories. We, Kyoto university, had run so-called “nano-medicine merger education program for five years, supported by MEXT. In this program, the members of two faculties of medicine and engineering, and an institute for frontier medical sciences have worked cooperatively to form curriculum for the new fields, and many graduate students of these organizations and the researches belonging to companies studied the basic as well as advanced contents related to the nano-medicine merger area.

In addition, some international collaboration programs have been carried out in these years. One of such the examples is the Micro-Alliance project, consisted from university of Michigan in USA, Freiburg university in Germany and Kyoto university in Japan, the outline of which is shown in Figure 8. Collaborative research and education focusing on the micro/nano electro mechanical system in graduate school level have been conducted very actively.

## ACKNOWLEDGEMENTS

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## ABOUT THE AUTHOR

*Kazumi Matsushige* ([matusige@kuee.kyoto-u.ac.jp](mailto:matusige@kuee.kyoto-u.ac.jp)) received his Ph.D. and D.Eng. degrees from Case Western Reserve university, USA in 1975 and from Kyushu university, Japan in 1981, respectively. He was a vice-president

of Kyoto university in charge of the academia-industry collaboration and intellectual properties, and is now a professor at the Department of Electrical Science and Technology and a director of VBL (venture business laboratory) of Kyoto university. Moreover, he is now working as a director of an expansion (international collaboration) program in the Kyoto EnviNano cluster initiatives, started from September of 2008. His major research topics are molecular electronics, nanotechnology and electric cars.

## Figure Captions

FIGURE 1 The fabrication technics of golden foils was used in traditional arts and has been applied to modern industrial products.

Figure 2 Concept of structure formation of interdisciplinary research organization “Int’tech center”.

FIGURE 3 Outline of an advanced institute of nanoscale science and technology at Int’tech center.

FIGURE 4 Outline of Kyoto university-“Strategic Alliance Program”.

FIGURE 5 Formation of novel organic substrates for EL devices, composed of natural nano-fibers.

FIGURE 6 Concept and structure of the national high-tech “Knowledge Cluster Initiative” projects.

FIGURE 7 Framework of low carbon research network in Japan.

FIGURE 8 Outline of an international Micro-Alliance project.



# Nanotech at Kyoto

- Gold: Create Culture and Modern Livings -



Gold Foil

~100 nm



Copper foil printed substrates for cell phones and computers



Kinkakuji Temple

“Zipangu”, an island of gold



Copper foil for touch panel

# Int'tech Center

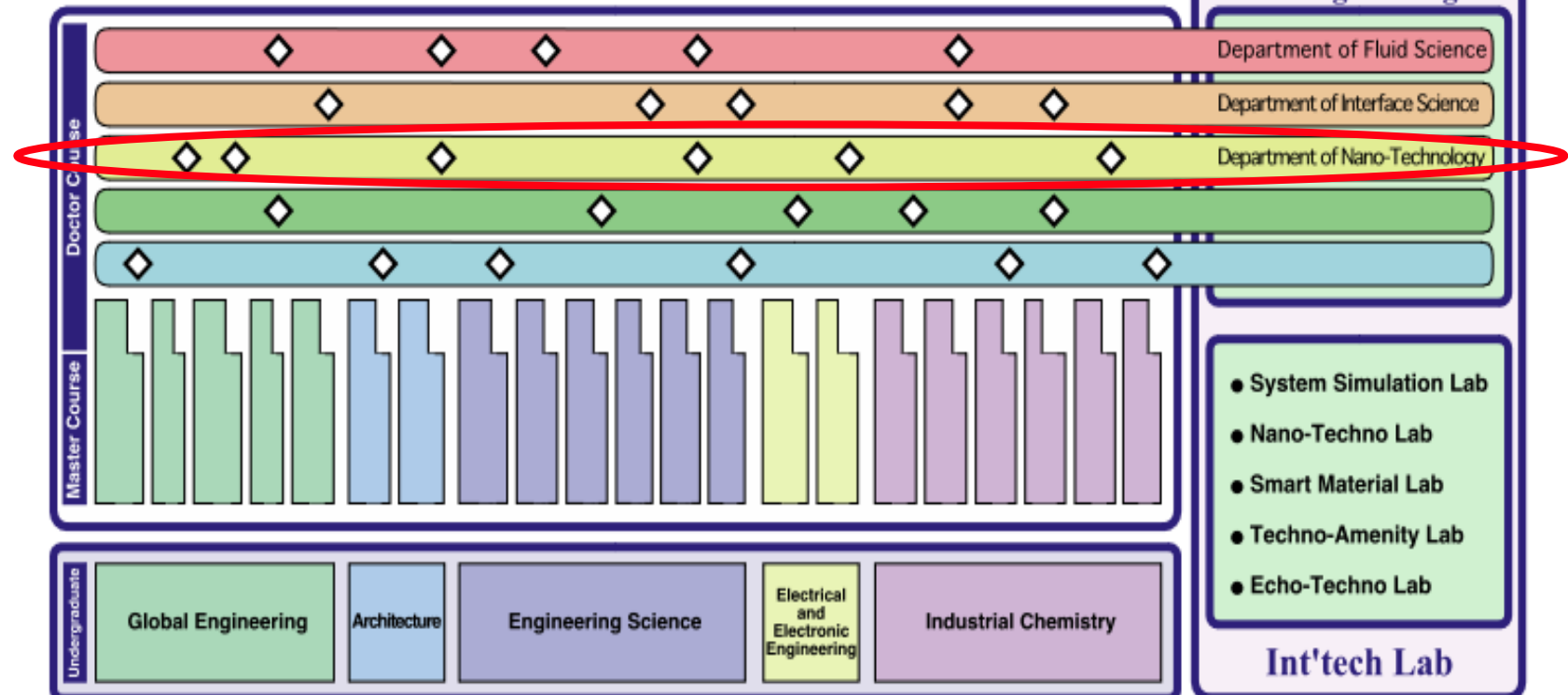
Graduate School of Engineering, Kyoto University at Katsura

International  
Interdepartment  
Interdisciplinary  
Intelligence  
Technology

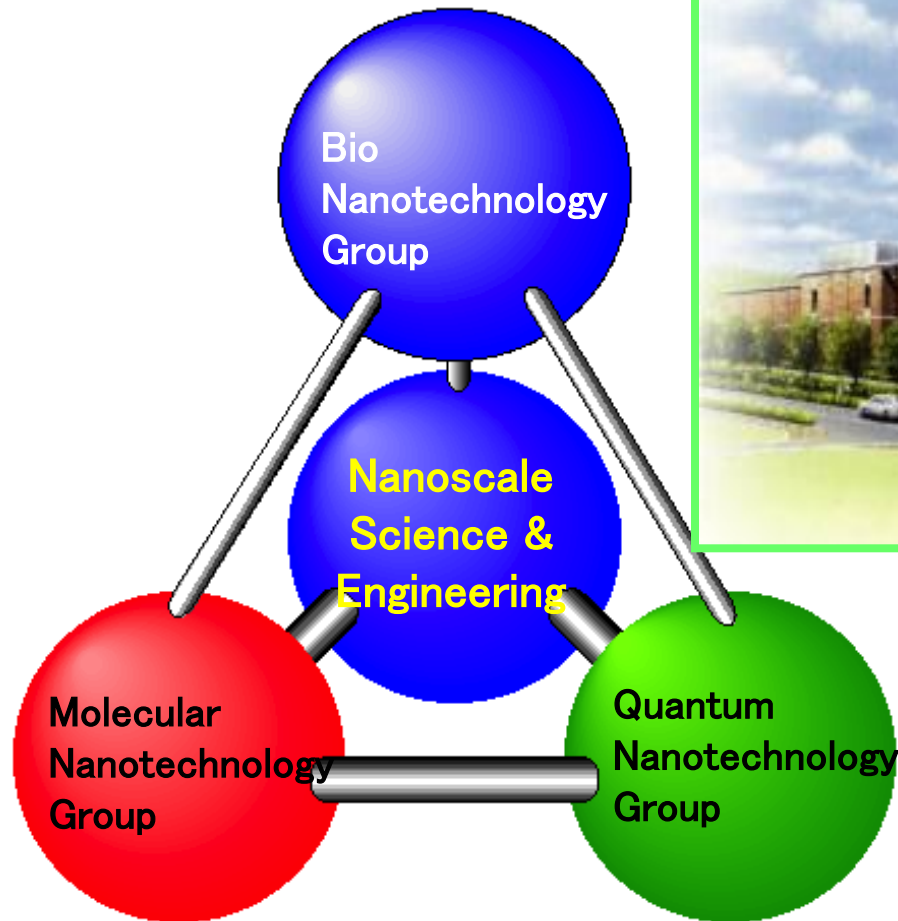


## Int'tech Center

### Graduate School of Engineering



# Advanced Institute for Nanoscale Science and Technology at Int' tech Center



**Creation of novel technologies and  
new industries in the 21st century**

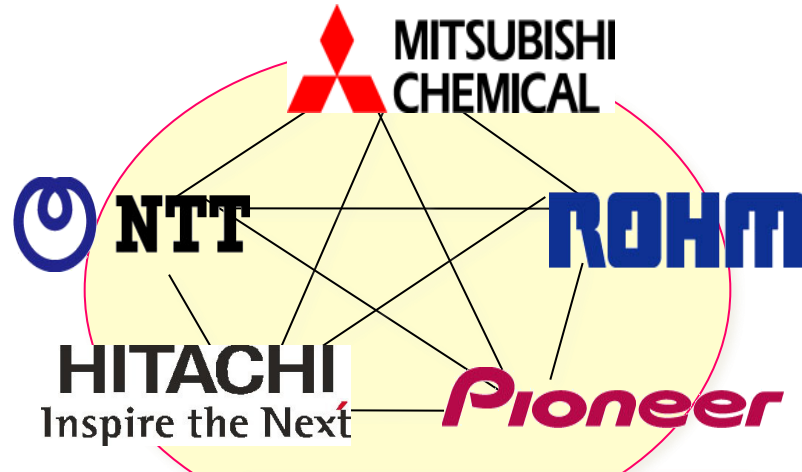
Interdisciplinary research over a wide variety of fields including physics, chemistry, biology, electronics, material science and mechanical engineering.

# Strategic Alliance Program with Five Companies



**Kyoto Univ.**

Members are from  
Fac. Of Eng., Sci, and  
Several Research Centers



Five companies of  
different categories

**General Managing Offices**

Strategic Committee

IP-WG

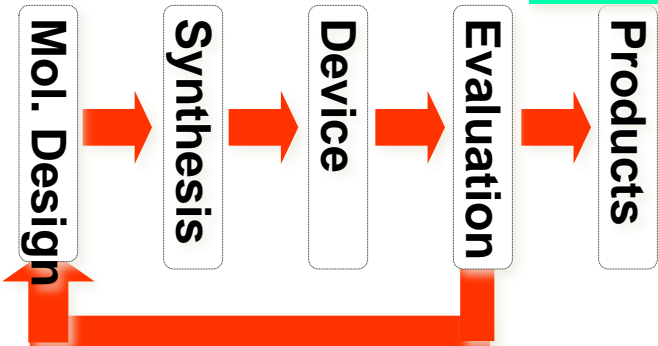
Promotion Committee

Publication-WG

4 Research WG, 18 Research Groups  
(Total No. of member: 150)

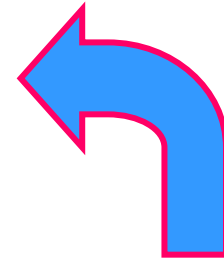
**Quick Return R&D Process**

Organic EL

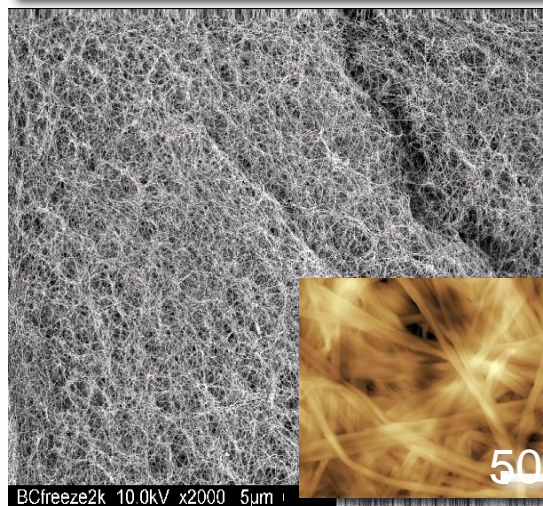
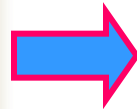


# Novel Organic Substrates for Electric Devices utilizing Bio Fibers

Transparent,  
Flexible, and  
Thermally stable  
Bio-fiber based  
Substrate



*nata de coco*



Bio Nano-fibers



Transparent film

# Knowledge Cluster Initiative

## Core Organizations

Foundations or Other Corporations  
Designated by Local Governments

Various projects

↑ Cooperation ↓

METI, JST, TLO etc

Integration of  
Knowledge &  
Industries

## Knowledge Cluster Headquarter

Planning &  
Implementation

Cooperation

Research  
Grant

Cooperation

■ Universities  
■ Public Institutions

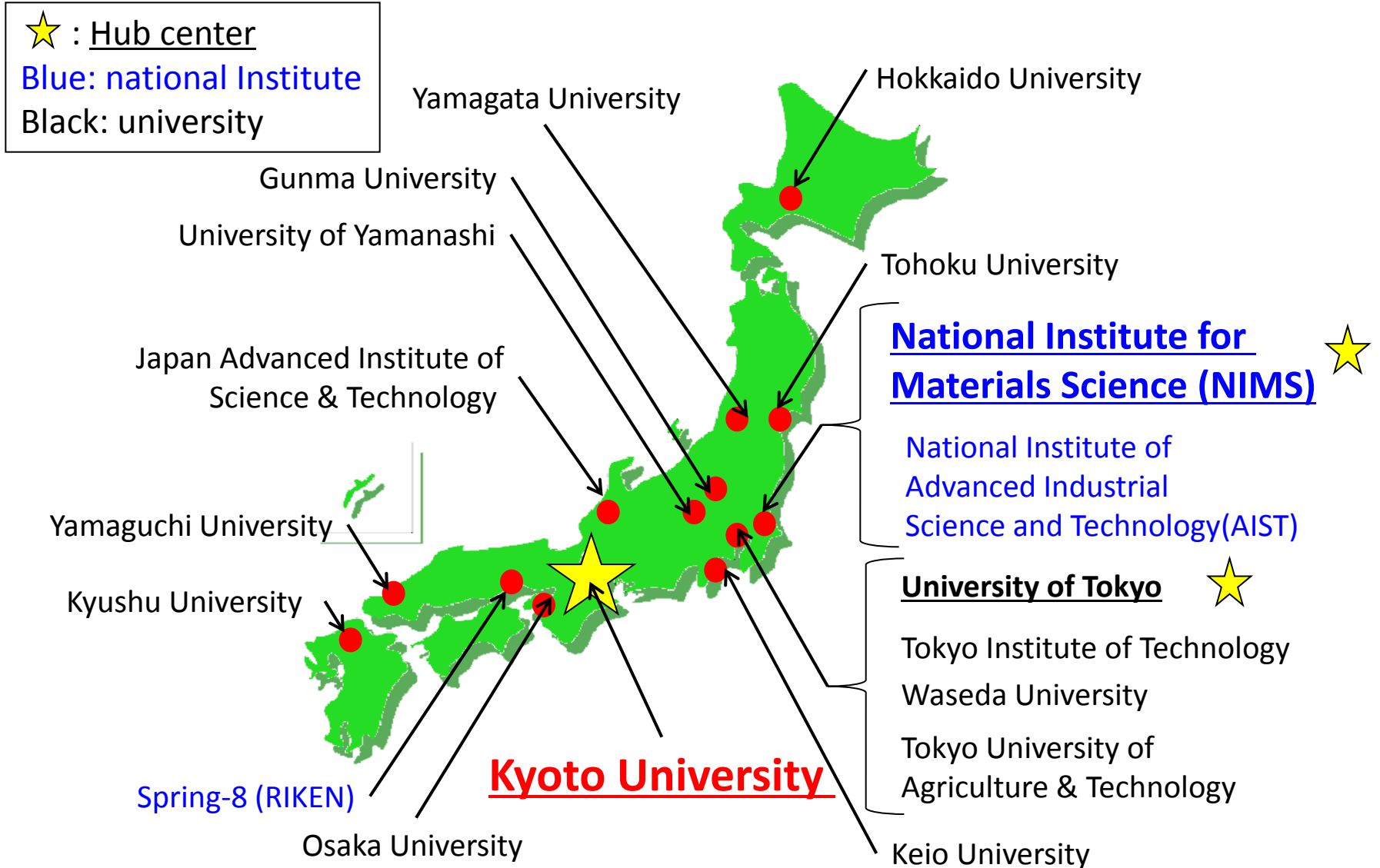
**Core Function**

Cooperation

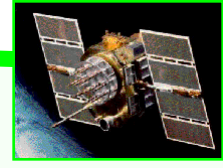
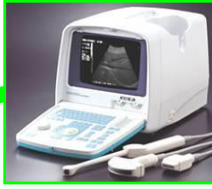
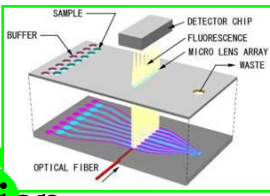
■ Industries  
■ Firms  
■ Venture Corporations

- Continuing Industry-Academia-Public Joint Research for Creating Innovation
- Staffing with Specialist Science & Technology Coordinators
- Promotion of Patent Application and Incubation of Research Products for Industry

# Low-Carbon Network Japan



# MicRO Alliance Project



Cooperative Industries

Freiburg Univ.

Application

Kyoto Univ.

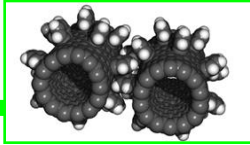


Students Exchange  
Researchers Exchange  
Educational Contents Sharing  
Research Infrastructure Sharing  
Academic Information Sharing  
Cooperative Research

Univ. of Michigan



Cooperative Industries



Cooperative Industries