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Japan's R&D Strategy of Nanotechnology

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Outline of Presentation

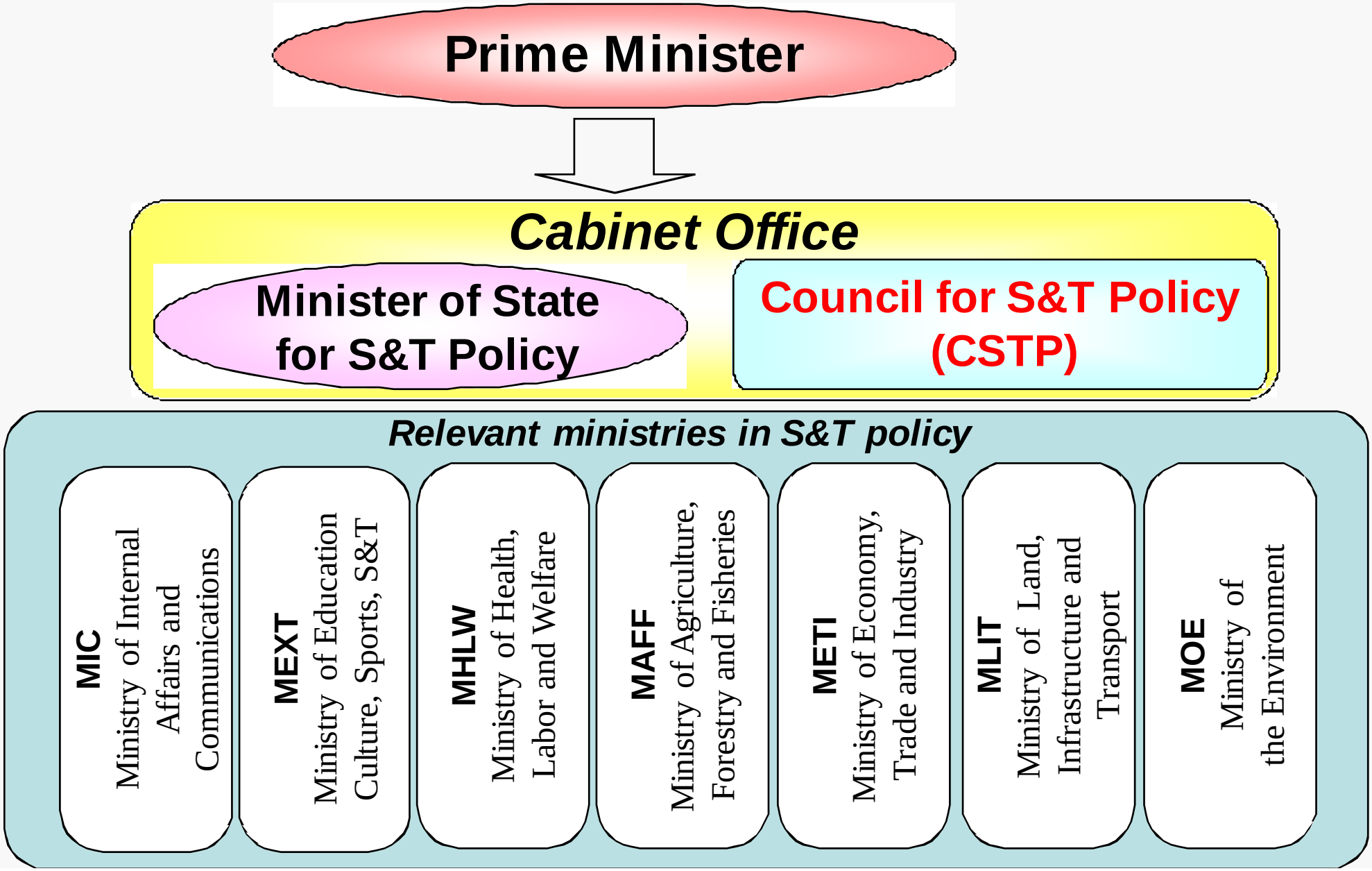
I. System and Strategy for Science and Technology (S&T) and Nanotechnology/Materials in Japan

II. Trends of Budget

III. Topics in Nanotechnology/Materials

IV. Draft of 4th Science and Technology Basic Plan (FY2011-2016)

3rd S&T Basic Plan
Promotion system of S&T policy in Japan



3rd S&T Basic Plan
Council for S&T Policy (CSTP)

Member

- Prime Minister (Chairperson): Naoto KAN
- 6 Relevant ministers
- 8 CSTP executive members

Mission

- S&T basic policies (Investigations and deliberations)
- Resources allocation (Investigations and deliberations)
- Nationally important R&Ds (Evaluations)

Dr. Masuo AIZAWA

Former President, Tokyo Institute of Technology

Dr. Tasuku HONJO

Visiting Professor, Kyoto University

Dr. Naoki OKUMURA

Former Representative Director and Executive Vice President, Nippon Steel Corporation, Ltd

Dr. Takashi SHIRAISHI

Vice President and Professor, National Graduate Institute For Policy Studies

Dr. Rhoji CHUBACHI

Vice Chairman, Sony Corporation

Dr. Toyoko IMAE

Professor, Keio University

Dr. Reiko AOKI

Professor, Hitotsubashi University

Dr. Ichiro KANAZAWA

President of Science Council of Japan

S&T Basic Law and S&T Basic Plan

Science and Technology Basic Law
（enacted in 1995）

1st Basic Plan (FY 1996-2000)

2nd Basic Plan (FY 2001-2005)

3rd Basic Plan (FY 2006-2010)

●Increase in governmental R&D expenditure

The total budget for governmental R&D expenditure exceeded **17 trillion yen**.
（Actual investment: 17.6trillion yen)

●Construction of new R&D system

- Increase in competitive research funds
- Support plan for 10,000 post-doctoral fellows
- Promotion of industry-academia-government collaboration
- Implementation of evaluation systems etc.

●Three basic ideas

(i) Creation of wisdom
(ii) Vitality from wisdom
(iii) Sophisticated society by wisdom

●Key policies

- Strategic priority setting in S&T
  — Promotion of basic researches
  — **Prioritization of R&D**
- S&T system reforms
  — Doubling of competitive research funds
  — Enhancement of industry-academia-government collaboration
- Total budget :**24 trillion yen**

（Actual investment: 21.1trillion yen)

●Three basic ideas

Create Human Wisdom, Maximize National Potential, and Protect Nation's Health and Security

●Key Policies

Promotion of basic researches

- **Quantum-jump knowledge, discovery and creation based on the free ideas of researchers**
- **Basic research in diversified areas**
- **Strategic basic research**

Promotion of R&D for policy-oriented subjects

Prioritized 4 Areas

- Life Science
- ICT
- Environment
- Nanotech/Materials

Promoted 4 Areas

- Energy
- Manufacturing technology
- Social Infrastructure
- Frontier

Key Technologies of National Importance

S&T System Reform

- **Developing, securing and activating human resources**
- **Creating scientific development and persistent innovation**
- Total budget :**25 trillion yen**

3rd S&T Basic Plan
8 Promotion Areas (4 Prioritized Areas)

Life Sciences

The CSTP promotes R&D that will help to enable the public to lead long and healthy lives. It also responds to infectious diseases, ensures food safety, improves Japan' s self-sufficiency in foods, and strengthens the industrial competitiveness. This R&D includes post-genome research into the analysis of protein structure and proteome, translational research to effectively apply the fruits of basic research to medical care and the development of medicine, research into cancer and infectious diseases, and R&D related to food production and supply. The CSTP will also endeavor to promote understanding public of genetically modified crops.

Torenia produced with a state-of-the-art biotechnology (courtesy of the National Agriculture and Food Research Organization)

Information and Communications

Aiming to achieve a ubiquitous society that can attract whole of the world, the CSTP promotes basic research such as next generation super computers, application and verification R&D such as next generation networks, devices, and robots, and R&D in areas into the future, such as automated voice translation.

Automated voice translation (courtesy of Advanced Telecommunications Research Institute International/National Institute of Information and Communications Technology)

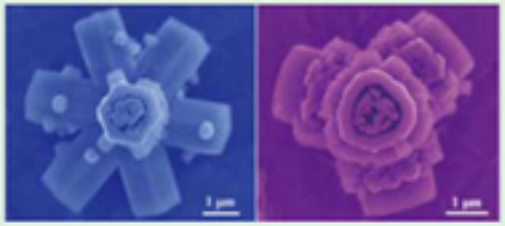
Environmental Sciences

The CSTP promotes R&D to satisfy both the conservation of the natural environment and economic growth, and to realize sustainable development: R&D related to climate change, hydro-logical cycles and solute transport in watersheds, ecosystem management, chemical risk and safety management. "3R" (reduce, reuse, recycle) technologies, and biomass utilization technologies. Japan would like to contribute to the world through these R&D activities.

Tower flux observation site measuring CO_2 balances of forest at Mt.Fuji (courtesy of the Forest and Forest Products Research Institute)

Nanotechnology / Materials

Nanotechnology /Materials, which aim to control the atomic- or molecular-sized structure, are remarkably improving the conventional materials, electronics, biomaterials technology, and so on. The technology contributes to the innovation as the scientific/technological infrastructure, creating new and extensive fields such as nanomaterials, nanoelectronics, and nanobio technology.



SEM images of ZnS nanocrystals grown by the CVD method (courtesy of National Institute for Materials Science)

3rd S&T Basic Plan
8 Promotion Areas

Energy

With growing concern about constraints on the supply and demand of energy and climate change around the world, the CSTP supports R&D that will help to balance environment and economy and at the same time ensure stable energy supplies and contribute to reducing environmental burdens, including energy-saving, renewable energy and nuclear power technologies.

Monju prototype of fast breeder reactor (courtesy of Japan Atomic Energy Agency)

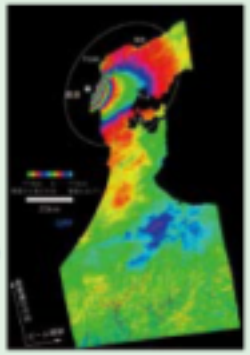
MONODZUKURI (manufacturing) technology

MONODZUKURI technology is more than just the development of technologies for manufacturing. One of the most important policy challenges is to maximize the added value by reaching the service and information technology industries. Technologies for minimal-resource, energy saving and manufacturing of high-quality products that can withstand the rigors of the consumer market have been the Japan's advantages. By boosting such technological strengths furthermore, the CSTP will seek to make Japan the world leader in MONODZUKURI.

Manufacturing of a turbine shaft (from the business report on MONODZUKURI EXHIBITION)

Social Infrastructure

To make Japan the world' s safest country, the CSTP encourages the development of technologies to monitor and manage national land and mitigates disasters, and new technologies to support activities at disaster sites. It also deals in the development of technologies for rebuilding infrastructure and urban areas, and new technologies for traffic and transport systems to make a major rehabilitation of the aging infrastructure and to respond to a society in which there are fewer children and more elderly people.



Analysis of crustal disturbance after an earthquake, created by the Advanced Land Observing Satellite "Daichi" (courtesy of JAXA)

Frontier

To establish technologies that will enable a full command of the frontiers of the ocean and outer space, and pioneering of the use of these frontiers, the CSTP encourages the development of highly reliable space transport systems, technologies for improving the reliability and functions of satellites, next-generation ocean exploration vessels, and offshore platform technologies.

Earth Observation and Ocean Exploration System (Deep Sea Drilling Vessel CHIKYU) (courtesy of Japan Agency for Marine-Earth Science and Technology)

Nanotechnology/Materials Area

5 Sub-Areas and 29 Key R&D Subjects

NANO-ELECTRONICS (6)

>Next-Generation Silicon-based Nano-electronics superior to conventional silicon semiconductors

>Electron/Photon-controlled Nano-electronics

>Nano-scale Manufacturing Technology for Electronics

>Cost Reduction Technology for Nano-electronics Components

>Energy-saving/Environmentally-friendly Nano-electronics

>Nano-electronics for Security

MATERIALS (9)

【To Deal with Energy Issues】

>Advanced Materials to Promote the Use of Unpopular Energy

>Advanced Materials for Highly Efficient Use of Energy

【To Build an Environmentally-friendly Sustainable Society】

>Materials to Deal with Toxic Substances

>Substitution and Saving Technology for Rare or Deficit Materials

>Materials for Environmental Improvement and Conservation

【To Build a Secure and Safe Society】

>Materials for a Secure and Safe Society

【To Maintain and Reinforce Industrial Competitiveness】

>Materials for the Most Advanced Electro-Apparatus

>Materials for Competitive Transport Equipment

>Manufacturing Technology for Innovative Materials and Components for the Next-Generation

NANO-BIOTECHNOLOGY & BIO-MATERIALS (8)

>Molecular Imaging Technology for Investigating Internal Structures and Mechanisms

>Manipulation Tech. for Internal Molecules

>Diagnosis and Treatment Methods using DDS and Imaging Technology

>Apparatus with Super-microscopic Processing Technology

>Detection Technology for Ultra Traces of Substances

>Patient-friendly Bio-devices with High Safety and Advanced Functions

>Regeneration Initiation Materials

>Nano-biotechnology Applied Food

FUNDAMENTALS for NANO. / MATERIALS (5)

【Technological Fundamentals】

>Advanced Nano-measurement and Nano-processing Technology

>Novel Utilization of Quantum Beams for Measurement, Fabrication and Manufacturing Technology

>Simulation and Design Technology to Exploit Material Properties and Functions

【Promotional Fundamentals】

>Responsible R&D of Nanotechnology

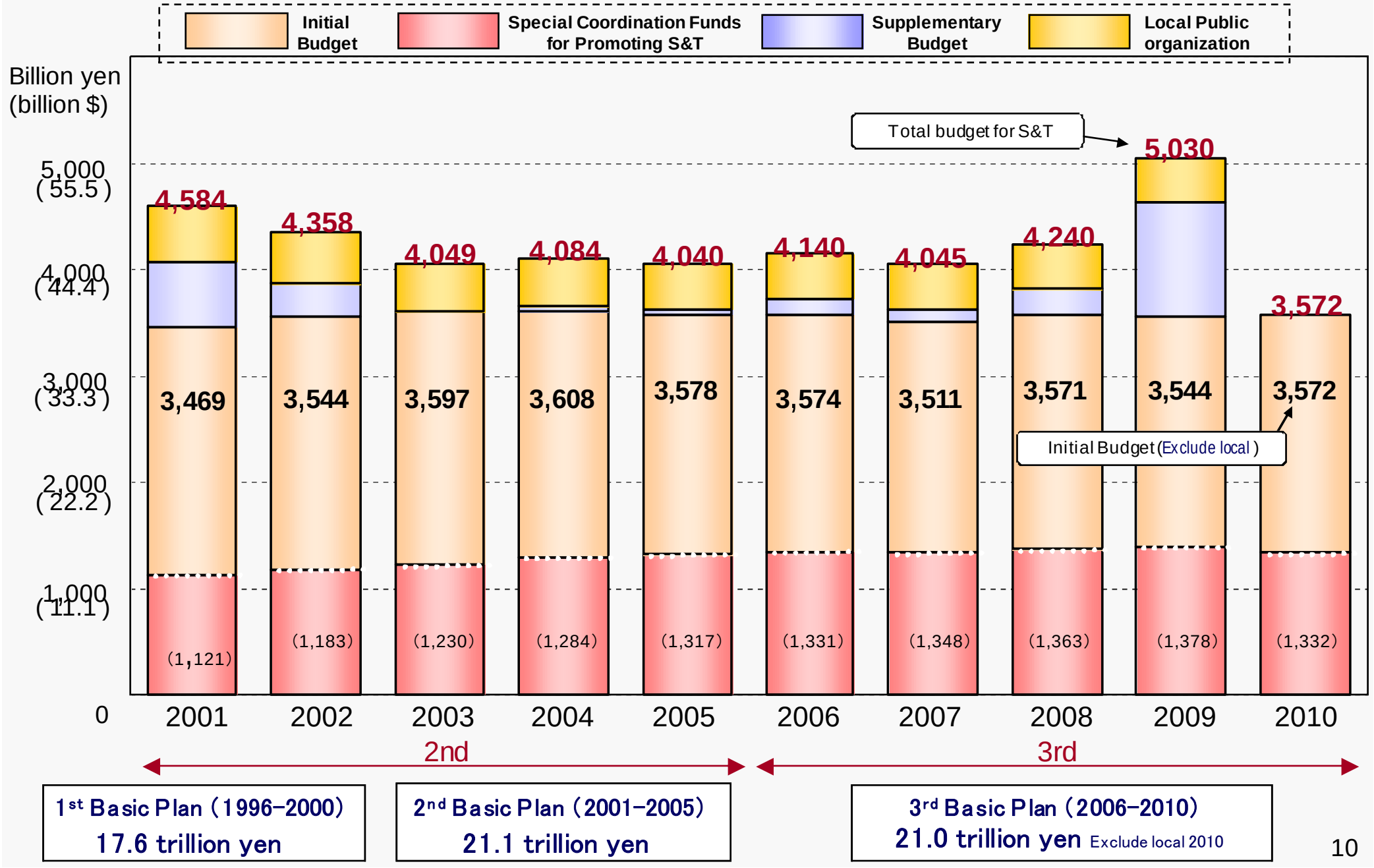
>Human Resource Development and Environmental Improvement for R&D Activities

NANO. and MATERIALS SCIENCE (1)

>Quantum Computational Technology, Clarification and Control of Interface Functions, Mechanism Clarification of Nano-scaled Bio-systems, Strongly Correlated Electronics

II. Trends of budget

Trends of budget for S&T



3 Categories in S&T and FY2010 Budget

Total: 3,572 billion Yen

Fundamental expenses and basic research

1,532 billion Yen

- University expenses
- Grant-in-Aid for Scientific Research
- Etc.

Policy mission-oriented R&D

(8 Promotion Areas)

1,664 billion Yen

29 key R&D subjects related nanotechnology/materials

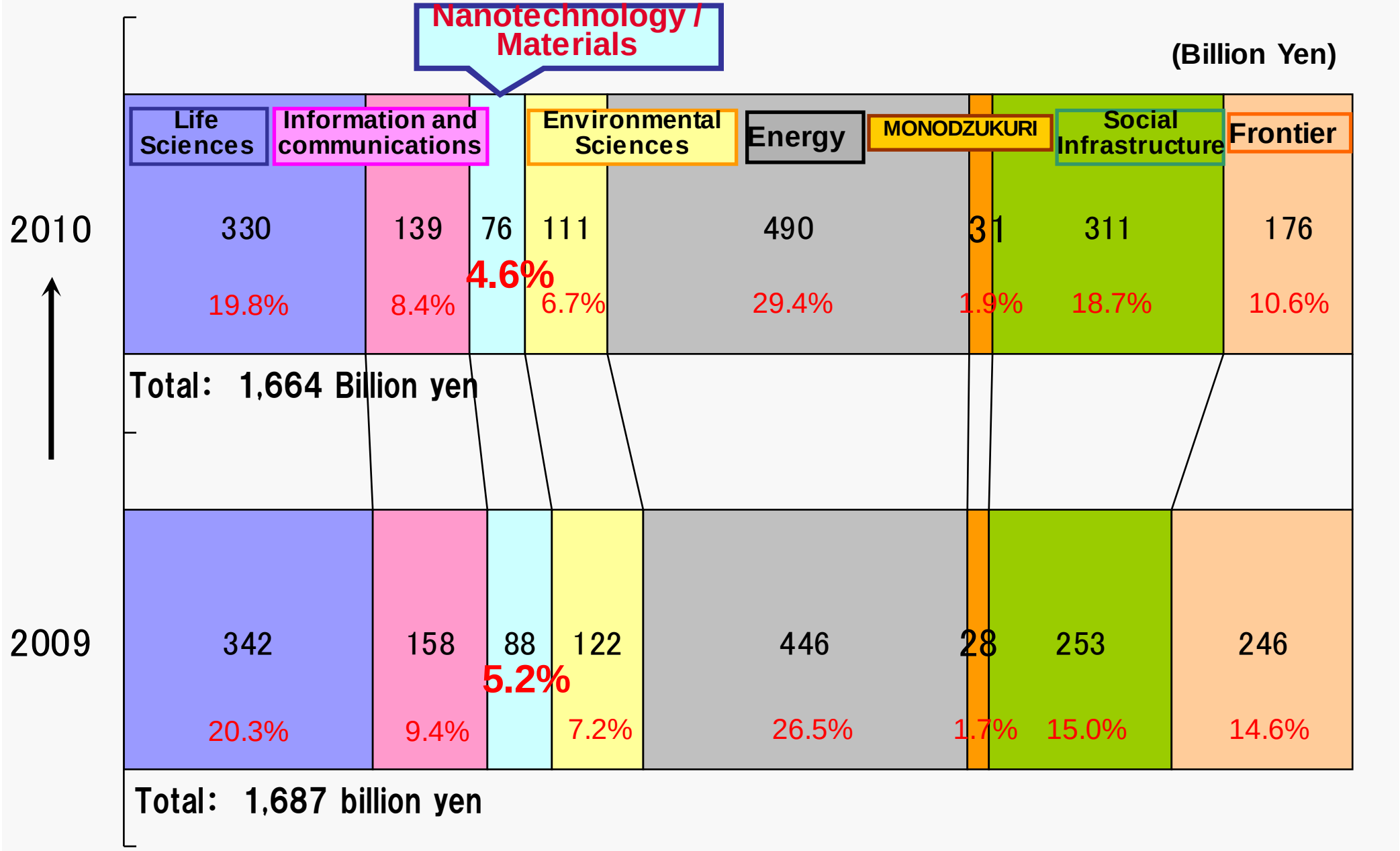
75.9 billion Yen

S&T systems reform, etc.

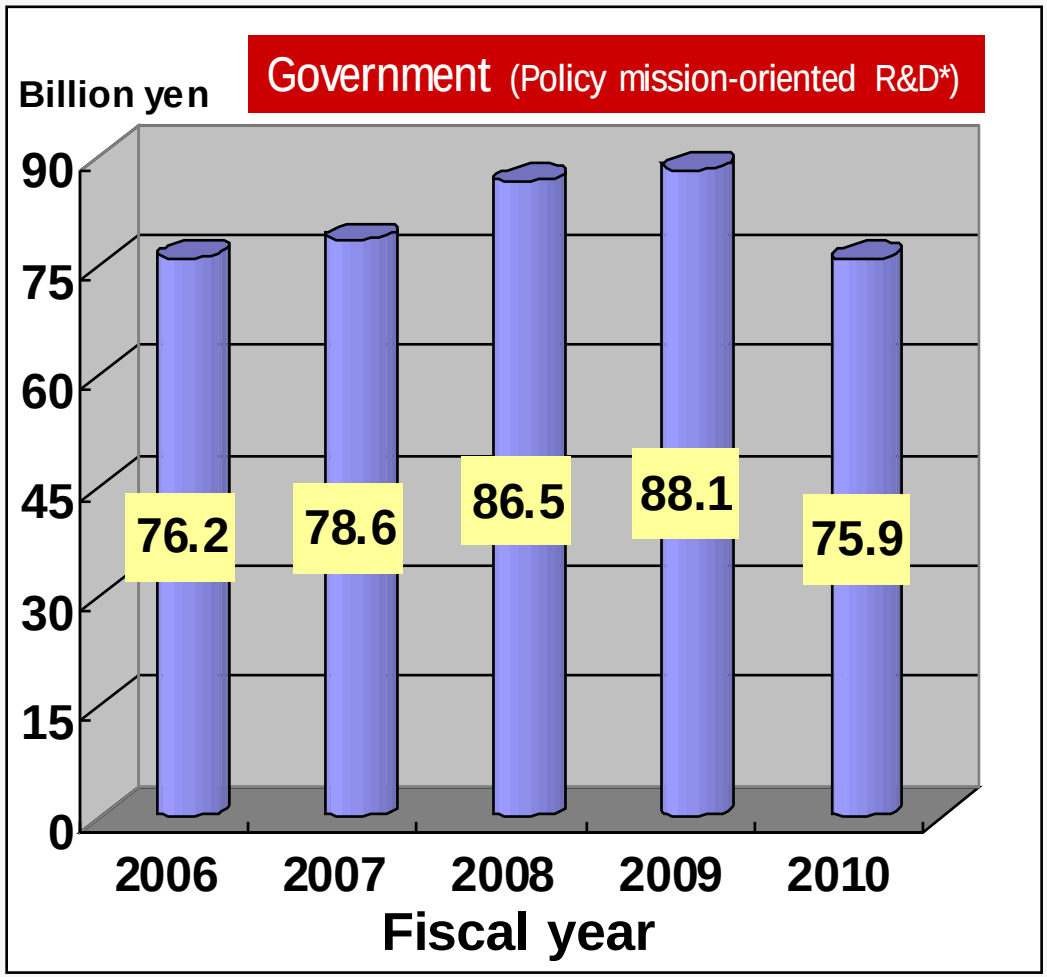
377 billion Yen

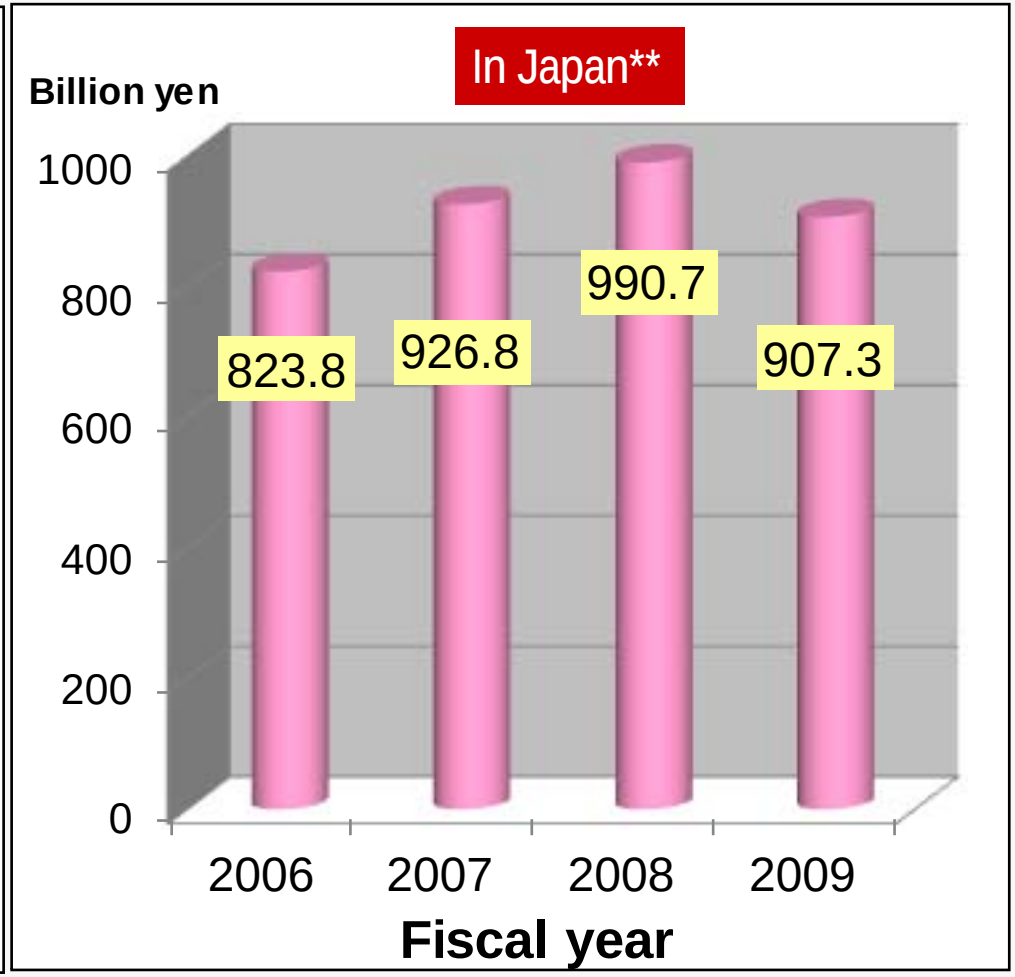
- Human resource
- Industry-academia collaboration
- Public communications
- IPR
- Innovations from local sectors
- Etc.

Budgets of 8 Promotion Areas



Budget: Nanotechnology/Materials Area





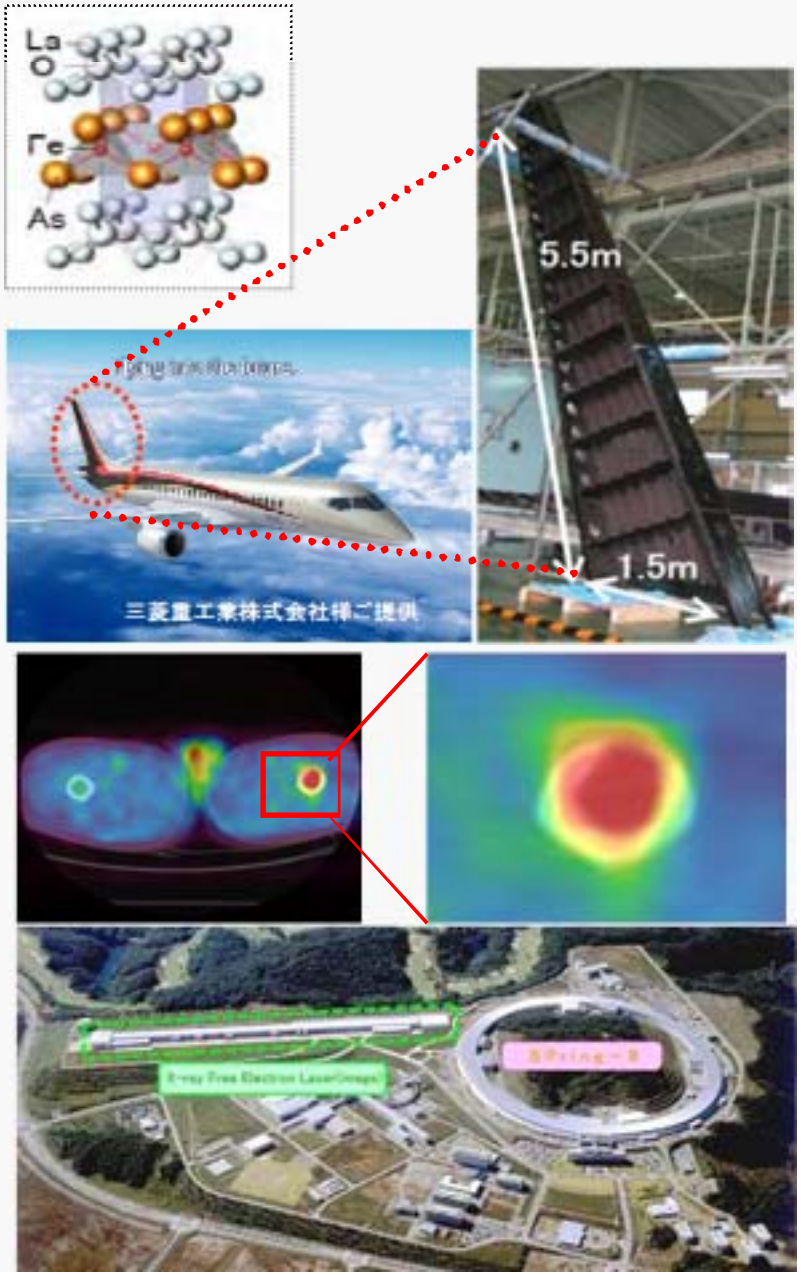
** Private companies with the capital over 0.1billion Yen, NPO, Government organizations and Universities

Source: 2009 Report on the Survey of Research and Development, Statistics Bureau, Ministry of Internal Affairs and Communications

III. Topics in Nano/Materials

The Main Achievement on Nanotechnology and Materials for 3rd Basic Plan

- **Discovery of new iron-based superconductor**
  - ➢adds a new variation to high- T_c superconductors.
  - ➢brings up possibilities of higher T_c .
- **Development of new materials progressing industrial applications, such as carbon fiber composite materials for aircrafts and vehicles**
  - ➢contributes to CO_2 cutting down by reducing weights of aircrafts, cars, etc.
- **Progress in molecular imaging researches for early diagnosis of cancer**
  - ➢improves diagnostic accuracy through new analyzing systems.
- **Construction of X-ray free electron laser (XFEL) facility for public use by 2011**
  - ➢provides microstructure analysis at atomic level.
  - ➢reveals dynamic chemical-reaction systems.



Funding Program for World-Leading Innovative R&D on Science and Technology

Purpose

Promote World-Leading Research Projects

- establishing research-supporting teams
- flexible and multi-year budgeting

Goal

Pick up actual or potential top-research talents in Japan
Produce top world-level R&D results in 3 - 5 years

Selected: 30 projects (Total applicants: 565)
Project duration: 3 to 5 years
Total budget : 100 billion yen (1.5 to 5 billion yen / project)

Out of 30 projects, 16 projects are related to Nanotechnology and Materials

Core Researcher & Research Subject Related to NT and Materials

	Name	Position	Title
Nano-Electronics	Chihaya ADACHI	Professor, Kyushu University	**Challenges for super organic electroluminescence devices through innovation of organic semiconducting materials**
	Yasuhiko ARAKAWA	Professor, The University of Tokyo	**Technology Development for Photonic-Electronic Integration System**
	Masayoshi ESASHI	Professor, Tohoku University	**Research and Development of Integrated Microsystems**
	Hideo OHNO	Professor, Tohoku University	**Research and Development of Ultra-low Power Spintronics-based Logic VLSIs**
	Naoki YOKOYAMA	Fellow, Fujitsu Laboratories Ltd.	**Development of Core Technologies for Green Nanoelectronics**
	Tsunenobu KIMOTO	Professor, Kyoto University	**Innovative SiC Power Electronics Technology Toward Low-Carbon Society**
Nano-Bio-technology & Bio-materials	Teruo OKANO	Director and Professor, Tokyo Women's Medical University	**System Integration for Industrialization of Regenerative Medicine: Creation of Organ Factory**
	Kazunori KATAOKA	Professor, The University of Tokyo	**Development of Innovative Diagnostic and Therapeutic Systems Based on Nanobiotechnology**
	Tomoji KAWAI	Professor, Osaka University	**Research and Development of Innovative Nanobiodevices Based on Single-Molecule Analysis**

Core Researcher & Research Subject Related to NT and Materials

	Name	Position	Title
Materials	Hideo HOSONO	Professor, Tokyo Institute of Technology	**Exploration of New Superconductors and Related Functional Materials and Application of Superconducting Wires for Industry**
	Noritaka MIZUNO	Professor, The University of Tokyo	**Innovative Basic Research Toward Creation of High-performance Battery**
	Hiroshi SEGAWA	Professor, The University of Tokyo	**Development of Organic Photovoltaics toward a Low-Carbon Society:**
	Masaru KURIHARA	Advisor, Toray Industries, Inc.	**Mega-ton Water System**
Fundamentals for nano/ materials	Akira TONOMURA	Fellow, Hitachi, Ltd.	**Development and Application of Atomic-Resolution Holography Electron Microscope**
Nano and Material science	Yoshinori TOKURA	Professor, The University of Tokyo	**Quantum Science of Strongly Correlated Systems**
	Yoshihisa YAMAMOTO	Professor, National Institute of Informatics	**Quantum information processing project**

Tsukuba Innovation Arena [TIA] nano

- Collaborative relationship among industry, government, and academia to create a world class R&D center (Agreement in June 2009)

TIA nano
Tsukuba Innovation Arena

筑波大学 University of Tsukuba　NIMS　AIST

Tsukuba Innovation Arena Promotion Office

- Chairman (Prof. Teruo KISHI)
- University of Tsukuba (Dr. Nobuhiro YAMADA)
- National Institute for Materials Science (Dr. Sukekatsu USHIODA)
- National Institute of Advanced Industrial Science and Technology (Dr. Tamotsu NOMAGUCHI)
- Federation of Economic Organizations (Dr. Ryoji CHUBACHI)

Tsukuba Innovation Arena [TIA] nano

Objectives

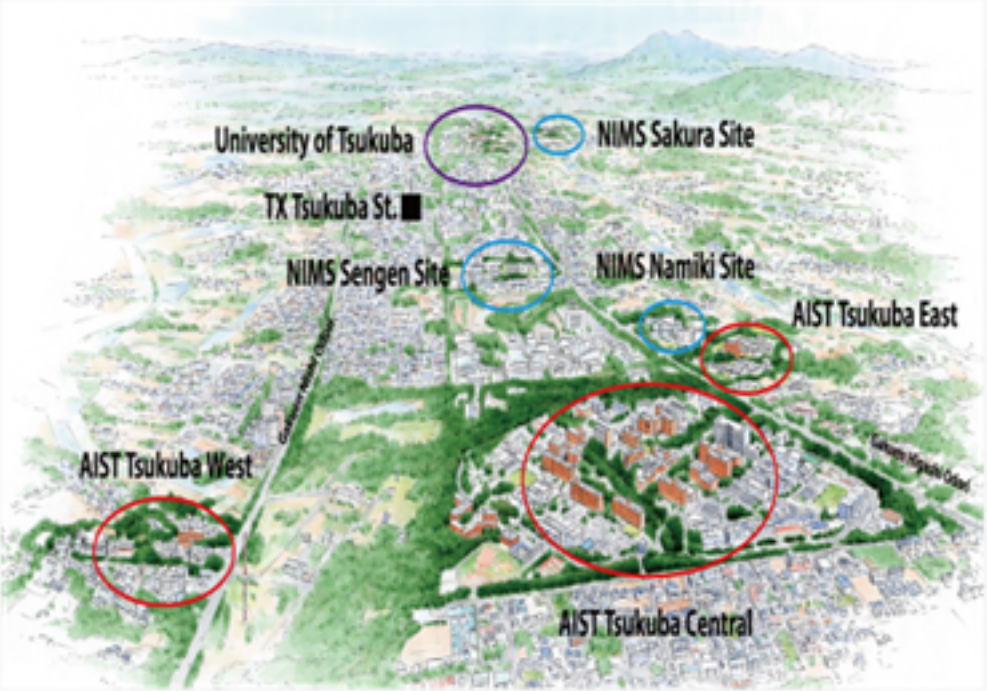
1) Value creation towards global business
Create an innovation for global markets, taking advantage of state-of-the-art research capabilities.

2) "Under One Roof"
Reaching beyond sectional walls, provide public and private researchers with common research bases where they collaborate under one roof.

3) Spiral-up benefit
Create differentiated and complimentary value for researchers and users to participate in the arena.

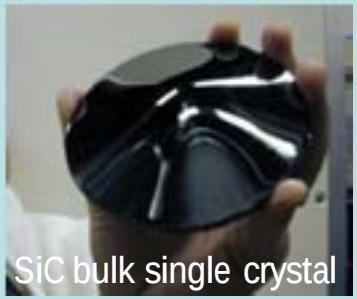
4) Networking for Win-Win
Strengthen the national and international networking and generate the win-win partnering.

5) Education of the next generation
Cooperate with industries and universities and strengthen nanotechnology education for the next generation.



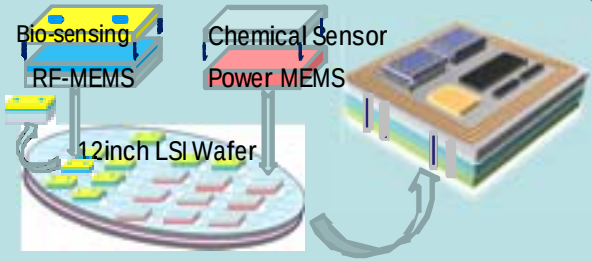
Tsukuba Innovation Arena [TIA] nano

6 Core Research Domains


SiC bulk single crystal

Power Electronics

Integrated R&D frame from SiC wafer, device to power system



Three-dimensional heterogeneous integration N-MEMS


Super clean room (SCR)

Nanoelectronics

- Nano CMOS
- Sillicon -photonics
- Carbon-electronics
- Backend device
- New material
- Advanced lithography (EUVL)

N-MEMS

High-value-added MEMS and mass production integrated N-MEMS

Nano-Green

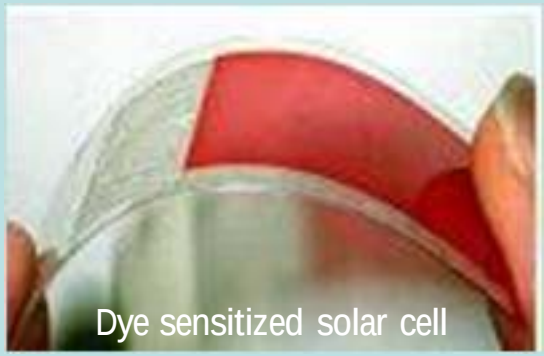
R&D framework for green innovation driven by nanotechnology

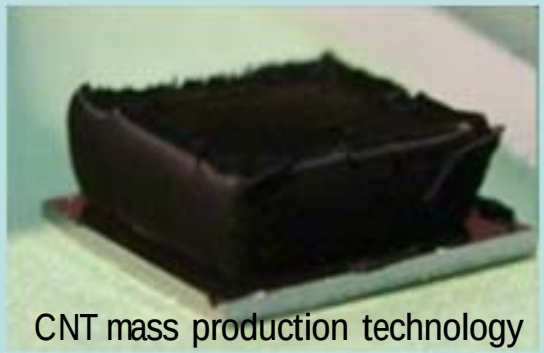
Carbon Nanotubes

R&D framework of CNT mass production and CNT composites for wide applications.

Nano-Material Safety

Integrative data center and research frame for nano-material safety.


Dye sensitized solar cell


CNT mass production technology


Risk evaluation report

Tsukuba Innovation Arena [TIA] nano

Nanodevice Research Foundry

- Prototype device (45 - 65nm CMOS and N-MEMS, etc.) fabrication and evaluation (ϕ 200-300 mm)
- SiC power device fabrication and evaluation

3 Core Infra-structure

Nanotech Open User Facilities

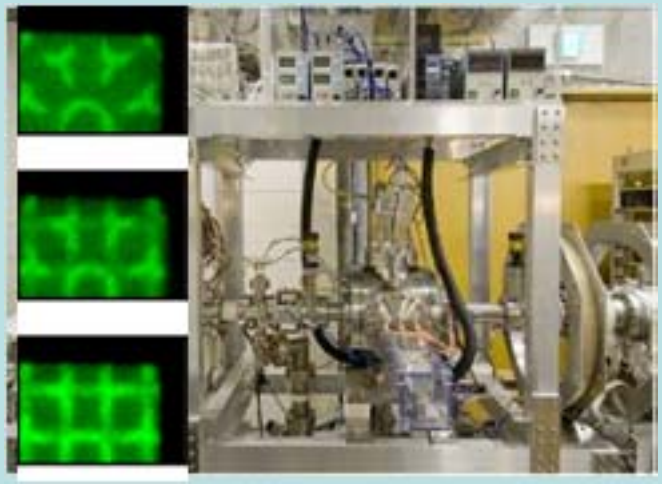
Open user research facilities in AIST and NIMS (nanocharacterization, nanoprocessing, etc.)

Networking School of Nanotechnology

Graduate school function through cooperation of University of Tsukuba and partnering universities

Ultrahigh-strength magnetic field NMR equipment (NIMS)

Nanoprocessing facility (AIST)



Nanomeasurement facility (measurement using positron) (AIST)

IV. Draft of 4th Science and Technology Basic Plan (FY2011-2016)

Science, Technology and Innovation to open up the Future

Dynamic changes of the world
- Asia as Global Center of Growth
- Global, Open, and Flat World
- Relatively deteriorating Presence of Japan

Facing various challenges
- Global-challenges of climate change
- Aging and population decline in Japan, fastest in the world

Progress of the basic researches and innovative technologies in Japan
- But, fiercer international competition
- Hard to connect to innovation

Introversion of Japanese youth

S&T Policy as the national strategy
- S&T as driving force of "New Growth Strategy"
- Comprehensive promotion of science, technology and innovation policy

Transform challenges to chance by issue-solving innovation
- International openness integrated with world vitalities
- Suggestion of growth model prior to the world
- Reinforcement of the structure of the innovation creation

Reinforcement of S&T potential in Japan
- Drastic reinforcement of basic research
- Promotion of issue-solving R&D
- Activation of international circulation of human resources

The 4th S&T Basic Plan and New Growth Strategy

New Growth Strategy (Basic Policies) (December 30, 2009, Cabinet decision)

Growth driven by Japan's strengths

Green Innovation

【Targets to reach by 2020】
- Create over ¥50 trillion in new markets and 1.4 million new jobs
- Reduce worldwide greenhouse gas emissions by 1.3 billion tons using Japanese technology

Life Innovation

【Targets to reach by 2020】
Foster industries that meet demand and create jobs:
-Roughly ¥45 trillion in new markets and 2.8 million new jobs

Opening new frontiers

- Asia
- Tourism & local revitalization

Platforms to support growth

- Science & Technology
- Employment & human resources

S&T for transforming challenges to growth

The 4th S&T Basic Plan (FY 2011-2015)

Comprehensive promotion of science, technology and innovation policy

S&T as an engine for New Growth Strategy

Main Issues of 4th S&T Basic Plan (Draft) (1)

Concept

Comprehensive promotion of science, technology and innovation(STI) policy

Perspective for 2020

- Nation which realizes sustainable growth
- Nation which takes pride in high quality of life
- Nation which holds bases of S&T
- Nation which takes the lead in solving global issues
- Nation which creates science knowledge and makes it our culture

Promotion of STI in two growth area

Green Innovation

- Renewable energy, Low carbon of energy supply and demand, Saving energy, Green infrastructure
- Accelerate overseas operations of the green infrastructure as a package

Life Innovation

- Promote preventive medicine, Develop innovative diagnostic and treatment method, Develop life-supporting technology for elderly and challenged people
- Promote translational research, regulatory science

Construct the STI system

- Establish STI Strategy Platform
- Establish Open Innovation Centers
- Create a new market by the new affirmative legal framework
- Promote intellectual property and international standardization

Addressing of important issues / challenges

Realize the high quality of life
- Necessities of life
- Safety assessment etc.

Enhance industrial competitiveness
- Make advantages of Japan
- New traffic system, Smart Grid etc.

Address of global issues
- Biodiversity, Emerging infectious disease etc.

Hold bases of S&T
- Security tech., HPC etc.
- Space, Ocean development

Develop Common Bases for R&D
- High level common devices
- Nano-tech. etc.

International activities of STI
-"East-Asia Science and Innovation Area" Initiative

Main Issues of 4th S&T Basic Plan (Draft) (2)

Enhancement of basic research, Fostering of STI person

Enhance basic research

- Promote basic research based on originality/diversity
- Promote the world leading basic research
- R&D Hub for International research network

Foster STI person

- Drastic reinforcement of the graduate school education
- Backup of various careers for doctorals
- Promote woman researchers' activity

Form research environment of international standard

- Maintain and utilize the research facilities

Science for Society

S&T policy combined with public

- Promote S&T communication

Reform of S&T System

- Construct PDCA (Plan-Do-Check-Action) cycle

Reinforcement of R&D investment

- Increase public and private sector investment in R&D to over 4% of GDP by 2020

Concluding Remarks

- **System and Strategy for Science &Technology and Nanotechnology/Materials**
  - ✓Nanotechnology/Materials is positioned as one of 8 promotion areas in 3rd Basic Plan
  - ✓29 key R&D subjects in 5 sub-areas
- **Budget in FY2010**
  - ✓Nanotechnology/Materials: 76 billion yen: 4.6% of initial budget in Science and Technology (3,572 billion yen)
  - ✓Some subjects of nanotechnology are located to "Energy area" which are promoted by "New Growth Strategy".
- **Topics in Nanotechnology/Materials**
  - ✓Funding Program for World-Leading Innovative R&D on Science & Technology
    16 out of 30 programs are related to Nanotechnology/Materials.
  - ✓Tsukuba Innovation Arena (TIA)
    Collaboration among industry, government, and academia since 2009.
- **Draft of 4th Science and Technology Basic Plan (FY 2011-2016)**
  - ✓S&T Policy as the national strategy, taking an important role in "New Growth Strategy"
  - ✓Promotion of STI in two growth areas: Green Innovation & Life Innovation

Nanotechnology leads strongly STI in many areas as common bases.

Thank you for your attention.

Data website:

- The Third Science and Technology Basic Plan:
  http://www8.cao.go.jp/cstp/english/basic/index.html#third (English version)
  http://www8.cao.go.jp/cstp/kihonkeikaku/index3.html (Japanese version)
- R&D Promotion Strategy for Nanotechnology and Materials Area:
  http://www8.cao.go.jp/cstp/kihon3/bunyabetu.html (Japanese only)