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

Prime Minister

Cabinet Office

Minister of State for S&T Policy

Council for S&T Policy (CSTP)

Relevant ministries in S&T policy

MIC
Ministry of Internal Affairs and Communications

MEXT
Ministry of Education, Culture, Sports, S&T

MHLW
Ministry of Health, Labor and Welfare

MAFF
Ministry of Agriculture, Forestry and Fisheries

METI
Ministry of Economy, Trade and Industry

MLIT
Ministry of Land, Infrastructure and Transport

MOE
Ministry of the Environment
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)
S&T Basic Law and S&T Basic Plan

1st Basic Plan (FY 1996-2000)

Science and Technology Basic Law (enacted in 1995)

2nd Basic Plan (FY 2001-2005)

3rd Basic Plan (FY 2006-2010)

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: 21.1 trillion yen)

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 of genetically modified crops.

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.

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, “3Rs” (reduce, reuse, recycle) technologies, and biomass utilization technologies. Japan would like to contribute to the world through these R&D activities.

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 nanobiology technology.
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.

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 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.

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.

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.
## Nanotechnology/Materials Area

### 5 Sub-Areas and 29 Key R&D Subjects

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<thead>
<tr>
<th>NANO-ELECTRONICS (6)</th>
<th>MATERIALS (9)</th>
<th>NANO-BIOTECHNOLOGY &amp; BIO-MATERIALS (8)</th>
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<tbody>
<tr>
<td>Next-Generation Silicon-based Nano-electronics superior to conventional silicon semiconductors</td>
<td>[To Deal with Energy Issues] - Advanced Materials to Promote the Use of Unpopular Energy</td>
<td>Molecular Imaging Technology for investigating Internal Structures and Mechanisms</td>
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<tr>
<td>Electron/Photon-controlled Nano-electronics</td>
<td>Advanced Materials for Highly Efficient Use of Energy</td>
<td>Manipulation Tech. for Internal Molecules</td>
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<tr>
<td>Nano-scale Manufacturing Technology for Electronics</td>
<td>[To Build an Environmentally-friendly Sustainable Society] - Materials to Deal with Toxic Substances</td>
<td>Diagnosis and Treatment Methods using DDS and Imaging Technology</td>
</tr>
<tr>
<td>Cost Reduction Technology for Nano-electronics Components</td>
<td>Substitution and Saving Technology for Rare or Deficit Materials</td>
<td>Apparatus with Super-microscopic Processing Technology</td>
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<td>[To Maintain and Reinforce Industrial Competitiveness] - Materials for the Most Advanced Electro-Apparatus</td>
<td>Regeneration Initiation Materials</td>
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<td>Materials for Competitive Transport Equipment</td>
<td>Nano-biotechnology Applied Food</td>
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<td>Manufacturing Technology for Innovative Materials and Components for the Next-Generation</td>
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### 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

Initial Budget (Exclude local)
Special Coordination Funds for Promoting S&T
Supplementary Budget
Local Public organization

Total budget for S&T

Initial Budget
Supplementary Budget
Local Public organization

1st Basic Plan (1996–2000)  
17.6 trillion yen

2nd Basic Plan (2001–2005)  
21.1 trillion yen

3rd Basic Plan (2006–2010)  
21.0 trillion yen (Exclude local 2010)
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 to 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

- **Life Sciences**
  - 2010: 330 (19.8%)
  - 2009: 342 (20.3%)
  - Total: 1,664 Billion yen

- **Information and communications**
  - 2010: 139 (8.4%)
  - 2009: 158 (9.4%)
  - Total: 1,687 billion yen

- **Environmental Sciences**
  - 2010: 76 (4.6%)
  - 2009: 88 (5.2%)

- **Energy**
  - 2010: 490
  - 2009: 446
  - Total: 1,664 Billion yen

- **MONODZUKURI**
  - 2010: 31
  - 2009: 28
  - Total: 1,664 Billion yen

- **Social Infrastructure**
  - 2010: 311
  - 2009: 253
  - Total: 1,664 Billion yen

- **Frontier**
  - 2010: 176
  - 2009: 246
  - Total: 1,664 Billion yen

- **Nanotechnology / Materials**
  - 2010: 111
  - 2009: 122
  - Total: 1,664 Billion yen
Budget: Nanotechnology/Materials Area

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

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
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Title</th>
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<tbody>
<tr>
<td>Chihaya ADACHI</td>
<td>Professor, Kyushu University</td>
<td>Challenges for super <em>organic electroluminescence</em> devices through innovation of <em>organic semiconducting materials</em></td>
</tr>
<tr>
<td>Yasuhiro ARAKAWA</td>
<td>Professor, The University of Tokyo</td>
<td>Technology Development for <em>Photonic-Electronic Integration System</em></td>
</tr>
<tr>
<td>Masayoshi ESASHI</td>
<td>Professor, Tohoku University</td>
<td>Research and Development of <em>Integrated Microsystems</em></td>
</tr>
<tr>
<td>Hide OHTO</td>
<td>Professor, Tohoku University</td>
<td>Research and Development of <em>Ultra-low Power Spintronics-based Logic VLSIs</em></td>
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<tr>
<td>Naoki YOKOYAMA</td>
<td>Fellow, Fujitsu Laboratories Ltd.</td>
<td>Development of Core Technologies for <em>Green Nanoelectronics</em></td>
</tr>
<tr>
<td>Tsunenobu KIMOTO</td>
<td>Professor, Kyoto University</td>
<td>Innovative <em>SiC Power Electronics Technology Toward Low-Carbon Society</em></td>
</tr>
<tr>
<td>Teruo OKANO</td>
<td>Director and Professor, Tokyo Women’s Medical University</td>
<td>System Integration for Industrialization of Regenerative Medicine: <em>Creation of Organ Factory</em></td>
</tr>
<tr>
<td>Kazunori KATAOKA</td>
<td>Professor, The University of Tokyo</td>
<td>Development of Innovative <em>Diagnostic and Therapeutic Systems Based on Nanobiotechnology</em></td>
</tr>
<tr>
<td>Tomoji KAWAI</td>
<td>Professor, Osaka University</td>
<td>Research and Development of Innovative <em>Nanobiodevices Based on Single-Molecule Analysis</em></td>
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<tr>
<td>Core Researcher &amp; Research Subject Related to NT and Materials</td>
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<td><strong>Materials</strong></td>
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<tr>
<td>Hideo HOSONO</td>
<td>Professor, Tokyo Institute of Technology</td>
<td>Exploration of New Superconductors and Related Functional Materials and Application of Superconducting Wires for Industry</td>
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<tr>
<td>Noritaka MIZUNO</td>
<td>Professor, The University of Tokyo</td>
<td>Innovative Basic Research Toward Creation of High-performance Battery</td>
</tr>
<tr>
<td>Hiroshi SEGAWA</td>
<td>Professor, The University of Tokyo</td>
<td>Development of Organic Photovoltaics toward a Low-Carbon Society:</td>
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<tr>
<td>Masaru KURIHARA</td>
<td>Advisor, Toray Industries, Inc.</td>
<td>Mega-ton Water System</td>
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<td><strong>Fundamentals for nano/materials</strong></td>
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<tr>
<td>Akira TONOMURA</td>
<td>Fellow, Hitachi, Ltd.</td>
<td>Development and Application of Atomic-Resolution Holography Electron Microscope</td>
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<td><strong>Nano and Material science</strong></td>
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<td>Yoshinori TOKURA</td>
<td>Professor, The University of Tokyo</td>
<td>Quantum Science of Strongly Correlated Systems</td>
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<tr>
<td>Yoshihisa YAMAMOTO</td>
<td>Professor, National Institute of Informatics</td>
<td>Quantum information processing project</td>
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Tsukuba Innovation Arena [TIA] nano

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

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

- **Power Electronics**: Integrated R&D frame from SiC wafer, device to power system.

- **Nano-electronics**:
  - Nano CMOS
  - Silicon-photonic
  - 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.
Tsukuba Innovation Arena [TIA] nano

Nanodevice Research Foundry
- Prototype device (45 - 65nm CMOS and N-MEMS, etc.) fabrication and evaluation (Ø 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
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

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

- Maintain and utilize the research facilities

- Promote S&T communication

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

- 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)
● R&D Promotion Strategy for Nanotechnology and Materials Area:
  http://www8.cao.go.jp/cstp/kihon3/bunyabetu.html (Japanese only)