RIETI-METI-NEDO-AIST Symposium
"R&D Partnership under the Globalized Economy - Our Experience and the Future"
September 3, 2007

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Challenges to "Eco-Innovation"

- Energy Saving and Beyond -

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1. Energy Demand and Energy Saving Policy

Projection of Energy Demand

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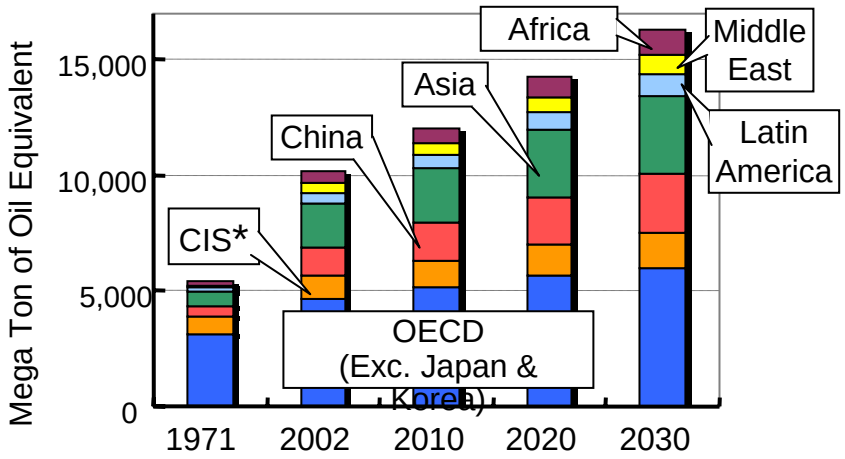
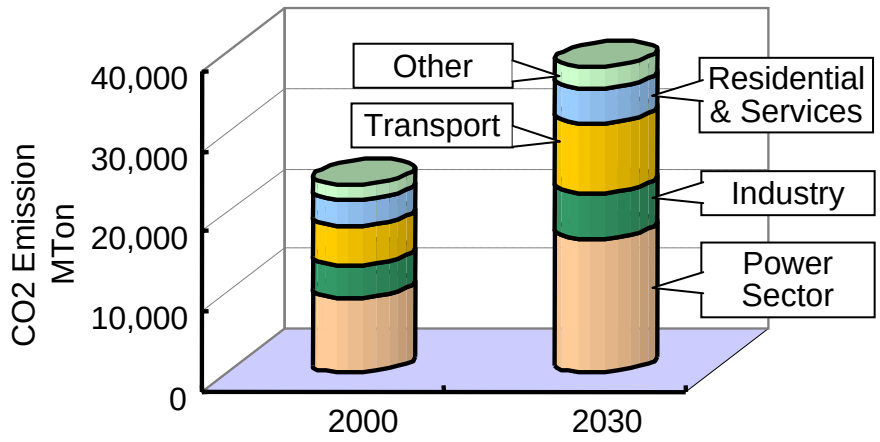
World Primary Energy Demand



* Commonwealth of Independent States

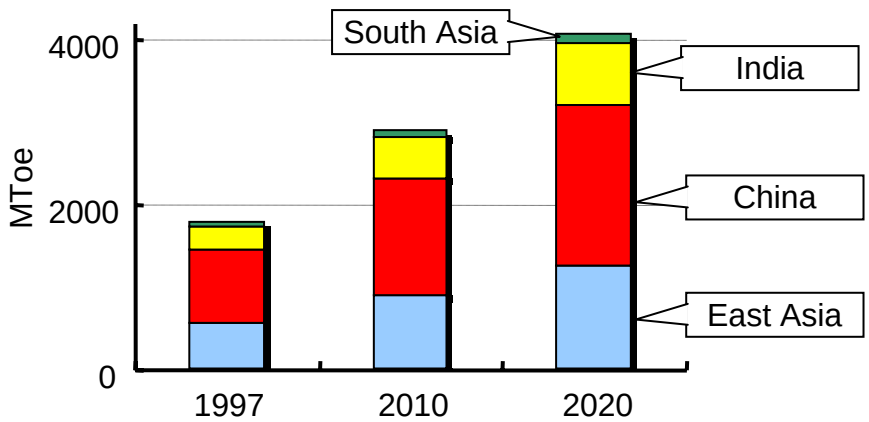
(IEA/World Energy Outlook 2004)

Sectoral World CO_2 Emission



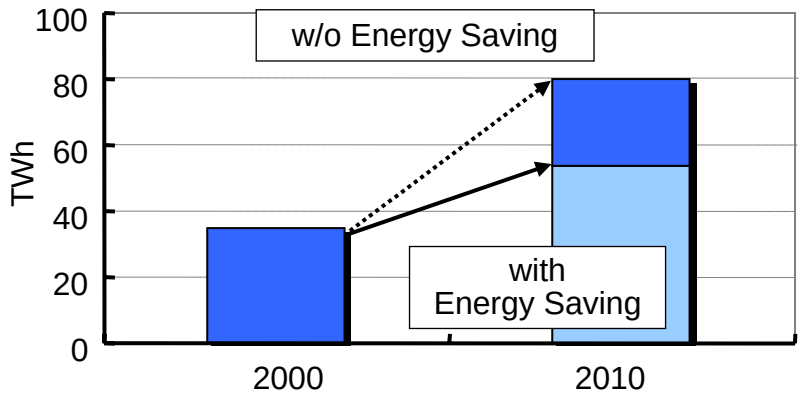
(IEA/ World Energy Outlook 2004)

Primary Energy Demand in Asia



(IEA/ World Energy Outlook 2004)

Energy Consumption of ICT in Japan



(MITSUI Knowledge Industry " *Research on the Evaluation of IT Influence on Earth Environment*" (in Japanese) (2002))

1-2 Innovation Stages of Japanese Electronics Industry

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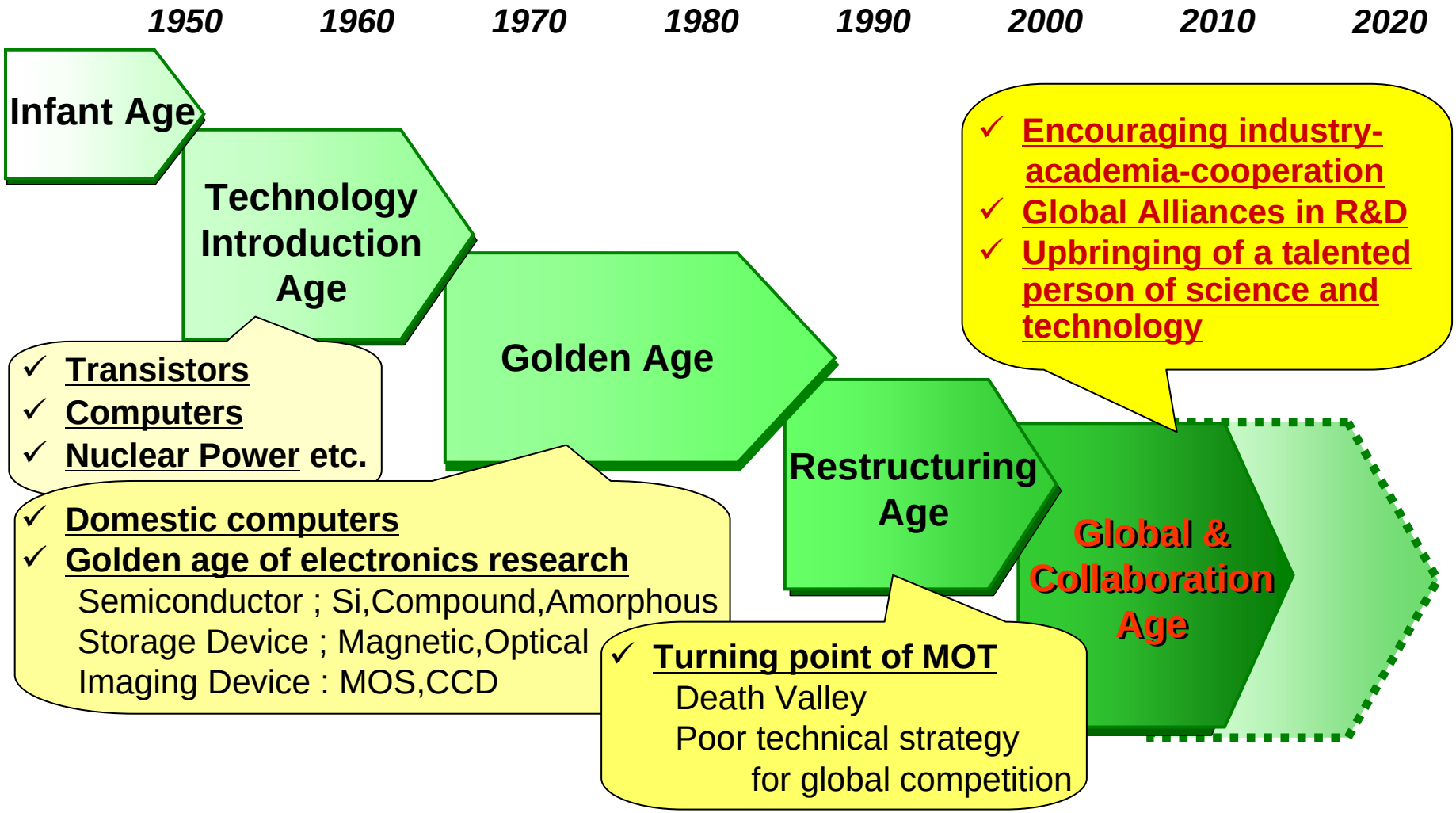

Governmental Activities

- The Agency of Industrial Science & Technologies
- The Science & Technology Agency
- The Council Science & Technology
- Science and Technology Basic Law
- Japanese Bayh-Dole Act
- Council for Science and Technology Policy

Eco-Innovation

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Energy Saving Policy by METI

Sector	Challenges
Industry	・Super-combustion Technology
Consumer	・Energy-saving House Structure ・Energy-saving Equipments
Transport	・Intelligent Transport Systems
Common / Basic	・Power Devices for Automobiles & Information Appliances

Energy Saving Action Plans of Japanese Industries

Industry	Targets
Iron & Steel	・10% energy saving in manufacturing processes
Chemical	・10% reduction of energy consumption rate
Paper	
Cement	・Energy saving to the utmost
Electric Power	・20% reduction of CO_2 emission rate

(1997 'Nippon Keidanren', *i.e.* Japan Business Federation)

State-of-the-art Energy-saving & Green Technology

Eco-Innovation
- Energy Saving & Beyond -

- Knowledge-based innovation
- Multi-disciplinary technologies
- Linkage of technologies and art / social sciences

Promotion for Eco-Innovation

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(1) Sustainable Manufacturing

- ✓ **Maximizing resource recycling**
- ✓ **Multi-step energy utilization**
- ✓ **Developing substitute materials for rare metals**

(2) Zero Emission Type Social Infrastructure

- ✓ **Super-efficient energy supply system (Power Generation and Energy Storage)**
- ✓ **Super-efficient energy transport system**

(3) Sustainable Living

- ✓ **Renovation for rationale of environmental values**

(4) Human-centric Innovations

- ✓ **KANSEI (Sensibility) and technology assimilation**

(5) Software Tools for Eco-Innovations

- ✓ **e.g. Visualizing environmental loads through whole supply chain**

(6) Global Collaboration

- ✓ **Innovation Roadmap, collaborative development**

1-5 Strategic Technologies in Energy Field

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Reproduced from Roadmap of METI

Power Generation and Energy Storage

- ✓ **High Temperature Gas Turbine**
- ✓ **A-PFBC (Advanced Pressurized Fluidized Bed Combustion Combined Cycle)**
- ✓ **AHAT (Advanced Humid Air Turbine)**
- ✓ **A-USC (Advanced Ultra Supercritical Steam Turbine)**
- ✓ **IGCC (Integrated Coal Gasification Combined Cycle)**
- ✓ **Lithium Ion Battery**
- ✓ **Fuel Cell: SOFC (Solid Oxide Fuel Cell) / PEFC (Polymer Electrolyte Fuel Cell)**

Energy Saving

- ✓ **Micro Plant System**
- ✓ **Information Equipment & System: Multi Processor / Sever / Network / Storage**
- ✓ **High Efficiency Heat Pump**
- ✓ **High Efficiency Lighting: LED / Organic EL**
- ✓ **Hybrid & Electric Vehicle / FC Vehicle**
- ✓ **Highly Insulated Airtight House and Building**
- ✓ **Device: SiC / Spintronics / 3D-Device / Low Power HDD / Flexible Display**

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2. New Challenges in Power Generation & Energy Storage

Micro Gas Turbine (MGT)

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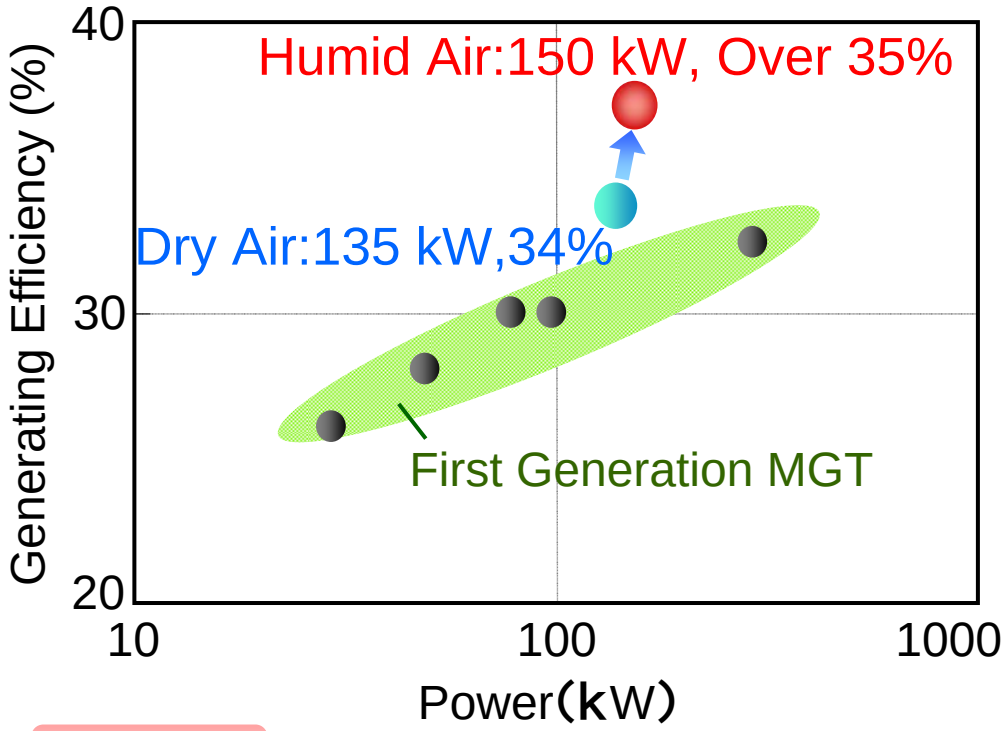

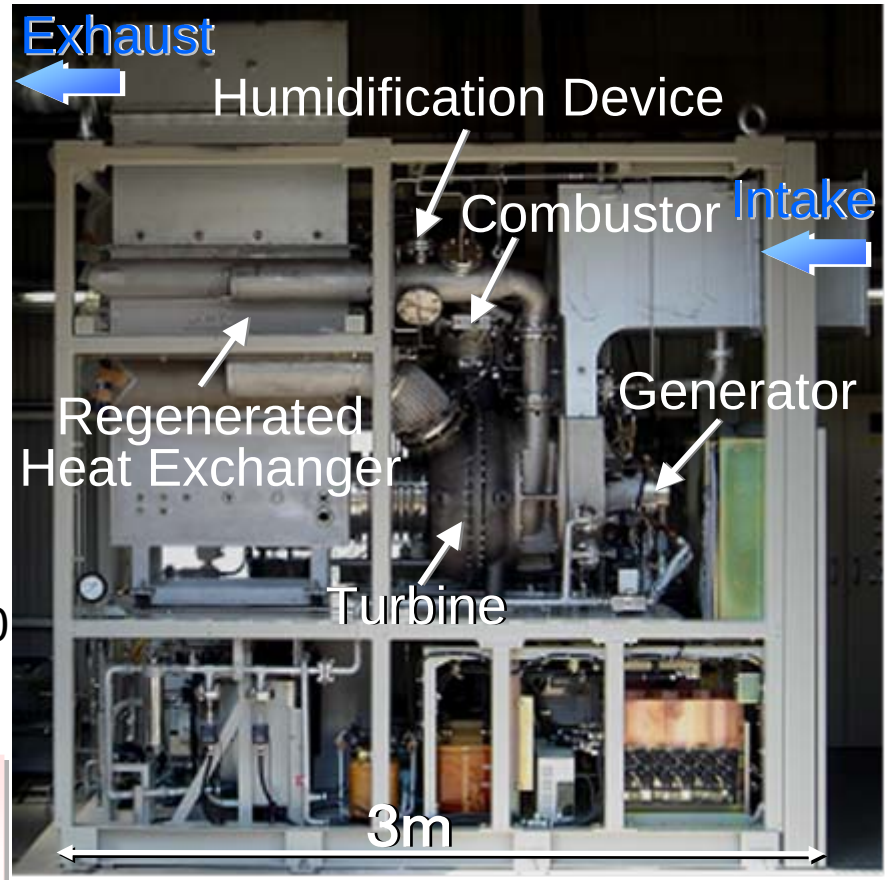

Pilot Unit

Feature

- Utilizing of Humid Air(HAT*& WAC**)
- Application of Water-lubricated Bearing (World First in Gas Turbine)

*HAT: Humid Air Turbine **WAC: Water Atomizing Inlet Air Cooling

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Class 700 ℃ A-USC* Plant System

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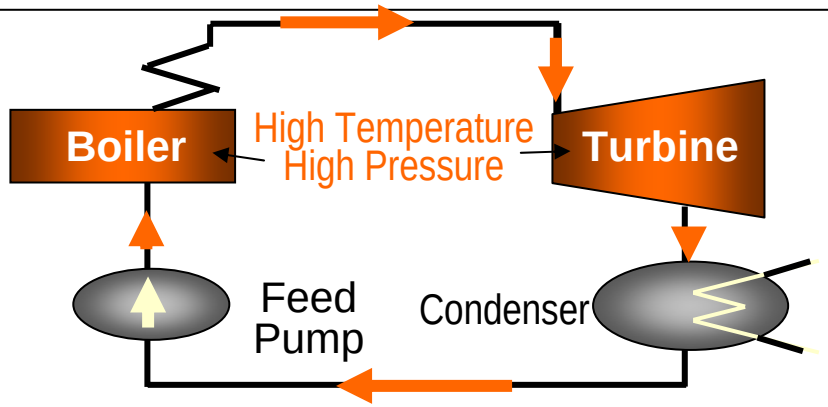
*A-USC:Advanced Ultra Supercritical

A-USC Plant System



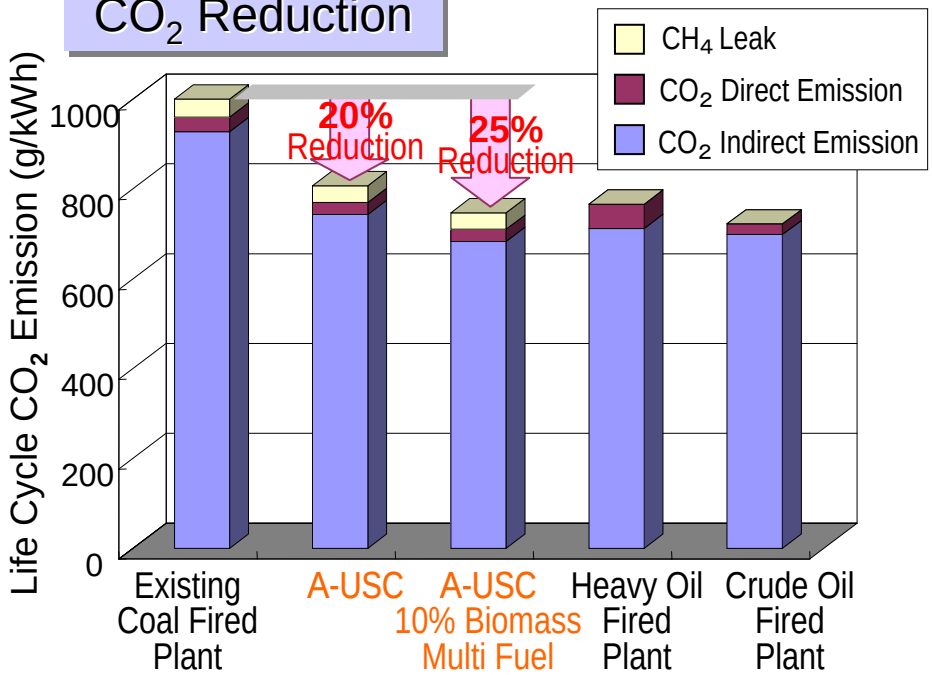
A-USC Plant has the same System as that of Existing Coal Fired Plant

Steam Conditions :

- High Temperature 600 ℃→**700 ℃**
- High Pressure 25 MPa→**35 MPa**

High Efficiency
40%→**46%**

CO_2 Reduction



20-25% reduction of Existing Coal Fired Plant
Comparable to Oil-fired Plant

Energy Saving

(All Coal-fired Plants in Japan → A-USC Plants)

Reduction of 680,000 kl/year Oil Equivalent in 2030

Challenges

- Critical Design for Steam Conditions
- Heat/Pressure-resistant Materials (Ni-base Superalloys)

Supported by NEDO

Applications of Li-ion Battery

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Today

Notebook PC

Cell-phone

Electric Power Tool

Consumer Products

Ensuring of Safety & Reliability

Courtesy of East Japan Railway Company

Diesel Hybrid Train

Transportation

Plug-in Hybrid Motor Vehicle

Emergency Power Source for Wireless Base Station →

Large-scale Power Storage/ Electric-load Leveling

Energy Storage System for Smoothing Grid Integration →

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Near Future

SOFC* Co-generation System

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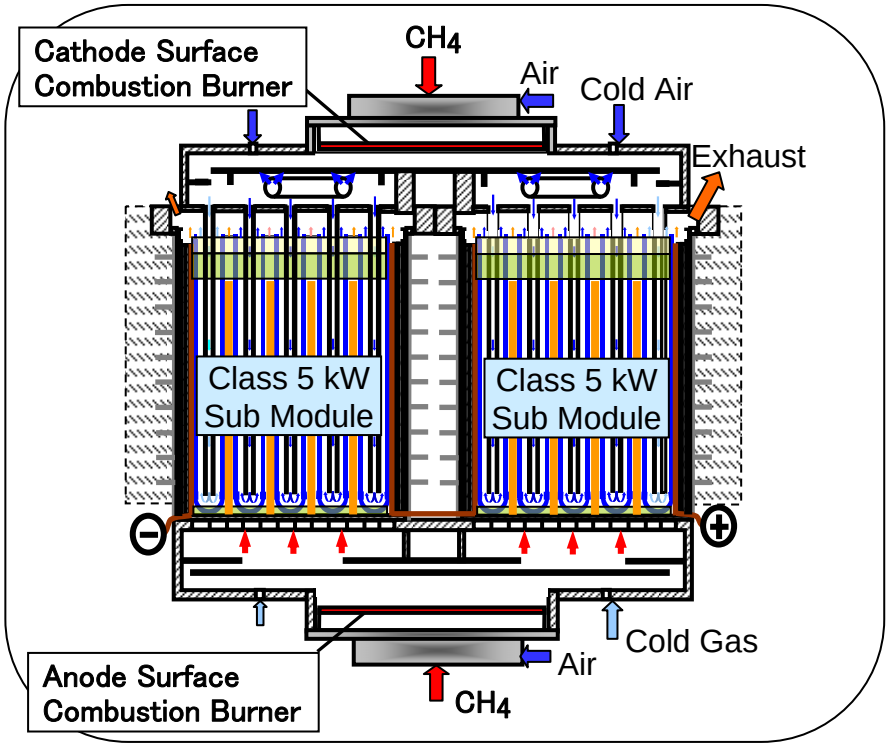
*SOFC: Solid Oxide Fuel Cell

Class 20 kW and Heavy Duty SOFC Co-generation System

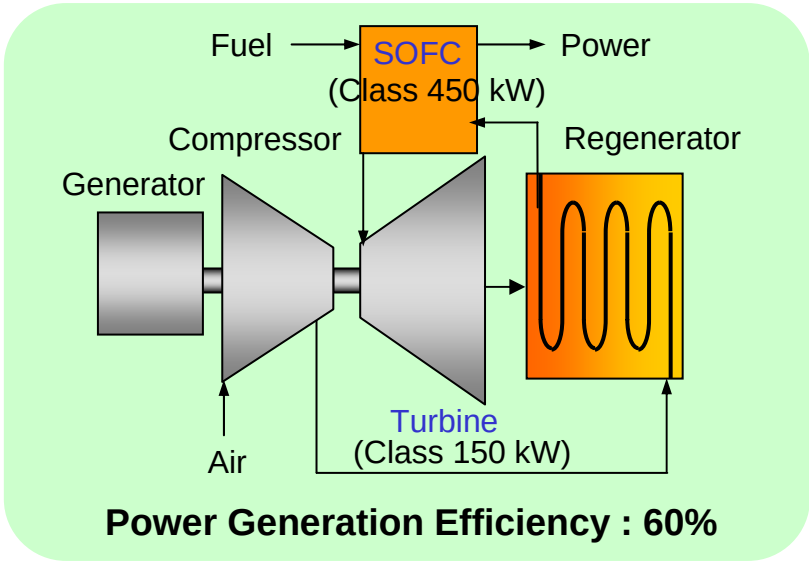
■ Target Specifications

- ✓ Output Level: Class 20 kW both Electricity and Heat
- ✓ Power Generation Efficiency:40 %
- ✓ Lasting: >40,000 hr



Class 10 kW Module Structure

Future System



Power Generation Efficiency : 60%

Class 600 kW SOFC-MGT** Hybrid System (Industrial Power Generation)

**MGT:Micro Gas Turbine

Challenges

- ■ **Durability Improvement**
- ■ **High-Power Stack**
- ■ **Cost Reduction**

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3. New Challenges in Energy Saving

Microreactor

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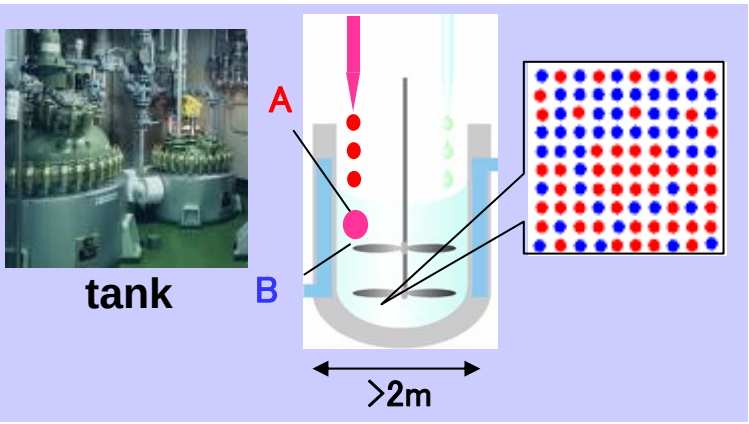
■ Conventional Batch Process

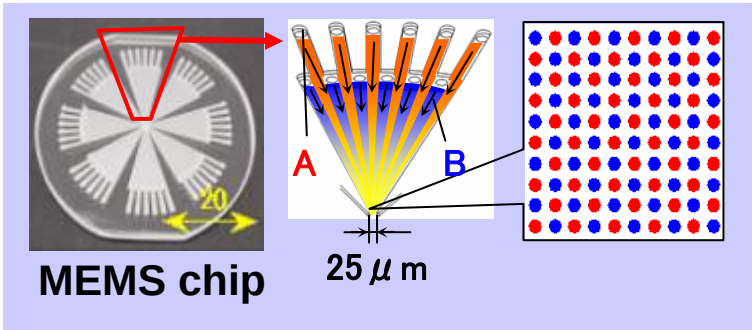
- ✓ Reaction in Large Space
- ✓ Heterogeneous Mixing
- ✓ Limited Yield



■ Microreactor

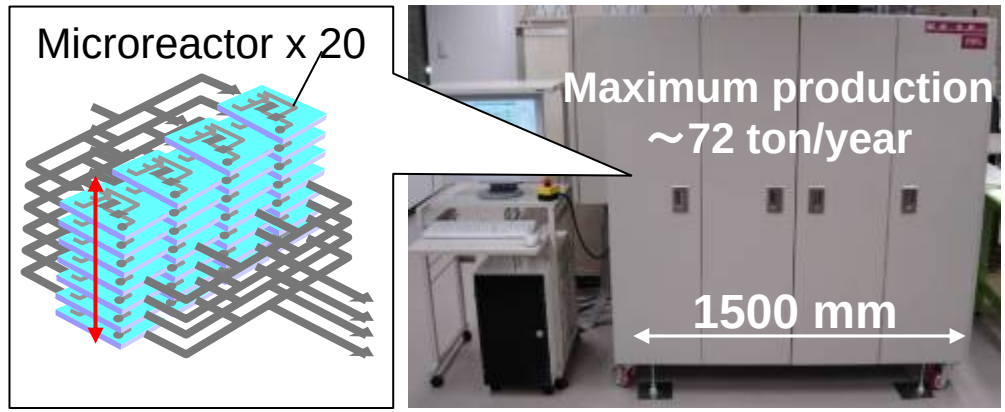
- ✓ Reaction in Small Space
- ✓ Homogeneous Mixing
- ✓ Higher Yield with lower energy

e.g. 58%(batch) ⇨ 98%
(bromination of dimethyl phenol)



■ Numbering-up of Microreactors

- ✓ Same Reaction Mechanism as in Single Microreactors
- ✓ Less Time needed from Test-Tube-Scale R&D to Plant-Scale Production



Numbering-up

■ Variation of Microreactors

Mixing **Reaction** **Emulsification** **Condensation**

Electric Power Saving (EPS) Data Center

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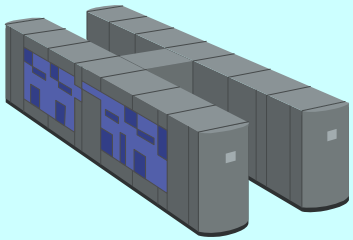
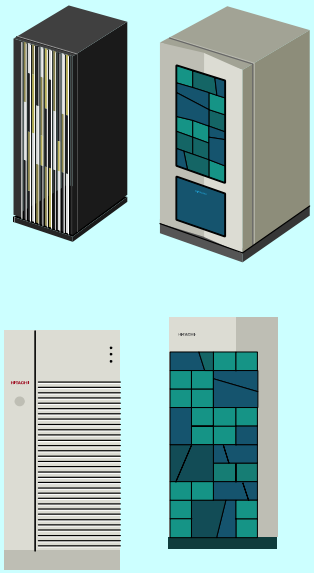
- User's own computer to computers over the network
- Evolution from mainframe to server to data center
- Computer has become one component of EPS data center

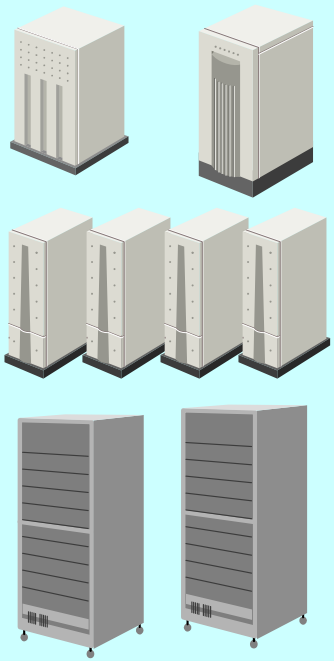
Equipment

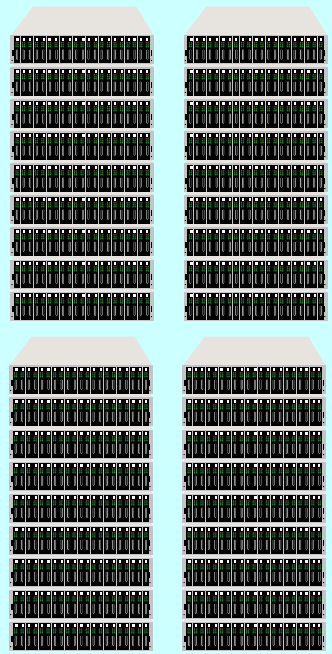
Mainframe	Open Server	PC Server	Blade Server	Module Server (Pico Server)
Equipment + Application Software	Commercial Software	Internet	Web Service	Web2.0, SaaS

Service









- Local cooling
- Modularized servers, routers, storage
- DC direct power supply

Data Center

3-3 Activities to Save Energy of ICT in U.S.

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Activity	Promoting body	Purpose
Data Center Energy Efficiency Act	U.S. Congress	Promotion of energy efficient servers (enacted : Dec. 2006)
Energy Star	EPA	Study & promotion of energy efficient servers, PCs and data centers
Climate Savers Computing Initiative	Google, Intel	Realization of energy efficient PCs, promoted by manufacturers of PC and its components (Jun. 2007)
Green Grid	AMD, HP, Sun, IBM	NPO to Improve energy efficiency of data center (Feb. 2007)
SPECpower	SPEC	Benchmark for evaluating the energy efficiency for server class computers (discussion started: May 2006)

EPA : Environmental Protection Agency
NPO : Non-Profit Organization
SPEC : Standard Performance Evaluation Corporation

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4. Toward Eco-Innovations in ICT

R&D Challenges for Nano-ICT

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1. Focused investment in energy-saving Nano-ICT projects
   - ✓ "More Moore" and "More than Moore" type R&D
     - Advanced CMOS, 3D System LSI, New Power Supply System, Optical Interconnection,
     - Novel Magnetic Recording, Flexible Display Panel, Energy-Saving Manufacturing, etc.
   - ✓ Increasing R&D budget

2. Industry-university-government collaboration for R&D on energy-saving Nano-ICT projects.
   - ✓ Improvement of Collaborative R&D Schemes (joint COE)
     - Collaborative R&D centers for Si technology (*More Moore*) have been established.
     - **Nano-ICT R&D Platform for novel concept (*More than Moore*) is urgently needed**.

       Expected functions:
       - ・R&D network hubs
       - ・Comprehensive research from material to system
       - ・Prototyping ability
       - ・Training and global recruiting of researchers

3. Enactment and Implementation of guideline on energy-saving ICT
   - ✓ Energy-saving goals and R&D Roadmaps
   - ✓ Incentive to R&D on energy-saving ICT

4-2 Power Devices for Low Power Consumption

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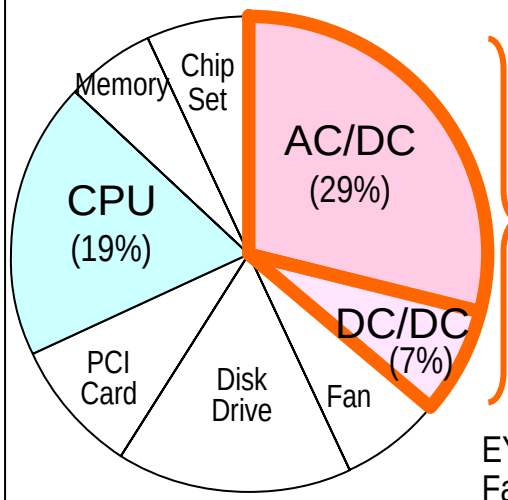
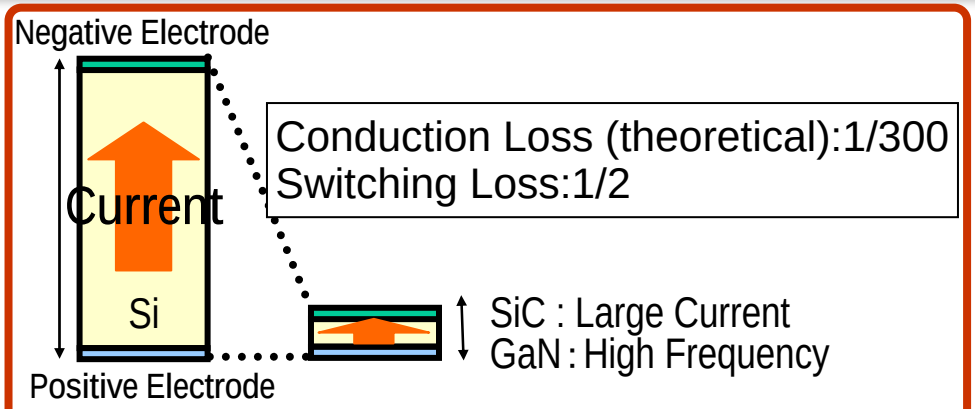


Power Loss caused by Electric Energy Conversion

EYP Mission Critical Facilities & Intel, 2006

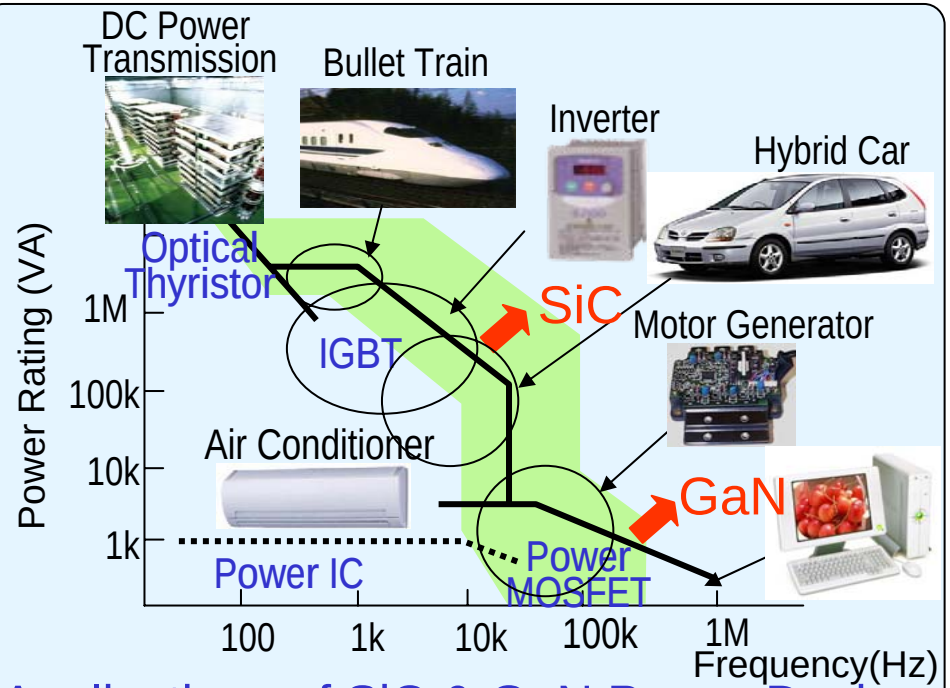
Power Consumption in a Server (450 W)



Application of SiC and GaN to Reduce Power Loss

	Si	SiC	GaN
Band Gap (eV)	1.1	3.3	3.4
Breakdown Electric Field Strength (MV/cm)	0.3	2.5	3.3
Thickness of Device (Relative to Si)	1	1/10	1/10

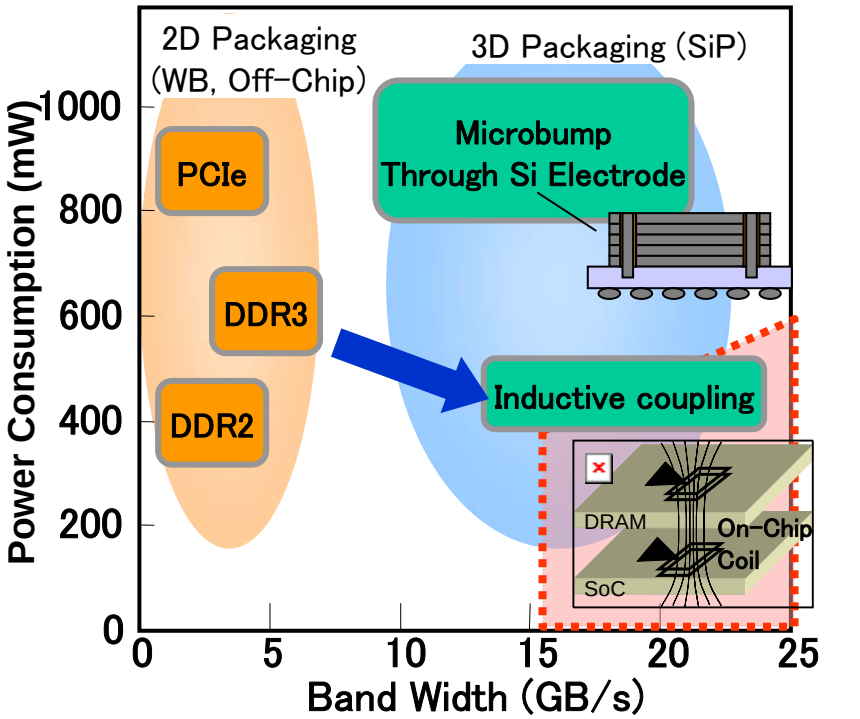
Wide-Gap Semiconductors

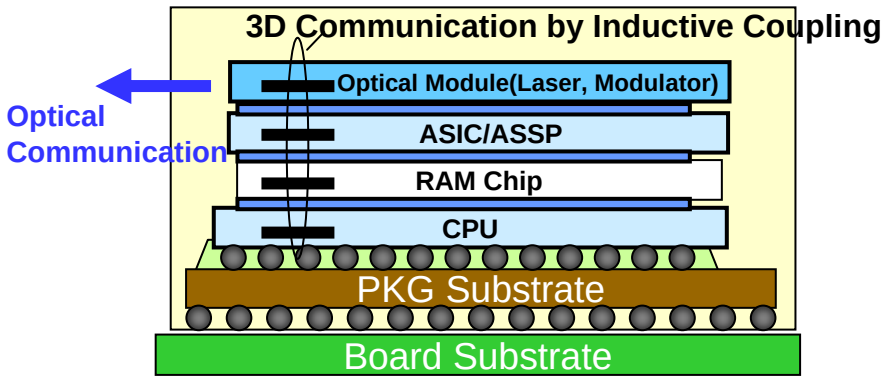


Applications of SiC & GaN Power Device

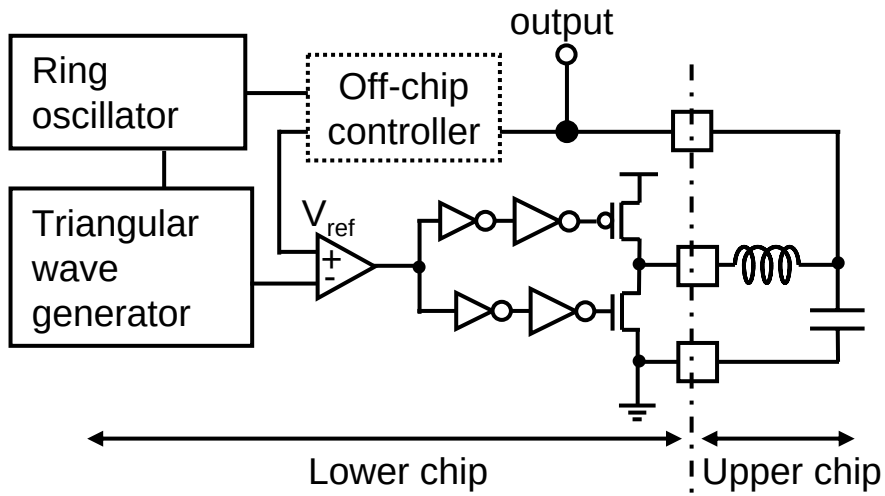
R&D on 3D-Device

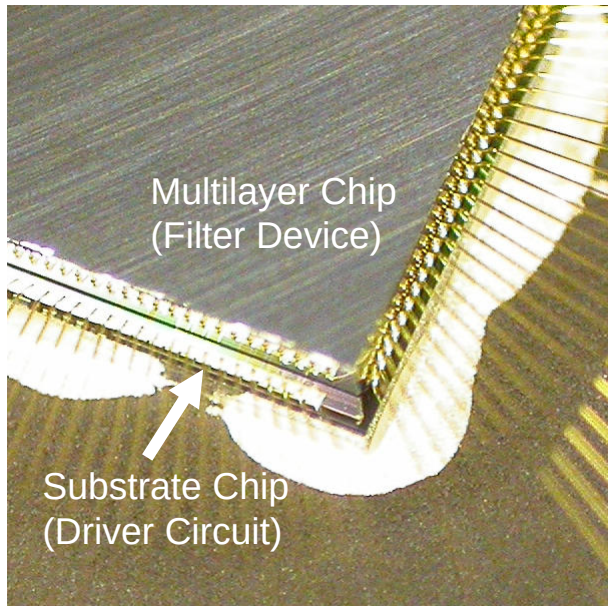
■ 3D Packaging for Reduction of I / F Power Consumption





■ 3D Packaging Filter for Low Cost Power（Prof. Sakurai, U. of Tokyo）





Realization of DC-DC Power Supply with 62% of Conversion Efficiency

Optical Interconnection

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- Breakthrough technology to achieve power reduction in the information explosion.
- Consolidation of optical technology with digital/analog CMOS technology.
- Si nano photonics is emerging technology.

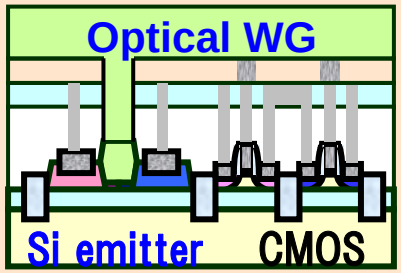
Electronics/photonics Consolidation

CMOS Integration Technology

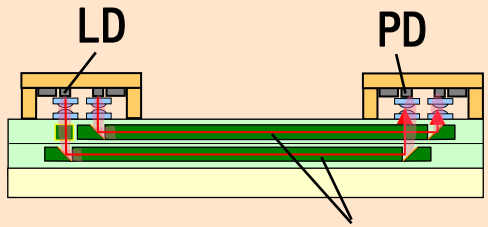
- Si Light Emitter
- Ⅲ-Ⅴ Laser Device Integration
- Si/SiGe Photo Detector
- Optical Waveguide Coupling
- Si Waveguide

Module Architecture

Si Photonics in Chip



Chip to Chip Optical Interconnection



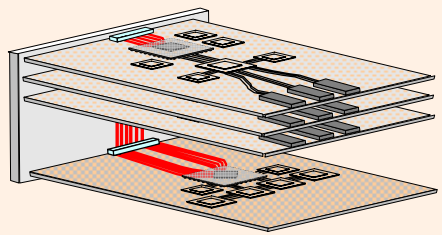
System Application

Digital Consumer
- digital TV, mobile, game

Industrial/Social Systems
- robots, automobiles

Data Center
- server / router

Optical Interconnection



Progress of Hard Disk Drive Tech.

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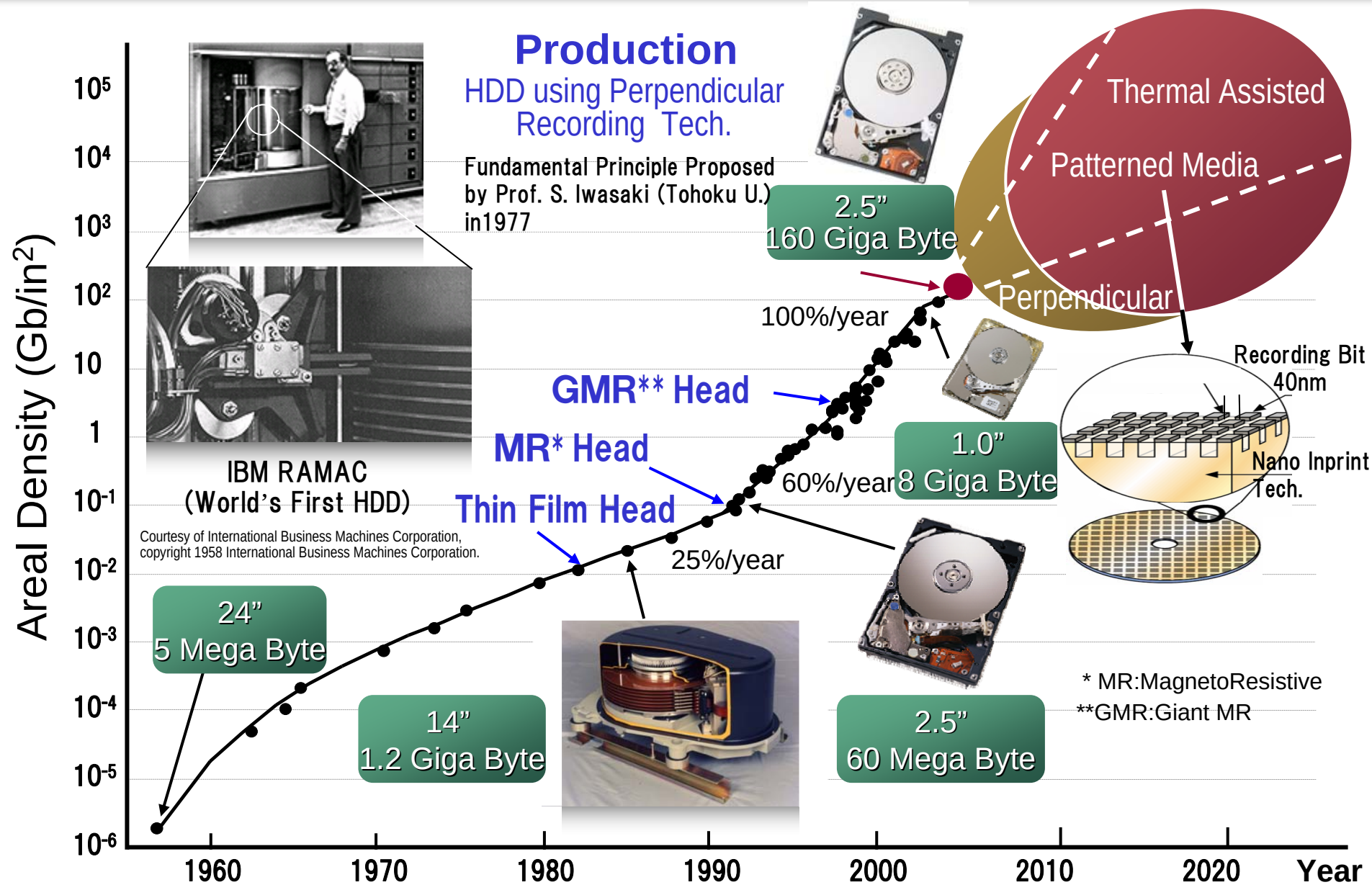
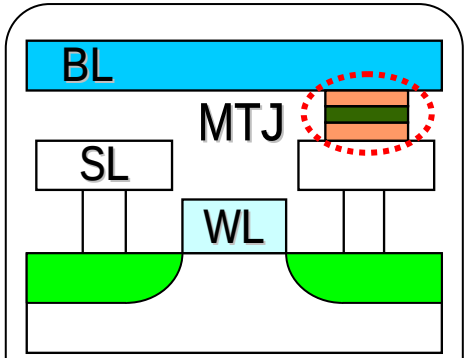
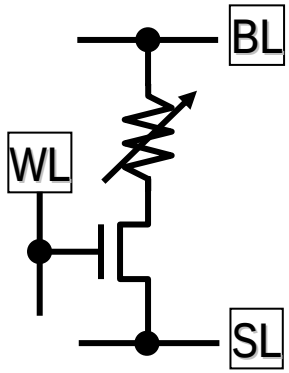


Supported by NEDO & MEXT

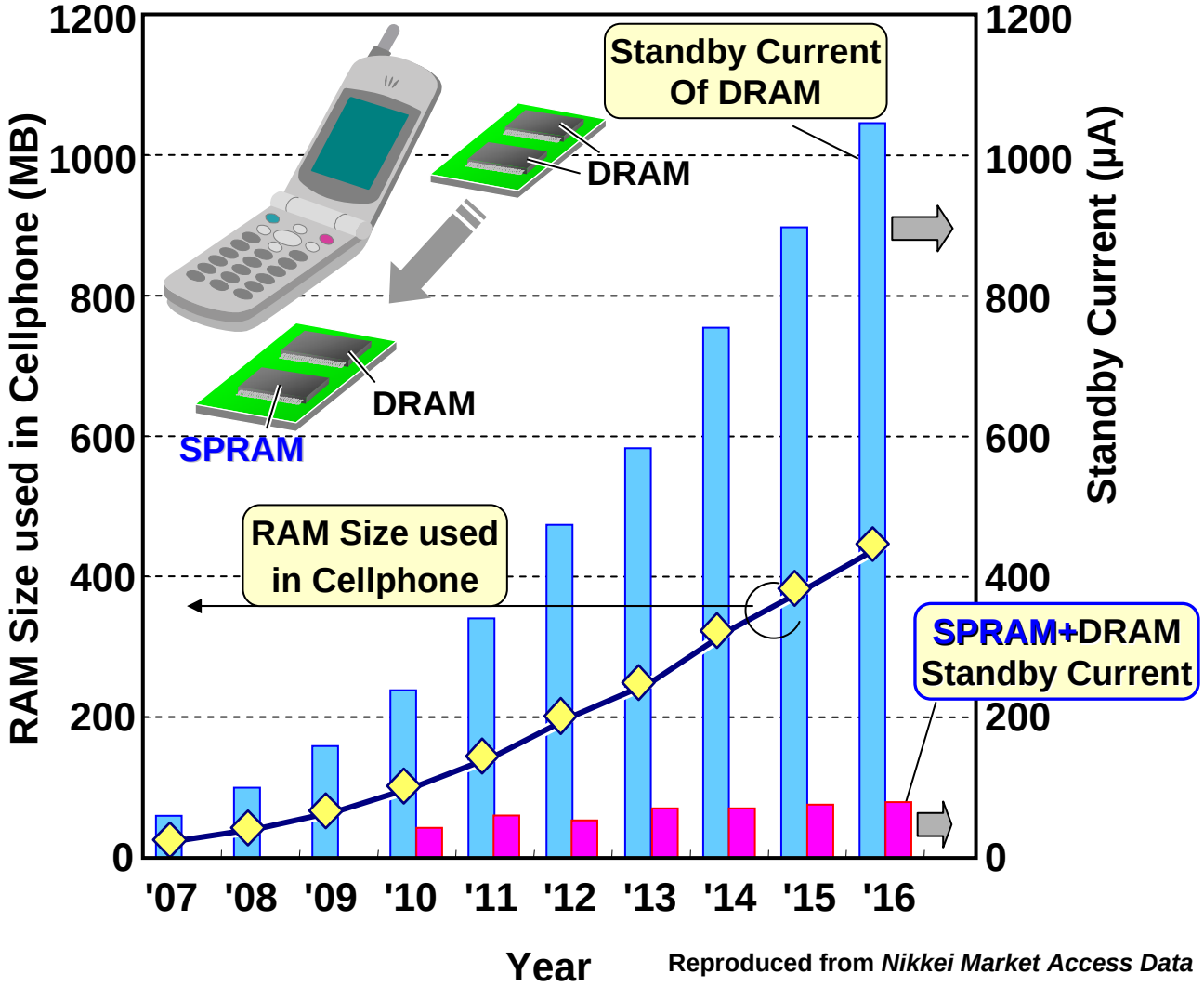
Development of Spintronics

Non-Volatile RAM for Reducing Power Consumption of Mobile Equipment





SPRAM
(SPin-transfer torque RAM)



Reproduced from *Nikkei Market Access Data*

Supported by MEXT

R&D of Flexible Display

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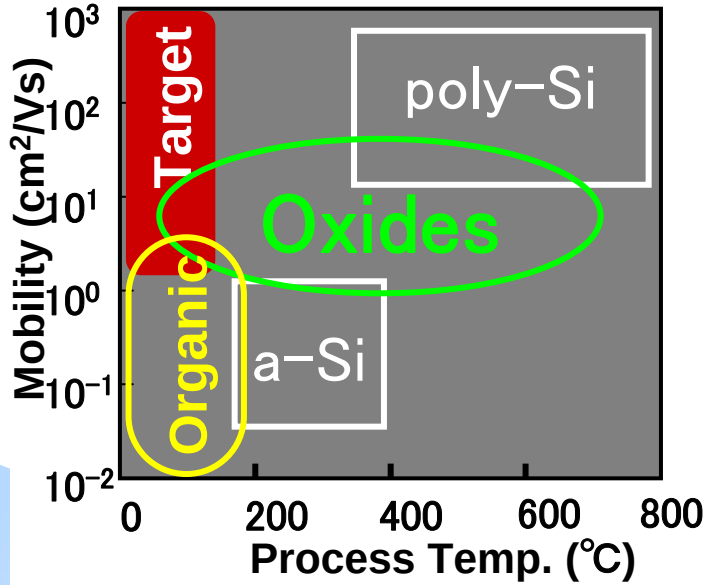
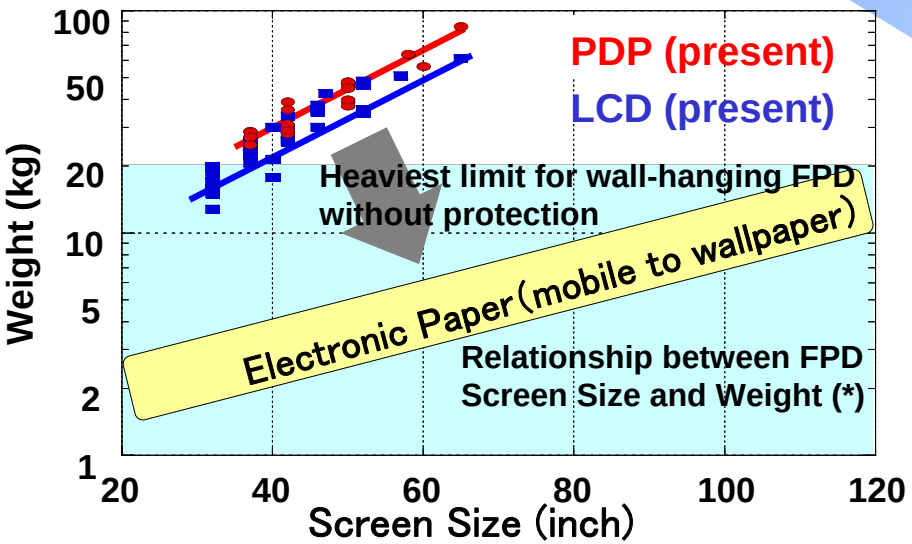
■Target : Large Area, Ultra Light, Ultra Thin, Highly Flexible, Low Temperature Process

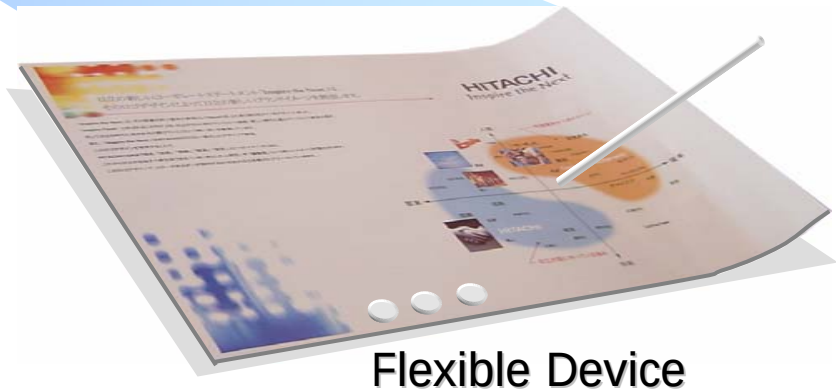
CRT

FPD (PDP, LCD)





(* : as of Apr. 2007, based on product catalogues)



Flexible Device
(Hand-Held～Wall Sized)

Summary

1. For the sustainable development of the global society, a new paradigm of innovation, Eco-Innovation, is designed and ongoing.
2. Eco-Innovation is aimed at creating socially important outcomes based on the development and implementation of breakthrough technologies and the fusion of technology and art/social sciences.
3. Eco-Innovation includes sustainable manufacturing system, zero-emission-type social infrastructure and sustainable living.
4. In the era of information explosion, energy saving in ICT is critical. Nano-ICT plays a key role. Establishment of global COE for novel nano-ICT development and product incubation will be a counter-measure.
5. Global collaboration is a key for target setting, R&D efficiency improvement, and support for developing regions.

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Thank you for your attention.