The 21st Century COE Program
Mechanical Systems Innovation
The University of Tokyo

News Letter

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Mechanical Systems Innovation, The University of Tokyo

Prospect of Mechanical Systems Innovation

In the 21st century, Mechanical Engineering is expected to play a major role in providing improved comfort and secure societies for the diverse people of the world through the creation and application of new knowledge. The International Center for Mechanical Systems Innovation has been established to focus on the energy and biomedical fields, which are indispensable fundamentals for individual life. This COE program aims to develop breakthroughs and innovations by collectively organizing and extending the discipline of mechanical engineering. By integrating the information, biomedical and nano/micro technologies, we aim to advance the present creative research on future mechanical systems and cultivate next generation engineering professionals. Key technology areas to realize this new challenge are miniaturization, distribution, mobilization, functionalization, process intensification, diversification, individualization, and so forth. By researching these we will establish, for example, new mechanical systems for multi-modal energy conversion with minimal environmental impact, integrated resource and environment monitoring, tailor-made medicines and delivery systems, and home health care. In order to make these leading-edge designs possible, we will also advance and establish hyper modeling and simulation methods for understanding, modeling, and optimizing various multi-physics and multi-scale phenomena.

Nobuhide Kasagi Program Leader

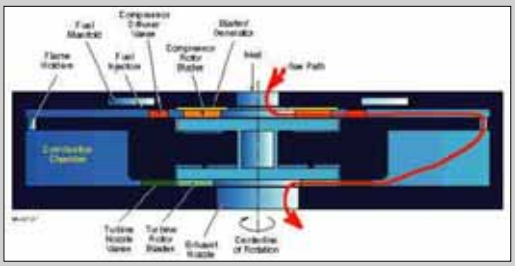
Energy Innovation Project

In order to enrich human life, it is increasingly necessary not only to deliver stable electric power, but also to provide users with various options for its delivery, such as a stationary small-scale distributed energy systems and mobile energy sources to power communication devices and patient care equipment. Future power technologies should also contribute to the safety and security of human society by reducing environmental load due to energy consumption, monitoring living environments, and exploring new natural resources in the ocean and in space. For achieving the above-mentioned goals, we will design, manufacture and evaluate advanced energy-delivery systems, such as ultra high-efficiency distributed power sources, micro heat engines, micro fuel cells and micro heat pumps. We will also address the challenges to the realization of power MEMS (Micro-electro-mechanical Systems) devices by advancing and applying micro-fabrication technologies. Smart control of flow and combustion will be investigated to reduce the environmental load and advanced monitoring systems will be developed to achieve safe energy consumption and secure life. We will also develop an ultra-compact satellite for exploring space energy and underwater autonomous robots for searching natural resources on the seabed.

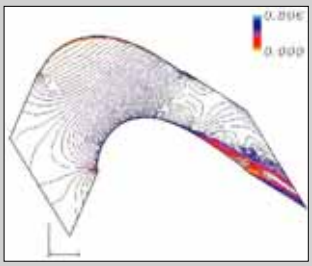
Micro energy conversion system

Next-generation innovative mobile power source

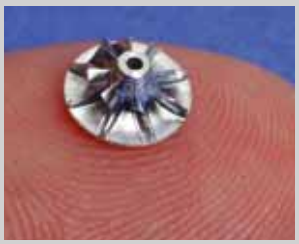
Ultra-micro gas turbine
／Professor Nagashima, Professor Kato



Finger-top Gas Turbine System

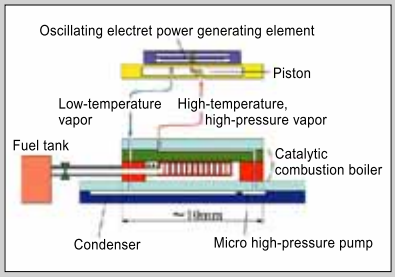


Transitional flow simulation

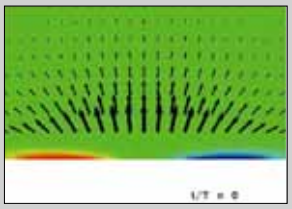


Very small-sized high-efficiency radial turbine

Micro Rankin-cycle
／Professor Kasagi

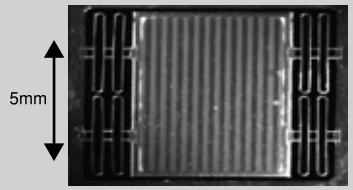


Micro Rankin-cycle system

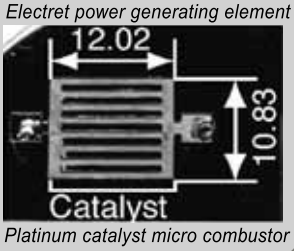


Numerical simulation of flow in micro pump

PIV measurement of micro pump



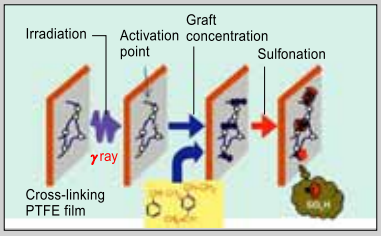
Electret power generating element

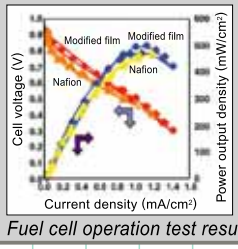


Platinum catalyst micro combustor

Fuel cell (Development and application of new electrolytic film)

Synthesis of polymer electrolyte using radiation graft
／Professor Terai





Fuel cell operation test results

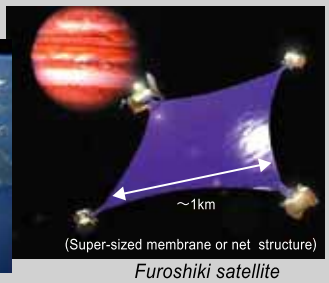
Exploration natural resources and use of space energy

See-bed resources exploration
／Professor Ura

Autonomous underwater robot (R2 robot)

Earth resources exploration and solar power generation at very large scale
／Associate Professor Nakasuka

Micro-sized satellite (CubeSat-1, 1kg weight)



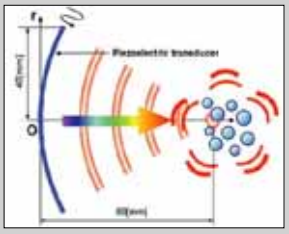
Furoshiki satellite

Biomedical Innovation Project

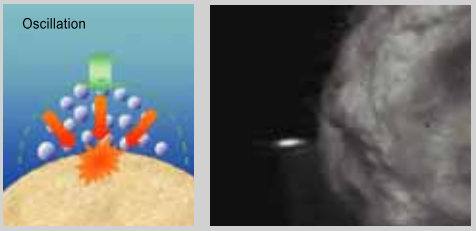
In our aging society, new medical treatment and health care technologies are crucial goals. The technologies of the future must provide a variety of mechanical systems capable of delivering advanced medical treatments for the maintenance of good health and for tailoring medical services to meet individual needs.
For these purposes, basic research concerning advanced medical support technologies will be conducted by integrating nano and micro mechatronics with biotechnology. We aim to create technologies to support various kinds of health care and medical treatment, including remote medical diagnosis and remote surgery supported by advanced data communication, medical robotics, artificial and tissue engineered organs, gene and cell-level treatment and diagnosis techniques supported by biomechatronics and micro machining and measurement technologies, and biochemical analysis chips. We will also establish the biomedical area as a discipline in mechanical engineering.

Noninvasive or minimally invasive medical therapy

Diagnosis and noninvasive medical therapy using ultrasound
／Professor Matsumoto

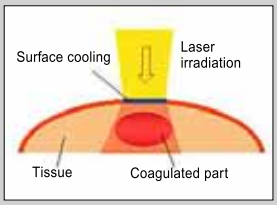


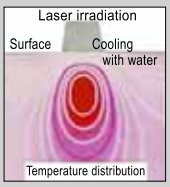
Synergy of ultrasound and micro bubbles



Cavitation Control Lithotripsy

R&D on low-invasive laser coagulation treatment
／Professor Shoji





Coagulation experiment for the stomach of dog

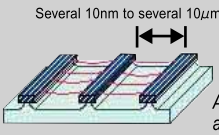
Coagulation on the inside surface of the stomach

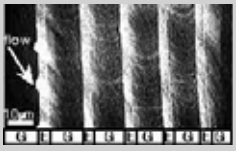
Un-coagulation on the outside surface of the stomach

Nano and micro bio-engineering

Construction of bio-nano system using DNA
(Application of DNA stretch-and-positioning)
Realization of tailor-made medical therapy
／Professor Washizu

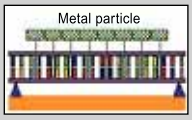
DNA stretch-and-positioning using microstructure



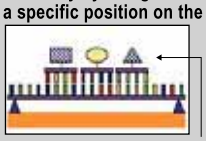


Anchoring only at molecular ends to avoid steric hindrance

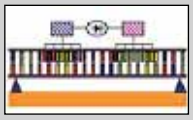
Construction of a molecular array by using a DNA as a template, which is immobilized to a specific position on the board



Utilization of intercalator →DNA wiring technology

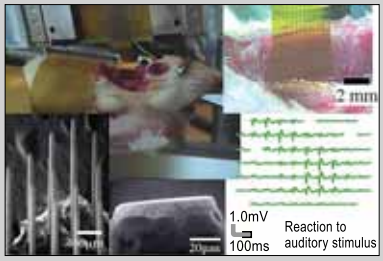


Utilization of complementary pairs →DNA array analysis Creation of functional molecular units

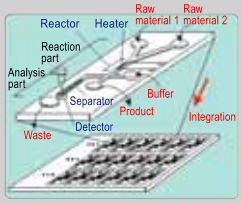


Utilization of triple-stranded DNA →Creation of molecular electronics devices

Real-time multipoint measurement of brain functions using ultra-precise electrodes: Development of auditory function recovering technology
／Professor Nakao

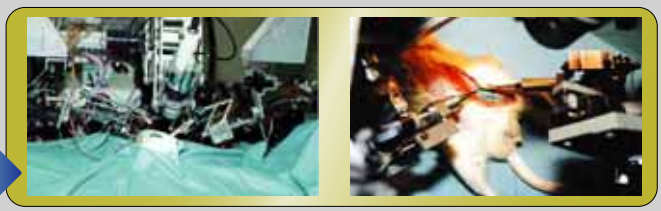


R&D on cell engineering devices: Micro biochemistry analysis
／Associate Professor Fujii



Medical information system

Remote medical system
(Tele-microsurgery system)
／Professor Mitsuishi



High-speed network, such as Gigabit Network

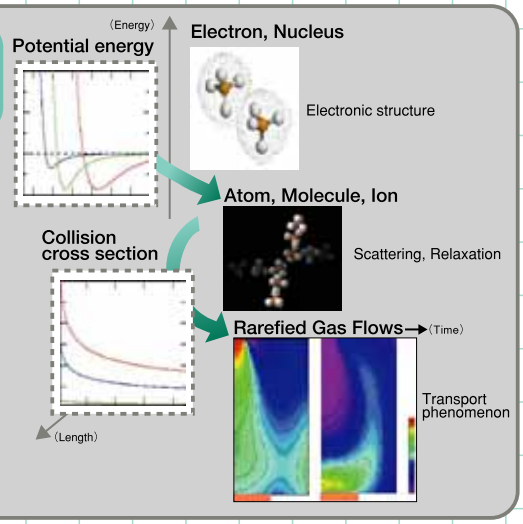
Hyper Modeling and Simulation Project

To cultivate and create various kinds of future technologies to better human life, it is indispensable to establish powerful design methodologies incorporating high performance simulations that accurately model the complex multi-scale and multi-physics phenomena that occur internal and external to real mechanical systems.
Such engineering methodologies must be developed based on a hierarchy from quantum to continuum mechanics, and advanced modeling should be promoted for micro and nano scale fundamental processes, physics and chemistry at interfaces between different phases, nonlinear multi-scale and biochemical phenomena, and so forth. In addition, ultra high-speed computational algorithms must be developed to achieve large-scale and complex simulations coupled with the new models. With these, the art of analysis and synthesis in the field of mechanical engineering will be advanced.

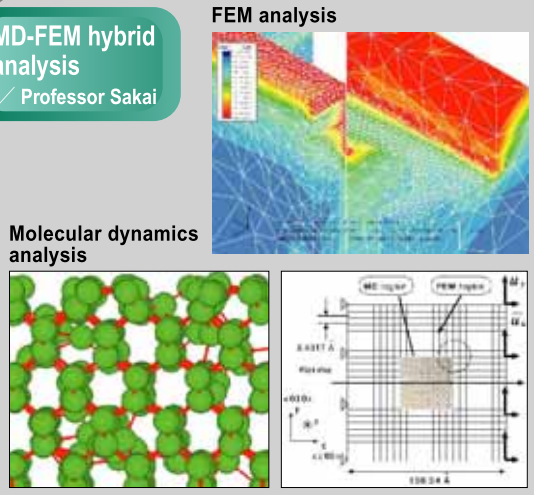
Establishment and enhancement of multi-physics and multi-scale analysis methods

Construction of a hierarchical dynamics system from quantum mechanics to continuum mechanics

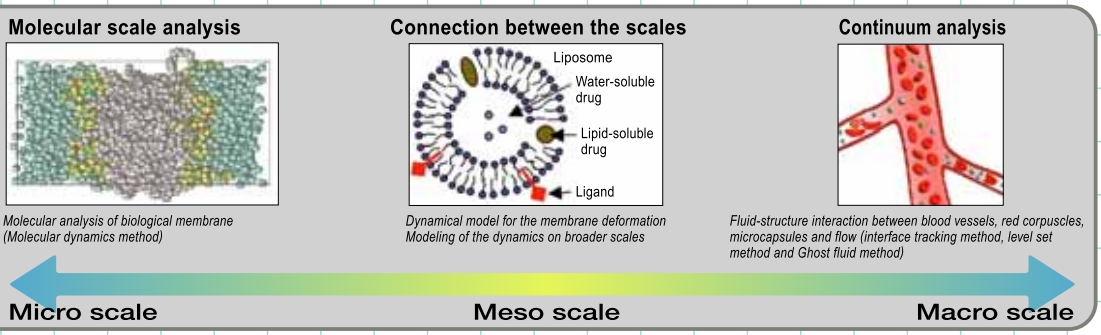
Semiconductor CVD analysis
Professor Matsumoto



MD-FEM hybrid analysis
Professor Sakai



Analysis of microcirculation
Professor Matsumoto



Molecular analysis of biological membrane (Molecular dynamics method)

Dynamical model for the membrane deformation Modeling of the dynamics on broader scales

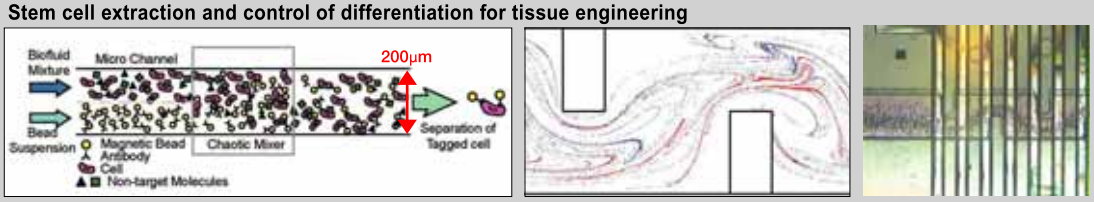
Fluid-structure interaction between blood vessels, red corpuscles, microcapsules and flow (interface tracking method, level set method and Ghost fluid method)

Realization of wide-range function through nano/micro miniaturization

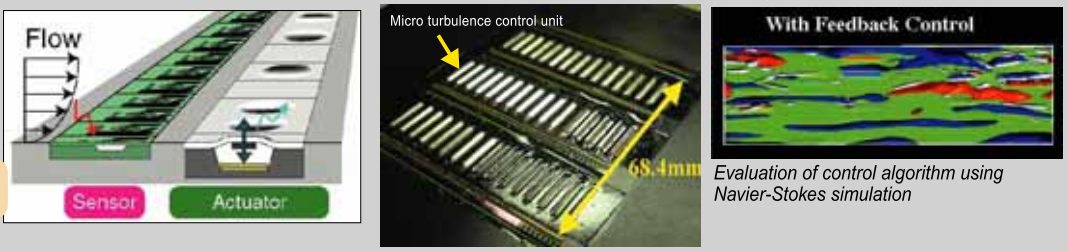
From biofluidics utilizing chaotic mixing to smart control of turbulence with MEMS devices

Micro cell processing
Professor Kasagi

Stem cell extraction and control of differentiation for tissue engineering



Turbulent drag reduction using MEMS devices
Professor Kasagi



MEMS stress sensor and MEMS actuator

Evaluation of control algorithm using Navier-Stokes simulation

Program Executive Organization

Project Promoters

Program leader

Nobuhide Kasagi	Vice Dean and Professor Department of Mechanical Engineering School of Engineering

Energy innovation

Toshio Nagashima	Professor Department of Aeronautics and Astronautics School of Engineering
Chisachi Kato	Professor, Department of Human and Society Institute of Industrial Science
Takayuki Terai	Professor Department of Quantum Engineering and System Science School of Engineering
Kazuro Kageyama	Professor Department of Environmental and Ocean Engineering School of Engineering
Nobuo Takeda	Professor, Department of Advanced Energy School of Frontier Sciences
Tamaki Ura	Professor Department of Environmental and Ocean Engineering Institute of Industrial Science
Shinichi Nakasuka	Associate Professor Department of Aeronautics and Astronautics School of Engineering
Toyohisa Fujita	Professor, Department of Geosystem Engineering School of Engineering

Biomedical innovation

Mamoru Mitsuishi	Professor, Department of Engineering for Synthesis School of Engineering
Masao Washizu	Professor, Department of Mechanical Engineering School of Engineering
Masayuki Nakao	Professor, Department of Engineering Synthesis School of Engineering
Masahiro Shoji	Professor, Department of Mechanical Engineering School of Engineering
Teruo Fujii	Associate Professor Department of Environmental and Ocean Engieering Institute of Industrial Science

Hyper modeling / simulation

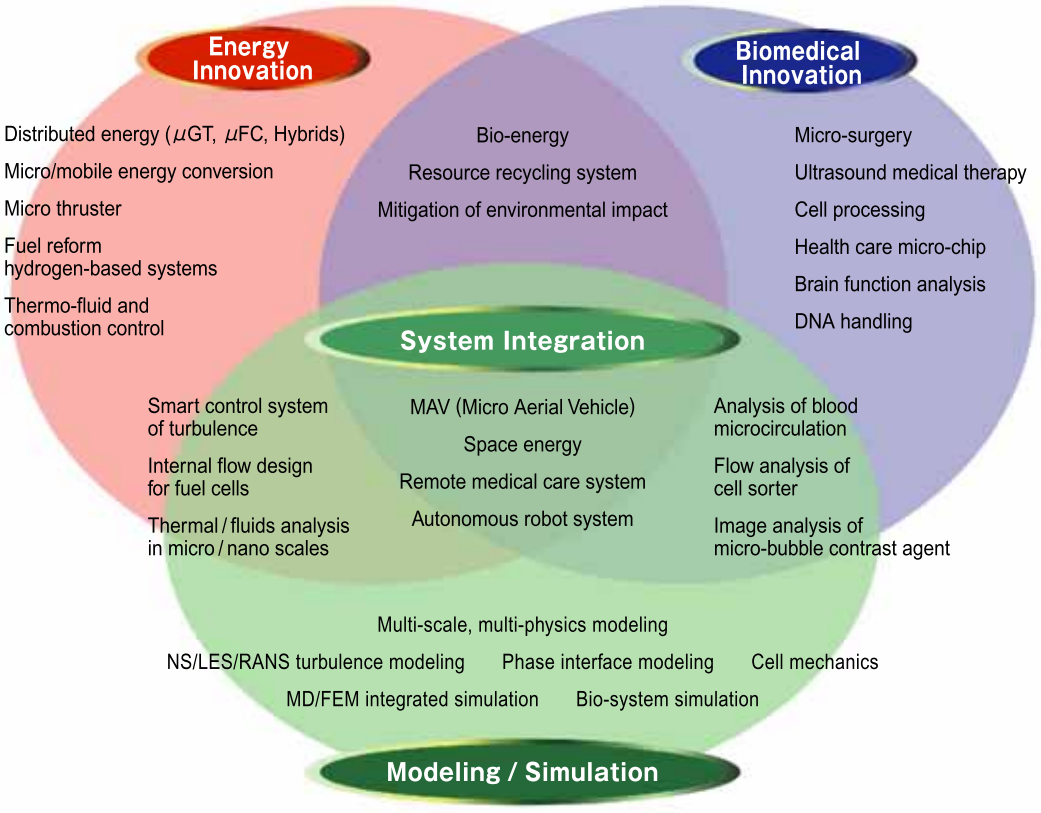
Yoichiro Matsumoto	Professor, Department of Mechanical Engineering School of Engineering
Genki Yagawa	Professor Department of Quantum Engineering and System Science School of Engineering
Takafumi Fujita	Professor, Department of Information and System Institute of Industrial Science
Hideaki Miyata	Professor Department of Environmental and Ocean Engineering School of Engineering
Shinsuke Sakai	Professor, Department of Mechanical Engineering School of Engineering

Advisory Committee

Koutaro Inoue	Senior Fellow, Japan Science and Technology Agency	Yoshitsugu Kimura	Chair, President, Kagawa University
Noboru Kikuchi	Professor, The University of Michigan	Tetsuya Tateishi	Professor, Tokyo Denki University

Security, Safety, Health and Amenity

Enrich Human Life



International Research and Education Center for Mechanical Systems Innovation

The purpose of the international research and education center will be to promote advancement of and maintain collaboration among the proposed projects, and to support the training of highly talented leaders in future technologies. The center will occupy research space on and around the university's Hongo campus, and will be staffed by administrative personnel and appointed faculty members in addition to the program executive members. The center will also employ doctoral students as research assistants, together with post-doctoral research fellows. In addition to participating in their respective research projects, faculty members will carry out routine managerial and administrative duties, and will be responsible for the annual review, updating, and implementation of advanced educational curricula. The program will sponsor exchanges of researchers with research institutes abroad, with assistance from the Offices of International Cooperation and Exchange, and of Global Ware Project of the School of Engineering. We will also foster cooperation with other 21st century COE program activities on the campus, in order to create interdisciplinary knowledge and technology by fusing diverse disciplines.

Activities of Mechanical Systems Innovation Program

<Kick off>

Date: September 8, 2003 (Hongo Campus)

<Open seminars>

◎ **First and Second Seminars**

Date : November 4, 2003 (Hongo Campus)
November 6, 2003 (Institute of Industrial Science)

Speaker : Dr. Jong Wook Hong
(Post doctoral researcher, Applied Physics, California Institute of Technology)

Subject : Integrated Nano/Microfluidic Systems for Bio/Medical Applications

◎ **Third Seminar**

Date : November 8, 2003 (Hongo Campus)

Speakers : F.A. Breugelmans (VKI Deputy Director, Retired)
Van Den Brauembusshe (VKI Professor, Turbomachinery)
Y. Ribaud (ONERA Professor, Energy Department)
S. Mizuki (Prof., Mech. Dept., Hosei University)
S. Yuasa (Prof., Aero & Astro. Dept., TMIT)
S. Kaneko (Prof., Dept. Mech., School of Eng., UT)
T. Nagashima (Prof., Dept. Aero & Astro., School of Eng., UT)

Subject : Ultra-Micro Gas Turbines & Wave Rotor Technology

<Workshops>

◎ Mechanical Systems Innovation Workshops
October 22 and November 19, 2003, January 14 and February 3, 2004

◎ Energy Innovation Group Workshops
October 18, October 30, 2003

◎ Biomedical Group Workshops
October 17, October 21, October 25, November 7 and November 13, 2003

◎ Hyper Modeling / Simulation Group Workshops
October 15 and October 25, 2003

<Domestic Symposium>

Symposium on the 21st Century COE Program:
Mechanical Systems Innovation
— How innovation will be made possible? —
Time and Date : 2pm~7pm, December 18, 2003
Venue : Takeda Hall, Takeda Sentanchi Bldg.,
School of Engineering, The University of Tokyo

<International Symposium>

International Symposium on Mechanical Systems Innovation
Dates : March 7~9, 2004
Venue : Tetsumon Memorial Auditorium, School of Medicine,
The University of Tokyo

1 March, 2004

The 21st Century COE Program Mechanical Systems Innovation Office, The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, JAPAN
Phone and Fax／＋81 3 5841 7437 URL／http://www.mechasys.jp/