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Development of Electrical Discharge Machining Devices for Curved Holes

Professor Tohru Ishida

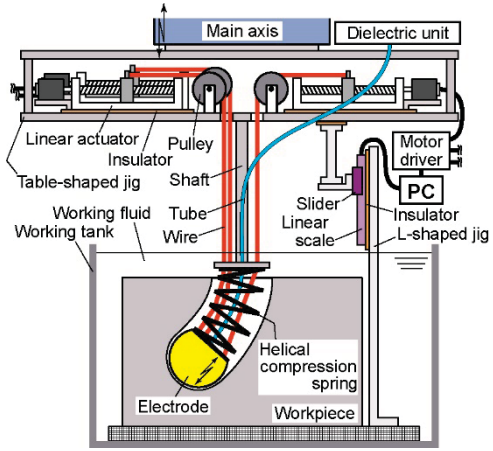

Fig.1 Schematic view of one of curved hole EDM devices

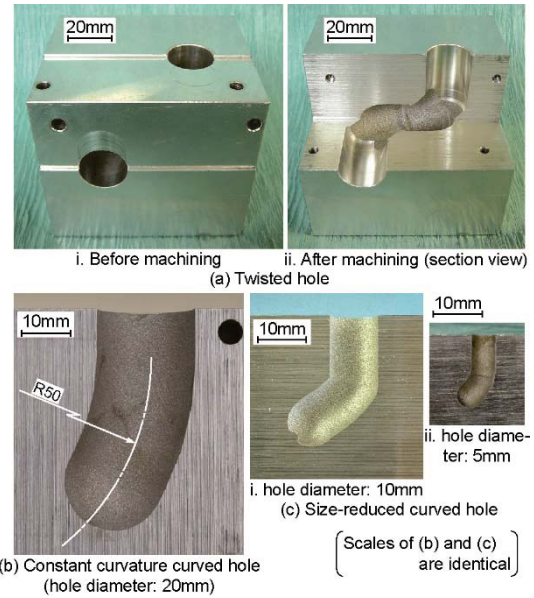

Fig.2 Examples of curved holes machined in this study

Content:

Mechanical engineers have taken it for granted that drilling is to machine a straight hole. Therefore, straight holes have been used even in unsuitable cases. The typical example of the cases appears in fabricating the water channels of molds. The water channels are the pipe lines built in molds and play an important role to properly control the temperature and thermal flow of molds in molding process by regulating the flow rate and temperature of the coolant running through the water channels, which prevents defects from occurring in products. Accordingly, the shapes and positions of the water channels are very important for achieving high productivity. However, the water channels are inevitably formed as the straight or polygonal-line-shaped pipe lines, since they are generally fabricated by drilling.

To solve the problem, the development of a curved hole machining method is strongly desired. Therefore, our laboratory has developed the devices to machine curved holes by means of electrical discharge machining (EDM). Figures 1 and 2 respectively show one of the devices and the curved holes machined by the devices.

Keywords: curved hole, electrical discharge machining (EDM), CAD/CAM

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Instrumentation for Scientific Measurements

Professor Tetsuo Iwata

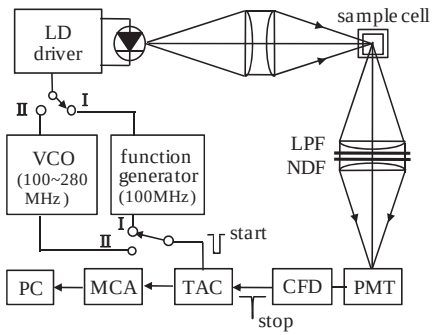

Fig.1 Photon-counting-type phase-modulation fluorometer.

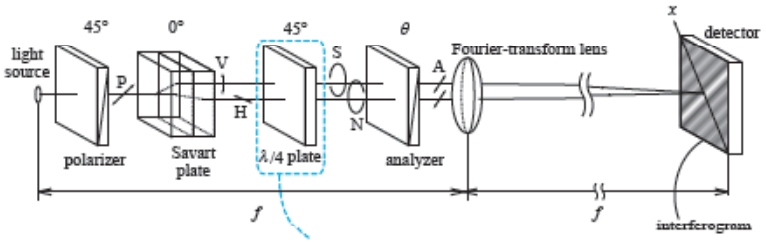

Fig.2 Measurement system of the geometric phase by use of a multichannel Fourier-transform spectrometor.

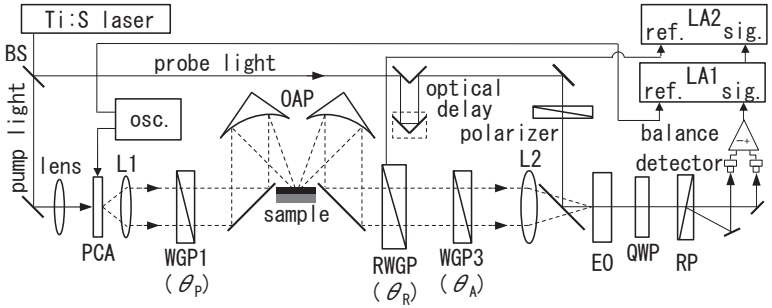

Fig.3 Double-modulation terahertz ellipsometer..

内容:

Our research interest is focused on making an instrument for scientific measurements and developing methodology for optical and/or spectro-physical measurements. Our research area covers fluorescence lifetime measurements, fluorescence anisotropy measurements, polarized-light measurements, terahertz ellipsometric measurements, surface plasmon resonance, and so on. Theree examples are shown in Figs.1~3. Figure 1 shows a photon-counting -type phase-modulation fluorometer, which can be used in a low-light-level situation with an improved resolution time. Figure 2 shows a multichannel Fourier-transform spectrometer equipped with a quarter-wave plate for measuring the geometric phase in the polarized light . Figure 3 shows a double-modulation terahertz (THz) ellipsometer used for measurements of the thickness of the thin paint film coated on the metal surface.

Expertise:

- ✓ Applied Optics
- ✓ Applied Spectroscopy
- ✓ Multivariate Analysis

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The Dynamics of Bubbles and Drops in Viscous Liquids

Professor Mitsuhiro Ohta

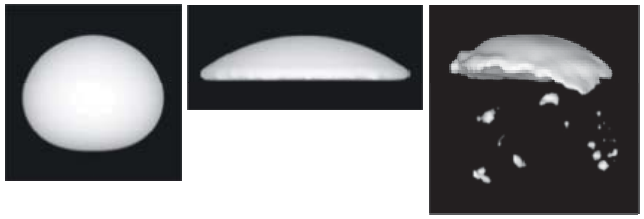

Fig. 1 Bubble motion rising in viscous liquids.

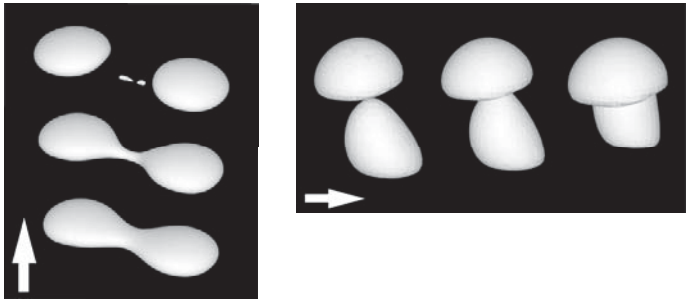

Fig. 2 Complex motion of bubble and drop.
Left: drop breakup Right: bubble merging

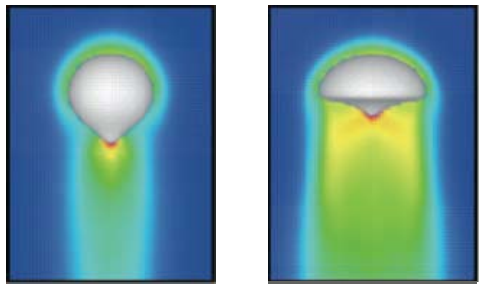

Fig. 3 Bubble motion rising in viscoelastic liquids.
(Elastic stress distribution)

Content:

Computational fluid dynamics (CFD) can be a useful tool for understanding detailed flow structures and mechanisms of the dynamic motion of bubbles and drops. Our laboratory computationally explores various motion of single bubbles and drops in immiscible viscous liquids including non-Newtonian fluids:

- Bubble/drop rise motion (Fig. 1)
- Complex (deformation/break-up/coalescence) bubble/drop motion (Fig. 2)
- Bubble/drop rise motion in non-Newtonian fluids (Fig. 3)

Our computations are implemented using sophisticated numerical methods such as Volume-of-Fluid, Coupled Level-Set/Volume-of-Fluid, Moment-of-Fluid methods to numerically track the interface.

Keywords: Two-phase flow, Bubble/Drop, Non-Newtonian fluid

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Microstructural Analyses with Electron Microscopy

Professor Tatsuya Okada

(1)

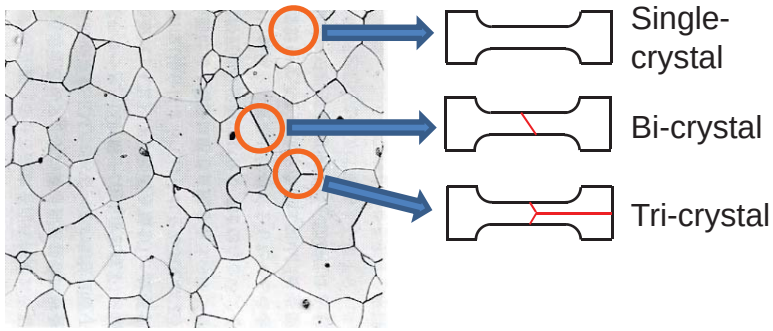

Fig. 1 Relationship between polycrystal and single-, bi- and tri-crystals

Fig. 2 Inverse pole figure orientation mapping of tensile-deformed Cu single crystal

(2)

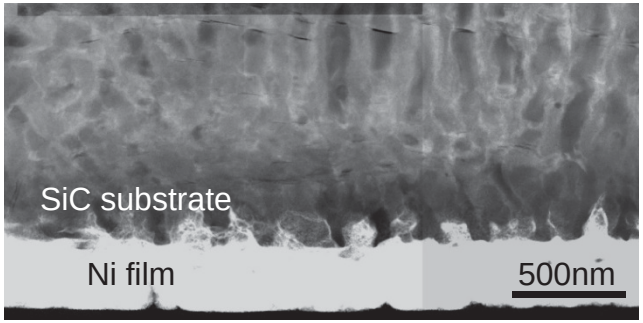

Fig. 3 Ni/SiC interface irradiated by femtosecond laser and subsequently annealed at 573K for 60s

Content:

(1) Analyses of crystal plasticity using single-, bi- and tri-crystals

We have been studying plastic deformation and recrystallization of orientation-controlled single-, bi- and tri-crystals of pure aluminum or copper. Polycrystalline materials are composed of grains with grain size of several ten to hundred μm. Hence, single-, bi- and tri-crystals are viewed as enlarged portions in a polycrystalline material (Fig. 1). In experimental studies, we carry out orientation analyses of deformed and annealed microstructures with a SEM/EBSD method (Fig. 2).

*SEM: scanning electron microscopy

*EBSD: electron backscatter diffraction

(2) Crystallographic analyses of defects with TEM

We also have been studying crystallographic defects with TEM. Our major interest is to find the laser-induced modification at Ni/SiC interfaces and its effect on the diffusion and formation of Ni-silicaide after the post-irradiation annealing. (Fig. 3)

*TEM: transmission electron microscopy

Keywords: crystallographic defect, electron microscopy, electron backscatter diffraction

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Clean Burner-Combustion of biomass fuel and waste oil

Professor Yoshiyuki Kidoguchi

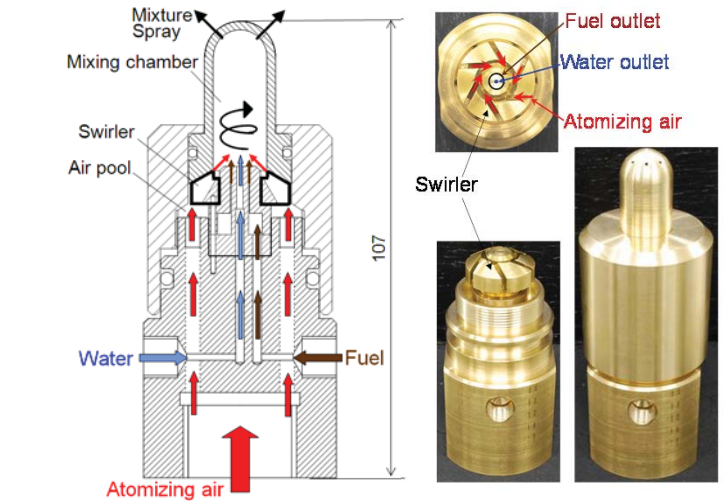

Fig.1 Fuel-water internally rapid mixing type of injector

Fuel100%

Water 50vol%

Fig.2 Burner flame

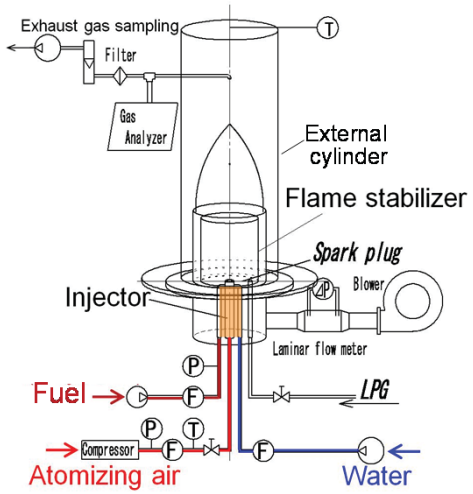

Fig.3 Experimental setup of burner combustion

Content:

Water addition to combustion field is known effective to reduce NOx and soot emissions for flame-retardant fuels. Therefore, water-emulsified technology has been used in burner combustion. However, water-emulsified fuel needs fuel-manufacturing process. In this process, addition agent is required to prevent separation of oil from water, which leads to an increase in cost of fuel. The fuel also has problem of time stability as fuel.

This study tries to use water directly in burner combustion with a newly developed injector shown in Fig. 1. Fuel and water are separately supplied to the injector. The supplied fuel and water are rapidly mixed with support of pressurized swirling air in a small chamber inside the injector. The well-mixed fluids are injected into combustion field from several small holes on the top of the chamber. The flow ratio of water to fuel can be easily adjusted in response to combustion condition. Low emission combustion achieved by this injector enables high load operation, which results in high combustion efficiency with less thermal loss of exhaust gas. The study works toward practical use of this injector.

Keywords : flame-retardant fuels, burner combustion, fuel-water mixing type of injector

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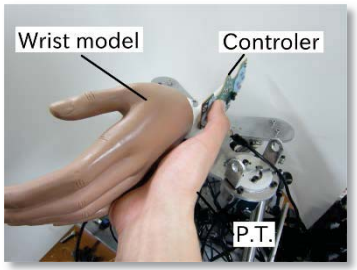
Development of Human Support System Using Pneumatic Drive

Professor Masahiro Takaiwa

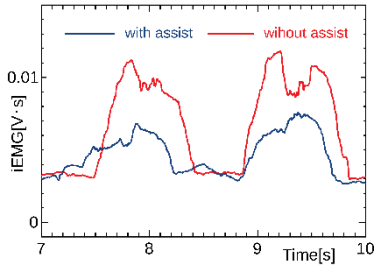
(a) Acquisition of PT's motion



(b) Patient simulator

Fig.1 Wrist rehabilitation using pneumatic manipulator

(a) Walking support shoes



(b) support efficiency comparison

Fig.2 Walking support shoes using wearer's weight

Fig.3 4-legs robot

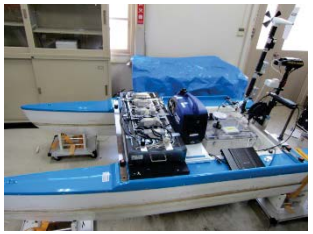


Fig.4 autonomous boat

We have been studying about the development of human support system based on pneumatic driving mechanism. Pneumatic actuator has a feature of low stiffness due to the air compressibility and back-drivability, which works as safe function.

Fig.1 shows a wrist rehabilitation equipment using pneumatic parallel manipulator. We proposed a strategy to acquire a P.T.'s motion and implement it for a patient. A patient simulator to train P.T. is also under the current investigation.

Pneumatic actuator has a feature of high power/weight ratio, that suitable for a wearable device. Fig.2 shows a walking support shoes for elderly person that can actively moves up their toe at the moment of swing phase. Energy autonomous drive based on wearer's weight is proposed.

Except for the above mentioned welfare-oriented equipment, a multiple legs robot (Fig.3) and an autonomous boat for preserving environment (Fig.4) are also developed.

Our purpose is to develop a mechanical system that contribute to both life and green innovation.

Keywords : human support system, pneumatic drive

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Development of Sustainable Composite Materials

Professor Hitoshi Takagi

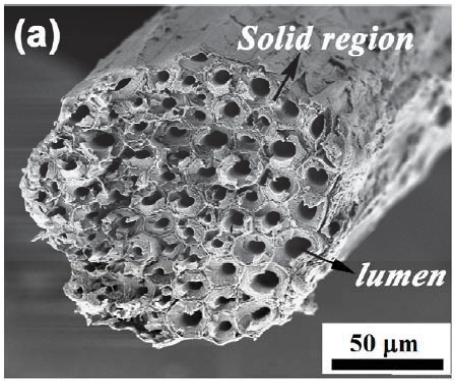

Fig. 1 Internal microstructure of natural fiber.
DOI: 10.1016/j.matdes.2011.04.006

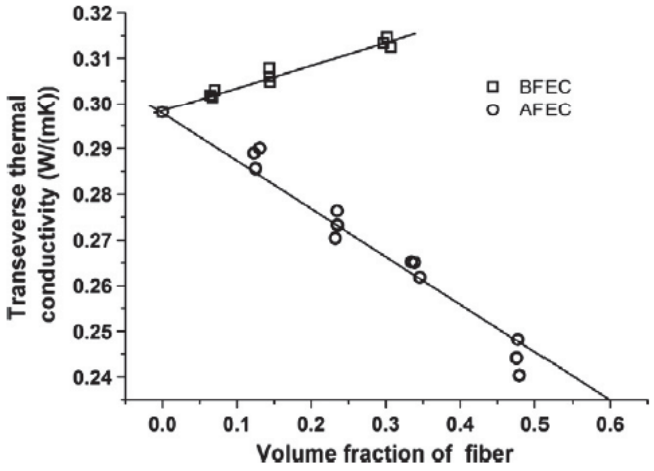

Fig. 2 Thermal conductivity vs. fiber content.
DOI: 10.1016/j.compositesa.2012.02.020

Content:

Glass fiber-reinforcing plastics (GRRP), that are widely used until now as a lightweight structure material, are produced from exhaustible resources, in addition there are difficult recycling problems in GFRP. We are now carrying out research work on natural fiber-reinforced polymer composites (sustainable composites), that have equivalent mechanical characteristics with GFRP, and their environmental load is much lower than that of GFRP.

Though the natural plant fibers have inferior strength properties to glass fibers, however natural fiber has the cavity called a lumen in the inside, as shown in Fig. 1. Therefore, it is expected that various functional properties are derived from this unique internal microstructure. For example, since the air filled in the lumen has smaller thermal conductivity than many solid materials, it has been demonstrated that the thermal conductivity of the natural fiber-reinforced composites have excellent thermal barrier properties (Fig. 2). We have been examining the relationship between thermal properties of the natural fiber-reinforced composites and internal microstructure of the natural fiber.

Keywords : Green composites, Cellulose nanofiber, Functionality, CFRP

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Development of Monitoring and Control Technologies of Industrial Systems Using Advanced Laser Diagnostics

Professor Yoshihiro Deguchi

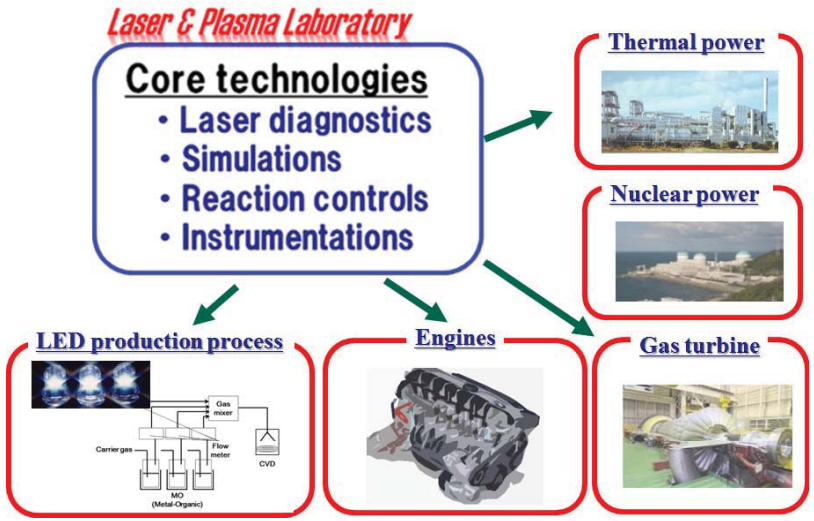

Fig.1 Application diagram of core technology

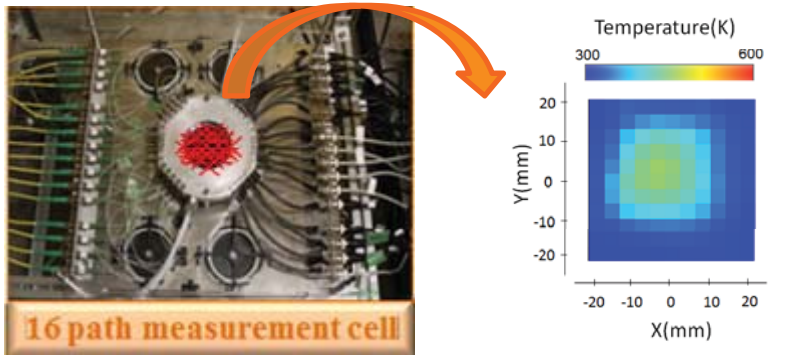

Fig.2 2D temperature and concentration measurement using CT-TDLAS (Application to engine, boiler and gas turbine)

➢ Background

It is becoming more important to reduce anthropogenic carbon dioxide emissions and improve the efficiency of industrial systems. Considering the situation mentioned above, detailed measurement techniques using advanced laser diagnostics have been developed to monitor and control the industrial systems such as engines, boilers, and gas turnines.

➢ Merit of laser diagnostics

	Conventional method	Laser Diagnostics
Physical Probe	Necessary	Unnecessary
Response	Slow (sec.～day)	Fast (ms～min.)
Measurement	One point	Multi-point(2D, 3D)
Sensitivity	Low	High

➢ Applications

1) Combustion systems : Exhaust gas, Combustion control
2) Plants(thermal, nuclear) : Process monitor and control
3) Semiconductor : Raw material monitor, Trace species
4) Medical application : Visualization of live

Keywords : Laser Diagnostics
Real-time Monitoring
Industrial Applications

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Ultrasonic Material Measurement and Evaluation

Professor Hideo Nishino

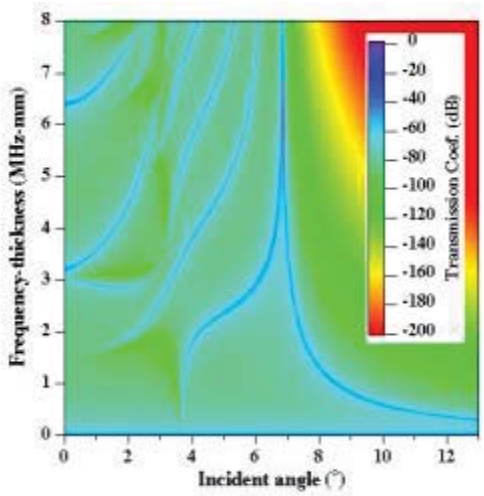

FIG. 1 Ultrasonic transmission coefficients of steel plate immersed in water

FIG. 2 Piezoelectric guided wave sensor system for piping inspection

Main Research Fields

- Nondestructive Ultrasonic Materials Evaluation

Projects

- Development of efficient inspection methodology using axial and circumferential guided waves
- Development of wall thinning monitoring using noncontacting air-coupled ultrasound
- Novel approach for laser ultrasound

Keywords : Ultrasonic Measurement, Wave Propagation Problem, Ultrasonic Nondestructive Evaluation, Guided Wave Inspection

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Research on Thermoelectric Semiconductor for Exhaust Waste Heat Recovery

Professor Kazuhiro Hasezaki

Fig.1 Photograph of Thermoelectric module

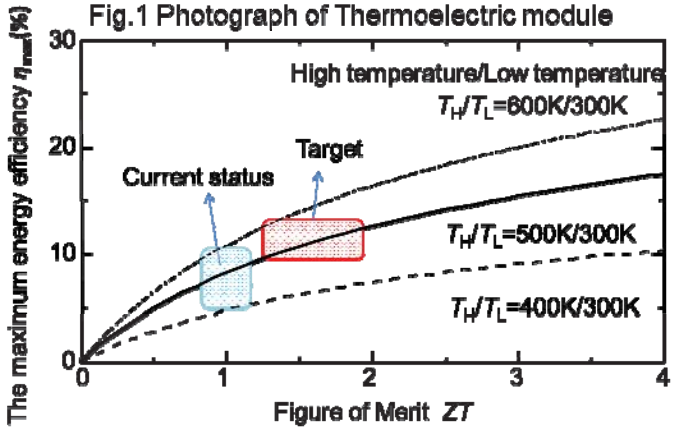

Fig. 2 Relationship of the maximum energy efficiency η_{max} and figure of merit ZT high temperature and Low temperature.

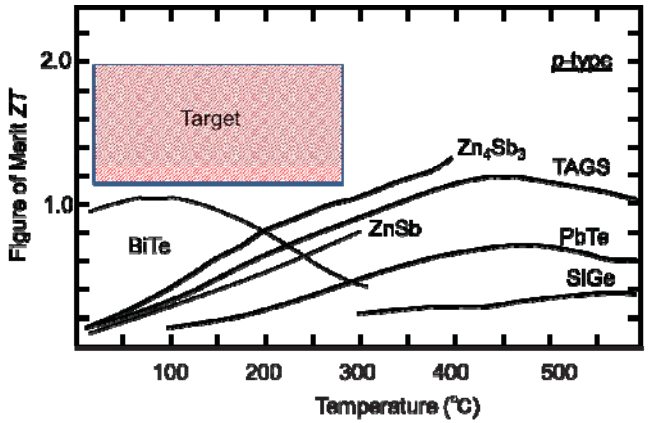

Fig.3 Figure of merit *ZT* versus temperature of thermoelectric materials

Content:

Thermoelectric semiconductor have been widely used as cooling and generating materials. Fig. 1 shows photograph of commercially available thermoelectric cooling module. These materials can be used to recover exhaust heat by thermoelectric conversion. The efficiency of a thermoelectric device is expressed by a dimensionless figure of merit, which is defined as $ZT = \alpha^2\sigma\kappa^{-1}T$, where α, σ, κ, and T are the Seebeck coefficient, electrical conductivity, thermal conductivity, and absolute temperature, respectively. Fig. 2 shows relationship of the maximum energy efficiency and dimensionless figure of merit. The heat of the low temperature range below 500 K generated from industrial apparatus has not been used effectively in the world. In our research, we propose to prepare the thermoelectric generation module for exhaust heat recovery of the low temperature range. We would like to clarify influences by the modularization to the thermoelectric properties of thermoelectric elements. Fig. 3 shows figure of merit versus temperature of thermoelectric materials. Furthermore, it is necessary to improve the figure of merit for BiTe, ZnSb and PbTe thermoelectric materials. We ultimately would like to contribute as the foundation of the effective use technology of exhaust waste heat.

Keywords : thermoelectrics,
energy conversion

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Modal Parameters Identification by Subspace Method

Professor Junichi Hino

System Identification ⇒ **Mechanical Systems**

Time domain (Time history) — **Frequency domain (FRF)**

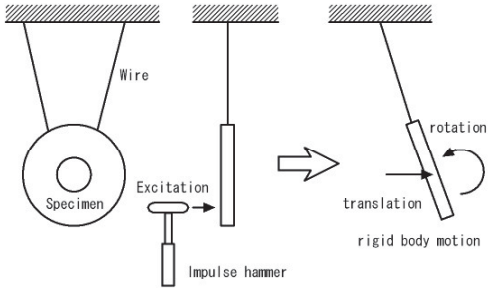

Fig.1 Vibration test.

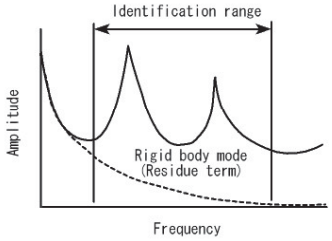

Fig.2 Rigid body mode in FRF.

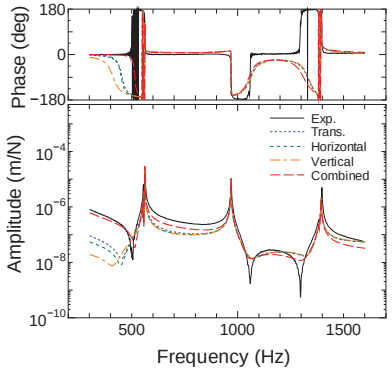

Fig.3 FRF for residual terms.

Table 1 Natural frequencies

	Natural frequency (Hz)				
Mode order	1	2	3	4	5
Calculation	564.1	565.3	971.2	1411	1411
n=10	553.7	560.9	967.6	1384	
n=12	553.7	560.9	967.6	1383	1396

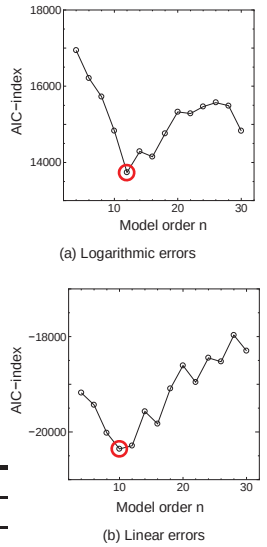

Fig.4 AIC-indexes.

Content:

It is very important to grasp the dynamic characteristics of machinery. Modal analysis is widely used for machine design. Various methods to identify the modal parameters of structures by the vibration test have been proposed. Recently the frequency domain subspace identification method is developed. Generally, it is easier to overview the dynamic properties of structures in frequency domain than time domain. We proposed a frequency domain subspace identification algorithm that takes account of the residual terms from rigid body modes. Additionally, Akaike Information Criterion (AIC) is used to determine the model order by using logarithmic error function. The proposed procedure is applied to identify modal parameters of an aluminum circular plate. The effectiveness of the proposed procedure is verified. The logarithmic error function is suitable for the frequency domain subspace identification method. We extend the proposed procedure to unknown input force estimation.

Keywords: Modal analysis, Subspace Identification, Model order, Input force estimation

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Continuity of Tactile Walking Surface Indicators and Audible Pedestrian Signals at Crosswalks

Professor Shoichiro, Fujisawa

Figure 1. Indoor laboratory

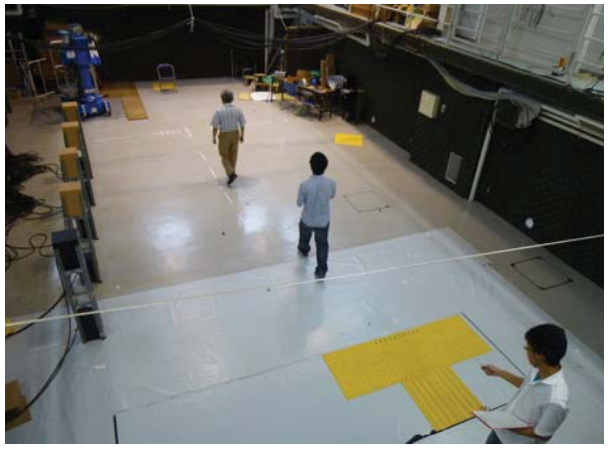

Figure 2. Actual experiment scene.

Content:

Crossing an intersection is one of the most risky actions for a visually impaired person. A visually impaired pedestrian is guided to the crosswalk entrance by the tactile walking surface indicators "TWSIs". It is then important that he/she safely and smoothly cross the intersection using the audible pedestrian signal. However, neither connectivity nor the continuity between the TWSIs and the audible pedestrian signal travel support systems has been verified. The purpose of this research is to verify this connectivity and continuity.

Figure 1 shows the floor exchange apparatus which can do the evaluation experiment of the TWSI's in the laboratory. The laboratory provided a soundproof and shaded structure consisting of the walls and ceiling. This laboratory facilitates safe and reproducible experiments. This laboratory can reproduce a crosswalk and an intersection. Figure 2 presents the photograph of experiment by the subject. The group of the speaker in the right of Figure 2 reproduces the noise in an actual intersection. It should be possible to acquire basic scientific data for developing guidelines from the findings of this research.

Keywords : <Tactile walking surface indicators, Audible pedestrian signals>

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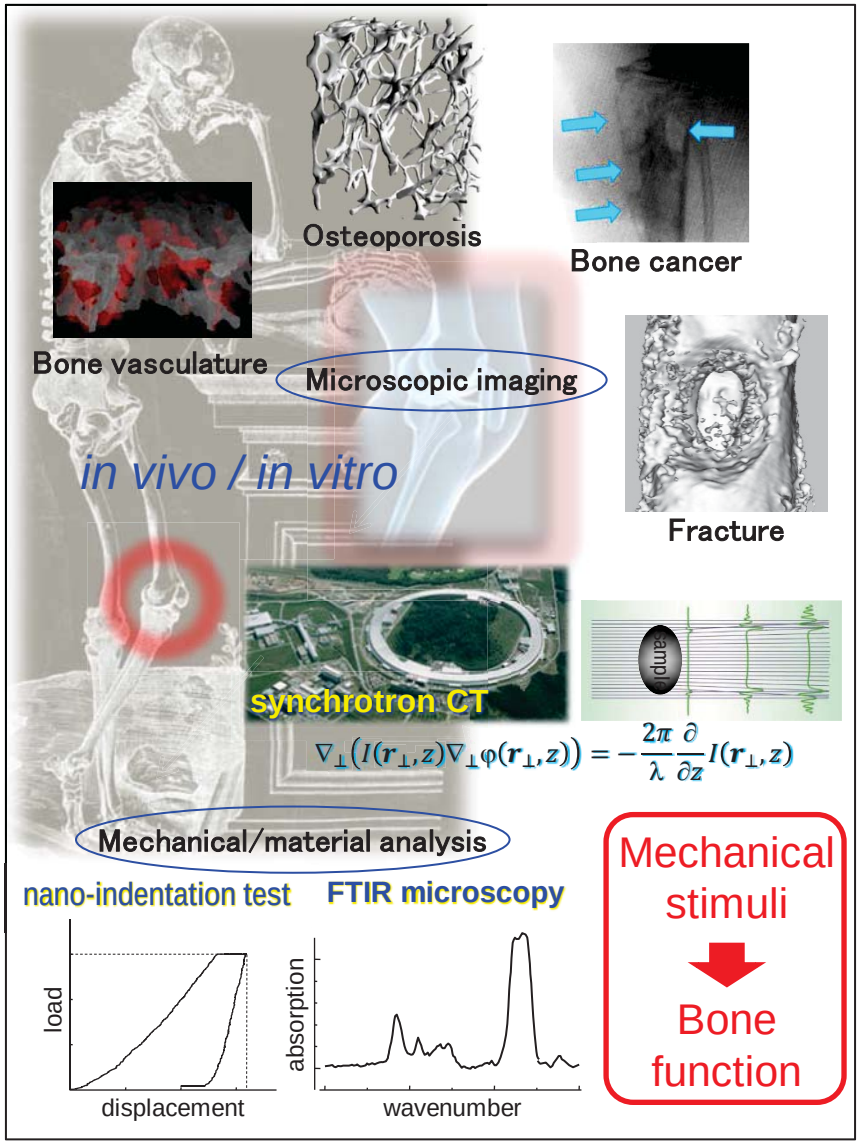
Bone response to mechanical stimuli

Professor Takeshi Matsumoto



Quantification of 3D bone microstructure is essential for evaluating bone functions, such as mechanical strength, fracture risk, or bone metabolism. Synchrotron radiation computed micro-tomography has opened up new possibilities in the analysis of bone microstructure. With the high intensity and natural collimation of synchrotron X-ray sources, bone images can be reconstructed with high resolution and high quality. The monochromatization of synchrotron lights also permits the enhancement of image contrast of a target material through harnessing its K-edge absorption jump. By taking these advantages, we have been working on in-vivo/vitro imaging of rodent bone microstructure in the 3rd generation synchrotron radiation facility, SPring-8 (Japan). In addition, we evaluate bone material properties by using nano-indentation test and FTIR microscopy. Our research interests are the effects of mechanical stimuli on bone development, fracture healing, and bone tumor growth, especially with focusing on bone vascularization.

Keywords: medical engineering, synchrotron radiation CT, osteoporosis, bone cancer

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Intelligent THz Metrology and Nonlinear Optical Microscopy

Professor Takeshi Yasui

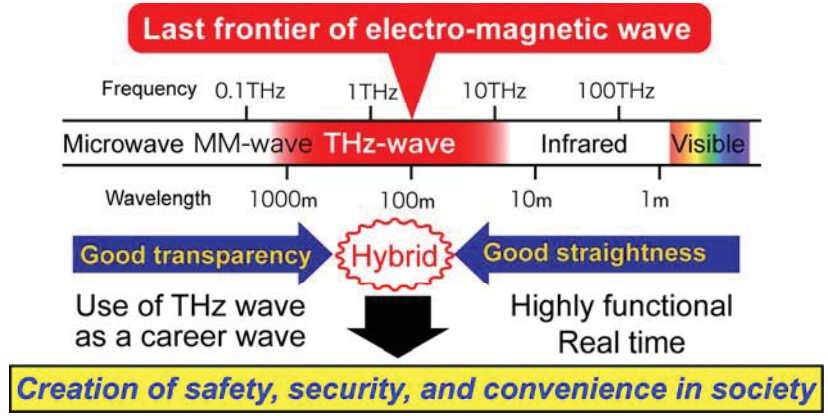

Fig. 1 Intelligent THz metrology

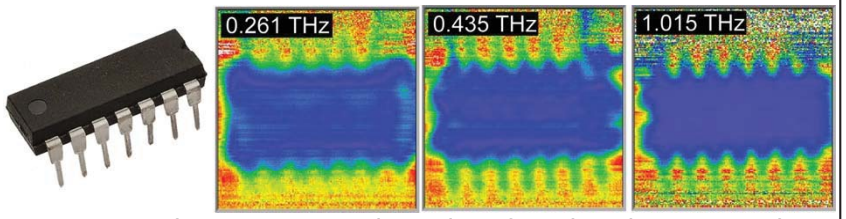

Fig. 2 THz spectral Imaging of semiconductor IC package

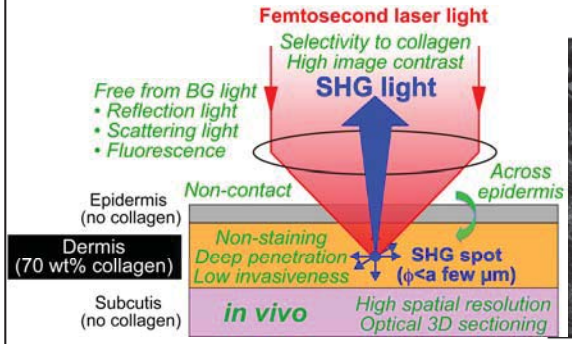

Fig. 3 Collagen-sensitive SHG microscopy

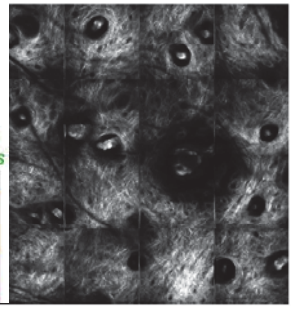

Fig. 4 Human facial skin

Content:

【Intelligent THz metrology】

THz wave, lying between optical and electrical waves, has attracted attentions as a new tool for non-destructive inspection, sensing, and other applications because of free-space propagation, good penetration, coherent beam, and imaging and spectroscopy available as shown in Fig. 1. However, the long image acquisition time has hampered its use for practical applications. We successfully reduced the image acquisition time by using 2D spatio-temporal imaging, asynchronous optical sampling, or THz comb (see Fig. 2).

【Nonlinear optical microscopy】

Second-harmonic-generation (SHG) light functions as an effective nonlinear optical probe that shows high selectivity and good image contrast to collagen molecules as well as high spatial resolution, optical three-dimensional (3D) sectioning, minimal invasiveness, deep penetration, the absence of interference from background light, and *in vivo* measurement without additional staining as shown in Fig. 3. We applied SHG microscopy to *in vivo* visualization of collagen fibers in skin and other tissues, as shown in Fig. 4.

Keywords: THz wave, SHG microscopy, frequency comb, laser control

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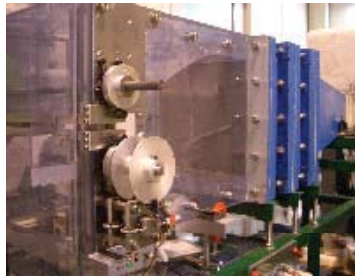
Turbulent Flow Analysis

Associate Professor Masashi Ichimiya

(a) A line of roughness elements



(b)Jet injection section in pipe

(c) Mixing layer exit oscillation plates

Fig. 1 Apparatuses in present investigation

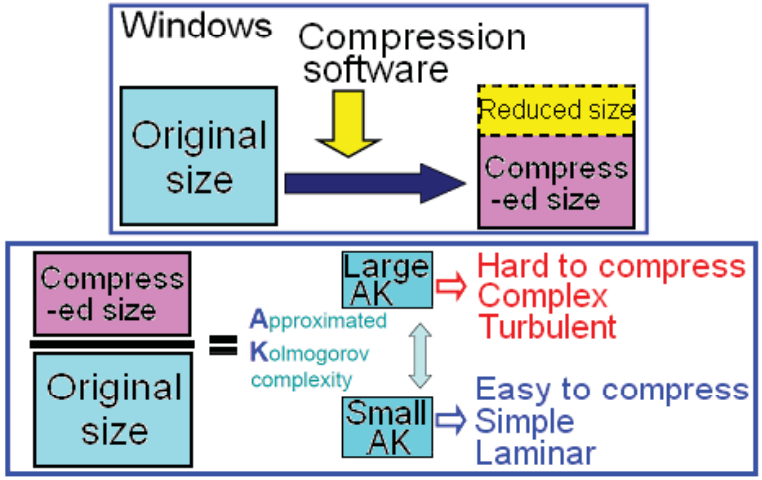


Fig. 2 Schematic diagram of complexity analysis

Content:

In fluid flows, although a turbulent flow and laminar-turbulent transition are often seen in a nature or industrial apparatus, it is hard to say that the details have been clear. Therefore, in our research, especially the laminar-turbulent transition is observed. In the laminar flow, forced transition is generated and the mechanism of transition progress is investigated experimentally.

Main experimental apparatuses are shown in Fig. 1. In (a), from a line of three-dimensional roughness elements in a flat-plate laminar boundary layer a wedge-shaped turbulent region is formed downstream from each roughness elements. In (b), an intermittent jet is periodically ejected in a circular pipe radially, then an isolated turbulent patch is generated within a laminar boundary layer and moves downstream. In (c), oscillating plates at the exit of a rectangular nozzle promote the transition of a mixing layer between the jet and surrounding quiescent air.

Moreover, the new measure which shows the transition process quantitatively is developed with the complexity analysis. Figure 2 shows the schematic diagram.

Keywords: turbulent flow, laminar-turbulent transition, boundary layer, complexity analysis

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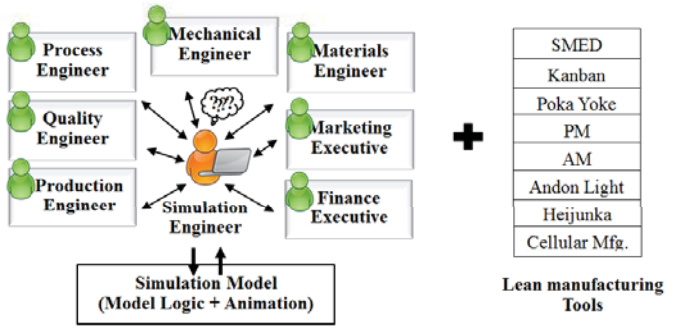
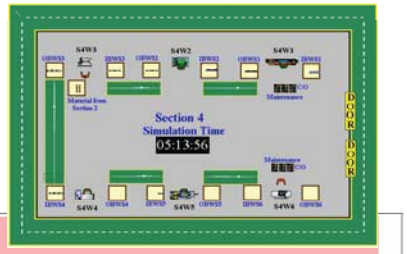
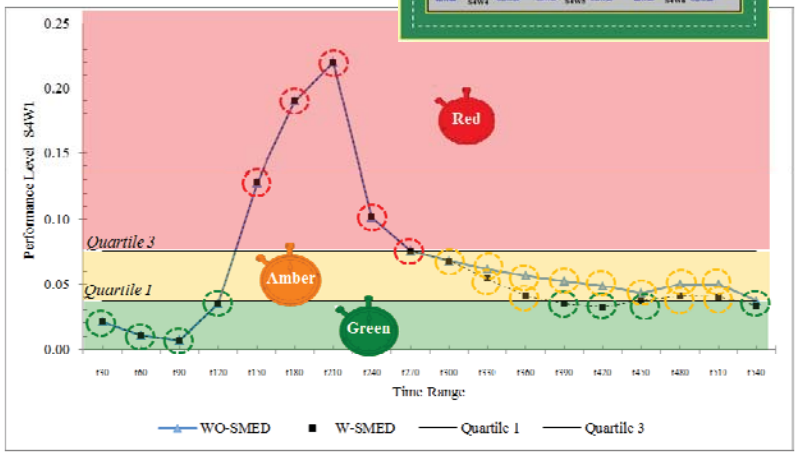
Modeling and simulation for visualization of manufacturing systems

Associate Professor Teruaki Ito







Content:

Lean manufacturing is to achieve the reduction of total production cost by eliminating possible waste, or *Muda* in production lines. Under the global competition in manufacturing systems of concurrent engineering, not only the profit but also various perspectives, such as global supply chain, environmental issues, human factors, etc. are required to be considered in manufacturing systems. However, it is not easy to share the status of process after this consideration in manufacturing systems among various people.

This study focuses on visualization of effectiveness by lean tools in concurrent engineering-based manufacturing systems which can be achieved by collaboration among various people. Designing and implementing a process simulation model of a manufacturing system, a software agent is under study for implementation in the model. The agent is designed to monitor the *Muda* level of the manufacturing process and to visualizes it during simulation. Since *Muda* cannot be judged just by the idle time only, the combination of historical data with time series of running data is used for the calculation of *Muda* level. The figure shows how the visualization of *Muda* level is presented in a prototype system.

Keywords : modeling, simulation, visualization

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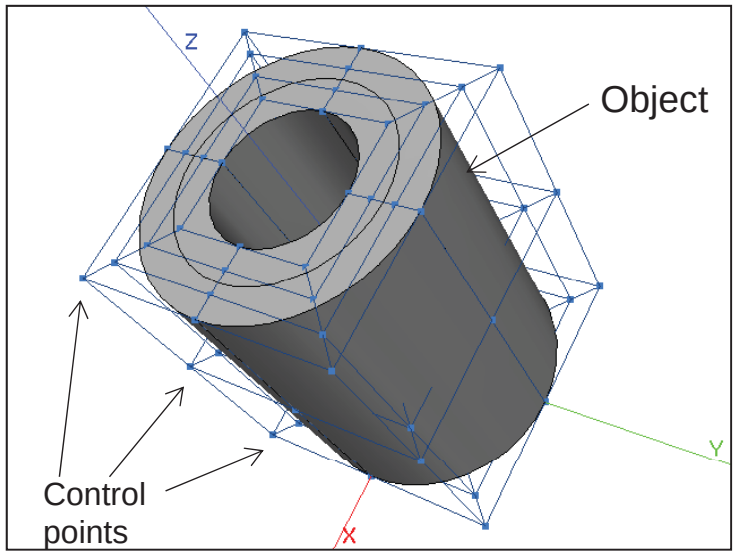
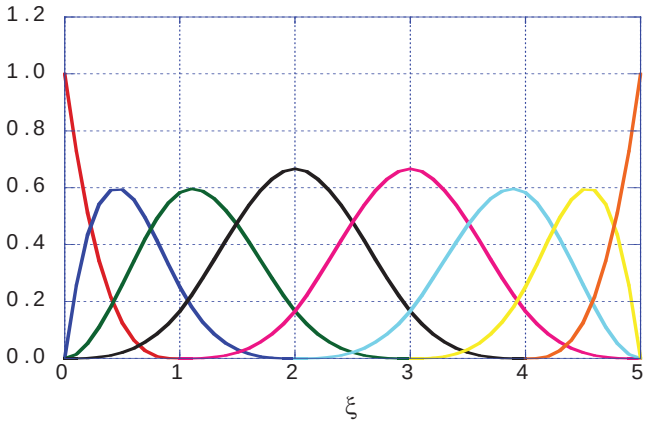
Ubiquitous CAE System on Mobile Devices

Associate Professor Atsuya Oishi



Isogeometric Analysis



NURBS Basis Functions

Content:

3D printers, which can make 3D solid objects, have become available to ordinary consumers. They will make it possible for everyone to be a manufacturer. In contrast to the mass production era, design is the most important feature of a product nowadays. Personal manufacturing inevitably needs personal CAE systems that support manufacturing : “personal” means “easy to use” and “ available anytime, anywhere”.

We have focused on mobile devices, such as smart phones and tablets based on Google’s Android OS or Apple’s iOS, as a base platform for personal CAE systems. Mobile devices have been rapidly gaining both popularity and enough performance to be used for our CAE system.

Isogeometric analysis (IGA) is a kind of finite element method. As it uses NURBS functions, de facto standard functions for representing 3D object in the CAD field, as basis functions for analysis, mesh generation, most inefficient and time-consuming process in FEM, is not necessary. We are developing an IGA-based ubiquitous CAE system for mobile devices. Our CAE system includes all processes: pre-process, main(solver)-process and post process. We are also developing new efficient human interface for mobile devices including the use of camera and/or sensors in mobile devices.

Keywords : CAE, Android OS, Isogeometric Analysis

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Contra-Rotating Small Hydro Turbine

Associate Professor Toru Shigemitsu

Fig.1 Pipe type agricultural water

Fig.2 Contra-rotating Small Hydro Turbine

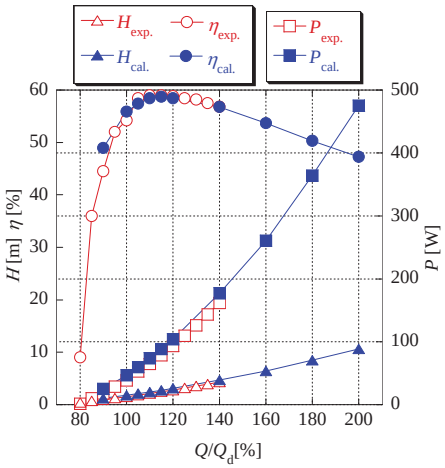

Fig.3 Performance curves

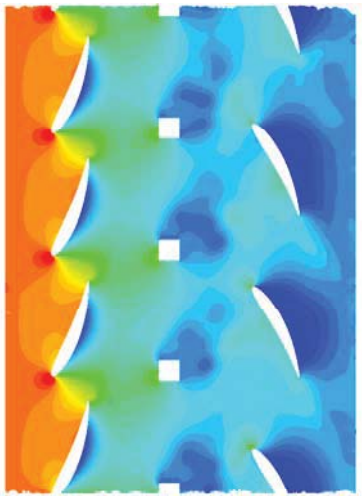

Fig.4 Pressure distributions by CFD

Content:

There is a strong demand to change energy resources of fossil fuels into renewable energy such as hydropower, wind power, solar energy and so on. Small hydropower generation is alternative energy, and there is a significant potential for small hydro turbines. Small hydropower facilities that generate about 100kW-1000kW have spread widely, however, it causes environmental destructions by a foundation construction and a set up of a draft tube. On the other hand, there are a lot of places that can generate about 100W-1kW (pico-hydropower) in agricultural water and a small stream. (Fig.1)Then, there are demands for small hydro turbines to keep high performance and wide flow passage. Therefore, we adopted contra-rotating rotors, which could be expected to achieve high performance and enable to use low-solidity rotors with wide flow passage.(Fig.2)

The maximum efficiency η_{max}=59% is obtained around 1.1Q_d-1.2Q_d, although the contra-rotating small-sized hydro turbine is extremely compact with a 60mm casing diameter. Furthermore, efficiency more than 50% is obtained in relatively wide flow rates range of 95%-180% of the design flow rate. (Fig.3) Now, the internal flow condition is investigated by CFD to improve the performance and realize a stable operation.(Fig.4) I would like to collaborate with a company because a battery and a generator are also key technology of this turbine.

Keywords : Small hydro turbine,
Internal flow, CFD,

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Powder processing of porous metals with uni-directionally elongated pore structure

Associate Professor Yoshihiro Tada

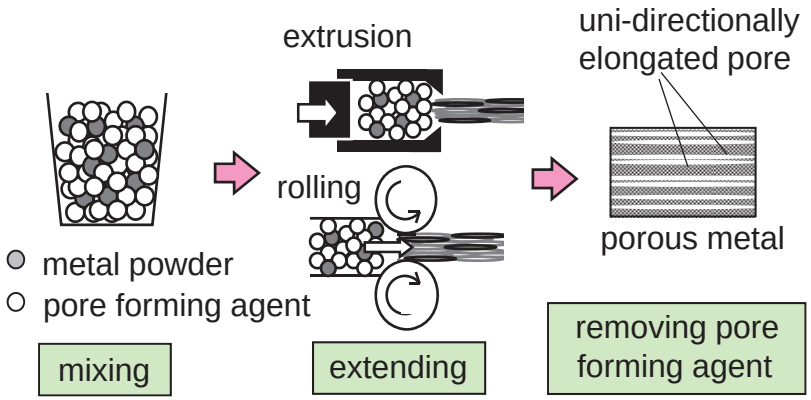
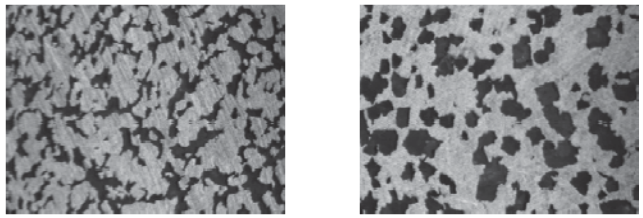


Fig.1 Schematic representation of the processing of porous metals with uni-directionally elongated pore structure



a) porosity : 35vol% b) porosity : 40vol%

Fig.2 Cross sectional microstructures of porous aluminum with uni-directionally elongated pore structure

Content:

Functional characteristics of porous metals, such as filtering properties and shock- or sound-absorbing characteristics, are strongly affected by the pore structure. A powder processing route for unique functional porous metals with uni-directionally elongated pore structures has been developed in our laboratory.

In the process, as shown in Fig.1, the following steps are carried out sequentially: a) mixing a matrix metal powder with a powdery pore forming agent whose flow stress is near to that of the matrix metal, b) extending the mixture by plastic working (extrusion, rolling etc.) to achieve the metallic powder particles adhering each other and c) removing the pore forming agent in a solvent to form a uni-directionally elongated pore structures.

The process shows wide controllable ranges of porosity and pore size (typically 25-70vol% and 0.01-1mm in cross-sectional diameter) . As shown in Fig.2, pore morphology is also widely changeable, so a lower flow resistance can be achieved even at a lower porosity.

Keywords : porous metal, powder forming, pore structure control

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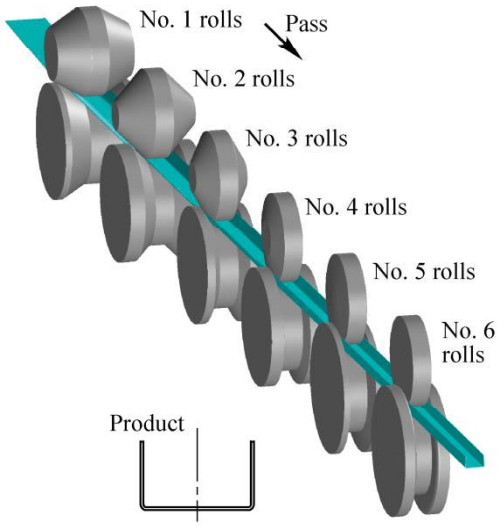
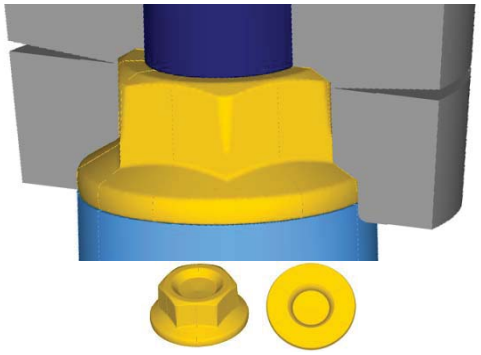
Development of New Forming Processes by Finite Element Simulation

Associate Professor Takuo Nagamachi



Roll forming process



Forging process

Main Research Fields:

Plastic deformation simulation

Projects:

Finite element simulation of forming processes.

Development of new forming processes.

Expertise:

Forming process, Plasticity, FE Simulation

Keywords: Forming process, Plasticity, FE Simulation

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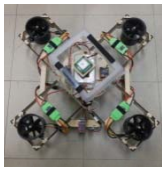
Unmanned Aerial Vehicle Control System

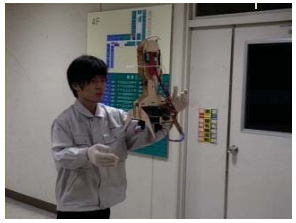
Associate Professor Masafumi Miwa

Flying Cargo System Based on Multicopter



Quad Ducted-fan Helicopter

Multicopter Operation
by Humanoid Robot



Inverted Flying Object

Content:

The performance of UAV (unmanned aerial vehicle) is improving by the performance gain of MEMS sensors, magnet, and battery technology. UAV takes the place of the real aircraft in proportion to improve the flight control technology. Because, the operation cost of the R/C single helicopter is lower than the actual one. In addition, required heliport size is smaller than that of actual one.

However, there is a possibility of accidents such as contact and crashed due to maneuver or operation error. Moreover, rotor and propeller as thrust device are dangerous in such case. So we have been conducting research and development on technology to operate UAV safely.

Currently, we present ducted fan helicopter, air cargo system with hand operation method, and Inverted Flying Object using thrust vectoring to improve UAV safety

Additionally, we study about the operation of multicopter by the movement center of gravity of the humanoid robot on it in order to develop a new personal mobility based on multicopter technology.

Keywords : <UAV, Thrust vectoring, External control>

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Fatigue Properties of PVD coatings

Associate Professor Daisuke Yonekura

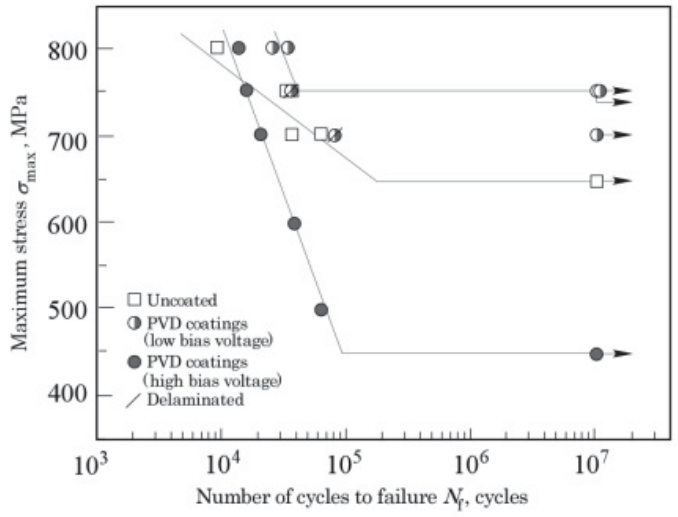
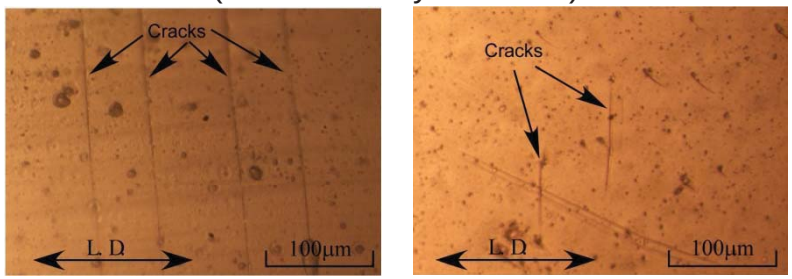


Fig. 1 S-N curves of uncoated samples & CrN coatings. (Ti-6Al-4V alloy substrate)



(a) High bias voltage, σ_a = 400 MPa, N = 1.5x10^5 cycles.

(b) Low bias voltage, σ_a = 650 MPa, N = 4.0x10^5 cycles.

Fig. 2 Typical images of film surfaces after cyclic loading.

Content:

Physical vapor deposition (PVD) coatings are well-known surface treatment methods to improve the surface properties of various materials. PVD coatings generally show high wear resistance, low coefficient of friction and seizure resistance. Therefore, the coatings are widely used for tools etc. Chromium nitride (CrN) film is one of the film materials to improve wear and corrosion resistance.

The fatigue properties of the coatings are also changed by the deposition of the hard thin film. The fatigue strength is improved by depositing of hard thin films, however, the fatigue strength often degrades by depositing of the thin films under inappropriate conditions.

We have examined the influence of the film properties on the fatigue and fretting fatigue properties of the coatings. In this study, CrN films are deposited on steels and titanium alloy under the various condition by arc ion plating (AIP) method. As a result, we have clarified the fatigue strength level is determined by the crack initiation behavior which is related to the hardness, grain size, surface morphology, defects etc.

Keywords: Surface Treatment, Physical Vapor Deposition, Fatigue, Fracture, Wear.

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Alternative methods to extract cellulose nanofibers

Associate Professor Antonio Norio Nakagaito

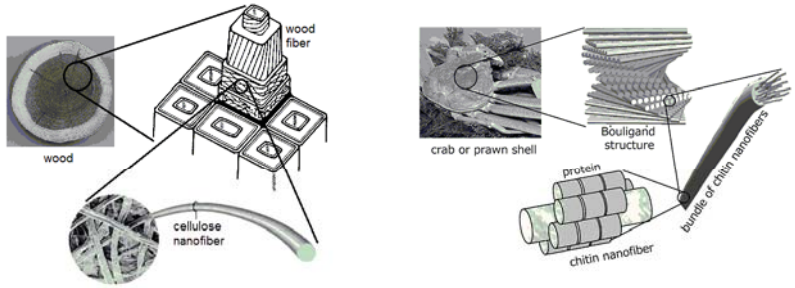
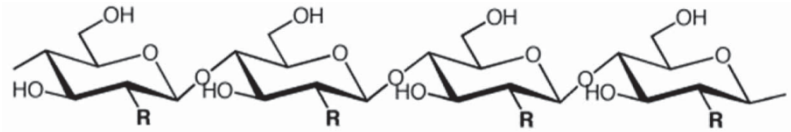


Fig. 1 Typical sources of cellulose (plant fibers) and chitin (crustacean shell) nanofibers



Cellulose: R = OH
Chitin: R = $NHCOCH_3$

Fig. 2 Structural formula of cellulose or chitin. The only difference is the functional group R

Content:

Cellulose is the most abundant biopolymer on earth, being a sustainable resource, biodegradable, and photosynthesized by fixing CO_2 from the atmosphere. They are mostly present in the cell wall of plants in the form of nanofibers. These elements have mechanical properties similar to aramid fibers and have the potential to reinforce plastics. However, the extraction requires specialized equipment, is energy consuming and costly, and the yield is low. To reduce the extraction cost, we are developing alternative methods with lower energy input and using affordable apparatuses like household blenders and ultrasonication devices. As the mechanical process of nanofibrillation relies on the application of impact and shear forces to the original plant fibers, in principle any mechanism to appropriately apply such forces has the potential to be a means to extract cellulose nanofibers affordably.

Chitin is another biopolymer present as nanofibers mainly in the exoskeleton of crustaceans, and can be extracted by the same method as cellulose nanofibers. Chitin nanofibers can also be used as reinforcement.

Keywords : cellulose, chitin, nanofiber, blender, ultrasonication

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Development of UAV Control System Using LED Panel

Faculty of Engineering
Tokushima University

Associate Professor Hiroyuki Ukida

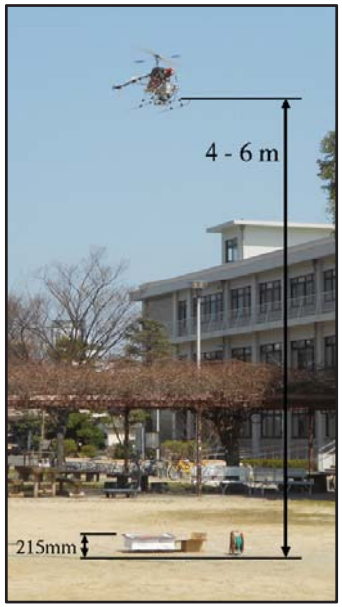
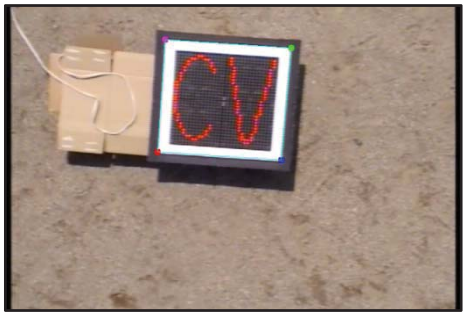


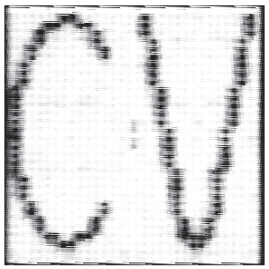
Fig.1 Scene of experiments.



(a) AR marker.

(b) QR code.

Fig.2 Captured images and LED panel detection.



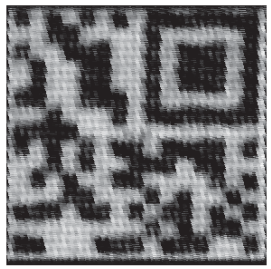


Fig.3 Corrected pattern images.

Content:

This study discusses the method to transmit the information by the LED panel and the video camera as one of the visible light communication. Here, we use the AR marker, QR and micro QR codes as 2D patterns to display on the LED panel, and propose the method to distinguish them automatically.

In the experiment, we use the video camera equipped on the radio controlled helicopter, and extract the information in the LED pattern images and estimate altitude from the LED panel by the captured images.

From the results of experiments, almost AR markers can be distinguished accurately, and the discrimination rate of the micro QR code patterns is more than 50%. But, the QR code patterns can not be discriminated. To realize the high discrimination rate of the QR and micro QR codes, it is necessary to improve the configuration of the LED panel. Moreover, to develop the flight control system of the helicopter it is also necessary to reduce the processing time.

Keywords : visual light communication, LED panel, AR marker, QR code, flight assist

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Residual Stress Measurement of Thin Films using X-Ray Diffraction

Associate Professor Kazuya Kusaka

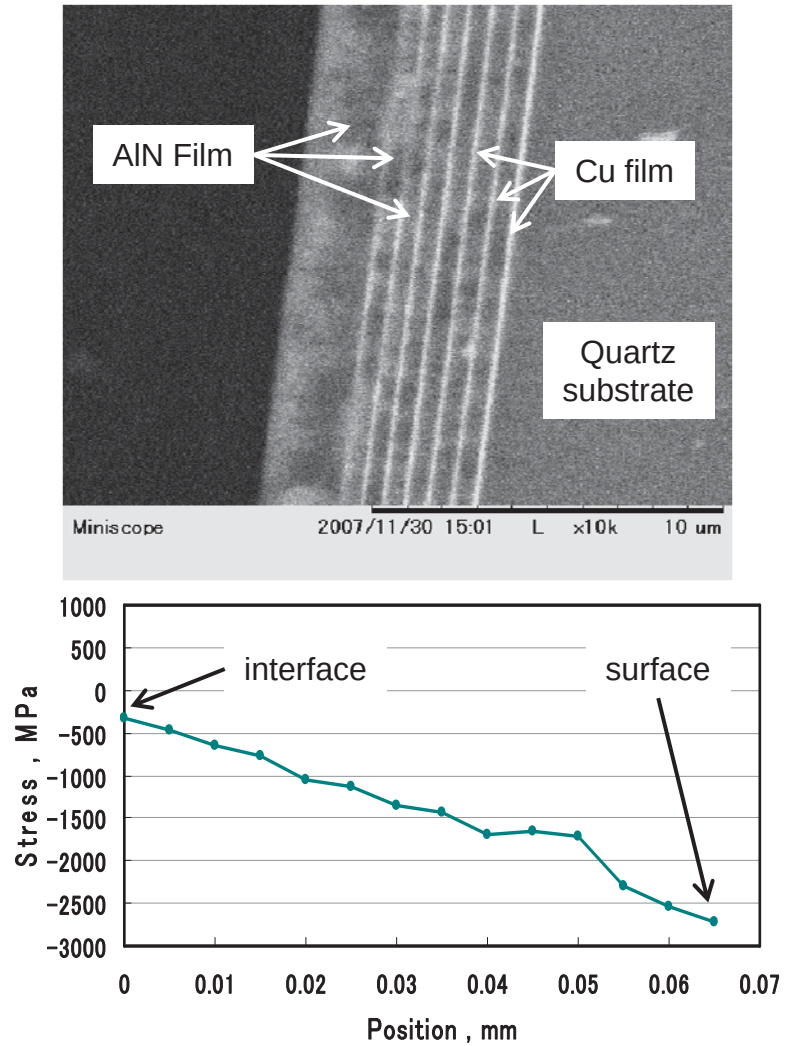

Fig.1. Internal stress of Cu layers in AlN/Cu multi-layers film

Content:

Coating is one of the surface modification technology. The mechanical properties of materials is improved by coating the film which has different mechanical properties. However, residual stresses occur in the film because of difference in lattice spacing and thermal expansion coefficient between the film and the substrate. Significant residual stress may lead to micro-cracking or cause the film to peel from the substrate. Therefore, measurement and control of residual stress is crucial for the synthesis of mechanically stable films.

It is possible to measure the residual stress of the films non-destructively using the X-ray diffraction method. As typical results, we proposed the stress measurement method for the c-axis oriented films such as AlN, GaN, and ZnO film. Our research target is to obtain high quality films which have high crystalline and small residual stress.

The left figure shows residual stress measurement result which was carried out at SPring-8 of JASRI.

Keywords: X-ray diffraction, residual stress measurement, PVD film

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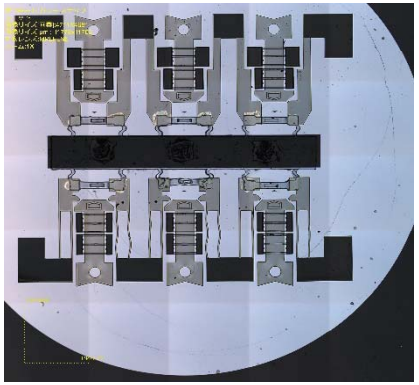
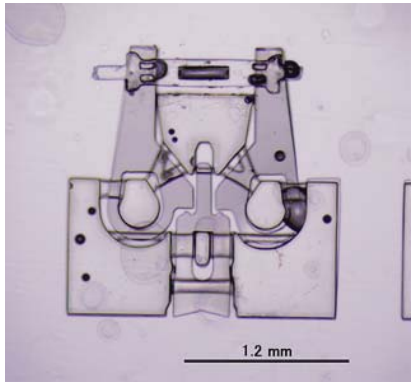
Evaluation of cellular response to mechanical stimulus using Bio-MEMS device

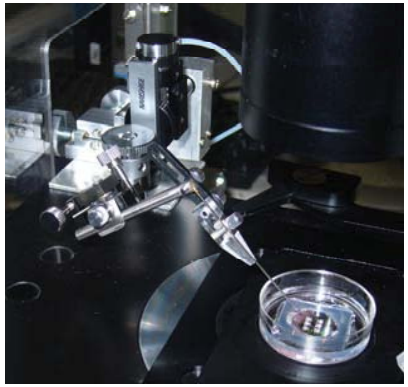
Associate Professor Katsuya Sato



Micorodevices fabricated on the cover slip



Magnified image of a cell stretching microdevice



Micorodevices are fabricated on the 35mm glass bottom dish

Fluorescent image of bone forming cell osteoslast

Content:

we developed a novel cell stretching microdevice to observe the initial cellular response to stretching deformation. Cells change their activities by sensing mechanical stimuli such as force or deformation.

With using a conventional cell-stretching device, the cellular responses that slowly arise (ex. in minutes, hours, days) after the application of stretch was observed. One factor that hinders the *in situ* observation of cellular response to stretching is the existence of large rigid displacement during the stretch. This rigid displacement makes it difficult to observe the initial cellular response to stretch with high spatial and temporal resolution.

A novel MEMS device consists of a transparent elastic microchamber and a microlinkage mechanism. To miniaturize the cell stretching chamber enables to minimize rigid displacement during stretching operation. This device can be used to observe and evaluate the initial cellular response and microstrain field on a cell membrane during uniaxial stretching.

Keywords : <Cell Biomechanics, Bone Remodeling, Regenerative Medicine, MEMS, Mechanical Stimuli>

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NOx Emission Characteristics of High Temperature Air Combustion

Associate Professor Yuzuru Nada

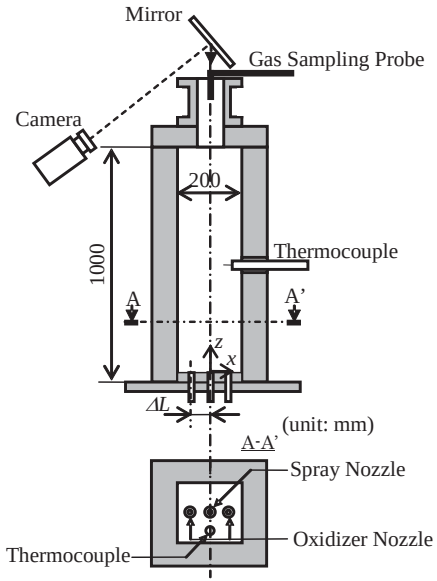

Fig. 1 HiTAC furnace.

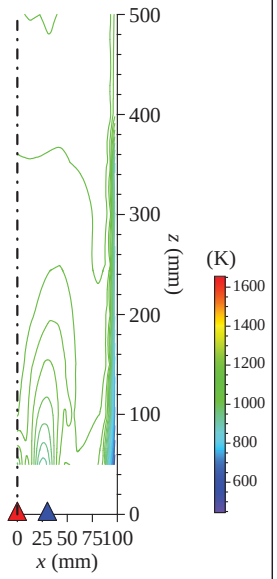

Fig. 2 Temperature distribution in HiTAC furnace.

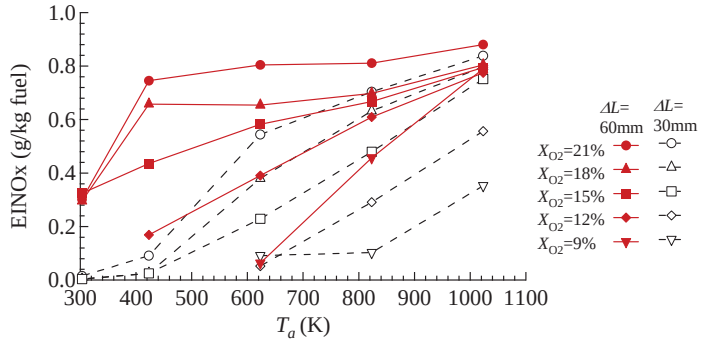

Fig. 3 Effects of properties of preheated oxidizer and nozzle distance on NOx emission.

Content:

To date, various combustion technologies based on dilution with burned gases have been developed to allow further reductions of NOx and soot emissions and to improve the thermal efficiency of furnace systems. These technologies are referred to as MILD combustion in Italy, flameless oxidation in Germany and high temperature air combustion (HiTAC) in Japan.

We focus on the flame stability and NOx emission characteristics of high temperature air combustion with liquid fuels. Figure 1 shows schematics of a HiTAC furnace used in our studies. The furnace has a parallel jet burner incorporating a central spray nozzle and oxidizer nozzles with electric heaters for preheating oxidizers. As shown in Fig. 2, in this furnace, a MILD combustion state with a uniform temperature distribution can be reproduced even in the laboratory-scale furnace. We investigate effects of nozzle distance between spray and oxidizer nozzles on NOx emission characteristics as shown in Fig. 3.

Keywords : combustion, NOx emission, flame stability

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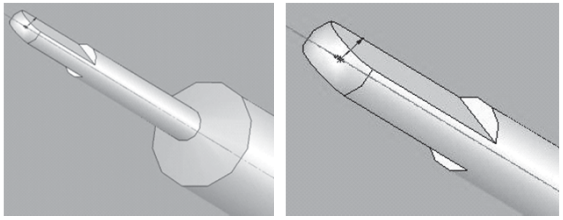
Development of Micro Hole Drilling Tool to Hard and Brittle Material

Associate professor Akira Mizobuchi



(a) Tool shape (b) Tool head

Fig. 1 Schematic drawing of designed tool

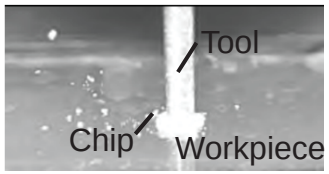
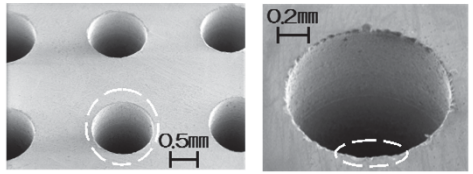


Fig. 2 Observation of chip removal



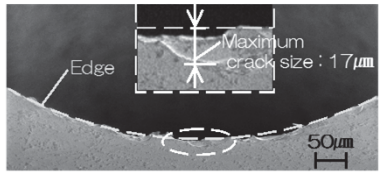


Fig. 3 Appearance of drilled hole

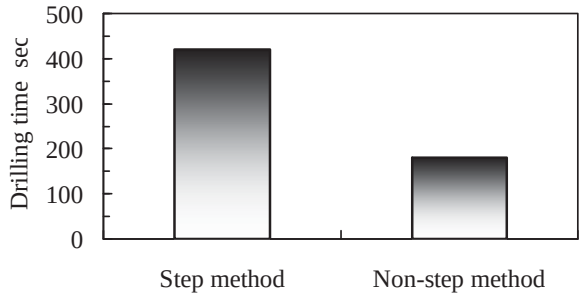


Fig. 4 Comparison of drilling time between step and non-step method

Content:

The aim of this study is the establishment of high drilling quality, high drilling efficiency and low drilling cost in through-hole drilling of hard and brittle material using an electroplated diamond tool. During drilling, the chipping is generated at the entrance side and the exit side of the material. In addition, chip generated is easy to adhere to the tool. By the adhered chip, the tool is damaged and the material is broken. In this study, we examined effectiveness of designed tool to improve chip removal in order to carry out crack-free drilling of the material.

Figure 1 shows the image of the tool designed. The tool is composed of a cylindrical body and a hemisphere shape with two straight planes. The tool has the following advantages compared to common tools.

(1) Chip adhered on the tool is little(Fig. 2).

(2) Drilling is possible without a backing plate(Fig. 3).

(3) Drilling time is shorter(Fig. 4).

(4) Drilling cost is cheaper.

Keywords : electroplated diamond tool, high quality, high efficiency

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Non-destructive testing using infrared thermography

Assistant professor Masashi Ishikawa

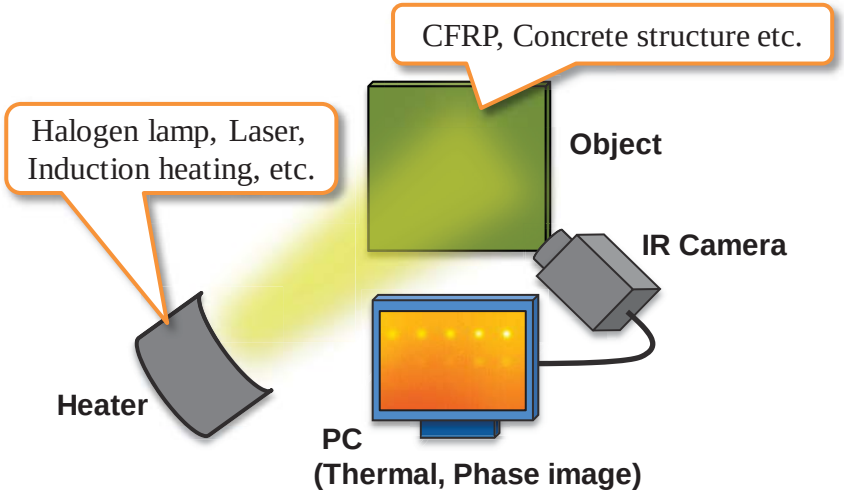

Fig. 1 Schematic illustration of infrared thermographic testing.

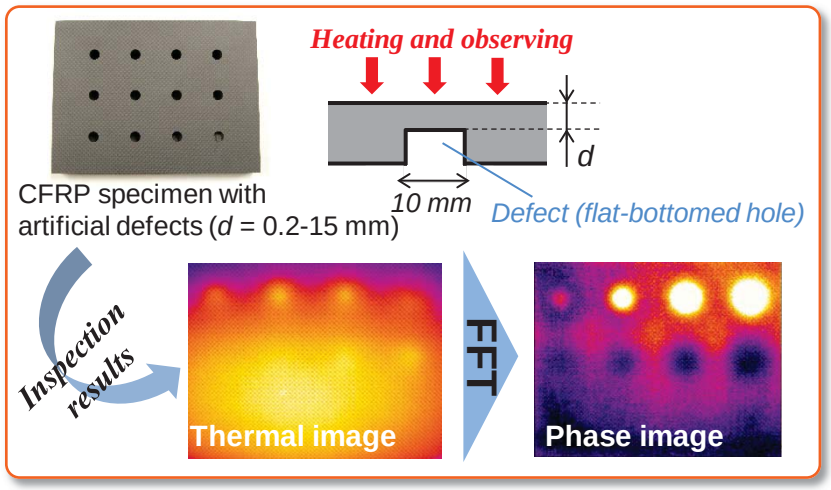

Fig. 2 Comparison of thermal and phase images obtained from experiment for a CFRP specimen with artificial defects.

● *About Infrared Thermographic Testing*

Infrared thermographic non-destructive testing is an effective and convenient inspection method because it is a non-contact testing method and can inspect large area in shorter time. In this method, surface of a test object is heated and temperature distribution after heating is monitored by an infrared camera (Fig.1). When there are some inhomogeneity inside the object, heat flow from the surface is disturbed by them and such a disturbance causes irregular temperature distributions on the surface. By detecting these irregular temperature areas, inside defects can be identified.

● *Research*

We are studying to:

- Improve defect detectability

  use phase images constructed by applying Fourier transform to thermal data (see Fig. 2).

- Develop more effective inspection system

  developing remote heating systems using high-power halogen lamps or scanning laser to inspect large structures (such as concrete bridges or large composite structures) located 10-20 m from observer.

Keywords: Non-destructive testing,
Infrared thermography

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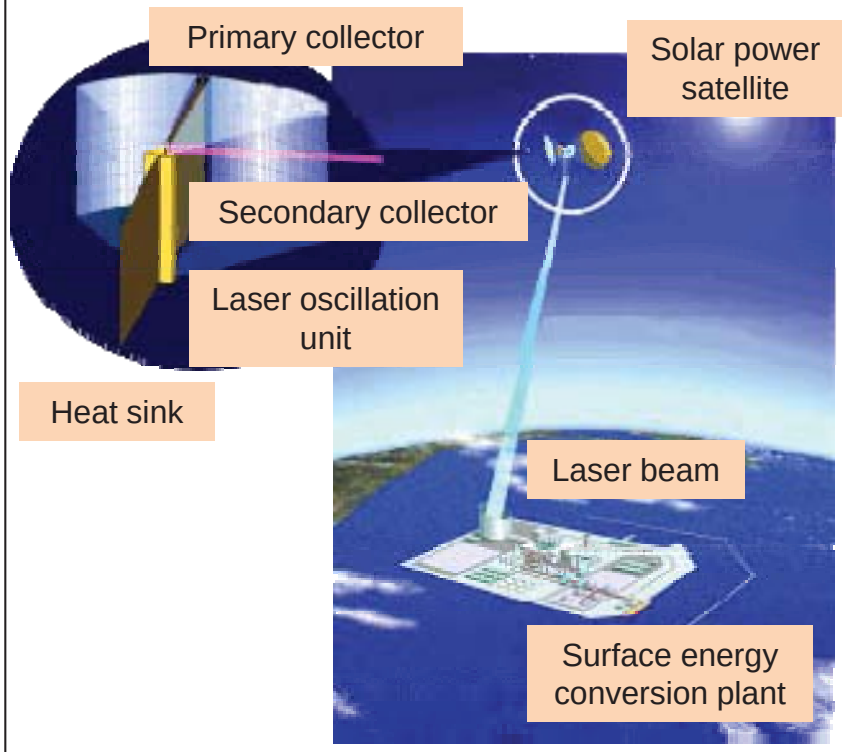
Thermal Design of Laser Beam Type Space Solar Power Systems

Assistant Professor Koji Kusano



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Content:

Space solar power system (SSPS) is the concept of stable power supply system, which collects solar power and generates electric energy in space for use on earth. Today, no prospect of actually using SSPS has yet emerged because of its technical challenges but practical use in near future is expected. In SSPS, two types of energy transmitting technique from solar-power satellite to Earth's surface are planned. One uses laser beam emitting, the other uses microwave wireless transmission. In particular in former system (Laser-beam type SSPS : L-SSPS), it is important that the cooling of laser diodes on space photovoltaic module and the design of beam collector on surface, which converts from high energy density laser beam to electric power.

Our purpose is to estimate and analyze the heat balance of PV/LD joint module, and design an optical heat sink dimension or the arrangement of individual device. Furthermore, new PV and solar thermal energy (STE) combined system for surface laser beam collector is being developed for high efficiency energy conversion.

Keywords : space based solar power,
radiative heat transfer,
PV/STE combined system

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Development of an Electric Skateboard with Load Measuring System

Assistant Professor Motomichi Sonobe

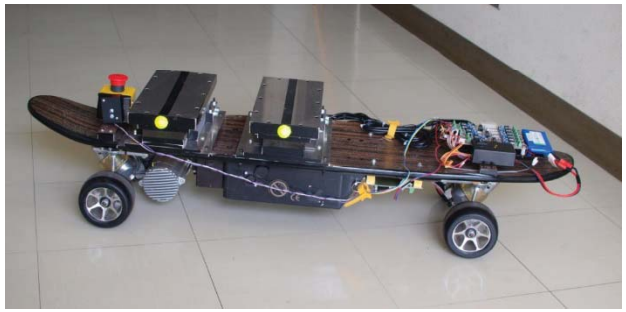

Fig. 1 Electric skateboard with load measuring device

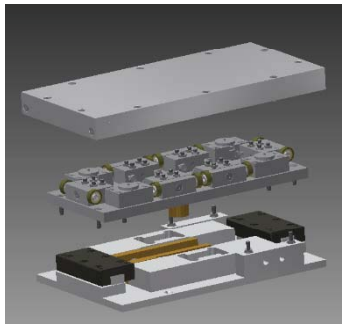

図2.Load measuring device

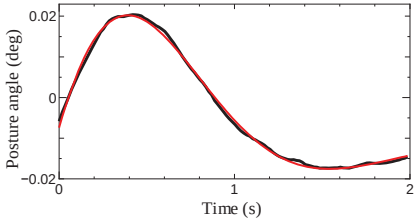

Fig. 3 Experimental result of impulse response test

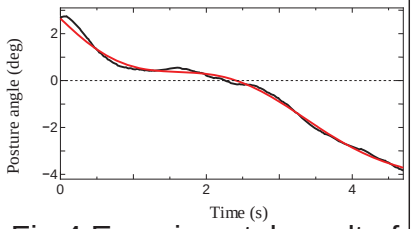

Fig.4 Experimental result of step response test

Content:

In recent years, electric skateboards have attracted much attention as a low-cost and compact mobility vehicle. But to ride the stand-up vehicle is difficult. In this study, we try to develop a electric skateboard shown in Fig. 1 to keep the driver's upright standing easily. We estimate driver's posture based on center of mass measured by load measuring device in Fig. 2.

Because the posture control of upright standing affects the stability of the electric skateboard system, to build the musculo-skeletal model is very important in this study, Especially, we focus on time delay in posture control which is generally estimated around 0.2 sec. We assume that the delay time is determined to curb the energy consumption. Delay time is estimated by the impulse response test and the step response test whose result are shown in Fig.3 and Fig.4 respectively. We will attempt to build the simple musculo-skeletal model for controlling skateboard and to identify the system parameters easily by establishing a way of estimating of delay time.

Keywords：Motion control, Biomechanics,Time delay

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