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Biological sound-based medical diagnosis system

Professor Takahiro Emoto

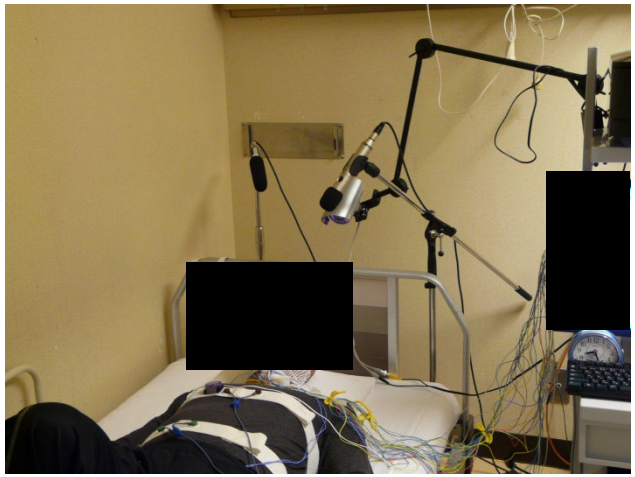

Fig.1 A sample of snoring sound recordings

Fig.2 A sample of bowel sound recordings

Content:

There are a lot of patients who suffer from chronic disease (e.g. obstructive sleep apnea and a bowel disease etc.). Recently the prevalence of these diseases is likely to be increasing in many countries. Polysomnography (PSG) and endoscopic test have been used for the diagnosis. However these tests are inconvenience and expensive. Our research group hypothesizes that the information on these diseases should be embedded in biological sounds (e.g. snoring and bowel sounds) obtained from the patients. Biological sounds can be simply acquired via non-contact and/or non-invasive measurements. The target of our study is to develop the automated diagnosis system based on the analysis of biological sounds. We are currently in the process of developing new sophisticated techniques for future medical applications. Biological sound-based techniques can be expected to provide an attractive alternative to the conventional test for chronic disease.

Keywords: Biomedical signal processing and bio-medical instrumentation

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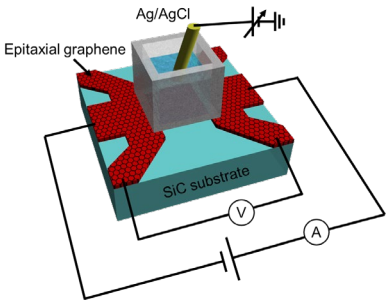
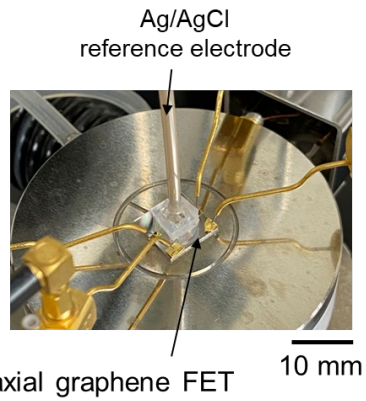
Biosensors based on nano-carbon devices

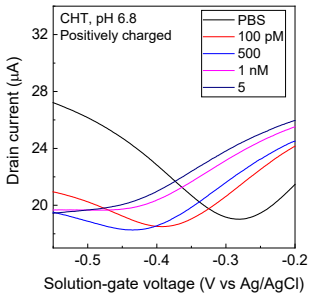
Professor Yasuhide Ohno

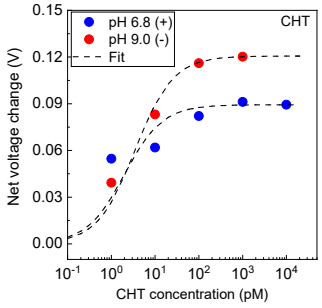
Epitaxial graphene devices

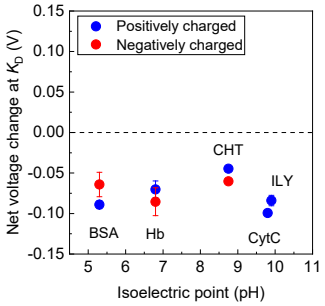


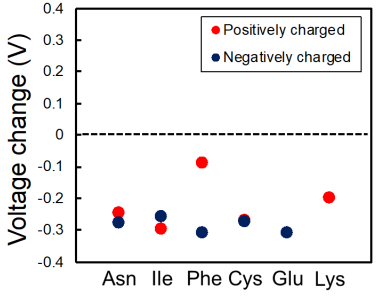


Protein & amino acid adsorption









Since the electrical characteristics of graphene field-effect transistors (FETs) are very sensitive for their environmental condition, the graphene FETs have high potential for chemical and biological sensors. In our laboratory, various sensors based on graphene FETs are investigated. The graphene FETs can be operated in the buffer solution by top-gated operation from a reference electrode without any passivation film owing to their large potential window.

The most original point of our work is to use the epitaxial graphene film on a SiC substrate, which has single crystal with large area. The epitaxial graphene FET is expected to obtain the inherent characteristics of graphene owing to the free of defects and dislocation. Now we have investigated protein and amino acid adsorption characteristics. They showed always electron doping to graphene, indicating the cleanness surface of the epitaxial graphene film. We now try to realize the specific target detection beyond the Debye screening length owing to the small quantum capacitance.

Keywords : graphene, device, biosensor

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Pulsed Power Application on Environment Engineering and Bioengineering

Professor Naoyuki Shimomura

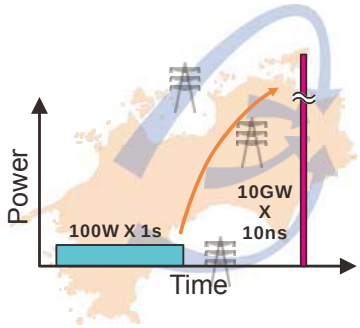

Fig.1 What is pulsed power

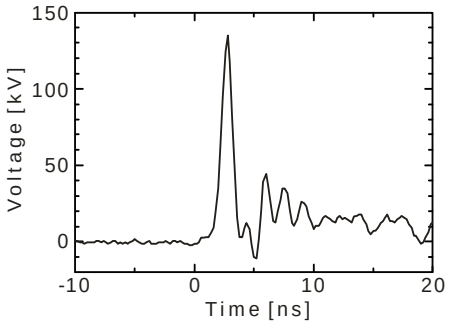

Fig.2 Ns voltage pulse

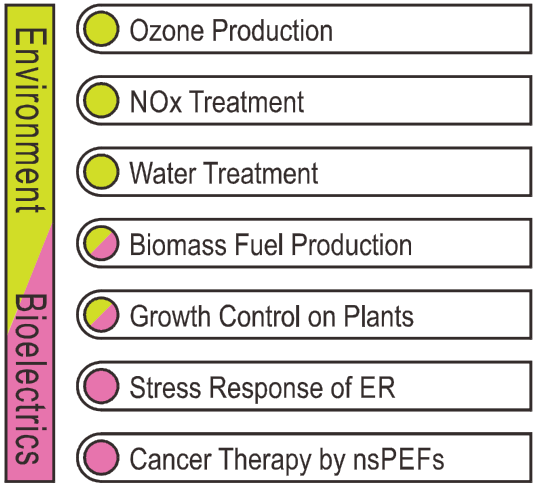

Fig.3 Pulsed power application

Fig.4 Steamer discharges

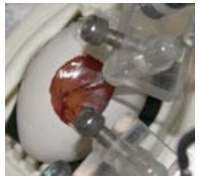

Fig.6 Cancer therapy

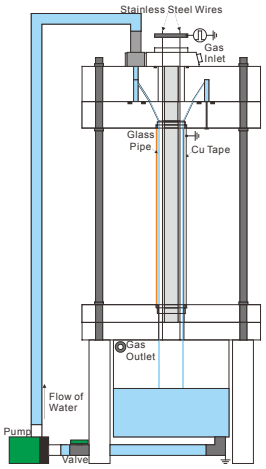

Fig. 5 Water Treatment

Content:

Pulse power is the technology of utilizing high power pulses obtained by compressing energy. We focus on green technologies and applications in bioengineering.

Nanosecond pulsed power has been applied on environmental protection technology. It can efficiently produce streamer discharges as which were suitable for discharge-chemical processing. There are the high-efficient ozone production, the exhaust gas treatment of nitrogen oxide (NOx), and the water treatment for persistent substances.

Applications in bioengineering utilize the influence of electric pulses and discharges on biological body. The influences can be controlled by the pulse width (spectrum), various applications can be expected. There are the production technology of micro algae biomass fuel and growth control of plants. We are developing the new cancer therapy and the control method of endoplasmic-reticulum-stress response aiming at prevention of disease, using nanosecond pulsed powers.

Keywords : pulsed power, bioelectrics, pulse electric field

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Video coding algorithm and its VLSI architecture

Professor Tian Song

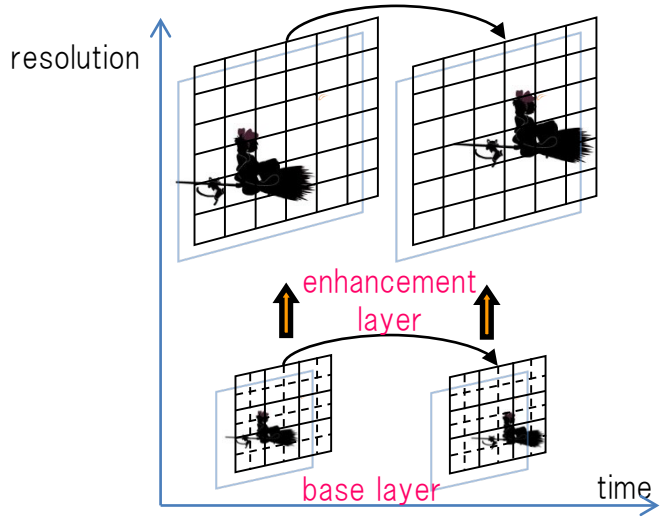

Fig.1: H.264/SVC inter layer prediction

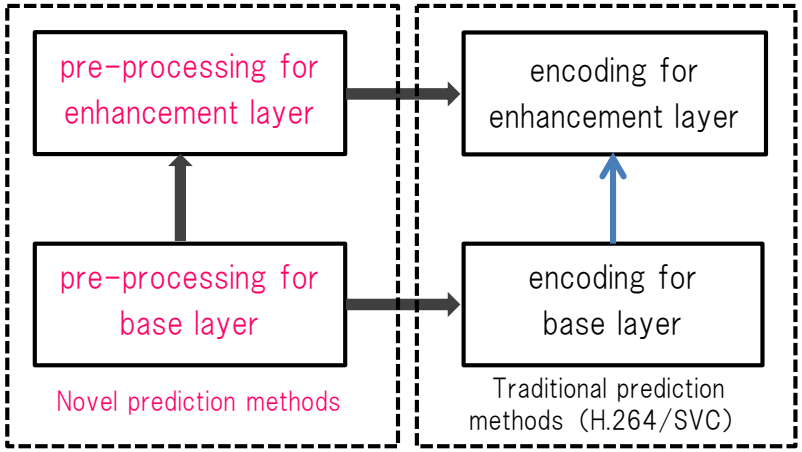

Fig.2: The proposed coding structure

With the widely spread of video applications, novel coding algorithms which can answer many kinds of emerging demands are highly required. Our research group is devoting to propose good ideas concerning the following themes.

1. Improvements of the algorithms of HEVC and its low complexity and low power VLSI architecture for the next generation applications which are over 4K resolutions. The algorithms and architectures are concerning the intra coding, motion estimation, and deblocking filter.
2. Scalable video coding algorithms which are suitable for high resolution applications. We will make full use of the high correlations between base layer and enhancement layer to propose new algorithms to improve the coding efficiency.
3. Highly parallel processing video coding algorithms on many core platforms. Most of traditional coding algorithms utilize the coding parameters of adjacent blocks to improve coding efficiency. However, this coding structure has essential demerit for parallel processing. As shown in Fig.2, our motivation is to find new coding structure which can achieve higher parallel coding performance.

Keywords : H.265/HEVC, Scalable Video coding(SVC), Parallel Video Coding

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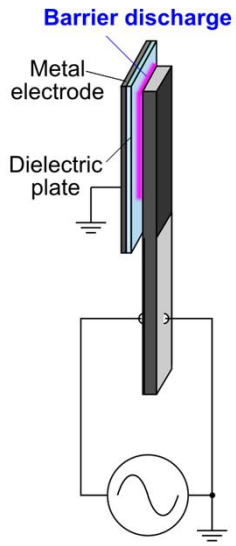
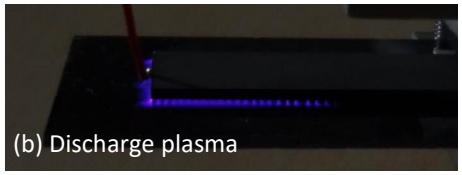
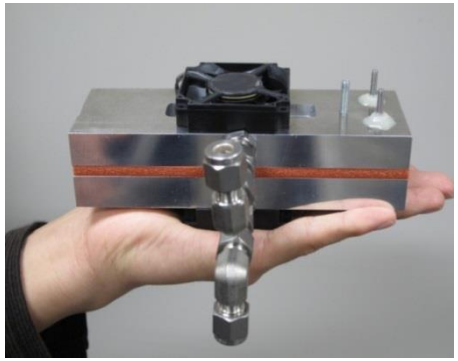
Generation, Diagnosis and Applications of Discharge Plasma

Professor Kenji Teranishi



(a) Configuration





(c) Application to ozone generator

Fig. 1 Compact plasma reactor using piezoelectric device and its application

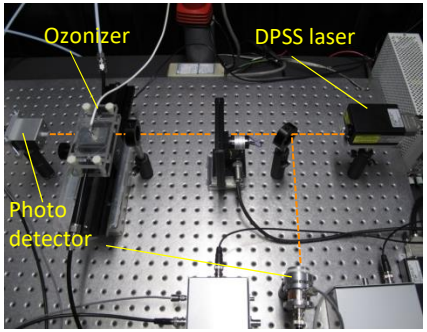


Fig. 2 *In-situ* O_3 measurement by laser optical absorption

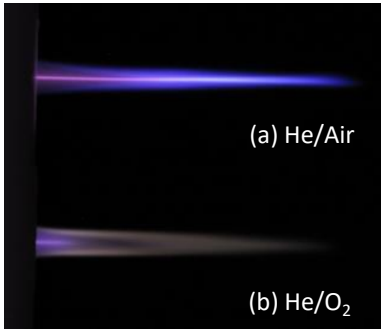


Fig. 3 SGF Plasma jet

Content:

Discharge plasma reactors consisting of a massive high voltage generator and discharge electrodes are more likely to become large-scale system. We have proposed and studied various types of compact plasma reactors using piezoelectric devices. Piezoelectric transformers (PTs) that act as compact high-voltage generator have been widely embedded in a backlight invertor for LCDs. Our proposed plasma reactors feature compact configurations because the devices serve as both high-voltage source and discharge electrode. Non-thermal plasmas, such as corona discharge, glow discharge and dielectric barrier discharge (Fig. 1(a)(b)) can be produced using the plasma reactors. Several applications of the plasma reactors to ozone generators (Fig. 1(c)) and vacuum ultraviolet light source have been demonstrated.

We have also promoted actively other research in generation, diagnosis and applications of non-thermal atmospheric pressure plasma, including *in-situ* measurement of ozone density inside DBD ozone generator (Fig. 2) and surrounding gas-fed (SGF) plasma jet (Fig. 3).

Keywords: Dielectric barrier discharge, ozone, plasma jet

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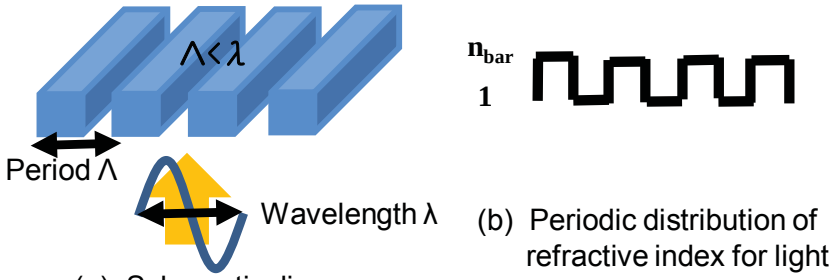
Polarization Control in Photonic Devices with Subwavelength Grating

Professor Yoshiki Naoi



(a) Schematic diagram

(b) Periodic distribution of refractive index for light

Fig.1 Sub-wavelength grating structure

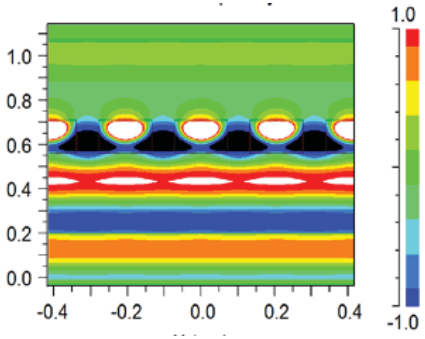


Fig.2 Electrical field distribution for TM light by FDTD theory (in case of λ/Λ=1.8)

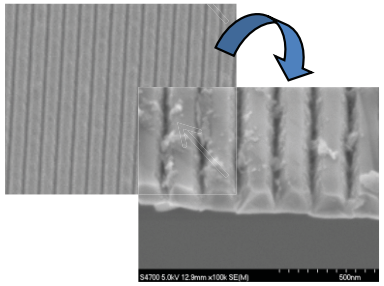


Fig.3 Fabricated sub-wavelength grating on UV-LED surface

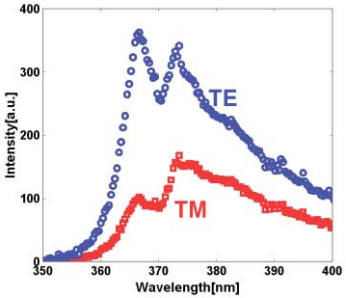


Fig.4 Emission spectra from UV-LED

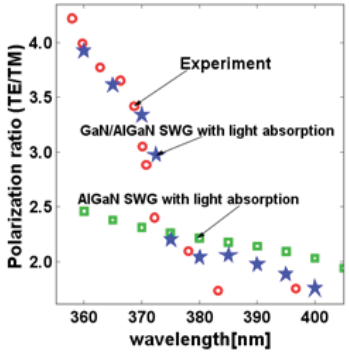


Fig.5 Polarization ratio from UV-LED with sub-wavelength grating

Content:

Highly polarized UV emission devices were expected to develop the applications, such as high resolution imaging, high sensitive sensors, etc. The compact polarization control device with high transmittance is required in order to develop integrated device for these applications.

One of the candidates to overcome the issue is the device using high contrast dielectric subwavelength grating (SWG) structure. In SWG, the pitch of the grating is shorter than the wavelength of incident light. The Bloch like eigen-modes within SWG region resulting from the spatial periodicity of refractive index distribution interacts with incident light. As a result, the desirable optical characteristics such as broadband high reflectivity and polarization sensitivity are obtained with optimal structures.

We have investigated the polarization characteristics of AlGaN-based UV-LED with SWG fabricated on the top of LED surface, and demonstrated the feasibility of high polarized UV-LED grown on c-plane sapphire.

Keywords : photonic device, sub-wavelength grating, polarization control, nano device

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Engineering Applications of Chaos

Professor Yoshifumi Nishio

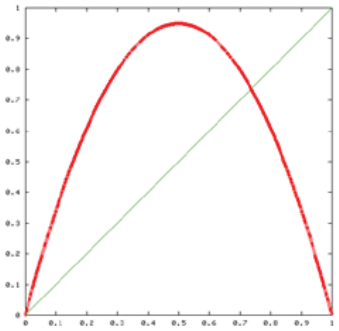

Fig. 1: Logistic map, one of the most famous one-dimensional map generating chaos.

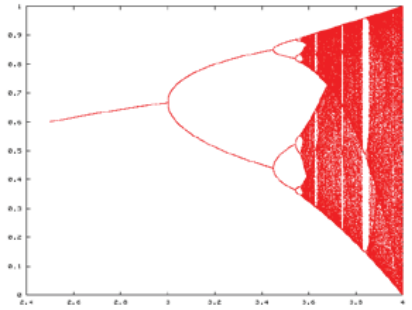

Fig. 2: One-parameter bifurcation diagram of the Logistic map.

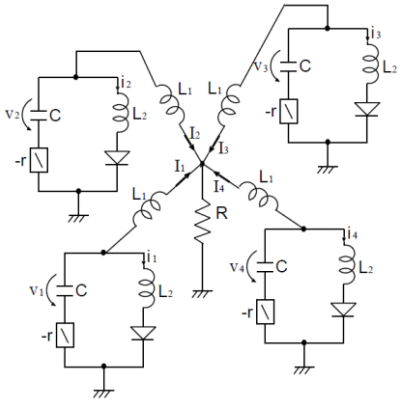

Fig. 3: Four autonomous chaotic circuits coupled by one resistor.

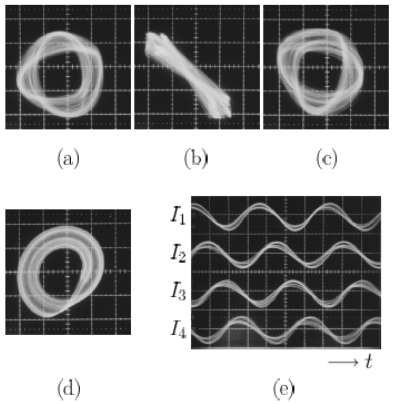

Fig. 4: Four-phase quasi-synchronization of chaos observed from the circuits in Fig. 3.

Content:

1. Chaos Cryptosystems

   Sensitive dependence of chaos on initial conditions and parameters is exploited for various security issues.

2. Chaos Communication Systems

   Continuity of chaotic sequences generated from an identical chaotic map is exploited to recover data correctly.

3. Complex Networks

   Various synchronization phenomena in coupled chaotic circuits are good models of various complex networks.

4. Nonlinear Time Series Analysis

   Chaos analysis is utilized to predict a trend of nonlinear time series or to diagnose medical signals.

5. Data Mining

   Self-organizing feature of artificial neural networks is exploited to carry out clustering of various data.

Keywords: chaos, chaos cryptosystems, chaos communication systems, complex systems, nonlinear time series analysis

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Diversity of Electrical Energy Resources in a Reliable Grid

[Keywords: Smart Grid, Reliability, Stability, Power Quality] Professor Masahide Hojo

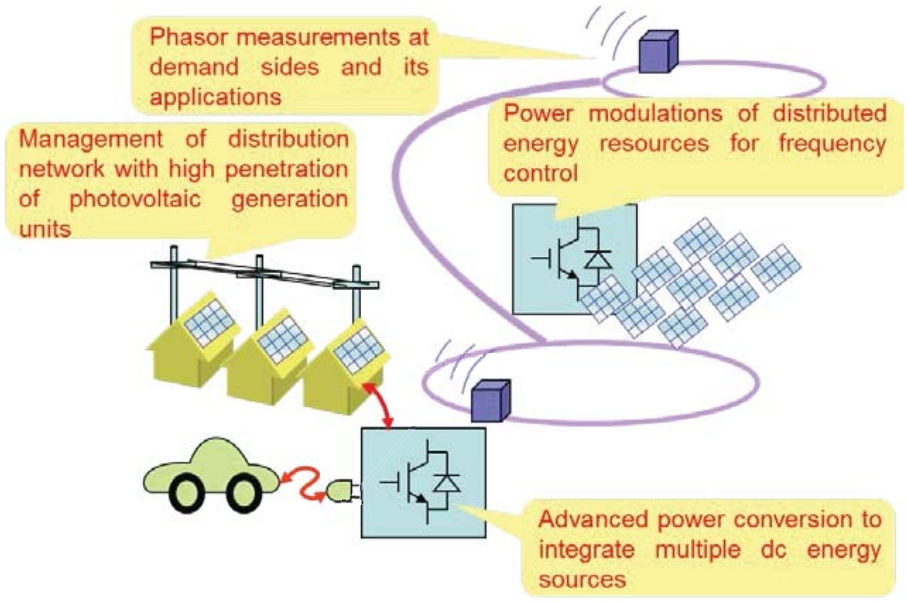

Fig. 1 My major researches.

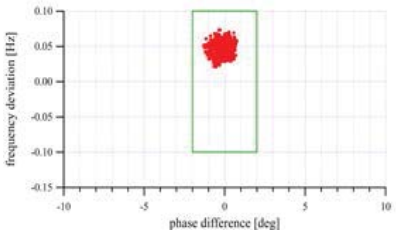

Fig. 2 Grid monitoring.

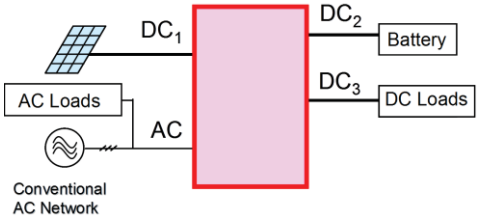

Fig. 3 Dc sources integration.

Topics

1. Phasor measurements at demand sides and its applications
   Developing an online monitoring of power system by multiple phasor measurement units with monitoring voltages at the outlets on the wall.

2. Management of distribution network with high penetration of photovoltaic generation units
   Investigating reasonable voltage regulation on high and low voltage distribution lines by cooperation of photovoltaic generation units and other apparatus.

3. Advanced power conversion to integrate multiple dc energy sources
   Integrating multiple dc voltage terminals to connect solar cells, batteries and loads easily, based on multilevel converter topology with flying capacitors.

4. Series-connected dc-dc converter for multi-end dc power transmission
   Developing a high frequency dc-dc power converter in series with a dc power transmission or distribution line to provide multi -ends.

5. Power modulations of distributed energy resources for frequency control
   Developing a voltage phasor modulation of grid-connected converters to regulate the system frequency as much as possible.

Keywords: Smart Grid, Reliability, Stability, Power Quality

Field: Power system and power electronics

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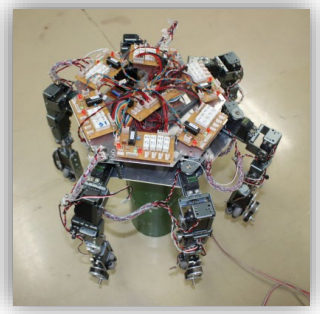
Engineering Applications of Intelligent Information Processing and Control Technique

Professor Takashi Yasuno


Wind Turbine


Power assist suit


Electric wheelchair


Multi-legged robot


Electric Vehicle


Pesticide spraying robot


Environmental monitoring

Content:

In recent years, demands for higher performance and added value in industrial and life support equipment that is designed to coexist with humans has been growing. In order to satisfy these demands, we are conducting research on the application of intelligent information processing technology based on a bio-inspired approach. The main research themes are as follows, and we are promoting the realization of the elemental technologies obtained in the research process through collaboration research.

- ◆ Prediction of wind and solar power output based on weather prediction models
- ◆ Control of automatic driving systems and cooperative control of swarm mobile robots
- ◆ Motion control for legged robots and robot manipulators
- ◆ Safe driving support system for electric wheelchairs
- ◆ Development of various agricultural support robots

Keywords : intelligent control, robot, wind energy and photovoltaic power generation, rehabilitation system

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Design for testability of VLSI chips

Professor Hiroyuki Yotsuyanagi

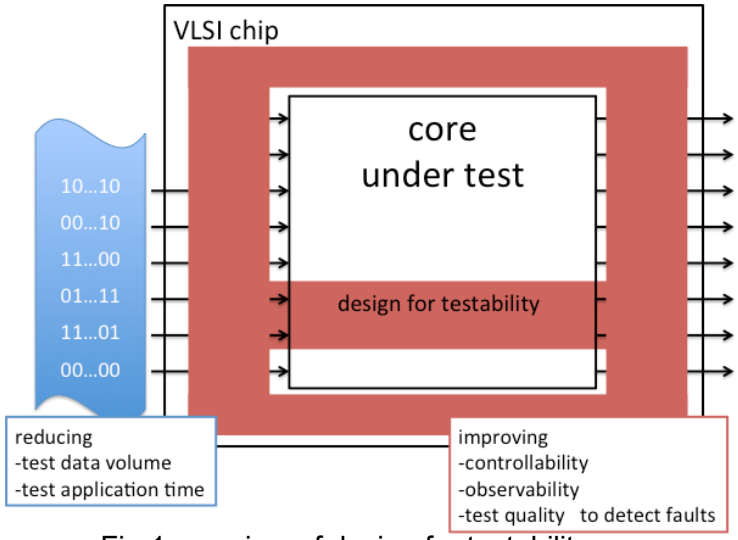

Fig.1 overview of design for testability

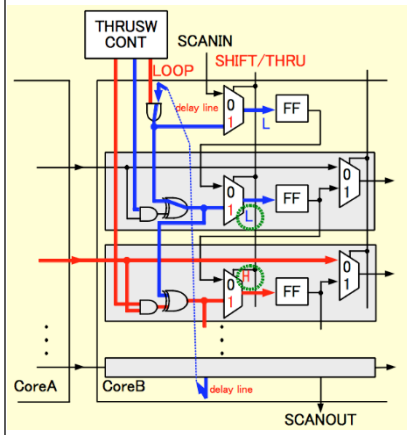

Fig.2 Boundary scan with TDC

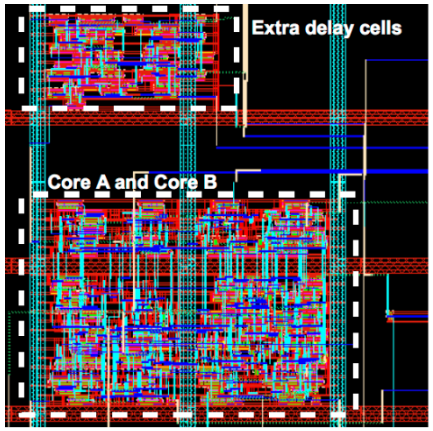

Fig.3 layout of an experimental chip

Content:

In recent highly integrated VLSIs, cost of testing is a major problem. To alleviate the difficulty in testing, design for testability techniques are widely used. In our research lab, we develop methods for reducing test cost such as test data volume, test application time, area overhead of test circuit, and for improving test quality especially in delay testing. One of the techniques is design for testability method for small delay faults using time-to-digital converter embedded in boundary scan called TDCBS, shown in the figures. The boundary scan cells are modified to be able to form a time-to-digital converter that is utilized for detecting delay. Using this architecture, defects like opens and shorts can be detected as extra delay caused by such defects even if the delay is small and cannot be detected by conventional logic test. The feasibility of the proposed methods is estimated by both simulation and experiments of fabricated chips.

Keywords: design for testability, VLSI testing, delay faults, test cost reduction

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Modeling of Dynamical Brain Networks by Coupled Oscillatory Systems

Associate Professor Yoko Uwate

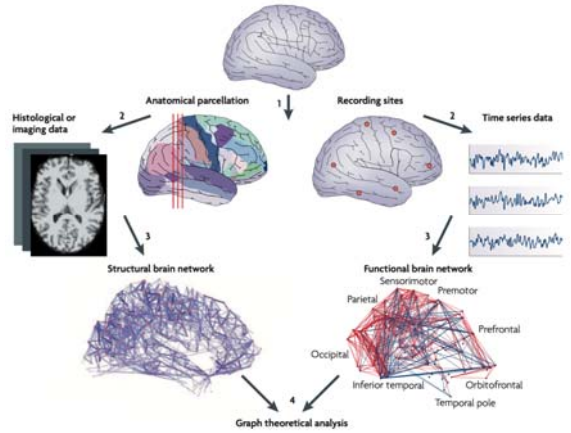

Fig. 1Structural and functional brain networks

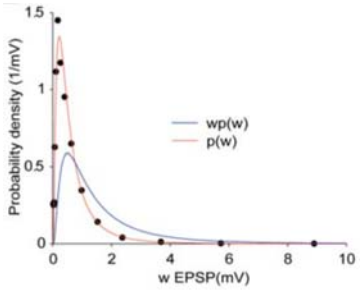

Fig. 2 Heavy tail distribution

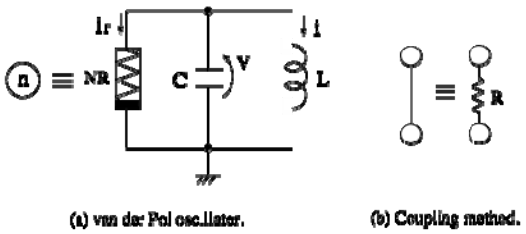

Fig. 3 van der Pol oscillator

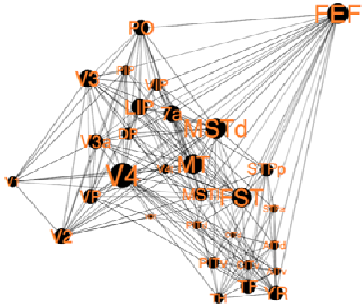

Fig. 4 Brain network model of macaque visual cortex

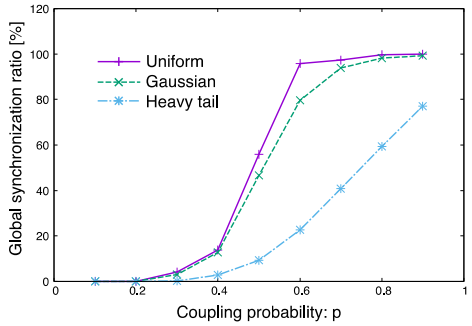

Fig. 5 Global synchronization

Content:

1 Introduction

Recently, structural and functional brain network have been made clear (Fig. 1). And, several research group have reported that the synaptic connection has heavy tail distribution as shown in Fig. 2. In this project, we investigate synchronization of brain network model of macaque visual cortex with heavy tail coupling distribution.

2 Proposed system and results

Figure 4 shows brain network model of macaque visual cortex. the node of network model is expressed by van der Pol oscillator (Fig. 3). Figure 4 shows the simulation results of global synchronization. The network with heavy tail distribution synchronized to avoid global synchronization.

3 Future works

Investigation of more large brain network and make clear the relationship between synchronization and high-function of brain are our future works.

Keywords : coupled oscillators, synchronization, clustering

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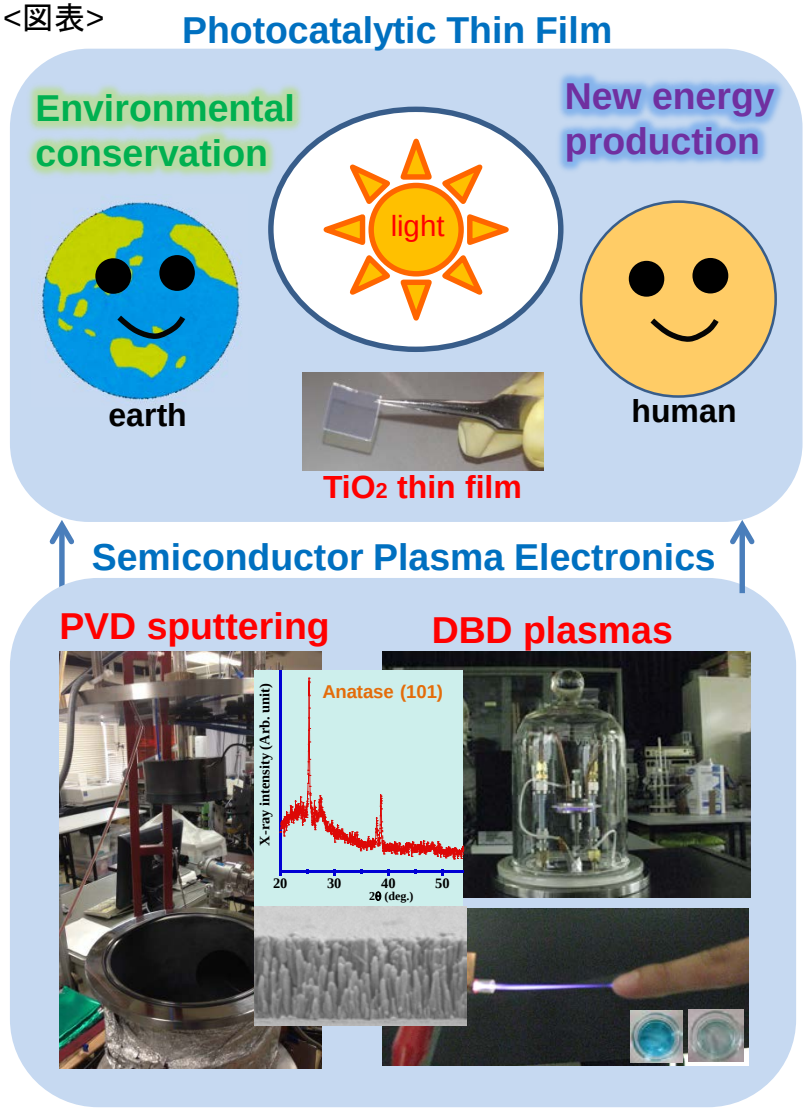
Study on Photocatalytic Thin films for Environmental Conservation and New Energy Production Based on Plasma Electronics

Associate Professor Retsuo Kawakami

<図表>



Content:

Photocatalyst has been attracting much attention as a material for environmental conservation and new energy production. The advantage is that the photocatalytic activity is activated semipermanently while the surface is irradiated with light. TiO_2 is a leading candidate as the photocatalyst. This reason is that the photocatalytic activity is activated easily under irradiation with near UV-visible light and that TiO_2 is hardly dissolved by its own photocatalytic activity. Since TiO_2 is an inorganic compound, TiO_2 is harmless for human and earth, and is stable in aqueous media and reactive gas. The thin films, rather than the powders, are required from the viewpoint of the practical application such as large area coating. The photocatalytic activity induced by use of the thin films, however, is less enhanced than that induced by use of the powders.

We have been studying TiO_2 thin films with excellent photocatalytic activity by using a magnetron facing target sputtering deposition device developed by our group. The characteristic of the deposition device is that the anatase thin films is fabricated without heating the substrate and performing the post-annealing. We have also been studying the anatase films treated by using an atmospheric pressure plasma device developed by our group, in order to further enhance the original photocatalytic activity. The characteristic of the treatment device is that the surface treatment is performed easily in the absence of expensive vacuum pumps.

Keywords: Photocatalyst, Wide band-gap semiconductor, Plasma electronics

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Physics and application of femtosecond laser irradiation

Associate Professor Takuro Tomita

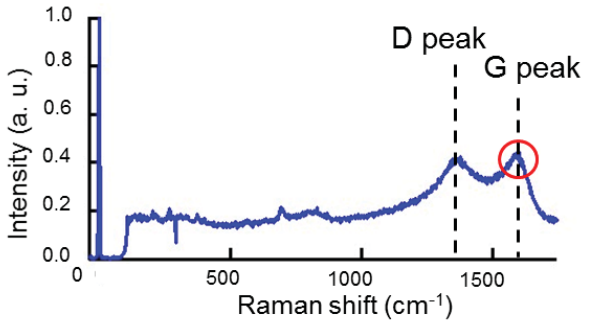
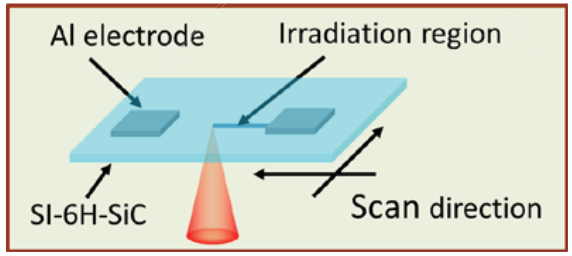


Fig.1 : Raman spectra with femtosecond laser irradiation on the interface between nickel and silicon carbide



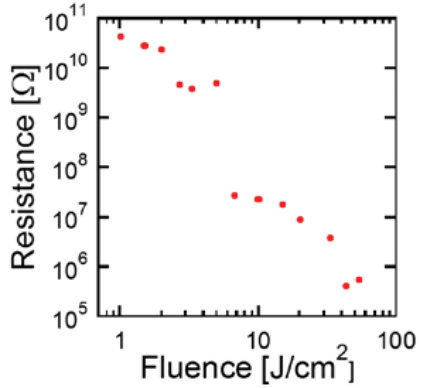


Fig.2 : Electrical conduction control by fs laser modification

The material modification due to the femtosecond laser irradiation on wide bandgap semiconductors has been studied. The spontaneous formation of nano-periodic structures and the amorphization due rapid heating and cooling process occurs after femtosecond laser irradiation. Wide bandgap semiconductors can be processed through the multi-photon process because of their transparency to femtosecond laser beam.

Fig. 1 shows Raman spectra after the femtosecond laser irradiation on the interface between silicon carbide and nickel. D and G bands due to carbon was observed, and this indicates that the carbon atom reached the nickel surface.

Fig. 2 shows the schematic of electrical conduction control by fs laser modification. The femtosecond laser beam is irradiated between two metal contacts on semiconductor. With increasing the irradiation fluence, the local electrical conductivity abruptly decreased at the threshold fluence.

Keywords : femtosecond laser, ablation
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Crystal Growth and Device Applications of Various Semiconductors

Associate Professor Katsushi Nishino

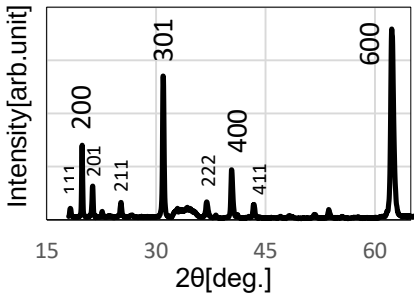

Fig.1 XRD pattern of $BaSi_2$ thin film

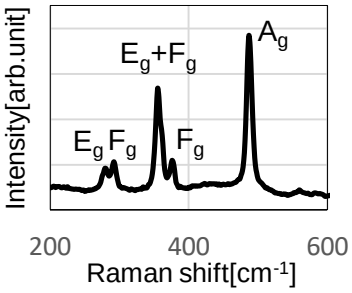

Fig.2 Raman spectrum of $BaSi_2$ thin film

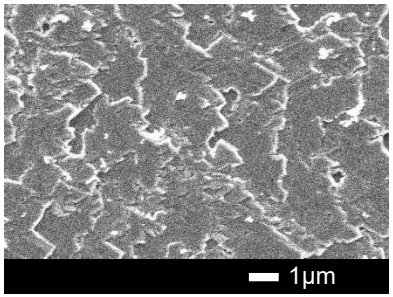

Fig.3 Surface SEM image of β-Ga_2O_3 thin film

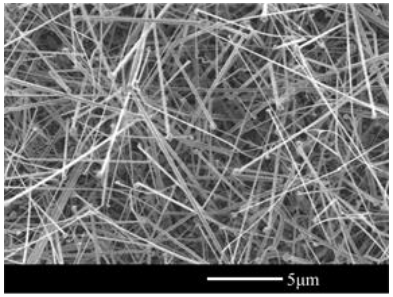

Fig.4 SEM image of β-Ga_2O_3 nanowires

We are studying on crystal growth and device applications of two kinds of semiconductors.

1. $BaSi_2$ has suitable properties for thin film solar cells, such as a bandgap, high absorption coefficients, and long minority carrier diffusion length. We grow $BaSi_2$ thin films on Si(100) substrates by conventional vacuum evaporation. Obtained films are a-plane oriented (Fig.1) and of high quality estimated by Raman scattering spectroscopy as shown in Fig.2. We are currently investigating the crystal quality, electrical and optical properties in detail for solar cell applications.

2. Ga_2O_3 is a widegap semiconductor and is expected as a material for high-power devices and various kinds of sensors. Among some polymorphs of Ga_2O_3 , we grow thin films and nanowires of most thermally stable β-phase by a direct synthesis method, which utilizes direct reaction of Ga and O_2 gas. Fig.3 shows a surface SEM image of a β-Ga_2O_3 thin film. The film has the step-terrace structure on the surface and is high quality with enough thickness. β-Ga_2O_3 nanowires with a diameter of about 100nm and a length of 10μm or longer can be grown on c-plane sapphire and glass substrates as shown in Fg.4.

Keywords: $BaSi_2$, Ga_2O_3, Nanowire

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Video codec extension algorithm and its VLSI architecture using machine learning

Associate Professor Takafumi Katayama

■ Prediction pixels generation using machine learning

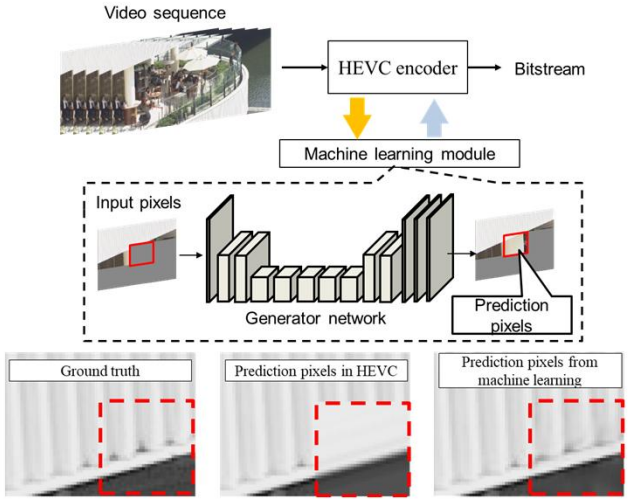

Fig. 1 Comparison of a conventional prediction pixels and proposed

■ LSI design of neural network for image processing

Represent complex neural network with ODE (Ordinary Differential Equation)

➡ Applicable to image processing

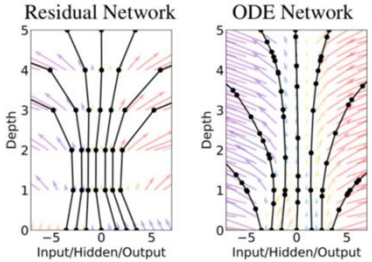

Fig.2 ResNet and ODE Net structure

Fig. 3 FPGA(PYNQ-Z1)

Content:

As the AI / IoT environment spreads to society, video will continue to play a major role as a technique of information transmission. In order to provide accurate and detailed moving images, video codec technology is implemented to various familiar devices. In the next generation codec technology, because parallel processing is difficult, an application to ultra-high resolution becomes more and more challenging. In this work, HEVC encoder is divided into two parts, an analysis circuit (machine learning module) and an encoding circuit (encoder) in order to establish a new encoding structure with high compression while achieving easy hardware implementation (Fig. 1). Predicted pixels value close to ground truth can be generated by embedding a machine learning module. In the future, we will implement FPGA of ODE Network to establish real-time processing of the image generation network (Fig. 2, 3).

By completing this work, we aim to make a significant contribution to the next-generation social infrastructure environment called AI, IoT, and 5G.

Keywords : Video coding, Machine learning, LSI design

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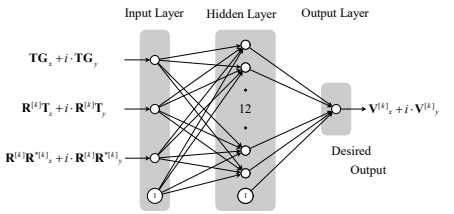
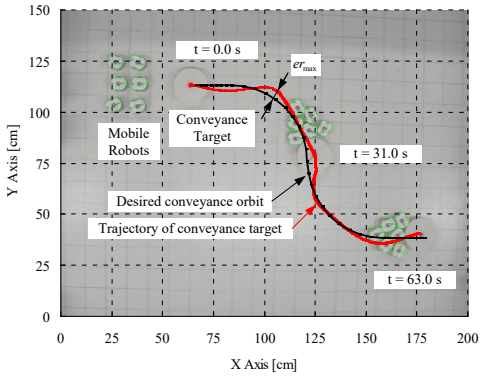
Intelligent Control of Swarm Robots

Associate Professor, Hiroshi Suzuki

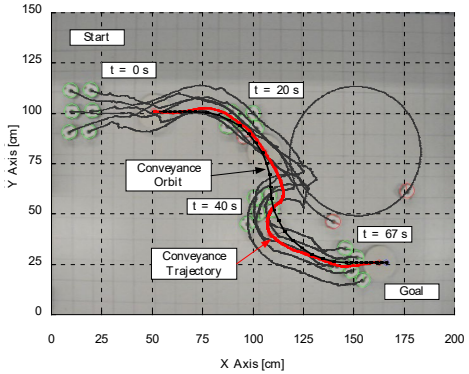
Swarm robots



Complex-valued NN



Experimental Result



Fault tolerance

Content:

The swarm robotics has a problem on the control system design cause of voluminous measured information and motion patterns. Therefore, we propose the control system which uses soft computing scheme e.g. neural networks (NN), fuzzy system and genetic algorithm (GA).

The left figures are our proposed cooperative control system for swarm robots using complex-valued NN (CVNN) and GA. The CVNN can treat a two dimensional position information and adaptable for control of mobile robots. The system inputs a position information for CVNN and outputs a velocity vector and parameters of CVNN are optimized by GA. We confirmed a tracking performance for desired conveyance orbit, and a fault tolerance performances of some robot's breakdown.

Moreover, we propose an extraction system of human operation skills using datamining method and analyze a behavior of robots basis on simple motion rules.

Keywords : Swarm robotics, Machine learning, Cooperative control

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Highly Sensitive Optical Refractive Index Sensor with Meta-Surface

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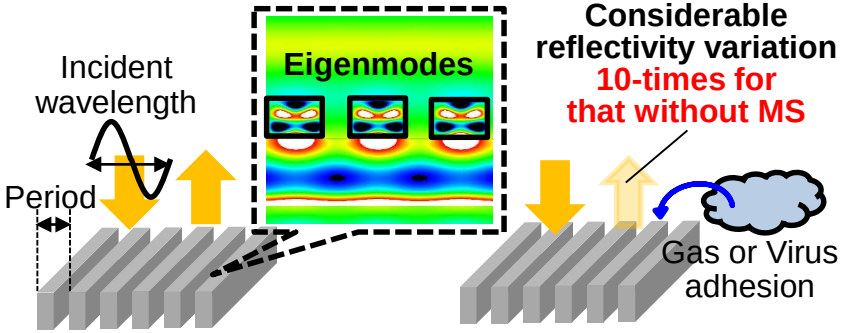
Assistant Professor Yuusuke, Takashima



Minuscule RI change owing to Gas or Virus adhesion
→Eigenmode amplitudes and phases strongly depend on the RI value of the ambient

Fig.1 Operation principle of RI sensing with meta-surface

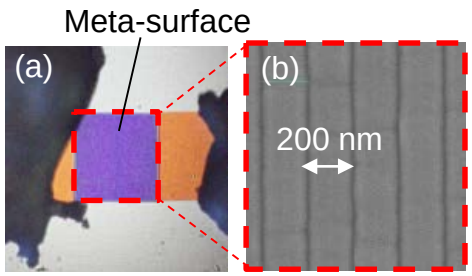
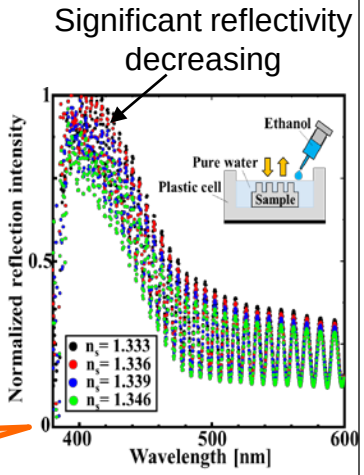


Fig. 2 fabricated meta-surface
(a)Optical image (b)SEM image



10^{-4} order RI change can be detected

Fig. 3 Dependence of reflectivity on the ambient RI value n_s

Content:

Optical refractive index (RI) sensors is highly desirable for many applications, such as gas-detection and bio-sensing. For these applications, high sensitivity and compactness are required.

Highly sensitive compact RI sensor was demonstrated with periodic meta-surface (MS), whose dimension is smaller than the incident wavelength (Fig.1). The amplitude and phase of the optical eigenmodes resulting from the subwavelength periodicity of the MS considerably depend on the ambient RI. As a result, highly sensitive RI sensing can be realized.

We fabricated the MS on GaN substrate (Fig. 2). The Blue-violet light is strongly reflected owing to the structure. Utilizing the eigenmodes in the MS, 10^{-4} order RI can be experimentally detected with very compact and simple optical system, as shown in Fig. 3. Our sensor is very suitable for the integrated devices for gas- and bio-sensing due to its high sensitivity and compactness

Keywords : Meta-surface, Subwavelength, Refractive index sensor

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