TOYOHASHI
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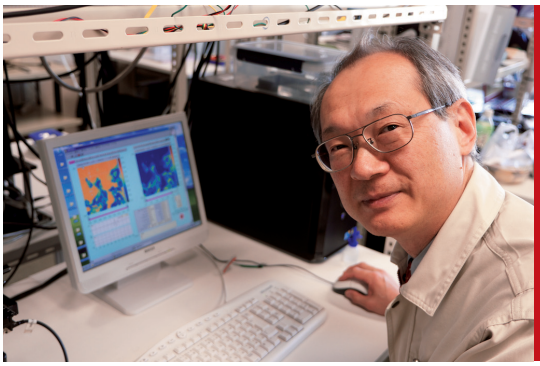
TOYOHASHI UNIVERSITY of TECHNOLOGY
e-Newsletter
News and views from one of Japan's most innovative and dynamic science and technology-based academic institutes



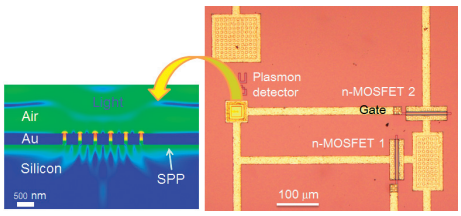
No. 13, December 2013

Features 2

Ultrasound microscopy: An aid for surgeons to make the invisible, visible.

An ultrasonic microscope emits a high frequency sound at an object, and the reflected sound captured by its lens is converted into two dimensional image of the object under scrutiny.

News



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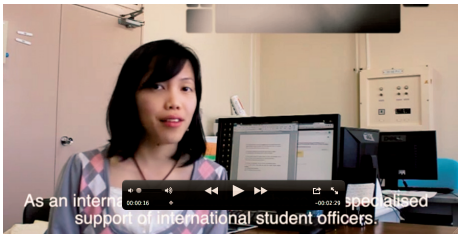


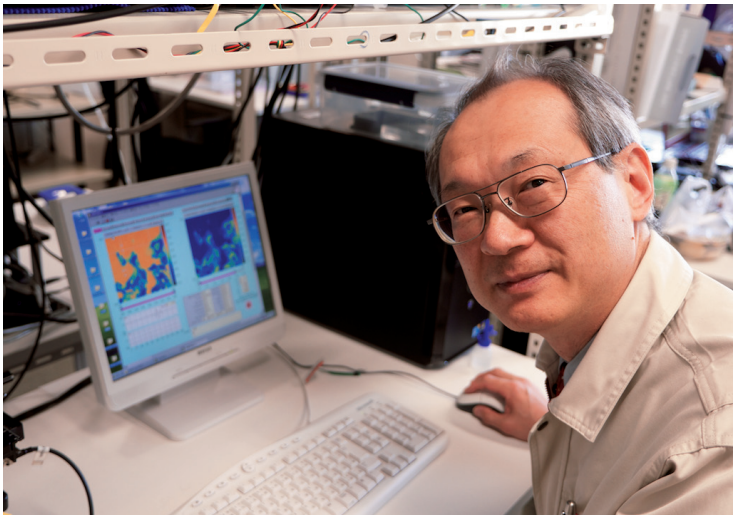
Video Letter

Ultrasound microscopy: An aid for surgeons to make the invisible, visible.

An ultrasonic microscope emits a high frequency sound at an object, and the reflected sound captured by its lens is converted into two dimensional image of the object under scrutiny.

Ultrasonic microscopes have a wide range of applications including determining the presence of otherwise invisible defects in components used in the automobile, aeronautical, and construction industries.

Professor Naohiro Hozumi of Toyohashi Tech's Department of Electrical and Electronic Information Engineering is developing the technology to monitor living tissue and cell specimens for medical purposes.



Professor Naohiro Hozumi

During surgical operations doctors often stop to inspect tissue taken from a patient's body for possible remnants signs of disease such as cancer. To do this, pathologists use an optical microscope to examine a slice of tissue taken from the periphery of what should be a healthy area. Now, typical tissues are optically transparency, and must be stained for inspection by an optical microscope. Pathologists can take several hours or possibly several days to evaluate the tissue for the presence of cancerous regions.

"But with my ultrasound microscope, staining is not required because the spectrum of the sound coming back from the tissue changes when the tissue is cancerous, which in turn changes the image," says Hozumi. "So instead of waiting an hour or more, tissue can be tested almost immediately. Also, because the reflected sound varies depending on the type of cancer, a doctor can interpret the type of disease from the image by comparing it to a reference material."

Whereas an optical microscope is limited to providing only a relative analysis that is based on contrasting shapes of healthy and diseased tissue, the ultrasound technique provides quantitative results based directly on the acoustic properties of tissues. "By working with quantitatively, we can create a database of information," says Hozumi. "Then, a doctor can use the database to compare the information of a patient's tissue specimen and readily know whether it is cancerous or not."

This type of procedure requires mounting the removed tissue on a plate for examination under the microscope. Now Hozumi and his colleagues are going a step further by developing an ultrasonic probe. This could be used to directly investigate a patient's condition immediately after surgery to make sure no cancerous cells remain, and without the need to remove more tissue. The Toyohashi Tech researchers are currently working with microelectromechanical system (MEMS) and semiconductor engineers to develop such devices.

International Student Seminar 2013 with ITB, UTM, and HCMUT

At Yamaha Motor Co., Ltd

Presentations on the final day

The International Student Seminar was held at Toyohashi University of Technology from 3 to 10 September 2013 with collaboration with Institut Teknologi Bandung (ITB), Indonesia, Universiti Teknologi Malaysia (UTM), Ho Chi Minh City University of Technology (HCMUT), Vietnam. This programme is aimed at promoting international, intercultural and mutual understanding among the students of Toyohashi Tech and partner universities, thus contributing to fostering young engineers who can play leading roles in the world of internationalization.

A total of 18 students from ITB, UTM and HCMUT were joined by 21 students from Toyohashi Tech to discuss the 'The Role of Engineers in Solving Environmental Problems'. The students were divided into 6 groups and each group chose one sub-topic. The results of their three-days of discussions were presented on the final day in front of students and academic staff of Toyohashi Tech.

The overseas participants were given opportunities to experience short lectures given by Toyohashi Tech academic staff. They also visited two leading research centers of Toyohashi Tech—EIIRIS (Electronics-Inspired Interdisciplinary Research Institute) and the Center for Human-robot Symbiosis Research—and one of the global manufacturers of this area, Yamaha Motor Co., Ltd.

A little cultural experience was also an important part of the programme. The participants attended lectures on Japanese language and culture, experienced the traditional tea ceremony, and at the weekend stayed at Japanese families near Toyohashi City.

The International Student Seminar 2013 was partly sponsored by JASSO (Japan Student Services Organization).

President Yoshiyuki Sakaki Selected as Person of Cultural Merit

President Yoshiyuki Sakaki

President Yoshiyuki Sakaki has been selecter as a Person of Cultural Merit for 2013 by the Japanese Government.

President Sakaki was born in 1942. He gained his Ph.D. in Biochemistry from the Graduate School of Science of the University of Tokyo. Following that, he became a researcher at the University of California Center for Virus Research, a research fellow at the Mitsubishi Kasei Institute of Life Sciences, a professor at the Research Center for Genetic Information, Medical Institute of Bioregulation, Kyushu University, a professor at the Institute of Medical Science, the University of Tokyo, director of the Human Genome Center of the aforementioned institute, and director of the RIKEN Genome Sciences Research Complex. Since April 2008 he has been the president of Toyohashi University of Technology.

In the field of genome science, President Sakaki has applied molecular biological techniques to complex humans and primates to clarify the functions of their genetic structure. Furthermore, President Sakaki also played a central role as leader in planning both the Japanese and international human genome projects to map the human genome. He is also the recipient of the Chunichi Cultural Prize in May 2003 and the Medal with Purple Ribbon in November 2003.

The Person of Cultural Merit system honors those recognized as having contributed to the advancement and development of culture through their achievements in academia or the arts. The system was established in 1951 under the Law on Pensions for the Persons of Cultural Merit, honorees being decided by the Minister of Education, Culture, Sports, Science and Technology from selections made by a panel of judges. The award-giving ceremony was held on November 5 in Tokyo.

President Sakaki is also well-versed with the arts and culture, and has made significant contributions to local musical culture since his appointment to Toyohashi. In particular, he appeared in the opera Carmen performed in 2009 by the Mikawa City Opera, and as a learned advisor to the 2013 opera Turandot, helping to create major achievements in the history of the local opera. Currently serving as the director of the Mikawa City Opera Chorus Group and the Mikawa City Chorus Club, he continues to be an irreplaceable presence in local musical culture.

The Irago Conference 2013

Participants at the Irago Conference 2013

The Irago Conference 2013 was held 24–25 October 2013 at the Irago Spa and the Irago Sea-Park & Spa Hotel, Tahara, Aichi, Japan. Underscoring the increasing awareness for an interdisciplinary approach to research and access to on-line live streaming of the proceedings attracted a total of approximately 200 people participants in the one and a half day conference.

Highlights included a talk via internet conferencing by Prof. S. Ramaswamy from the National Center for Biological Sciences (NCBS) in Bangalore on "Converting Discovery to Innovation in an Academic Environment". Professor Ramaswamy described a program at The Centre for Cellular and Molecular Platforms to nurture and develop commercially viable academic discoveries "through a combination of scientific and non-scientific expertise and infrastructure, along with its collaborators in the science and business domains."

Dr Hiroshi Fujiwara, president of Broadband Tower, Inc., Japan, emphasized the impact of 'big data' on the 4th Industrial Revolution.

Developments in science and technology in Korea were described by Professor Kwang Sun Kim, Korea University of Technology and Education and Eun Kyu Lee of the National Research Foundation, Korea. Similarly, Dr Chadaram Sivaji, Embassy of India, Tokyo, described science and policy in India.

In the life sciences speakers discussed advances in unlabeled chemical image sensing; cancer diagnostics; and open innovation in biotechnology.

Innovative contributions by mathematicians were described by Professor Toru Uzawa of Nagoya University, Japan.

The Graduate Student Session was held during the lunch break, with members of the audience given the taks of selecting the best student speaker.

Papers from the Irago Conference will be published in AIP Conference Proceedings.

The Irago Conference 2014 is scheduled to be held 24-25 October 2014 at AIST, Tsukuba.

Nanoscale photonic integrated circuit using surface plasmon polaritons on silicon

Surface plasmon polaritons (SPPs) are waves that propagate along the surface of a conductor and collective oscillation of electrons coupled with the optical field in the nano-scale area beyond the diffraction limit of propagating light waves. Recently, there is increasing interest in SPPs as signal carriers in nanoscale integrated circuits.

Many researchers are developing photonic devices employing SPPs for applications to photonic integrated circuits.

Here, Mitsuo Fukuda and his group at Toyohashi University of Technology (Toyohashi Tech) have developed a nanoscale integrated circuit consisting of SPP and electron devices on silicon in cooperation with the Integrated Circuit and Sensor System Group.

The integrated circuit consists of a SPP detector and two metal-oxide-semiconductor field-effect transistors (MOSFETs). The SPP detector was a gold/silicon Schottky-junction diode with multi-grating slits and fabricated on the gate electrode of a MOSFET.

Mitsuo Fukuda

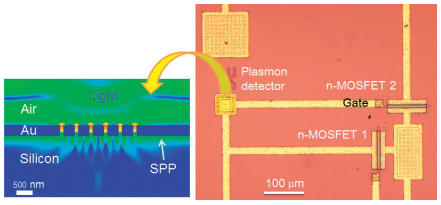
Free electrons excited by SPPs within the gold-metal cross over the junction and result in photocurrent to drive the MOSFET. The SPPs were converted from propagating 1550-nm-wavelength light at the multi-grating slit.

The integrated Schottky-junction diode drove the MOSFET well with a 1550-nm- wavelength light beam which is transparent to silicon. The photocurrent detected at the Schottky diode was amplified by about 14000 times in the integrated circuit.

This device is expected to contribute to a new phase of nano-scale photonic integrated circuits on silicon.

Reference:

- Authors: T. Aihara, M. Fukuhara, A. Takeda, B. Lim, M. Futagawa, Y. Ishii, K. Sawada, and M. Fukuda.
- Title of original paper: Monolithic integration of surface plasmon detector and metal-oxide-semiconductor field-effect transistors
- Journal, volume, pages and year: IEEE Photonics Journal, 5, 6800609 (2013).
- Digital Object Identifier (DOI): 10.1109/JPHOT.2013.2272779
- Affiliation(s): Department of Electrical & Electronic information Engineering.
- Website: www.photon.ee.tut.ac.jp



Top view of the integrated circuit (right) and cross sectional view of simulation result for SPP detector.

High pressure cold spray technology: Producing thick metallic coatings on polymer substrates

Lightweight materials, such as polymers, are used to reduce the weight of aircraft and automobiles. However, poor resistance to erosion, electrical conductivity, and low operating temperature limit their applications. These short comings may be mitigated by 'cold-spraying' a thick metallic coating onto the polymer surface.

Cold spray is a low temperature and rapid coating process where high velocity particles, propelled by supersonic gas, are exploited to coat

Masahiro Fukumoto

surfaces. However, instead of coating polymer substrates, the high energy particles cause severe erosion of polymer surfaces.

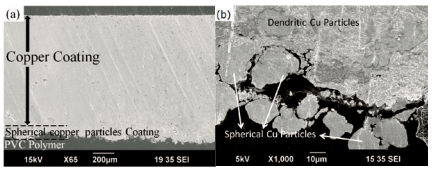
Recently, Masahiro Fukumoto and his group at Toyohashi University of Technology (Toyohashi Tech) demonstrated the formation of thick metallic coatings on polymers and composite materials by the cold spray process. Furthermore, they found that unlike particles of low density materials such as aluminum and tin, the successful deposition of thick layers of high density materials such as copper was significantly affected by the

particle morphology.

A thick copper coating was deposited on a PVC polymer substrate by carefully selecting the morphology of the copper particles. Initially, the base stratum was deposited using spherical copper particles and then a thick coating was fabricated using dendritic shape copper particles.

The shear adhesion strength of the coating and electrical resistivity were 2 ± 0.4 MPa and 11.39 ± 1.6 μΩ cm, respectively. These values are far superior to copper coating produced by other methods.

This study shows the possibility of producing a highly conductive copper surface on polymer substrates for automobile, electronic and aerospace industries.



(a) Homogeneous copper coating on a PVC substrate; (b) Coating interface at high magnification.

Reference:

- Authors: Ganesan Amirthan, Jon Affi, Motohiro Yamada, Masahiro Fukumoto
- Title of original paper: Bonding behavior studies of cold sprayed copper coating on the PVC polymer substrate
- Journal, volume, pages and year: Surface and Coating Technology 207, 262-269 (2012).
- Digital Object Identifier (DOI): 10.1016/j.surfcoat.2012.06.086
- Affiliation(s): Department of Mechanical Engineering.
- Website: http://isf.me.tut.ac.jp

Hard electronics: Nitride semiconductor Hall effect magnetic field sensors for extreme environments

Hall effect magnetic sensors made of silicon, indium arsenide, and gallium arsenide are widely used to monitor the rotation of moving parts in automobiles and personal computers, as well as more innovation applications including mapping magnetic fields by scanning Hall probe microscopy, and detection of nanomagnetic labels biomedical diagnostics and biomolecular recognition.

However, the performance of Hall sensors fabricated using these small bandgap semiconductors deteriorates drastically at high temperatures and in the presence of high energy radiation. Thus these conventional semiconductor Hall sensors are not applicable for increasing important applications in space exploration, particle accelerators, and thermonuclear power stations.

Here, researchers in Japan at the Electronics Inspired Interdisciplinary Research Institute (EIIRIS) colleagues at Toyohashi University of Technology (Toyohashi Tech) and Quantum Beam Science Directorate, Japan Atomic Energy Agency (JAEA), Takasaki describe the properties of AlGaN/GaN micro-Hall sensors exposed to high

Abderrahmane Abdelkader

energy protons and demonstrate the feasibility of using these robust devices for 'hard electronics' in space and high radiation environments.

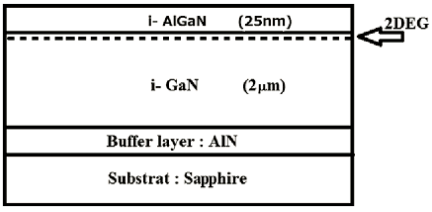
The AlGaN/GaN heterostructure micro-Hall sensors were fabricated by metal organic chemical vapor deposition, and the sheet carrier density and electron mobility at room temperature were 7.36 x10 cm^{12} and 1775 cm^2/Vs, respectively. Unpackaged sensors were irradiated with 380 keV protons and fluencies of 10^{14}, 10^{15}, and 10^{16}(proton/cm^2).

The performance of Hall sensors irradiated with 10^{14} protons/cm^2 was unaffected by the exposure to the protons. However, the resistance of sensors exposed to higher fluences increased, showed degradation due to the formation of defects and traps in the GaN layer. Notably, annealing restored the electrical characteristics of these devices due to the rearranging atoms in the GaN.

The sensors are expected to find applications in extreme environments, where device packaging will protect them against higher proton fluences.

Reference:

- Authors: A. Abderrahmane, S. Koide, H. Okada, H. Takahashi, S. Sato,* T. Ohshima,* and A. Sandhu
- Title of original paper: Effect of proton irradiation on AlGaN/GaN micro-Hall sensors



Structure of AlGaN/GaN heterostructor

- Journal, volume, pages and year: Applied Physics Letters, 102, 193510, (2013)
- Digital Object Identifier (DOI): 10.1063/1.4805357
- Affiliation(s): Electronics-Inspired Interdisciplinary Research Institute (EIIRIS)
  * Quantum Beam Science Directorate, Japan Atomic Energy Agency (JAEA), 1233 Watanuki-cho, Takasaki, Gunma 370-1292
- Website: http://www.eiiris.tut.ac.jp

Hollow bioprobe: Innovative analytical tool for the life sciences and biotechnology

A deep understanding of the functions of cells is crucial for such as medical diagnostics, drug discovery, and tissue engineering.

With the aim of opening up new possibilities for revolutionary approaches to analyze cellular functions at the single-cell level, Takayuki Shibata and colleagues at Toyohashi University of Technology propose the 'bioprobe' : an innovative probe for atomic force microscope (AFM) that is integrated with a sharp-tipped hollow silicon dioxide (SiO_2) nanoneedle instead of a conventional solid tip.

The bioprobe enables both the quantitative introduction of the desired biomolecules (DNA, proteins, etc.) into living cells and extraction of an extremely small number of biomolecules or cellular components expressed inside the cells as well as a variety of functions of conventional AFM functions.

The electrically insulating and optically transparent properties of the hollow structure of the SiO_2 nanoneedle provides other useful functions including (1) scanning ion conductance microscopy (SICM) for non-damaging imaging of biological cells; (2) scanning near-field optical microscopy (SNOM) for high-resolution optical imaging; and (3) surface enhanced Raman scattering (SERS) spectroscopy for characterizing molecular interactions in the biological cell.

Takayuki Shibata

Importantly, bioprobe has the potential to enable simultaneous imaging of multiple signals from single living cells. The researchers are confident that this approach will provide a method for correlation analysis of cellular functions with high spatial and temporal resolution for the development of a viable strategy for improving health and quality of life.

Reference:

- Authors: Takayuki Shibata, Kenji Nakamura, Shuhei Horiike, Moeto Nagai, Takahiro Kawashima, Takashi Mineta, and Eiji Makino.
- Title of original paper: Fabrication and characterization of bioprobe integrated with a hollow nanoneedle for novel AFM applications in cellular function analysis.
- Journal, volume, pages and year: Microelectronic Engineering 111, 325-331 (2013).
- Digital Object Identifier (DOI): 10.1016/j.mee.2013.02.051
- Affiliation(s): Department of Mechanical Engineering.
- Website: http://mems.me.tut.ac.jp/

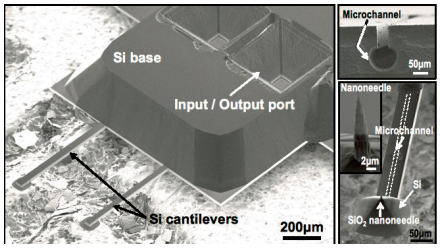


Fig 1: Bioprobe with a fully integrated sharp-tipped hollow SiO_2 nanoneedle and fluidic microchannel embedded into a Si cantilever beam structure.

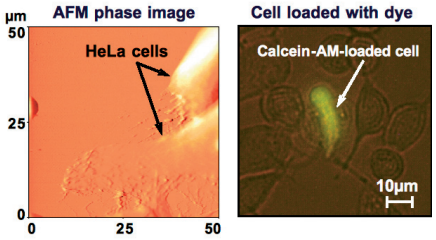


Fig 2: Atomic force microscope (AFM) phase images of HeLa cells in a culture medium and introduction of a fluorescent dye into a living HeLa cell by penetration of its cell membrane with the nanoneedle tip of bioprobe.

Launch of the Toyohashi Tech astronomy club: TT3913–CosmicHunters

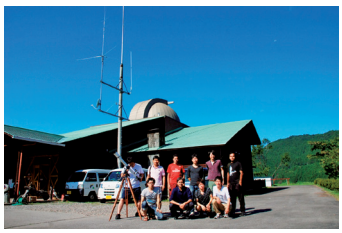
Ryoji Yukino is the inaugural leader of the Toyohashi Tech astronomy club launched on 3rd September 2013. The members of the club will use their expertise in engineering and computer programming to develop technology for observing and analyzing stars, planets, nebula, and comets. The TT3913–CosmicHunters includes Adarsh Sandhu, professor at the Electronics-Inspired Interdisciplinary Research Institute (EIIRIS), advisor to the group.

Examples of projects in the pipeline include the development of smart phone-based optical spectrometers for analyzing the light emitted by stars and nebula; 24/7 monitoring of the sky asteroid showers using dedicated ultra-high sensitivity cameras and software that only records images during an event, thereby saving time to analyze video footage; and internet-based remote control of an astronomical observatory.

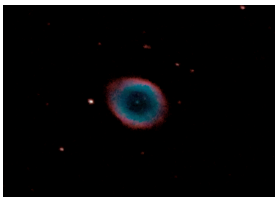
The Toyohashi Tech students are also planning to set up a network with fellow amateur astronomers from other universities in both Japan and overseas to share information and learn from each other about the latest trends and developments in astronomy and cosmology.

The night sky at Toyohashi Tech campus is dark enough to enable the observation of well-known constellations such as Ursa Minor, Cassiopeia, and Scorpius. Notably, a short trip to northern parts of Aichi, Gifu, and Shizuoka prefectures affords excellent views of deep sky objects.

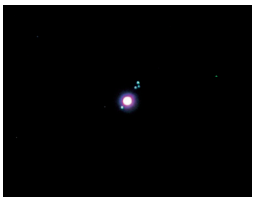
Launch of TT3913–CosmicHunters



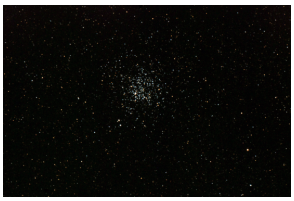
Field trip to the Toei-cho observatory in northern Aichi prefecture by some of the founders of TT3913–CosmicHunters.



A photograph of the Ring nebula (M57) taken by a member ofTT3913–CosmicHunters.



Jupiter and four of its moons taken by a member of TT3913–CosmicHunters.



A photograph of the Wild Duck Cluster (also known as Messier 11), an open cluster in the constellation Scutum, taken by a member of TT3913–CosmicHunters.

Beyond the Overseas Training Program

Taira Furuichi, Department of Mechanical Engineering

I was one of 15 students from Toyohashi University of Technology who took part in an overseas training program in Malaysia from September 1st to 7th, 2013.

I was very surprised to find myself in Malaysia because I had never been overseas before. This was indeed my first visit to another country.

We traveled to the city of Johor Bahru in Malaysia via Singapore by bus. This was also the first time that I had crossed an international border on land. Although I was a little worried, we entered Malaysia without any problems.

On the night of our arrival, we walked a little around the downtown area of Johor Bahru. Malaysia was not as hot as I had imagined. So, it was pleasant to stroll about. I was surprised to learn that English was understood everywhere in Malaysia.

From the 2nd day, we joined a workshop at Universiti Teknologi Malaysia (UTM). The campus of UTM was larger than I had imagined and I was very surprised—it can take 30 minutes to walk from the dormitories to a lecture room! The students of UTM were very frank and it was easy for me to talk with them.

In the workshop, our group discussed the issue of climate change. In Japan, when we discuss climate change, we tend to only focus on topic of global warming. However, as the Malaysian students began to talk about the heat island effect in their country, I started to understand the differences of culture and the environment of Malaysia. On the final day of workshop, each group gave a presentation. After that, we visited various places, such as Nusajaya and Tanjung Piai. We were able to experience traditional culture during our stay in a village in Tanjung Piai for a night.

Through this overseas training program, I once again realized the importance of the English language. For me, these 6 days were a memorable experience.

Making a presentation at UTM

Group photograph of the participants

Hear from Lao Students about Toyohashi University of Technology

This letter was produced by students from Laos studying at Toyohashi Tech. The students describe their experiences at Toyohashi Tech. Have a look!

Introduction to the Toyohashi Tech e-Newsletter

The *Toyohashi Tech e-Newsletter* is a quarterly publication with updates of news, research, and other activities at the Toyohashi University of Technology (Toyohashi Tech). This printed issue is an abridged version of the original *Toyohashi Tech e-Newsletter No. 13* that was published on-line in December 2013.

The original *Toyohashi Tech e-Newsletter No. 13*: http://www.tut.ac.jp/english/newsletter/

The contents of The *Toyohashi Tech e-Newsletter No.14* include:

Features

- Focus on ceramics

News

- Agreement on Student Exchange Program with Queens College, City University of New York
- Opening Ceremony Held for TUT-USM Penang

Research Highlights

- Cilia of Vorticella for Active Microfluidic Mixing
- Label-free biosensor based on a microelectromechanical system Fabry-Perot interferometer integrated with a photo detector
- Silver nanoparticle on graphene oxide support: An efficient catalyst for organic transformations

Club Activities

- Toyohashi Animation & Comics Society (TACS)

Excursions

- Momiji Matsuri Shinshiro City

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