The University of Electro-Communications

UEC e-Bulletin

Updates on research, innovation, and events at UEC:
Unique and Exciting Campus in Tokyo

Vol.7, September 2015

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Feature

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Frontiers of research on solar cells: Lead (Pb) perovskites with efficiencies over 20%

Qing Shen, associate professor at the Department of Engineering Science, Faculty of Informatics and Engineering at UEC, Tokyo.


Assoc. Prof. Qing Shen

25 April 1954 was a seminal day in the history of research on solar cells. On this date scientists at Bell Labs, Murray Hill, USA, announced the invention of the world's first practical panel of solar cells for converting sunlight into electricity. The solar cells were made of silicon and had an efficiency of 6 percent--a tremendous achievement even by today's standards. Notably, the solar cells were used to power a radio transmitter and energize a motor to drive a Ferris wheel--both practical applications of solar cells.

Fast forward to 2015 and silicon-based solar panels are ubiquitous. They have become an indispensable means of generating energy for human habitats, space exploration, and wearable devices such as wrist watches.

Now, at the research level, scientists are innovating to produce even more efficient solar cells at low cost, using environmentally friendly materials. Notably, recent reports of solar cell conversion efficiencies of 20.1% for cells fabricated using organometal trihalide perovskite have caught the imagination of scientists in the search for high performance, cheap solar cells.

"This very high 20% efficiency exhibited by organolead halide perovskite solar cells has galvanized scientists to focus on understanding the physics of this material system," says Qing Shen, associate professor at the Department of Engineering Science, Faculty of Informatics and Engineering at UEC. "Two of the main issues to resolve are clarifying why organolead halide perovskites yield such a high efficiency, and potential alternatives to lead based perovskites."

The material properties governing the high conversion efficiency of perovskite-based organic/inorganic solid state solar cells (OIHSCs) include their direct band gap and high optical absorption; large dielectric coefficient leading to smaller exciton binding energy; long photoexcited carrier lifetimes; no deep level defects; and very small Urbach energy.

"Our research is focused on clarifying the physical properties of this material that are responsible for such a high conversion efficiency," says Shen. "More specially, we are studying the relationship between carrier lifetime, charge separation and charge recombination dynamics and the performance of photovoltaic perovskite-based OIHSCs."

Shen has developed a dedicated transient absorption (TA) system to measure charge separation and recombination dynamics from the sub-picoseond to milli-second range. Recent experiments shows perovskite

$CH_3NH_3PbI_xCl_{3-x}$ to show long carrier lifetimes in the micro-second range and charge separation efficiency of TiO2/$CH_3NH_3PbI_xCl_{3-x}$/Spiro to be as high as 90%.

"Decreasing the recombination at TiO2/Spiro OMeTAD interface is a critical factor for improving the efficiency," says Shen. "Other issues are devising methods to suppress recombination, surface passivation of TiO2, and interface engineering."

Further improvements in the efficiency of these solar cells are expected by capturing more light from the near infra-red region of the spectrum. Professor Shuzi Hayase of the Kyushu Institute of Technology, leader of the JST CREST research group--which Shen has recently joined-- has reported that this can be achieved by using a 'Sn/Pb cocktail perovskite' in the form of $CH_3NH_3SnxPbI_{1-x}I_3$ perovskite solar cells that cover the spectral range up to 1060 nm.

Shen and colleagues have combined transient absorption with photoacoustic spectroscopy to analyze the properties of these materials to improve the Jsc, Voc and FF of Sn/Pb cocktail perovskite solar cells. Initial findings indicate that better solar cells could be produced by reducing non-radiative recombination by improving the crystalline quality of the Pb/Sn perovskites and suitable passivation of the TiO2/Sn/Pb perovskite interface, and realization of pinhole-free perovskite films.

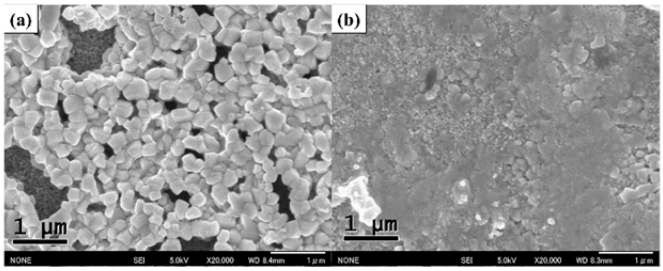
"This is an exciting time to be involved in solar cell research," says Shen. "This is interdisciplinary research requiring many different skills. I am currently working with Professor Shuzi Hayase at Kyushu Institute of Technology and other collaborators on producing high efficiency, inexpensive perovskite organic/inorganic solar cells."

Further information

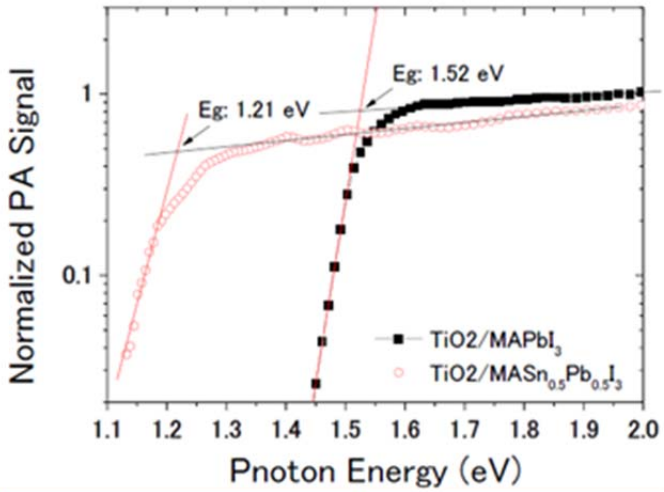
SHEN GROUP: http://www.shen.es.uec.ac.jp/introduction.htm (in Japanese)

1. **Qing Shen**,* Yuhei Ogomi, Jin Chang, Taro Toyoda, Kosei Fujiwara, Kenji Yoshino, Koki Sato, Kouhei Yamazaki, Masaya Akimoto, Yuki Kuga, Kenji Katayama, and Shuzi Hayase*: Optical Absorption, Charge Separation and Recombination Dynamics in Sn/Pb Cocktail Perovskite Solar Cells and Their Relationships to Photovoltaic Performances, ***J. Mater. Chem. A***, 2015, 3, 9308-9316, **DOI**: 10.1039/C5TA01246E.
2. **Qing Shen**,* Yuhei Ogomi, Jin Chang, Syota Tsukamoto, Kenji Kukihara, Takuya Oshima, Naoya Osada, Kenji Yoshino, Kenji Katayama, Taro Toyoda and Shuzi Hayase*: Charge transfer and recombination at the metal oxide/$CH_3NH_3PbClI_2$/*spiro*-OMeTAD interfaces: uncovering the detailed mechanism behind high efficiency solar cells, ***Phys. Chem. Chem. Phys.***, 2014,**16**, 19984-19992, **DOI**: 10.1039/C4CP03073G
3. Yuhei Ogomi *, Atsushi Morita, Shota Tsukamoto, Takahiro Saitho, **Qing Shen** *, Taro Toyoda, Kenji Yoshino, Shyam S. Pandey, Tingli Ma, and Shuzi Hayase*, All-Solid Perovskite Solar Cells with HOCO-R-NH_3+I-Anchor-Group Inserted between Porous Titania and Perovskite, ***J. Phys. Chem. C***, 2014, 118 (30), pp 16651-16659, **DOI**: 10.1021/jp412627n.

4. Yuhei Ogomi,* Kenji Kukihara, **Qing Shen**,* Taro Toyoda,Kenji Yoshino, Shyam Pandey,Hisayo Momose,and Shuzi Hayase*: Control of Charge Dynamics through a Charge-SeparationInterface for All-Solid Perovskite-Sensitized Solar Cells, ***CHEMPHYSCHEM***, 2014. DOI: 10.1002/cphc.201301153.
5. Yuhei Ogomi,* Atsushi Morita, Syota Tsukamoto, Takahiro Saitho, Naotaka Fujikawa, **Qing Shen**, Taro Toyoda, Kenji Yoshino, Shyam S. Pandey, Tingli Ma, and Shuzi Hayase*: $CH_3NH_3SnxPb_{(1-x)}I_3$ Perovskite Solar Cells Covering up to 1060 nm, J. Phys. Chem. Lett.. Vol. 5, 1004−1011 (2014) dx.doi.org/10.1021/jz5002117

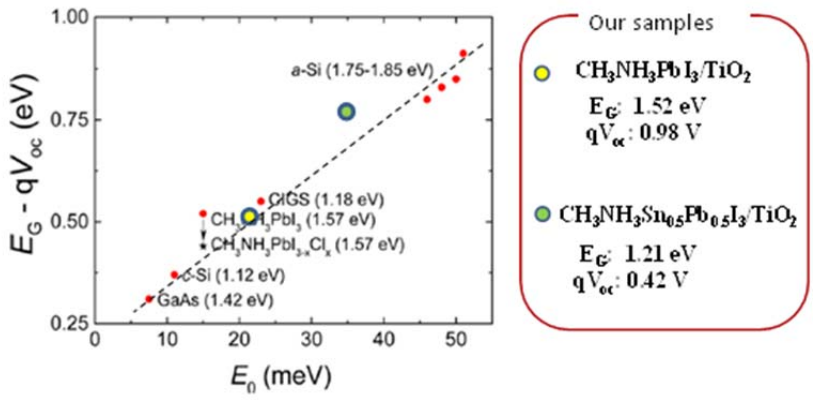


Top-view SEM image of (a) TiO2/MASn0.5Pb0.5I3 perovskite and (b) TiO2/MASn0.5Pb0.5I3 perovskite/P3HT samples. The scale bar is 1 μm in both images.

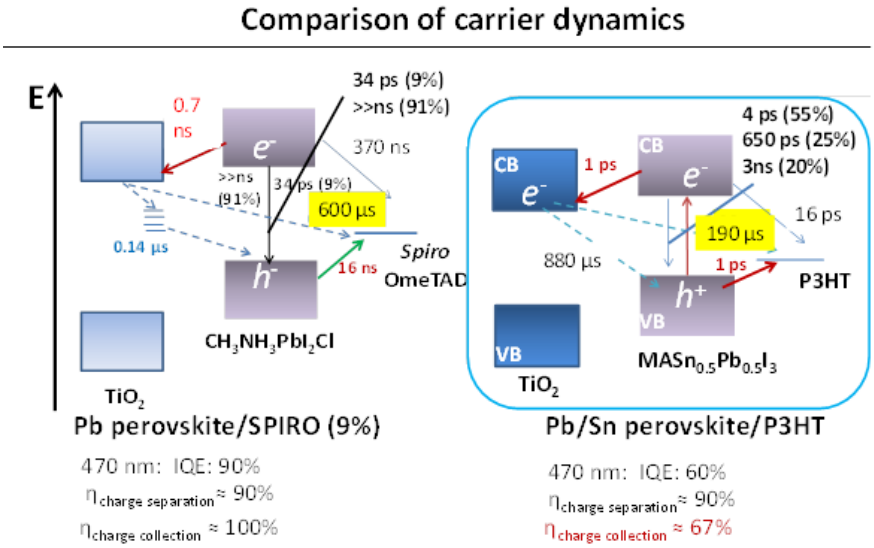


Sample	Urbach Energy E_0
$CH_3NH_3PbI_3/TiO_2$	22 mV
$CH_3NH_3Sn_{0.5}Pb_{0.5}I_3/TiO_2$	34 mV

Optical absorption spectrum of MAPbI3 and Sn/Pb cocktail MASn0.5Pb0.5I3 perovskite measured using a photoacoustic (PA) technique. The bandgap energy and Urbach energy were determined to be 1.21 eV and 34 meV, for MASn0.5Pb0.5I3 perovskite, and to be 1.52 eV and 22 meV for MAPbI3, respectively.



(EG/q)-Voc versus Urbach energy for our samples and for typical photovoltaic materials at room temperature which were reported by Wolf and co-authors in J. Phys. Chem. Lett. 2014, 5, 1035-1039. The higher loss in Voc for CH3NH3Sn0.5Pb0.5I3 compare to CH3NH3PbI3 corresponded to the larger Urbach energy E0 of CH3NH3Sn0.5Pb0.5I3.



Typical carrier transfer and recombination dynamics in Pb perovskite and Pb/Sn cocktail perovskite solar cells. The low efficiency of Pb/Sn cocktail perovskite solar cell was found to be due to faster recombination between TiO2 and P3HT interface. This faster recombination could be suppressed by making pinhole-free perovskite layers.

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UEC hosts Japanese Neural Network Society Workshop on "Data-driven approach for understanding cerebellar mechanisms on eye movement control"

Organizers Tadashi Yamazaki, University of Electro-Communications in Tokyo , and Akira Katoh, Tokai University.

On 1 August 2015, a full day workshop on "data-driven approach for understanding cerebellar mechanisms on eye movement control" was held at UEC, Tokyo. The workshop was organized by Tadashi Yamazaki (assistant professor, UEC, Tokyo) and Akira Katoh (associate professor, Tokai University) and jointly sponsored by the Japanese Neural Network Society (JNNS) and Brain Science Inspired Life Support Research Center, UEC, Tokyo.

The workshop consisted of 10 speakers, most of whom were recently promoted to principle investigators at their research institutes. In planning the workshop, the organizers endeavored to maintain a good balance of speakers from Japan and overseas, and male and female representation. The final program consisted of three speakers from the USA and the remainder from Japan, where four of the talks were given by female participants. In spite of the combination of a highly technical program, the holiday season, and hot and humid weather, more than 30 scientists participated in the workshop. The presentations and resulting heated discussions were held in English, and the workshop was successful in achieving its aims.

In cerebellar research, Marr (1969) and Albus (1970) proposed so-called "perceptron hypothesis" that regards the cerebellum as a pattern recognition device via supervised learning. Ten years later, Ito et al. (1982) discovered long-term depression, which was the memory mechanism within the cerebellum and was the missing piece of the Marr-Albus model.

Since then, the Marr-Albus-Ito model has influenced successive cerebellar research while acting as a compass that points to the correct direction of research and way of thinking about the system. Hence, we often say, "cerebellar research is hypothesis driven".

However, where did the hypothesis come from? Of course, it came from data, specifically anatomical and morphological data of cat's cerebellum obtained in the 1950s to 1960s. In those days, a very detailed wiring diagram, or "blue print" of the cerebellum was already available. That is, detailed data allowed scientists to build a good hypothesis. In other words, "no data, no theory". Meanwhile, a data-driven approach has become popular in brain research, where scientists try to extract latent meanings or relationships behind the massive amounts of data. Therefore, in the workshop, we focused on "data".

The workshop included presentations on the cerebellum and eye movement control in primates. Recently, it has been difficult to conduct primate research, so the participants had the privilege to see the latest and detailed data in primate research. The data presented at the workshop ranged from microscopic level

(molecular biology), mesoscopic level (electrophysiology) and macroscopic level (system / behavioral level), underscoring the very comprehensive nature of the workshop in covering research on cerebellum and eye movement control.

Notably, Dr. Shinji Matsuda from UEC, Tokyo presented his technique to control long-term depression by light. This technique will provide the final means to elucidate the causal relationship between long-term depression and cerebellar motor learning.

In summary, the workshop was very successful. The organizers would like to have this kind of workshop on a regular basis to promote brain science at UEC, Tokyo and cerebellar research in Japan.

Finally, the organizers are grateful for the generous financial support from the following organizations: International Neuroinformatics Coordinating Facility (INCF) Japan Node Cerebellar Platform; Comprehensive Brain Science Network; Tokai University Educational System General Research Organization; and The University of Electro-Communications.

Further information

1. Workshop website: http://numericalbrain.org/jnnsjigen/index.en.html
2. Speakers and titles of talks
   Kenichiro Miura (Kyoto Univ)
   Visual control of eye movements in mice: the optokinetic response
   Shuntaro Miki (Chubu Univ)
   Cerebellar dependent predictive optokinetic response associated with oculomotor velocity storage mechanism in goldfish, carp, zebrafish, medaka, and human
   Naoko Inaba (Kyoto Univ)
   The role of the cortical areas MT and MST in coding of visual motion during pursuit eye movements
   Pablo M Blazquez (Washington Univ St. Louis)
   Thinking inside the box. Signal processing by cerebellar cortex interneurons in the macaque ventralparaflocculus
   Tatyana Yakusheva (Washington Univ St. Louis)
   Role of GABAergic inhibition in the vestibular signal transformation carried out by the cerebellar nodulus and uvula
   Aya Takemura (AIST)
   Neural activity in monkey's cortical area MST Represents Retinal Error during Motor Learning
   Yoshiko Kojima (Univ Washington)
   Substantia nigra pars reticulata influences the error signals for the saccade adaptation
   Shinji Matsuda (UEC, Tokyo)
   Understanding and controlling synaptic plasticity

Seiji Ono (Tsukuba Univ)

Role of visual velocity and position error signals in smooth pursuit adaptation

Yutaka Hirata (Chubu Univ)

Promoted motor learning of oculomotor velocity to position neural integrator under hyper-gravity and brighter visual stimulation

Poster of the workshop

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UEC launches the Info-Powered Energy System Research Center (iPERC)

Susumu Morikura
UEC, University Research Administrator, Organization for Research Promotion


President Fukuda, UEC

University of Electro-Communications, Tokyo (UEC, Tokyo) held a symposium to commemorate the launch of the Info-Powered Energy System Research Center (iPERC) on 31st July, 2015. The iPERC was established to investigate and resolve global energy issues by nurturing human resources as part of an inter industry-academia-government collaboration.


Keynote by President Tsuge, Japan International Science and Technology Exchange Center

The symposium included talks by prominent scientists, educators, government officials, and industrialists specializing in energy issues. More than 150 people attended the symposium, including participants from other universities, industry and government.

Takashi Fukuda, the President of UEC opened the symposium by welcoming the participants and giving a brief overview of iPERC. Then, Nobuaki Kawakami, the Director General, Science and Technology Policy Bureau, MEXT, gave a congratulatory message. Ayao Tsuge, the President of the Japan International Science and Technology Exchange Center, then gave a keynote speech on Japan as an "Innovative Country driven by Sustainable Science and Technology". Haruhisa Ichikawa, the Director of iPERC, gave a more detailed description of the mission and plans of iPERC.


Prof. Ichikawa, Director of iPERC

In the session for industry leaders, Takemitsu Kunio, senior vice president of NEC, Tomiyasu Ichimura, senior director of Fujitsu Ltd, and Chiaki Itoh, vice president of Yokogawa Electric Corporation described their activities on their energy management businesses. These talks were very highly informative in understanding the current status of the energy business.


Symposium speakers and UEC executive board members

Finally, Seiichi Shin, vice director of iPERC gave concluding remarks on behalf of all the people associated with the symposium.

Following the success of this symposium, the directors of iPERC are planning to hold further meetings with associated members to explore and promote advanced solutions in energy management.

Further information
Info-Powered Energy System Research Center (iPERC) website: http://www.iperc.uec.ac.jp/

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Delegates from Binghamton University, State University of New York, visit UEC

UEC welcomed delegates from Binghamton University on 25-26 August 2015. The visitors from Binghamton University, State University of New York (SUNY-B) were led by Distinguished Professor Krishnaswami Srihari, Dean of the Thomas J. Watson School of Engineering and Applied Science and also Executive Vice Provost for International Initiatives and Chief Global Affairs Officer. The other members of the delegation were Professor Hiroki Sayama, Department of Systems Science and Industrial Engineering and Director of the Center for Collective Dynamics of Complex Systems, and Ms. Amanda Chiarot, International Alumni and Career Connections Coordinator of the Watson School.

President Fukuda and Dean Srihari exchanged greetings

Three representatives from Binghamton University

UEC and SUNY-B have had a collaborative agreement since 2014, and the visit was arranged to identify specific areas of interaction including research, education, internships, and exchange of students and administrative staff.

The activities of SUNY-B were first introduced by Prof. Srihari to UEC faculty members in English, and then in Japanese by Prof. Sayama to UEC students and faculty members. SUNY-B, a prestigious university in U.S.A., is one of four universities with doctoral degree courses at SUNY, which includes over sixty higher education institutions including universities, colleges, academic medical centers, and an online learning network.

Introduction of BU to UEC students and faculty members

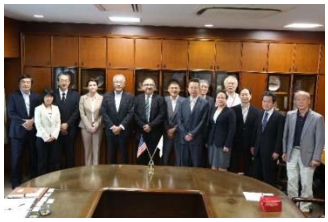
The main topics described by the two professors were: the location of the university; number of students (undergraduate and graduate); student life on campus; different entrance systems between Japan and U.S.A; and outstanding research findings.

Prof. Kajimoto's Lab

The visit also included a tour of seven research groups at UEC, to give the visitors first hand insights into research at UEC. The main research areas and people visited were: Virtual Reality and Interface (Prof. Kajimoto); Info-Powered Energy (Prof. Ichikawa); Control Engineering and Security (Prof. Sawada); Brain Science (Prof. Yokoi); Advanced Research Facilities (Prof. Nozaki); Nano Electronics and Solar Cell (Prof. Shen); and Organic Synthesis (Prof. Maki).

The meeting between UEC and BU

Achievements made during the visit include (1) defining specific areas for potential collaborative research; (2) clarification of specific organizations at both universities to manage collaboration themes; (3) enhancement of mutual understanding of student exchange programs offered by each university and sharing ideas to proceed with taking advantage of these programs; and (4) subjects such as international internship, collaboration on English language education, and administrative staff exchange were positively discussed.



UEC-KMITL GAL (Global Alliance Lab)

At the end of the visit, Dr. Kazushi Nakano, Member of the Board of Directors for Education at UEC, gave a closing address. In his speech, Dr. Nakano touched on some global education programs being developed at UEC and asked for possible cooperation from Binghamton University in the future.

In conclusion, the visit by the SUNY-B delegation was a huge success and very productive. As a matter of a fact, UEC believes that the process of interacting with SUNY-B may serve as a model case in seeking inter-university matching of research collaboration themes. UEC is grateful to the SUNY-B delegation for visiting us and we look forward to a fruitful collaboration in the future.

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Nanowire quantum dot solar cells: oxide layer boosts performance

Attempts to improve solar cells can seem a balancing act, as optimising one variable can compromise another. The introduction of nanowires to colloidal quantum-dot solar cells (CQDSCs) aroused interest as a means of improving a limitation in the charge-collection layer thickness. However the high nanowire surface area brings other inhibiting factors. Now Jin Chang, Qing Shen and colleagues demonstrate how a further modification using an oxide layer can reduce the nanowire surface area effects for better-performing solar cells.

Colloidal quantum dots offer a number of advantages for solar cells: they provide effective charge separation layers for producing a photocurrent; have tunable band gaps; and can be solution-processed at low temperatures. However the low diffusion length for charge carriers generated in colloidal quantum dots limits the maximum layer thickness - it must be no thicker than the distance the carriers can travel to reach the heterojunction before recombining. This limited thickness caps the energy absorption capacity.

Penetrating the quantum-dot layers with nanowire heterojunctions can allow greater thicknesses. But since recombination occurs at interfaces, the higher surface of nanowire heterojunctions undermines the advantage made.

Chang, Shen and colleagues at the University of Electro-Communications and CREST in Japan, Universitat Jaume I in Spain, Kyushu Institute of Technology and King Abdulaziz University in Saudi Arabia show that a titanium oxide layer can passivate the surface of the nanowires thereby reducing recombination. The oxide layer allows a 40% improvement in the energy conversion efficiency of the devices and they are stable in air for over 130 days.

"This work highlights the significance of metal oxide passivation in achieving high performance bulk heterojunction solar cells," conclude the authors. "The charge recombination mechanism uncovered in this work could shed light on the further improvement of PbS CQDSCs and/or other types of solar cells."

Reference

Jin Chang,*[1,2] Yuki Kuga,a Iván Mora-Seró,[3] Taro Toyoda,[1,2] Yuhei Ogomi,[4,2]
Shuzi Hayase,[4,2] Juan Bisquert[3,5] and Qing Shen,*[1,2] High reduction of interfacial charge recombination in colloidal quantum dot solar cells by metal oxide surface passivation, *Nanoscale*, **7**, 5446 (2015).

1. Faculty of Informatics and Engineering, The University of Electro-Communications,1-5-1 Chofugaoka, Chofu, Tokyo 182-8585, Japan.
2. CREST, Japan Science and Technology Agency (JST), 4-1-8 Honcho, Kawaguchi, Saitama 332-0012, Japan
3. Photovoltaic and Optoelectronic Devices Group, Department de Física, Universitat Jaume I, 12071 Castelló, Spain

4. Faculty of Life Science and Systems Engineering, Kyushu Institute of Technology, 2-4 Hibikino, Wakamatsu-ku, Kitakyushu, Fukuoka 808-0196, Japan
5. Department of Chemistry, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia

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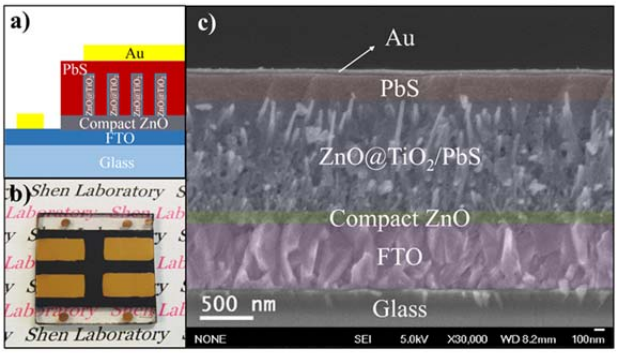

(a) A schematic illustration of the solar cells with zinc oxide (ZnO) nanowire heterojunctions passivated with titanium oxide (TiO2) and lead sulphide (PbS) colloidal-quantum-dot charge separation layers (ZnO@TiO2/PbS solar cells);(b) a photograph of standard PbS CQDSCs fabricated in Shen's lab; (c) a typical cross-section scanning electron microscope image of the ZnO@TiO2/PbS solar cells.

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Motor behaviour: understanding the jerks that lurk in smooth movements

Apparently smooth continuous movements to trace moving objects harbour jerks. These jerks are absent when there is no object to be traced and so are thought to stem from changes in motor instructions anticipated and fed forward by the brain to compensate for sensorimotor time lags. However so far there is no conclusive evidence that this is the case. Now Yasuyuki Inoue and Yutaka Sakaguchi at the University of Electro-communications have demonstrated a method for analysing apparently smooth movements that may help to understand their jerky components.

"The true purpose of detecting discontinuities is to know when and how our brain divides a continuous motor task into separate movement segments," explain Inoue and Sakaguchi in their report. While studies of intermittency have been tackled using frequency analysis of the velocity profiles, the intervals between the intermittent motor discontinuities vary, so this may not be appropriate.

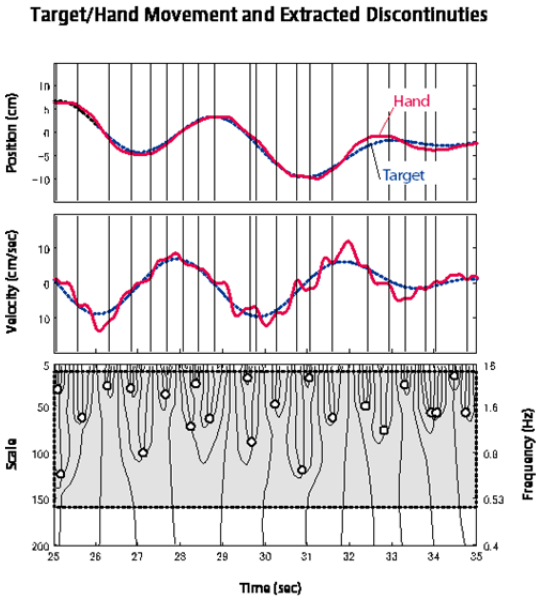
Another approach is to extract the sub-movements that comprise apparently continuous motion by identifying the discontinuities. However the methods to do this - using kinematic parameters and curve fitting optimisation - become unmanageable for long movements.

Inoue and Sakaguchi show that continuous wavelet transforms are an effective means of identifying discontinuities without suffering the drawbacks of other approaches for longer movements. They also show how to distinguish the discontinuities from other movement features such as hand tremors or peaks in a pulse of movement.

"Our method is essentially equivalent to detecting the jerk change points, but it uses both the amplitude and phase information of the complex wavelet transform to much improve detection performance," explain Inoue and Sakaguchi in their report. They successfully detected all the discontinuities in an artificial data set with no false detections, as well as demonstrating their approach on human subjects asked to trace a moving object with their hand.

Reference

Inoue Y, Sakaguchi Y A wavelet-based method for extracting intermittent discontinuities observed in human motor behavior Neural Networks 62: 91-101 (2015)
doi:10.1016/j.neunet.2014.05.004



Researchers at the University of Electro-Communications demonstrate their wavelet approach for discontinuity detection in hand movements during the target tracking task.

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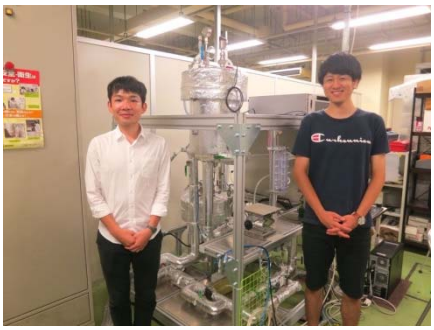
UEC students receive prestigious awards at international conference

Two UEC graduate students studying at the same laboratory were awarded prizes for their presentations at the 23rd International Conference on Nuclear Engineering, held in Chiba, Japan, 17-21 May 2015.



Naoki Miyano (left) and Kazuhiro Kaiho in the Okawa-Enoki lab at UEC.

Naoki Miyano received the best poster prize (1) and Kazuhiro Kaiho the best paper prize (2). Miyano and Kaiho are both master's degree students at UEC's Department of Mechanical Engineering and Intelligent Systems studying under the supervision of Professor Tomio Okawa.

Further information

Website of the 23rd International Conference on Nuclear Engineering, held in Chiba, Japan, 17-21 May 2015:http://www.icone23.org/about.html

Related technical publications

1. Kazuhiro Kaiho, Tomoyuki Kajihara, Tomio Okawa, 2015. Visualization of bubble nucleation process during water subcooled flow boiling using a transparent heated surface, 23rd International Conference on Nuclear Engineering, ICONE23-1121. [Best Paper Award]
2. Naoki Miyano, Tomio Okawa, Takafumi Suginaka, 2015. Study of bubble lift off from a vertical heated surface in pool boiling, 23rd International Conference on Nuclear Engineering, ICONE22-1123. [Best Poster Award]
3. Tomio Okawa, Muhamad Zuhairi Bin Sulaiman, Daisuke Matsuo, 2014. Experimental study on the critical heat flux and heat transfer coefficient in nanofluid pool boiling, 10th International Topical Meeting on Nuclear Thermal Hydraulics, Operation and Safety, NUTHOS10- 1346.
4. Tomio Okawa, 2015. Enhancing Numerical Stability of a Two-Fluid Model by the Use of Interfacial Pressure Terms, ASME Journal of Nuclear Engineering and Radiation Science, Vol. 1, Issue 2, 021001-11.

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A career in ultrashort pulse lasers, ultrafast spectroscopy, and quantum information

Takayoshi Kobayashi Laboratory, Advanced Ultrafast Laser Research Center, University of Electro-Communications, Tokyo.

Professor Takayoshi Kobayashi joined the University of Electro-Communications, Tokyo (UEC, Tokyo) as a Specially Appointed Professor after retiring from The University of Tokyo in 2002. "Over my 49 year research career I have published about 580 original papers on a wide range of optical phenomena," says Kobayashi. "I even broke my own world record for generating sub- femtosecond laser pulses."

Indeed Kobayashi is one of the pioneers of using non-collinear optical parametric amplification (NOPA) to produce ultrashort pulse lasers. In 1999 Kobayashi and colleagues set a world record by producing 4.7 femtosecond (fs) laser pulses in the 500-800 nm range after that Kobayashi kept breaking his own world record from 1999 for more than 15 years. In 2011 Kobayashi broke his own world record by generating carrier-envelope phase (CEP) stabilized 2.4 fs near infra-red pulses in the 410-820 nm wavelength range.

Such short pulses of intense laser light are important for investigating ultrafast and nonlinear optical properties of various condensed materials including polymers, optoelectronic device materials, and topological insulators. Specific research being undertaken by Kobayashi and his colleagues includes: Real time, sub 5 femtosecond spectroscopy of conducting polymer polyacetylenes and polydiacetlenes with highly optical nonlinear, and another quasi-one-dimensional system of halogen-bridged mixed-valence metal complexes. Also important study has been made for topological insulators which are recently attracting many researchers.

Other areas of research include quantum quantum photobiology, and femtosecond dynamics of bacteriorhodopsin, a molecule that uses solar energy to generate energy by pumping protons across a membrane.

Another field of his research using nonlinear optical parametric interaction is a quantum information. This is also a technique for ultrashort pulse generation. "Quantum entanglement is a fascinating area of research with a wide range of practical applications," says Kobayashi. "For example we are using so called entangled photons to measure the spectrum of materials on the surface of the moon with the monochromator on earth. These experiments can be carried out with a high sensitivity and low noise visible detector coupled with a noisy infra-red detector."

Recently, Kobayashi is doing research of development of super resolution optical microscopes, based on novel ideas now being applied to several patents.

Kobayashi is also passionate about education and nurturing young scientists. "One of the rewarding things about research is seeing how young scientists develop with time. It is highly rewarding to see students turn into quality scientists."

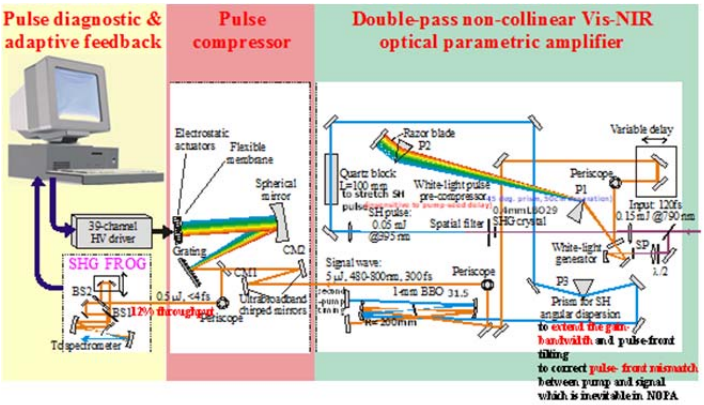
Further information

Takayoshi Kobayashi website: http://femto.pc.uec.ac.jp/index.html

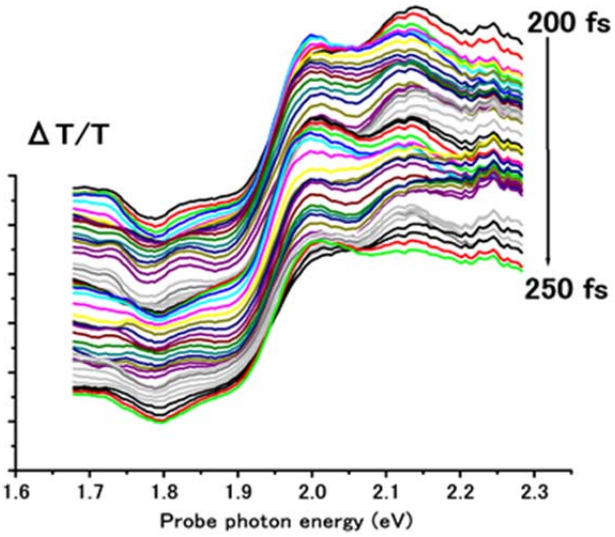
References

Selection of ten papers out of about 580 original papers published by Takayoshi Kobayashi.

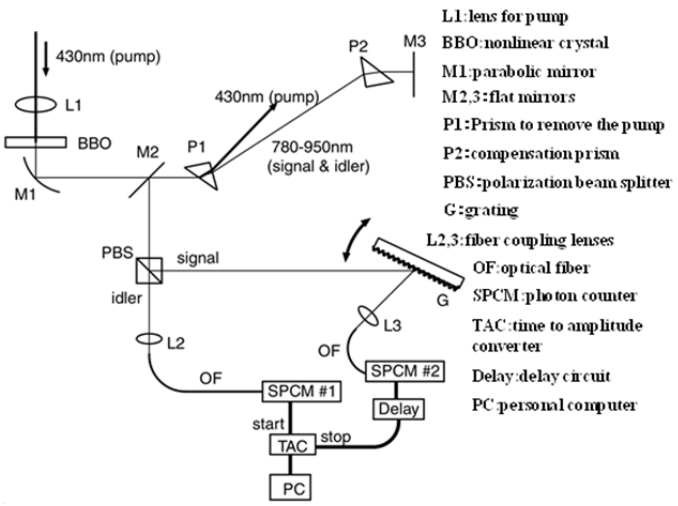
1. Sub-5-fs visible pulse generation by pulse-front-matched noncollinear optical parametric amplifier, A. Shirakawa, I. Sakane, M. Takasaka, and T. Kobayashi, Appl. Phys. Lett. 74, 2268-2270, (1999).
2. Real-time spectroscopy of transition states in bacteriorhodopsin during retinal isomerization: T. Kobayashi, T. Saito, and H. Ohtani, Nature 414, 531-534(2001).
3. Controlling the carrier-envelope phase of ultrashort light pulses with optical parametric amplifiers A. Baltuska, T. Fuji, and T. Kobayashi, Phys. Rev. Lett. 88, 0133901, (2002).
4. Visible pulse compression to 4 fs by optical parametric amplification and programmable dispersion control, Baltuska, T. Fuji, and T. Kobayashi, Opt. Lett. 27, 306-308, (2002).
5. Cascaded four-wave mixing and multicolored arrays generation in a sapphire plate by using two crossing beams of femtosecond laser, J. Liu and T. Kobayashi, Opt. Exp. 16, 22119-22125, (2008).
6. Primary conformation change in bacteriorhodopsin on photoexcitation, A. Yabushita and T. Kobayashi, J. Biophys. 96, 1447-1461, (2009).
7. Ultrafast Spectroscopy of oxy-hemoglobin during photodissociation, A. Yabushita and T. Kobayashi, J. Phys. Chem. B, 114, 11654-11658, (2010).
8. Kinetic isotope effect on the proton-transfer in indigo carmine, I. Iwakura, A. Yabushita, and T. Kobayashi: Chem. Phys. Lett. 484, 354-357(2010)
9. Temporal contrast enhancement of femtosecond pulses by a self-diffraction process in a Kerr bulk medium, J. Liu, K. Okamura, Y. Kida, T. Teramoto, and T. Kobayashi, Opt. Exp. 18, 22245, (2010).
10. Octave-spanning carrier-envelope phase stabilized visible pulse with sub-3-fs pulse duration, K. Okamura and T. Kobayashi, Opt. Lett. 36,226-228, (2011).



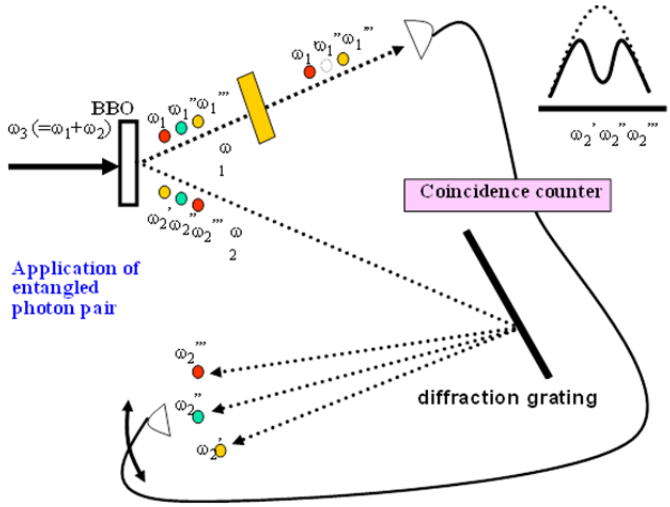
Experimental set up of ultrafast spectroscopy composed of NOPA, pulse compress system, and pulse form characterization system



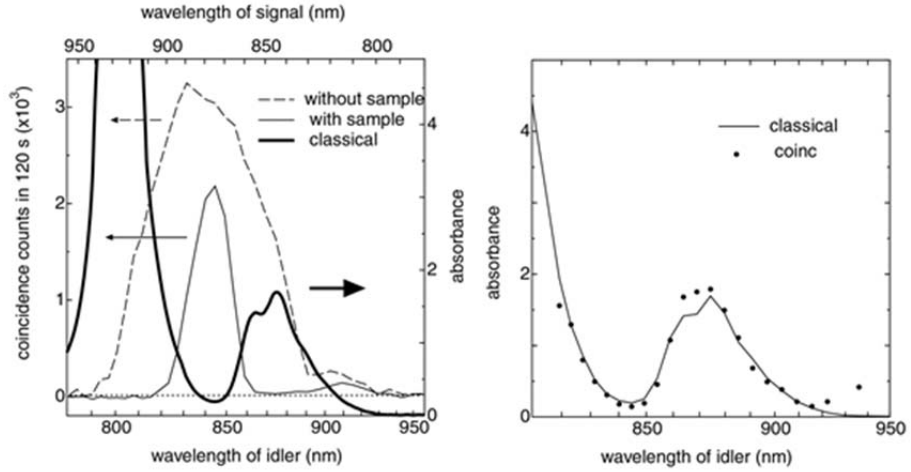
Probe delay time dependence of difference transmission spectrum: The time-resolved spectrum at 201fs (= delay time of probe pulse from the pump pulse introducing the change, which is probed by the probe, is different from that of 200fs.



Experimental set up for the application of "ghost image" to the measurement spectrum of distant materials using quantum entangled photon pairs.



Measurement of spectrum of materials on the moon is possible in principle using the entangled photon pair with a monochromator on the earth. Or Measurement of infrared spectrum can be performed using high sensitivity low noise visible detector using a noisy infrared detector.



Result of absorption spectrum of distant materials using the entangled photon pairs.

The University of Electro-Communications (UEC) in Tokyo

is a small, luminous university at the forefront of applied sciences, engineering, and technology research. Its roots go back to the Technical Institute for Wireless Commutations, which was established in 1918 by the Wireless Association to train so-called wireless engineers in maritime communications in response to the Titanic disaster in 1912. In 1949, the UEC was established as a national university by the Japanese Ministry of Education, and moved in 1957 from Meguro to its current Chofu campus Tokyo.

With approximately 4,000 students and 350 faculty, UEC is regarded as a small university, but with particular expertise in wireless communications, laser science, robotics, informatics, and material science, to name just a few areas of research.

The UEC was selected for the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Program for Promoting the Enhancement of Research Universities as a result of its strengths in three main areas: optics and photonics research, where we are number one for the number of joint publications with foreign researchers; wireless communications, which reflects our roots; and materials-based research, particularly on fuel cells.

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