E-MRS 2018 Spring Meeting (in Strasbourg, France)

Satellite Event

STAM-WPI Joint Workshop

"Near Future Frontier Forecast by Materials Science"

Date: June 20 (Wed), 2018

Time: 14:00-16:00

Venue: Auditorium CASSIN (Ground floor), Strasbourg Convention Centre

STAM Science and Technology of Advanced Materials

wpi World Premier International Research Center Initiative

Scope:

The importance of materials science is becoming greater every day to build a sustainable society. In particular, developing novel high-performance materials for energy harvesting, energy saving, and environmental clean-up (including the development of biocompatible materials) is one of the most important challenges in materials science, and many studies aiming to solve such problems are in progress also in Japan. This time, researchers from the four WPI centres related to materials science and editorial board members of Science and Technology of Advanced Materials (STAM) will gather at E-MRS 2018 Spring Meeting and hold STAM-WPI Joint Workshop entitled “Near Future Frontier Forecasted by Materials Science” which showcases the Japanese activities to create the future society through materials research. The organizers hope that many participants in the E-MRS Meeting join this workshop and consider the near future frontier together.

Reference websites:

WPI: https://www.european-mrs.com/wpi

https://www.jsps.go.jp/english/e-toplevel/index.html

STAM: http://www.tandfonline.com/toc/tsta20/current

Program:

Introductory presentations

14:00-14:15 Susumu Ikeda (Director, Research Support Division, WPI-AIMR, Tohoku University)

“Introduction to the workshop and WPI”

14:15-14:30 Shu Yamaguchi (Professor, The University of Tokyo, STAM Editor-in-Chief)

“New materials science beyond borders (STAM introduction)”

Research presentations

14:30-14:45 Hiroshi Yabu (Jr PI, Associate Professor, WPI-AIMR, Tohoku University)

“Experimental and theoretical approaches for controlling of morphologies of nanostructured polymer particles”

14:45-15:00 Tomonobu Nakayama (PI, Deputy Director, WPI-MANA, NIMS)

“Neuromorphic networks of nanowires for brain-like signal processing”

15:00-15:15 Roland Hany (STAM Deputy Editor, Empa)

“Transparent organic optoelectronic devices using near-infrared absorbing dyes”

15:15-15:30 Shuhei Furukawa (PI, Associate Professor, WPI-iCeMS, Kyoto University)

“Materials chemistry controls cellular functions”

15:30-15:45 Motonori Watanabe (Associate Professor, WPI-I^{2}CNER, Kyusyu University)

“Design of organic-inorganic composite photocatalyst for visible light driven water splitting hydrogen production”

15:45-16:00 Discussion on our future prospects

(16:15- Plenary Session)

Dr. Susumu Ikeda

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Introduction to the workshop and WPI

The World Premier International Research Center Initiative (WPI) is the Japanese version of the research excellence initiatives (REIs) and it was launched in 2007 by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) to build within Japan "globally visible" research centres that hold a very high research standard and outstanding research environment, sufficiently attractive to researchers from around the world[1,2). Eleven WPI centres in a variety of research fields have been established in Japan so far. In order to let European researchers in materials science know our activities, the following four WPI centres related to materials science

Advanced Institute for Materials Research (AIMR), Tohoku University[3)],

International Center for Materials Nanoarchitectonics (MANA), NIMS[4)]

Institute for Integrated Cell-Material Sciences (iCeMS), Kyoto University[5)]

International Institute for Carbon-Neutral Energy Research (I^2CNER), Kyushu University[6)]

jointly participated in E-MRS Spring Meetings in 2014 and 2016 (these two meetings were held in Lille, France). This time, we firstly join the E-MRS Spring Meeting held in Strasbourg together with the editorial board members of Science and Technology of Advanced Materials (STAM)[7)]. This workshop aims to show the Japanese research activities in materials science and consider the near future frontier together with the European researchers.

References

1) http://www.jsps.go.jp/english/e-toplevel/index.html
2) https://www.european-mrs.com/wpi
3) https://www.wpi-aimr.tohoku.ac.jp/en/index.html
4) http://www.nims.go.jp/mana/index.html
5) https://www.icems.kyoto-u.ac.jp/en/
6) http://i2cner.kyushu-u.ac.jp/en/
7) http://www.tandfonline.com/toc/tsta20/current

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New Materials Science Beyond Borders (STAM introduction)

Science and Technology of Advanced Materials (STAM) was born in the year 2000 to serve the ever-growing materials science community as a leading journal covering a broad spectrum of materials science topics. With an impact factor around four, STAM has become a top Gold Open Access journal in the materials science. The journal is currently supported by the National Institute for Materials Science (NIMS) and the Swiss Federal Laboratories for Materials Science and Technology (Empa), and publishes only high-quality scientific content.

Materials science has a unique feature of interdisciplinary research, which grows markedly these days. Through interactions between related disciplines, materials science expands creating new research fields. Emerging areas, which look far from materials science today, will become its core categories within a decade. One good example that we experienced was the STAM focus issue on “nanomedicine” published in 2016, which contained articles related to biology and medicine. Since then, many materials science journals began publishing articles related to nanomedicine. Such rapid growth of a new discipline by fusion with other scientific areas drives the ever-expanding nature of materials science.

This joint World Premier International Research Center Initiative (WPI) -STAM workshop is aimed at seeking new disciplines and future directions of materials science. Each WPI was established to develop and promote leading research in a certain scientific area. All the involved institutes cover different fields of materials science, but with different scopes, flavors and visions.

There is no doubt that materials science plays a vital role in science and technology and, therefore, is the key for developing a sustainable society in the future. New directions in materials science can emerge through the discovery of new materials. We are always keen to expand materials science beyond its borders, and will be glad if STAM could contribute to this mission by publishing unpolished gems selected from a pool of research embryos.

I am looking forward to fruitful discussions to find a key to the gate of a new *materials science* at this workshop.

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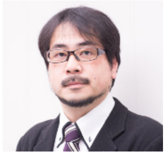

Experimental and theoretical approaches for controlling of morphologies of nanostructured polymer particles

Nanostructuring of polymer particles offers realizing virus-like particles, which can be applicable to platforms for medical diagnosis, drug delivery systems, and other photonic and electronic applications. Block copolymers, which form nanoscale phase-separated structures, allow for nanostructuring of particles. We have developed a simple method for fabricating block copolymer particles by simple solvent evaporation from polymer solutions containing poor solvents (Self-ORganized Precipitation, SORP)[1)]. By using this technique, various kinds of nanostructures formed inside and outside of block copolymer particles[2)]. Recently, we found unique phase-separated structures different from their bulk states formed inside of the small-sized block copolymer particles. To control these "frustrated phases" of block copolymer phase separation[3)], we employed a mathematical model based on coupled Cahn-Hilliard equations[4)]. This model can reproduce frustrated phases found in experimental results, and it also explains transformation processes of phase-separated structures inside of block copolymer particles during a thermal annealing process[5)].

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Neuromorphic networks of nanowires for brain-like signal processing

Computers, the most important tools for our society at present, are now consuming a lot of energy. We, however, need more powerful computers to solve complex or simply large-scale problems in the era of “big data”. Even using huge energy, there exists difficult problems to be solved and, to overcome these issues, researchers are working hard to establish new types of computing such as quantum computing, neuromorphic computing, and other kinds of so-called “natural computing”. In this presentation, I propose the use of complex nanowire networks for future neuromorphic computation.

We prepared inorganic/organic nanowires, i.e., doped poly-aniline nanowires (PANI NWs) and polyvinylpyrrolidone (PVP)-coated sliver nanowires (PVP-Ag NWs), and formed networks of nanowires by spin-coating or drop-casting them onto insulating substrates. Then, we used multiple-probe scanning probe microscope (MP-SPM) [1,2] and related techniques to investigate emerging properties of those nanowire networks. Prepared networks exhibited “small-world” characteristics [3], suggesting that there were multiple ways to topologically and efficiently connect two separated sites in the network. This would be a “motivation” for materials to think “which way is better”. Also, the Ag nanowire network showed interesting behaviour owing to the PVP layer at the interface between Ag nanowires, namely, memory effect and fluctuation behaviour similar to the electrical signal observed for neuron-networks in brain, suggesting that our nanowire networks are “neuromorphic nanowire networks”. We demonstrate that such neuromorphic networks can be used for brain-like signal processing.

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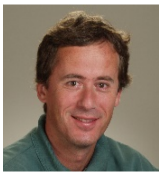

Transparent Organic Optoelectronic Devices Using Near-Infrared Absorbing Dyes

Combining organic semiconductors with discrete absorption and emission bands outside the visible wavelength range with transparent and conductive electrodes allows for the fabrication of visibly transparent organic electronics, such as solar cells (OSCs), photodetectors (OPDs) or organic light-emitting diodes. Such devices enable a manifold of novel and alternative applications in sensors, integrated on-glass electronics or power-generating windows. Transparent electronics is a nascent field of research but the product development is hindered, mainly due to the limited availability of organic semiconducting materials with exclusive spectral response outside the visible. Here, we report on the use of selective near-infrared (NIR) absorbing dyes for the fabrication of visibly transparent and high-performing OSCs and OPDs with an average visible transmittance of over 65%. Recently, we were able to synthesize such dyes with absorption maxima beyond 1100 nm, the silicon band edge. This enables advanced applications, such as organic devices that directly convert NIR light into visible light.

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Materials chemistry controls cellular functions

Living cells are recognized as an ultimate assembly of molecules. As its active matter, a living cell regulates its function by intracellular signalling molecules and communicates to each other by extracellular signalling molecules. We develop porous materials that accommodate important signalling molecules (nitric oxide, carbon monoxide, or glutamic acid) and give materials a chemical trick to release these signalling molecules by external trigger.[1-4] This new type of porous materials is demonstrated to directly regulate the biological activity of living cells. Here we show a synthetic strategy for developing spatiotemporally controllable NO-releasing platforms based on photoactive metal-organic frameworks (MOFs). By organizing molecules with poor reactivity into framework structures of MOFs, we observe increased photoreactivity and adjustable release using light irradiation. We further embed photoactive MOF crystals (NOF-1 = nitric oxide framework-1) in a biocompatible matrix, PDMS, leading to a functional cell culture NOF-1/PDMS substrate, and demonstrate precisely controlled NO delivery at the cellular level via localized two photon laser activation. The biological relevance of the exogenous NO produced by this strategy is evidenced by an intracellular change in calcium concentration, mediated by NO-responsive plasma membrane channel proteins. We further shape photoactive MOF crystals at the mesoscale[5] by coordination modulation[6] and confirm its delivery inside cell and NO stimulation at the subcellular resolution.

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Design of organic-inorganic composite photocatalyst for visible light driven water splitting hydrogen production

Production of hydrogen from water directly using sunlight is a highly desirable, carbon-neutral method. Because water can be split into hydrogen and oxygen by chemical reaction, such as this is via electrolysis, however, the source of energy for electrolysis should be 100% renewable, otherwise the problem of CO_2 production is still an issue. To overcome this issue, hydrogen production using light from the sun is one of the holy grails of hydrogen energy engineering. To using of wide-range of sun-light, we have developed the visible-light driven photocatalyst that composed organic and inorganic materials. In the case of dye-sensitized photocatalyst, which of structure is similar of dye-sensitized solar cell. In generally metal-free dyes of exhibit low hydrogen production efficiency for short charge injection efficiency than metal complex dyes such as N719 (turn over number, TON=300). Our design of metal-free dyes showed higher TON as high as 23557, due to elongate the charge recombination life time. The modification of dye system could improve the catalytic activity over 80h. Furthermore, Z-scheme type of an organic-inorganic composite showed up to 1000 nm of absorption range was covered, and complete water splitting to production of hydrogen which rate exhibited as high as 40 μmolh^{-1} of hydrogen production rate. This hydrogen production rate 5 times faster than without dye system.

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