



MOLECULAR ARCHITECTONICS

Orchestration of Single Molecules for Novel Functions

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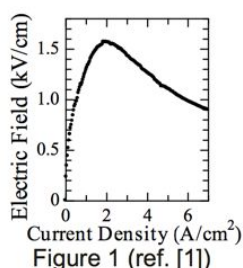
Achievement

A04 Prof. Hideo Kishida

External-field Control of the Charge States in Molecular Aggregates

We have been trying to control the charge states in molecular aggregates. In order to achieve the molecular-level switches, we need to precisely control the molecular states. Possible controllable parameters of the molecular states are not only the structure of the molecules but also the charge state of the molecules. In the aggregated states of molecules, various interactions work and several electronic states can energetically compete, so that several charge states can be achieved. We studied the nonlinear conductivity in a BEDT-TTF complex (Figure 1), which is due to the change of the charge states, and performed optical observations of the nonlinear conducting states at 73 K [1]. In this compound, the negative differential resistance leads to the spontaneous current oscillation with the help of several passive electric components, resistors and a capacitor. Its oscillation period is in the order of several tens of milliseconds or longer. The oscillation is controllable by the parameters of the external circuit. In this Molecular Architectonics project, we found the nonlinear conducting behaviors in another BEDT-TTF complex at a much higher temperature region. In order to realize more desirable molecule-based electric oscillations and pulse generations, we are trying to exploit various nonlinear conducting materials working at high repetition rate and at higher temperatures.

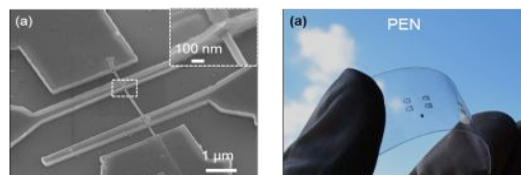
[1] A. Ito *et al.*, Phys. Rev. Lett. **111**, 197801 (2013).



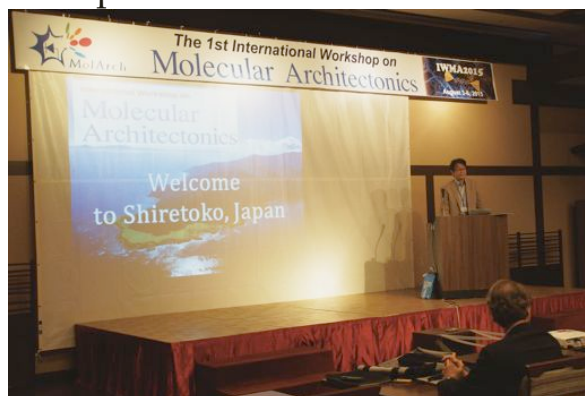
A04 Prof. Takeshi Yanagida

Molecule Sensor using Nanowire Device

Integrating sensors for volatile molecule species into portable electronic devices is strongly desired for the forthcoming sensor network society. However, the high energy consumption (\sim mJ) and high temperature (\sim 300°C) required for operating conventional gas sensors have been bottleneck issues to apply these for CMOS electronics and also emerging wearable electronics. Here we demonstrate a rational sensing methodology, which substantially reduces the energy consumption of gas sensors down to \sim pJ/sec. Our methodology utilizes (1) a pulse self-Joule heating of suspended SnO₂ nanowire device and (2) reduces the short thermal relaxation time down to microseconds. These features allow us to sense volatile molecules at the energy consumption of \sim pJ/sec via heating up only the local sensing part within a short time by applying a pulse voltage. We show the feasibility of the present methodology for sensing NO₂ (100ppb) by applying a pulse voltage down to microseconds. Surprisingly, the sensitivity can be significantly enhanced by utilizing the present pulse method when compared with conventional continuous heating method. Furthermore, we successfully demonstrate the applicability of the present methodology for volatile molecule sensors on flexible PEN substrate.



Report of the 1st International Workshop on Molecular Architectonics



The 1st International Workshop on Molecular Architectonics was held from August 3 to 6, 2015 at Shiretoko, Hokkaido. Shiretoko is a peninsula protruding into the Sea of Okhotsk and is registered as a UNESCO World Heritage Site. This workshop was open for the world-wide attendance. The total number of the attendees is 87 including 12 from abroad. All the attendees stayed at Shiretoko Grand hotel Kita-Kobushi and shared meals together.

The research topics of the oral and poster presenters ranged from the synthetic chemistry, single molecular measurement, nano-fabrication, carrier transport theory and information processes. Through these presentations and discussions, we expanded our perspective of molecular architectonics and even began international collaborations. Here are the comments given by plenary speakers.



The IWMA-2015 in Shiretoko was not a big, but a great conference. It brought together experts working in molecular chemistry and physics and covered important up-to-date topics of molecular electronics, spintronics and quantum information processing. I want to emphasize particularly the sessions on synthesis and properties of new (magnetic) molecules and molecular architectures as well as their application in future devices each introduced by excellent invited overview talks. Further highlights were the plenary talks addressing novel developments in molecular logic and involved energy dissipation as well as a new scanning probe technique for single-spin investigations. Finally I wish to thank the organizers of IWMA-2015 for a stimulating conference atmosphere and permitting marvelous insights into Japanese scenery, cuisine and way of life for the international speakers.

By Prof. R. Koch
Johannes Kepler University Linz



8/3-6, Grand Hotel "Kita-Kobushi", Shiretoko, Hokkaido, Japan



IWMA-2015 was devoted to the fundamental aspects and recent developments of single molecular devices. Prof. Christian Joachim's plenary talk showed their newest quantum-analog molecular computing results "a la Feynmann's dreams". In his plenary talk, Prof. Reinhold Koch's plenary talk showed a new, combined RF and STM method with observing various standing-wave modes in single-molecular structures. In the third plenary talk, limits and yet open fundamental questions, such as the controversial zero-point term in fluctuation dissipation theorem, were featured. Interesting invited talks, regular talks, posters, and social events with warm hospitality represented a great opportunity to learn, brainstorm, get together, and get updated about the field.

By Prof. Laszlo Bela Kish
Texas A&M University



August 3-6th 2015, the Shiretoko International Workshop on Molecular Architectonics (IWMA) was a fantastic occasion to learn on one side about the progresses of LT-UHV-STM experiments on a single molecule trying to access intramolecular functionalities and by extension of break junction experiments on single molecules. On the other side, it was also very important to learn about the progresses towards molecular nanomaterials properties. For electronics and/or magnetic device applications, this distinction between single molecule functioning and nanomaterials properties was also evident during the poster session. With the very important contributions at IWMA Shiretoko of the synthetic chemists, it is precisely at the frontiers between nanomaterials and single molecule where Molecular Architectonics can burgeon for the future developments of Molecular Electronics.

By Prof. C. Joachim
Pico-Lab CEMES CNRS



5th Area Meeting 23-24 April, 2015, Chiba University



The Fifth Area Meeting of Molecular Architectonics was held from April 23 to 24, 2015 at Chiba University. There were about 60 members and students from our area.

All the group leaders described their recent progress in their research work and collaborations via oral or poster presentations. Many promising results were presented. Then we discussed possible collaborations in the future, in particular between A04 and other groups, which is important for Molecular Architectonics. Prof. Fukuyama, Prof. Murai and the new academic investigator, Dr. Katagiri encouraged us in the lead-up to the middle evaluation to be held this October. Finally, we would like to give our deep thanks to Prof. Toyokazu Yamada and the students of his group, who organized and managed this meeting at Chiba University.

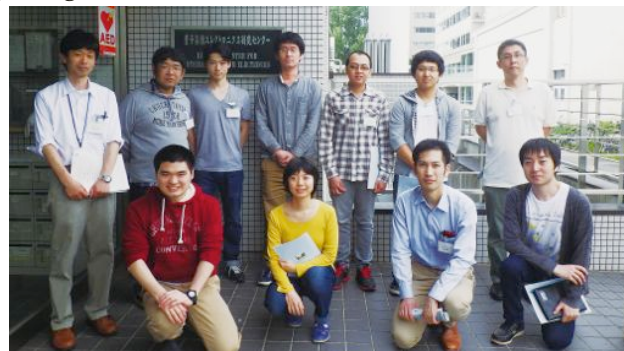


3rd Workshop for Young Researchers 1-2 June, 2015, Hokkaido University



The 3rd Workshop for Young Researchers, attended from approximately 10 students and staffs from our area, was held from June 1 to 2, 2015 at Hokkaido University.

The Field effect transistor (FET) is one of the most essential electric devices and molecular architectonics also aims to create molecular FET. Although the fabrication process of FET is new to synthetic chemists, surface scientists and theorists, its deep understanding is beneficial for collaboration between research groups. In this workshop, participants fabricated FET based on Al under the instruction of Prof. Kasai. They learnt the photolithography technique, thermal deposition of Al and measurement of FET properties. Everyone succeeded in obtaining good FET properties. We also discussed the future plans of the workshops for young researchers.



Next Meeting

Molecular Architectonics Meeting
23-24, October 2015, Kyoto University

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