Joint Studies Programs

As one of the important functions of an inter-university research institute, IMS facilitates joint studies programs for which funds are available to cover the costs of research expenses as well as the travel and accommodation expenses of individuals. Proposals from domestic scientists are reviewed and selected by an interuniversity committee.

(1) Special Projects

A. Development of Polarized Quantum Beam Sources and their Applications to Molecular Science

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KURIKI, Masao (*Hiroshima Univ.*)
TOYOKAWA, Hiroyuki (*AIST*)
KIMURA, Shin-ichi *(Osaka Univ.)*

By using particle accelerator technologies, polarized quantum beams of various kinds can be produced, which can be powerful tools for molecular science. In this joint study program, we have been developing techniques to produce polarized quantum beams and exploring their applications. The major part of the researches has been carried out in the UVSOR facility.

We have succeeded in producing intense circular polarized UV and VUV radiation by using polarization-variable undulators and free electron lasers. We successfully demonstrated that they could be a powerful tool for the investigations on the photon induced chirality on the bio-molecules.[1,2] Towards higher intensity polarized photon beams, we developed a new undulator system called optical klystron and installed it in the ring (Figure 1). The ordinary undulator radiation is useful for experiments that requires wide tunability of the wavelength from UV to VUV but does not require very high intensity. Some experiments on the base metal complexes utilizing these polarized lights have started by the Tokyo Univ. Sci. team. We have successfully demonstrated the generation of coherent VUV radiation by using the undulator and an external laser, based on Coherent Harmonic Generation (CHG) technique. The CHG radiation is also polarization variable and has much higher peak intensity than the ordinary undulator radiation. A combined use of the CHG radiation and coherent terahertz radiation, which is generated simultaneously, is under preparation.

We successfully demonstrated the generation of polarized gamma-rays by using a technique called Laser Compton Scattering (LCS) in collaboration with AIST. Laser photons are injected to the electron beam and are scattered off, and they are converted to gamma-rays via inverse Compton scattering process. The polarity of the gamma-rays can be changed by changing that of the laser photons. We have successfully demonstrated that these gamma-ray photons can be used for the photon-induced positron annihilation lifetime spectroscopy.[3] The possible applications utilizing their polarization are being explored.

In Nagoya University, a polarized electron source has been developed based on an electron gun technology using the GaAs photocathode. The spin polarization higher than 90% has been demonstrated.[4] In collaboration with the Nagoya University team, we have been developing a spin polarized electron source at UVSOR. Some experiments on the chirality of the bio-molecules has been started. An inverse photoelectron spectroscopy system is being developed in collaboration with Osaka University team.

Based on the results on this joint study program, several research projects have started, based on other grants, such as Astrobiology program of CNSI, NINS, Grant-in-Aid for Scientific Research, and so on.

Figure 1. Twin Polarization-variable Undulator System at UVSOR-III.

References

1) J. Takahashi, H. Shinojima, M. Seyama, Y. Ueno, T. Kaneko, K. Kobayashi, H. Mita, M. Adachi, M. Hosaka and M. Katoh, *Int. J. Mol. Sci.* **10**, 3044–3064 (2009).
2) H. Nishino, M. Hosaka, M. Katoh and Y. Inoue, *Chemistry* **19**, 13929–13936 (2013).
3) Y. Taira, H. Toyokawa, R. Kuroda, N. Yamamoto, M. Adachi, S. Tanaka and M. Katoh, *Rev. Sci. Instrum.* **84**, 053305 (2013).
4) N. Yamamoto, X. G. Jin, A. Mano, T. Ujihara, Y. Takeda, S. Okumi, T. Nakanishi, T. Yasue, T. Koshikawa, T. Ohshima, T. Saka and H. Horinaka, *J. Phys.: Conf. Ser.* **298**, 012017 (2011).

B. Development of a Power Delivery IC for Wavelength Selective Organic Solar Cells

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The present project aims at new solar cell system symbiotic with plants. The system uses mainly green-yellow wavelength region, unnecessary for the photosynthesis. One of the research elements is a development of a photocurrent extraction system with a small loss from circuit network connecting the vast number of cells. The system is realized by the Integrated Circuits, based on a new concept, named as a Power Delivery IC (PDIC).

The PDIC block diagram is shown in Figure 1. The voltage drop of the transfer-gate depends on the current flow. But it can be designed to be smaller by enlarging the transistor width. It means that the power of each solar cell can be taken out with little loss in comparison with a conventional one. The transfer-gate goes OFF, when the generated voltage of a cell drops below the reference voltage, preventing the power loss toward the non-active cell. The PDIC also notifies the locations of non-active cells outside, by outputting the memory data. Since the non-active cells are easily detected, they can be replaced in order to sustain whole system performance.

The PDIC was designed, and was fabricated with the 0.18μm CMOS process. The PDIC timing chart is shown in Figure 2, obtained by the actual chip evaluation. Note that the circuits consume the DC power only during the period of activating comparators (MONEN = high.). It is easy to make the PDIC power consumption negligibly small, since the climate changing speed is very slow as an order of second, or even millisecond.

Dye Sensitized Solar Cells (DSSC) are connected to the 4 stage PDIC for power generation system. Figure 3 depicts AC and DC characteristics of the output, PWSUM (power summation). It is shown that in case of 4 active cells, the PWSUM drivability increases and the power is accumulated by PDIC. Actually, because of the performance variation among cells, the total drivability did not exactly equal to 4 times of one cell active case.

The PDIC concept has been successfully verified by evaluating the actual chip. The device concept can be applied not only to DSSC, but also to organic solar cells. In other words, the PDIC, the combination IC of analog & digital circuits and power transistors, enables to accumulate low-density energy source, widely spread over in nature, effectively.

This work is supported by VLSI Design and Education Center, the University of Tokyo in collaboration with Synopsys, Inc., and Cadence Design Systems, Inc.

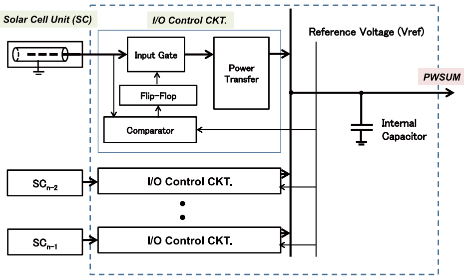


Figure 1. Block Diagram of PDIC. The interface with each Solar Cell is not a conventional blocking diode but a CMOS transfer-gate. The comparator detects whether a cell is active or not, by comparing the generated voltage by a Solar Cell with the reference voltage. The information is stored in the memory, which controls the gate of transfer-gates. The electric power obtained by each active cell is accumulated on the internal capacitor.

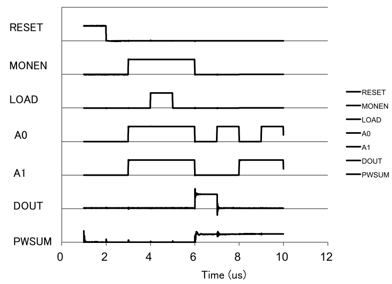
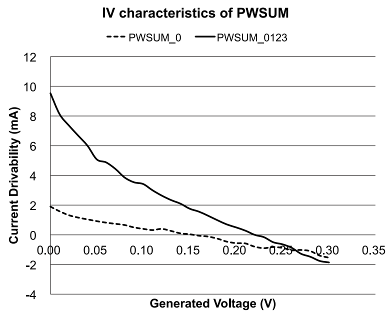


Figure 2. PDIC Timing Chart. At first, the RESET turns all the transfer-gates OFF. Then, the MONEN (Monitor Enable) makes comparator active, and the status of a Solar Cell is loaded in the memory at the LOAD timing. In the Figure, because only one cell is active, DOUT goes high only when the address of the SC, (A0, A1) equals to (0, 0). The accumulated power appears on the PWSUM (Power Summation).

(A)



(B)

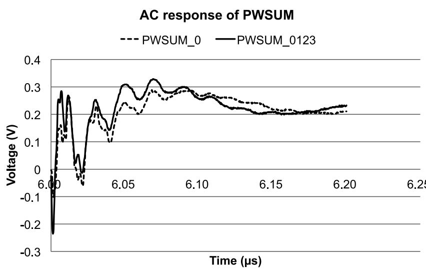


Figure 3. DC (a) and AC (b) Characteristics of PDIC connected to DSSC in both cases of 4 active cells (PWSUM_0123) and just one active cell (PWSUM_0). The PWSUM waveforms correspond to those in Figure 2 between 6 μs and 6.2 μs.

(2) Research Symposia

(From Oct. 2013 to Sep. 2014)

Dates	Theme	Chair
Oct. 3– 4, 2013	Photo-Controllable Electronic Phases in Molecular Conductors	**YAMAMOTO, Hiroshi**
Oct. 25–26, 2013	Future Materials Initiative from π-System Figuration with Multi-Discipline Integration	**ISOBE, Hiroyuki** **SAKURAI, Hidehiro**
Nov. 18–19, 2013	Developing New Ideas Based on the History of Rhodopsin Studies	**IMAMOTO, Yasushi** **FURUTANI, Yuji**
Nov. 25–27, 2013	IMS Asian International Symposium Korea-Japan Seminars on Biomolecular Sciences—Experiments and Simulations	**KATO, Koichi**
Dec. 18–19, 2013	Survey and Perspective of Material Science by Advanced ESR Studies	**OTA, Hitoshi** **NAKAMURA, Toshikazu**
Mar. 12–13, 2014	Structure and Function of Metal Clusters and Coordination Polymers	**NORO, Shin-ichiro** **MURAHASHI, Tetsuro**
Sep. 27, 2014	Molecular Science in the Cell Nucleus	**URISU, Tsuneo** **FURUTANI, Yuji** **SAITO, Shinji**
Jun. 15, 2014	Preparation Meeting for 54th Young Researchers Society for Molecular Science, 2014 Summer School	**FUKUDA, Masahiro** **FURUTANI, Yuji**
Jul. 21–23, 2014	12th ESR Summer School	**TANAKA, Ayaka** **NAKAMURA, Toshikazu**

(3) Numbers of Joint Studies Programs

Categories		Oct. 2013–Mar. 2014		Apr. 2014–Sep. 2014		Total		
		Regular	NanoPlat	Regular	NanoPlat	Regular	NanoPlat	Sum
Special Projects		0		1		1		1
Research Symposia		6		1		7		7
Research Symposia for Young Researchers		0		2		2		2
Cooperative Research		32	24	30	32	62	56	118
Use of Facility	Instrument Center	17	43	14	54	31	97	128
	Equipment Development Center	4	4	3	9	7	13	20
Use of UVSOR Facility		70	30	67	22	137	52	189
Use of Facility Program of the Computer Center						185*		185*

* from April 2013 to March 2014