Materials and Processes for Next-Generation Innovative Devices

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1. Introduction

The JST-PRESTO project "Materials and Processes for Next Generation Innovative Devices" for which I dedicated myself as a Research Supervisor started in 2007 to overcome the limitation of Si CMOS technology and break up a novel paradigm for next-generation device technology, *beyond CMOS*, according to the Strategic Sector given by the Ministry of Education, Sports, Culture and Science (MEXT). The scope of this project involves spintronics materials, wide-gap semiconductors, materials of strongly-correlated system, quantum dots, nano-carbons, and organic materials. The project ended on March, 2013.

2. Achievements

Total of 33 young researchers (average age of 35 years old) have been involved in this project and more than 1656 publications including 339 international journals papers and 195 invited talks in international conferences.

3. Topical Outcomes of the Project

In the following I will focus on a few epoch-making results among these achievements.

E. Saitoh (Tohoku University) succeeded in transferring electric signals through $Y_3Fe_5O_{12}$ (YIG) by using spin waves in the ferrimagnetic insulator [1]. Important point of this finding is that he first showed that spin current can be injected from a metal to an insulator. He also succeeded in converting thermal spin current to voltage in magnetic metals and insulators and named the effect as spin-Seebek effect [2].

T. Fukumura (University of Tokyo) succeeded in voltage control of magnetic properties in a ferromagnetic semiconductor TiO_2:Co, whose Curie temperature is above room temperature [3].

N. Mizuochi (Osaka University) realized a single photon source at room temperature using a diamond LED to excite the NV-center, which is a promising technology for next-generation quantum information communications [4].

M. Takenaka (University of Tokyo) fabricated high performance Ge n-MOSFET and opened up a new-field of Ge CMOS technology [5]. He also succeeded in fabricating a high performance Ge photo-detector for optical interconnection.

K. Tomioka (Hokkaido Univ.) succeeded in fabricating a high performance InAs nanowire/Si hetero-junction tunneling FET with sub-threshold swing value of as low as

21mV/dec, breaking the physical limit of 60mV/dec of conventional FET structure [6].

M. Shiraishi (Osaka University) unambiguously demonstrated for the first time an evidence of injection of spin-polarized electrons into a graphene sheet [7].

K. Hamaya (Kyushu University) succeeded in spin-injection to a non-metallic silicon, which enabled control of spin-injection behaviors by gate voltage [8].

K. Yamamoto (Inst. Molecular Science) realized a high performance phase-change transistors using organic charge-transfer materials [9],

Recently, Takahashi (Univ. Osaka Pref.) obtained promising experimental evidences for realization of Si-Raman laser in Si photonic crystals [10], which will lead to new paradigm of optical interconnection technology.

4. Self-evaluation

The project has been evaluated by the evaluation committee of JST and will be published in the Web site,

Here I evaluate this project as follows: The project is quite successful due to (1) suitable setting of research area by JST and MEXT, (2) suitable selection of active and challenging themes and researchers under strong leadership of the supervisor, (3) an appropriate target setting through an intimate discussion on occasions of site visit of the supervisor, (4) repeated research area meetings and "mini-workshops", which inspire researchers by stimulating discussions.

5. Conclusion

Thus, the PRESTO system is quite different from ordinary funding system such as the Grant-in-Aid from Japan Society for Promotion of Science (JSPS), in which researchers are free from control of managements. The PRESTO is a sort of Virtual Laboratory under the leadership of a supervisor. I am confident that the system is well designed to be quite effective if appropriately operated.

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