【Grant-in-Aid for Specially Promoted Research】
Science and Engineering (Engineering)

Title of Project : Semiconductor Materials and Devices with Nonvolatile and Reconfigurable Functions

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Research Area : Applied materials science/Crystal engineering, Electronic materials
Keyword : spintronics, semiconductor, nonvolatile, reconfigurable

【Purpose and Background of the Research】

Semiconductor based materials with magnetic or spin-related properties can lead to new devices that use not only the charge of electrons and holes but also their spins. Fabricating such new materials and artificial nanostructures has been the fertile ground for novel functionalities, such as spin dependent transport, magnetoresistance, and magneto-optical effects.

For about twenty years, we have been studying ferromagnet / semiconductor heterostructures, III-V based magnetic semiconductor thin films and heterostructures, III-V / MnAs nano-composite structures, and devices using the spin degrees of freedom, including III-V based magnetic tunnel junctions, three terminal devices, spin MOSFETs and reconfigurable logic devices, and single-electron spin-transistors (SEST). In this project, based on these achievements, we aim at creating the following spintronic devices with nonvolatile memory and reconfigurable logic functions.

(1) III-V based magnetic tunnel junctions and heterojunction-type spin transistors
(2) Group-IV semiconductor based MOSFET-type spin transistors (spin MOSFETs)
(3) Magnetic tunnel junctions and single-electron spin transistors containing ferromagnetic nanoparticles.

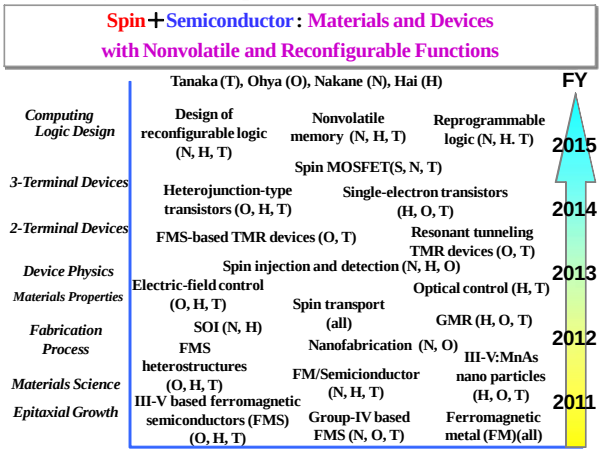

Figure 1 Research plan and schedule

【Research Methods】

Towards the applications to nonvolatile memory and reconfigurable logic, we carry out our research thoroughly from the material fabrication, understanding and control of the properties, physics of spin transport, device fabrication, and logic design. Principal and co-investigators work together following the plan shown in Fig. 1.

【Expected Research Achievements and Scientific Significance】

Spin transistors are potentially applicable to integrated circuits for ultrahigh-density nonvolatile memory whose memory cell is made of a single spin transistor and for nonvolatile reconfigurable logic based on the spin-dependent output of the spin transistors. The new devices and materials studied in this project will be able to give an impact on the future electronics industry.

【Publications Relevant to the Project】

・ M. Tanaka and S. Sugahara, "Metal-Oxide-Semiconductor Based Spin Devices for Reconfigurable Logic", *Invited paper*, IEEE Transactions on Electron Devices Vol. **54**, pp.961-976 (2007).
・Pham Nam Hai, Shinobu Ohya, and Masaaki Tanaka, "Long spin-relaxation time in a single metal nanoparticle", Nature Nanotechnology **5**, pp.593-596 (2010).
・Shinobu Ohya, Kenta Takata, and Masaaki Tanaka, "Nearly non-magnetic valence band of the ferromagnetic semiconductor GaMnAs", Nature Physics **7**, pp.342-347 (2011).

【Term of Project】 FY2011-2015

【Budget Allocation】 414,700 Thousand Yen

【 Homepage Address and Other Contact Information】

http://www.cryst.t.u-tokyo.ac.jp/