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1. Research Highlights

1) Spin filtering effect at ferromagnet/semiconductor interfaces under optical spin orientation

Detection of the spin polarization of electrons in semiconductor is one of the most critical issues to be developed for spintronic devices; a very promising approach is to use spin filtering effect at the ferromagnet/semiconductor interfaces. In this study, we employ optical spin orientation method to excite spin polarized electrons in GaAs or GaAs/AlGaAs quantum wells and spin filtering effect of the spin polarized electrons at Fe₃O₄/GaAs interfaces is investigated in detail. The 10 nm thick Fe₃O₄ layer was grown epitaxially on a very flat GaAs surface which is prepared using molecular beam epitaxy, giving rise to a spin filtering efficiency associated with the negative spin polarization of Fe₃O₄ bulk. The results demonstrate that the spin polarization of 10 nm thick Fe₃O₄ remains negative given a clear interface between Fe₃O₄ and GaAs. Also, the potential of half metallic Fe₃O₄ for spintronic devices is promisingly ensured.

2) Electric control of magnetic domain structures in ferromagnet/ ferroelectric heterostructures

Electric field control of magnetic domain structures is very important technology as an alternative means, instead of the conventional magnetic field control. In this study, our aim is to develop a new approach to control magnetic domain structures in ferromagnet/ferroelectric heterostructures using magnetoelastic effect at the interface. In particular, we studied strain induced variation of magnetic domain structures in Fe dots/BaTiO₃ heterostructures and firstly observed switching between a multidomain structure and a single domain structure by reversing an electric voltage locally applied to BaTiO₃ just underneath Fe dots. The results indicate that magneto-electric effects can open a venue toward electric field control of magnetic domain structures using ferromagnet/ferroelectric heterostructures.

2. Original Articles

E. Wada, K. Watanabe, Y. Shirahata, M. Itoh, M. Yamaguchi, T. Taniyama, "Efficient Spin Injection into GaAs Quantum Well across Fe₃O₄ Spin Filter", *Appl. Phys. Lett.*, **96**(10) (2010) 102510-1-3.

T. Obata, M. Pioro-Ladrière, Y. Tokura, Y.-S. Shin, T. Kubo, K. Yoshida, T. Taniyama, and S. Tarucha, "Coherent Manipulation of Individual Electron Spin in a Double Quantum Dot Integrated with a Micromagnet", *Phys. Rev. B* **81**(8) (2010) 085317-1-5.

T. Obata, M. Pioro-Ladriere, Y. Tokura, R. Brunner, Y.-S. Shin, T. Kubo, K. Yoshida, T. Taniyama, and S. Tarucha, "Selective Addressing of Single Electron Spins in a Semiconductor Double Quantum Dot Integrated with a Micro-magnet", *AIP Conf. Proc.* **1199** (2010) 381-382.

K. Hamaya, M. Kitabatake, K. Shibata, M. Jung, S. Ishida, T. Taniyama, K. Hirakawa, Y. Arakawa, and T. Machida, "Spin-Related Current Suppression in a Semiconductor-Quantum-Dot Spin-Diode Structure", *Phys. Rev. Lett.* **102**(23) (2009) 236806-1-4.

K. Hamaya, H. Itoh, O. Nakatsuka, K. Ueda, K. Yamamoto, M. Itakura, T. Taniyama, T. Ono, and M. Miyao, "Ferromagnetism and Electronic Structures of Nonstoichiometric Heusler-Alloy Fe_{3-x}Mn_xSi Epilayers Grown on Ge(111)", *Phys. Rev. Lett.* **102**(13) (2009) 137204-1-4.

Z. He, M.-H. Wangbo, Y. Ueda, Y. Narumi, K. Kindo, T. Taniyama, M. Itoh, and W. Cheng, "Synthesis and Magnetic Properties of $\text{Ba}_2\text{Mn}_2\text{Si}_2\text{O}_9$: the First Example of $S = 2$ Spin-Dimer with Spin-Singlet Ground State", *Chemistry-An Asian Journal* **4**(10) (2009) 1530-1535.

I. Suzuki, T. Koike, M. Itoh, T. Taniyama, and T. Sato, "Stability of Ferromagnetic State of Epitaxially Grown Ordered FeRh Thin Films", *J. Appl. Phys.* **105**(7) (2009) 07E501-1-3.

T. Taniyama, K. Akasaka, D. Fu, and M. Itoh, "Artificially Controlled Magnetic Domain Structures in Ferromagnetic Dots/Ferroelectric Heterostructures", *J. Appl. Phys.* **105**(7) (2009) 07D901-1-3.

H. Sakuma, H. Kawano, K. Ishii, and T. Taniyama, "Low-temperature Ordering in FePt Films Deposited by Gas Flow Sputtering", *Trans. Magn. Soc. Jpn.* **33**(3) (2009) 167-170.

E. Wada, M. Itoh, T. Taniyama, and Y. Yamaguchi, "Spin Polarization of Electrons Injected from Fe into GaAs Quantum Well Characterized using Oblique Hanle Effect", *Mater. Res. Soc. Symp. Proc.* **1183** (2009) 1183-FF06-05-1-6.

T. Obata, M. Pioro-Ladrière, Y. Tokura, R. Brunner, Y.-S. Shin, T. Kubo, K. Yoshida, T. Taniyama, and S. Tarucha, "Dynamical Polarization Effect of Nuclear Spin Bath Dragged by Electron Spin Resonance in Double Quantum Dot Integrated with Micro-magnet", *J. Phys.: Conf. Ser.* **193**(1) (2009) 012046-1-4.

S. Kimura, T. Takeuchi, M. Hagiwara, K. Okunishi, Z. He, T. Taniyama, and M. Itoh, "Low Temperature Magnetism of the $S = 1/2$ Quasi One-dimensional Ising-like Antiferromagnet $\text{BaCo}_2\text{V}_2\text{O}_8$ ", *J. Phys.: Conf. Ser.* **150**(4) (2009) 042090-1-4.

3. Books

Nanoscale Physics for Materials Science

T. Tsurumi, H. Hirayama, M. Vach, and T. Taniyama

CRS Press (Taylor & Francis), 2009

4. Conference presentations

International Conference

T. Taniyama, M. Itoh, P. Sharma, H. Kimura and A. Inoue, "Strain Driven Spin Reorientation Transition in Glassy Ferromagnet/Ferroelectric Heterostructures", The Third International Conference on the Characterization and Control of Interfaces for High Quality Advanced Materials, and Joining Technology for New Metallic Glasses and Inorganic Materials (ICCCI2009) (Kurashiki, Japan)

T. Shimizu, T. Era, H. Taniguchi, D. Fu, T. Taniyama, and M. Itoh, "Phonon Dynamics in BiFeO_3 studied by Raman Scattering", 12th International Meeting on Ferroelectricity and 18th IEEE International Symposium on Applications of Ferroelectrics (IMF-ISAF-2009) (Xi'an, China)

T. Obata, R. Brunner, M. Pioro-Ladrière, Y. Tokura, T. Obata, Y.-S. Shin, T. Kubo, K. Yoshida, T. Taniyama, S. Tarucha, "Dynamical Polarization Effect of Nuclear Spin Bath Dragged by Electron Spin Resonance in Double Quantum Dot Integrated with Micro-Magnet", 16th International Conference on Electron Dynamics In Semiconductors, Optoelectronics and Nanostructures (EDISON16) (Montpellier, France)

E. Wada, K. Watanabe, Y. Shirahata, M. Itoh, T. Taniyama, M. Yamaguchi, "Spin Injection into a GaAs Quantum Well through an Fe_3O_4 Epilayer", International Conference on Magnetism (ICM 2009) (Kalsruhe, Germany)

T. Taniyama, M. Itoh, P. Sharma, H. Kimura, A. Inoue, "Spin Reorientation Transition in Glassy Ferromagnet/Ferroelectric Heterostructures", International Conference on Magnetism (ICM 2009) (Klsruhe, Germany)

M. Pioro-Ladrière, R. Brunner, Y. Tokura, T. Obata, Y.-S. Shin, T. Kubo, K. Yoshida, T. Taniyama, and S. Tarucha, "Manipulating single electron spins with micro-magnets", The 18th International Conference on Electronic Properties of Two-Dimensional Systems (EP2DS-18) (Kobe, Japan)

R. Brunner, M. Pioro-Ladrière, Y. Tokura, T. Obata, Y.-S. Shin, T. Kubo, K. Yoshida, T. Taniyama, S. Tarucha, "Coherent Single Electron Manipulation in a Double Quantum Dot Specially Designed for Scalable Qubits", The 18th International Conference on Electronic Properties of Two-Dimensional Systems (EP2DS-18) (Kobe, Japan)

T. Takakura, M. Pioro-Ladrière, T. Obata, Y. -S. Shin, R. Brunner, K. Yoshida, T. Taniyama, S. Tarucha, "Triple Quantum Dots with Micro-Magnets for Implementing Three Spin Qubits", The 18th International Conference on Electronic Properties of Two-Dimensional Systems (EP2DS-18) (Kobe, Japan)

E. Wada, K. Watanabe, Y. Shirahata, M. Itoh, T. Taniyama, and M. Yamaguchi, "Temperature Dependence of Spin Injection Efficiency in Fe₃O₄/GaAs Quantum Well Heterostructures", The Third International Conference on the Science and Technology for Advanced Ceramics (STAC-3) (Yokohama, Japan)

I. Suzuki, T. Koike, M. Itoh, and T. Taniyama, "Magnetoelectric Properties of Epitaxially Grown Ordered FeRh Thin Films on MgO (001) Substrates", The Third International Conference on the Science and Technology for Advanced Ceramics (STAC-3) (Yokohama, Japan)

K. Yoshino, A. Nagaoka, Y. Shirahata, and T. Taniyama, "Optical and Magnetic Characterization of Mn-doped AgGaSe₂ Alloys Grown by Hot-press Method", The Third International Conference on the Science and Technology for Advanced Ceramics (STAC-3) (Yokohama, Japan)

T. Taniyama, M. Itoh, P. Sharma, H. Kimura, A. Inoue, "Imaging of the Evolution of Spin Reorientation Transition in a Glassy Co-Fe-Ta-B Film", 2009 MRS Spring Meeting (San Francisco, USA)

T. Taniyama, K. Akasaka, D. Fu, M. Itoh, "Magnetic Anisotropy of Artificial Multiferroic Fe layer/BaTiO₃ Heterostructure", 2009 MRS Spring Meeting (San Francisco, USA)

E. Wada, M. Itoh, T. Taniyama, M. Yamaguchi, "Spin Polarization of Electrons Injected from Fe into GaAs Quantum Well Characterized Using Oblique Hanle Effect", 2009 MRS Spring Meeting (San Francisco, USA)

T. Obata, M. Pioro-Ladrière, Y. Tokura, R. Brunner, Y.-S. Shin, T. Kubo, K. Yoshida, T. Taniyama, and S. Tarucha, "Dynamical Polarization Effect of Nuclear Spin Bath Dragged by Electron Spin Resonance in Double Quantum Dot Integrated with Micro-Magnet", International Symposium on Nanoscience and Quantum Physics (nanoPHYS'09) (Tokyo, Japan)