

Tomoyasu TANIYAMA, Prof.

Department of Materials Science and Engineering

1. Main Research Results

1) Spin injection into semiconductor quantum wells and circular polarization analysis of light emission

Spin injection is one of the most critical issues to be developed for spintronic devices. In this study, spin injection from half-metallic Fe_3O_4 into a GaAs quantum well is done and circular polarization of light emission due to the recombination of spin polarized electrons and holes in the well is analyzed. As a result, we have observed a circular polarization of 30% at 10 K in a magnetic field of 3 T, which is the largest value reported for half-metallic spin sources so far. Also, the circular polarization decreases with increasing temperature and becomes constant at 6% above 100K which corresponds to the Verwey transition temperature. Therefore, the large circular polarization is associated with the metal-insulator transition at the Verwey transition, giving rise to a different mechanism of spin transport at the $\text{Fe}_3\text{O}_4/\text{GaAs}$ interface. These combined results suggest that Fe_3O_4 is one of the most promising candidates for spin injectors to be incorporated in spintronic devices.

2) Correlation between magnetic anisotropy and interfacial stress 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 spin reorientation transition in $\text{CoFeTaB}/\text{BaTiO}_3$ heterostructures and firstly observed spin reorientation transition at the structural phase transition temperature of BaTiO_3 , i.e., the magnetic easy axis switches from out-of-plane to in-plane at 280 K due to the stress occurred at the interface. The results indicate that magneto-electric effects can open a venue toward electric field control of magnetic domain structures using ferromagnet/ferroelectric heterostructures.

2. List of publications (original article, comment/book)

1) Original Paper

- (1) T. Taniyama, K. Akasaka, D. Fu, M. Itoh, "Artificially controlled magnetic domain structures in ferromagnetic dots/ferroelectric heterostructures", *J. Appl. Phys.* 105(7) (2009) 07D901-1-3.
- (2) I. Suzuki, T. Koike, M. Itoh, T. Taniyama, T. Sato : , "Stability of ferromagnetic state of epitaxially grown ordered FeRh thin films", *J. Appl. Phys.* 105(7) (2009) 07E501-1-3.
- (3) K. Hamaya, M. Kitabatake, K. Shibata, M. Jung, M. Kawamura, S. Ishida, T. Taniyama, K. Hirakawa , Y. Arakawa, and T. Machida, "Tunneling magnetoresistance effect in a few-electron quantum-dot spin valve", *Appl. Phys. Lett.* 93(22) (2008) 222107-1-3.

- (4) M. Pioro-Ladrière, T. Obata, Y. Tokura, Y. S. Shin, T. Kubo, K. Yoshida, T. Taniyama and S. Tarucha, "Selective manipulation of electron spins with electric fields", *Prog. Theor. Phys. Suppl.*, 176 (2008) 322-340.
- (5) D. Fu, H. Taniguchi, T. Taniyama, M. Itoh, and S. Koshihara, "Reply to comment on ``Origin of giant dielectric response in nonferroelectric $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$: inhomogeneous conduction nature probed by atomic force microscopy", *Chem. Mater.* 20(19) (2008) 6286-6287.
- (6) S. Kimura, M. Matsuda, T. Masuda, S. Hondo, K. Kaneko, N. Metoki, M. Hagiwara, T. Takeuchi, K. Okunishi, Z. He, K. Kindo, T. Taniyama, and M. Itoh, "Longitudinal spin density wave order in a quasi-1D Ising-like quantum antiferromagnet", *Phys. Rev. Lett.* 101(20) (2008) 207201-1-4.
- (7) M. Pioro-Ladrière, T. Obata, Y. Tokura, Y.-S. Shin, T. Kubo, K. Yoshida, T. Taniyama, S. Tarucha, "Electrically driven single electron spin resonance in a slanting Zeeman field", *Nature Phys.* 4(10) (2008) 776-779.
- (8) D. Fu, M. Endo, H. Taniguchi, T. Taniyama, and M. Itoh, "Piezoelectric properties of lithium modified silver niobate perovskite single crystals", *Appl. Phys. Lett.* 92(17) (2008) 172905-1-3.
- (9) S. Ray, P. Mahadevan, S. Mandal, C. S. Kuroda, T. Sasaki, T. Taniyama, and M. Itoh, "High Temperature Ferromagnetism in Single Crystal Dilute Magnetic Oxide: An Intriguing Story of Intrinsic Disorder and Magnetism in Fe-doped BaTiO_3 ", *Phys. Rev. B* 77(10) (2008) 104416-1-6.
- (10) K. Hamaya, M. Kitabatake, K. Shibata, M. Jung, M. Kawamura, S. Ishida, T. Taniyama, K. Hirakawa, Y. Arakawa, T. Machida, "Oscillatory changes in the tunneling magnetoresistance effect in semiconductor quantum-dot spin valves", *Phys. Rev. B* 77(8) (2008) 081302(R)-1-4.
- (11) D. Fu, H. Taniguchi, T. Taniyama, M. Itoh, and S. Koshihara, "Origin of giant dielectric response in nonferroelectric $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$: Inhomogeneous conduction nature probed by atomic force microscopy", *Chem. Mater.* 20(5) (2008) 1694-1698.
- (12) S. Kimura, T. Tekeuchi, K. Okunishi, M. Hagiwara, Z. He, K. Kindo, T. Taniyama, and M. Itoh, "Novel ordering of an $S=1/2$ quasi one-dimensional Ising-like antiferromagnet in magnetic field", *Phys. Rev. Lett.* 100(5) (2008) 057202-1-4.
- (13) T. Taniyama, T. Mori, K. Watanabe, E. Wada, M. Itoh, H. Yanagihara, "Optically spin oriented electron transmission across fully epitaxial $\text{Fe}_3\text{O}_4/\text{GaAs}(001)$ interfaces", *J Appl. Phys.* 103(7) (2008) 07D705-1-3.
- (14) E. Wada, M. Itoh, and T. Taniyama, "Crossover of electron transmission mechanism and spin filtering effect at $\text{Fe}/\text{GaAs}(001)$ interfaces", *J Appl. Phys.* 103(7) (2008) 07A702-1-3.
- (15) K. Seki, H. Kura, T. Sato, and T. Taniyama, "Size dependence of martensite transformation temperature in ferromagnetic shape memory alloy FePd ", *J Appl. Phys.* 103(6) (2008) 063910-1-9.
- (16) K. Yoshino, A. Kinoshita, Y. Shirahata, and T. Taniyama, "Carrier induced magnetic anomalies in Mn-doped AgGaSe_2 magnetic semiconductor", *J Appl. Phys.* 103(7) (2008) 07D103-1-3.
- (17) K. Yoshino, S. Oyama, M. Yoneta, and T. Taniyama, "Structural and magnetic characterization of Mn-doped ZnO films grown by spray pyrolysis method", *Mater. Sci. & Eng. B* 148(1-3) (2008) 234-236.

3. Invited/Plenary Talks in Conference

1) International Conference or Workshop

- (1) 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) (口頭発表)
- (2) T. Taniyama, K. Akasaka, D. Fu, M. Itoh, P. Sharma, H. Kimura and A. Inoue, “Effect of Interfacial Strain on Magnetism of Ferromagnetic Metal/Ferroelectric Oxide Heterostructures”, The IUMRS International Conference in Asia 2008 (IUMRS-ICA2008) (Nagoya, Japan) (招待講演)
- (3) M. Cho, H. Takashima, H. Tetsuka, K. Ikegami, Y. Inaguma, N. Miura, T. Ebina, T. Taniyama and M. Itoh, “Photoluminescence of Epitaxial of $\text{SrTiO}_3:(\text{Pr},\text{Al})$ Thin Films”, The IUMRS International Conference in Asia 2008 (IUMRS-ICA2008) (Nagoya, Japan) (口頭発表)
- (4) T. Taniyama, K. Akasaka, D. Fu, and M. Itoh, “Artificially Controlled Magnetic Domain Structures in Ferromagnetic Dots/Ferroelectric Heterostructures”, 53rd Annual Conference on Magnetism and Magnetic Materials (MMM2008) (Austin, Texas, USA) (ポスター発表)
- (5) I. Suzuki, T. Koike, M. Itoh, and T. Taniyama, “Stability of Ferromagnetic State of Epitaxially Grown Ordered FeRh Thin Films”, 53rd Annual Conference on Magnetism and Magnetic Materials (MMM2008) (Austin, Texas, USA) (ポスター発表)
- (6) D. Fu, M. Endo, H. Taniguchi, T. Taniyama, S. -Y. Koshihara, and M. Itoh, “Piezoelectric Properties of Silver-Based Perovskite $\text{Ag}(\text{Li},\text{Nb})\text{O}_3$ ”, The 6th Asian Meeting on Ferroelectrics (AMF-6) (Taipei, Taiwan) (口頭発表)
- (7) T. Obata, M. Pioro-Ladrière, Y. Tokura, 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”, The International Conference on the Physics of Semiconductors (Rio de Janeiro, Brazil) (口頭発表)
- (8) Tomoyasu Taniyama, Kyohei Akasaka, Desheng Fu, and Mitsuru Itoh, “Strain Induced Magnetization Switching of Fe/BaTiO_3 (001) Heterostructures”, Joint Conference of The 2nd International Conference on the Science and Technology for Advanced Ceramics (STAC) and The 1st International Conference on Science and Technology of Solid Surface and Interface (STSI) (Chiba, Japan) (口頭発表)

2) Domestic Conferences

18 presentations at the domestic conference