2018年度　提案書（Web公開用）　　作成者：　温振超（東北大CSRN）

研究プロジェクト名：　Voltage control of magnetic anisotropy in spintronic heterostructures (スピントロニクヘテロ構造における磁気異方性の電圧制御に関する研究)

概要：　Voltage or electric field control of magnetic anisotropy in spintronic heterostructures is a promising technology for achieving energy-efficient spintronic devices. In this research, we will study the electric effect in magnetic heterostructures fabricated by engineering materials and interfaces for the purpose of enhancing performance of spintronic devices.

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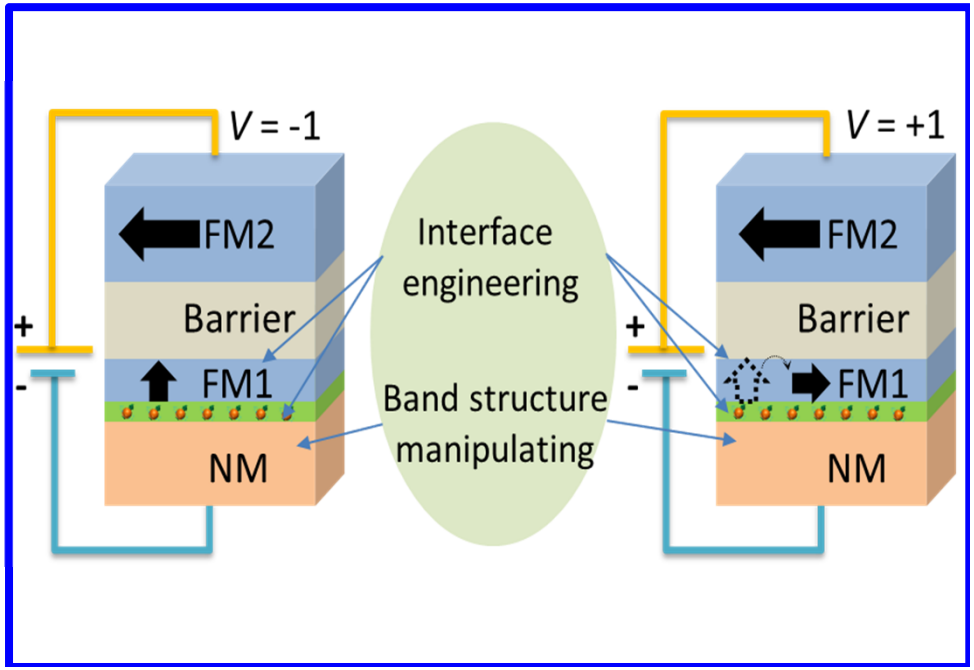
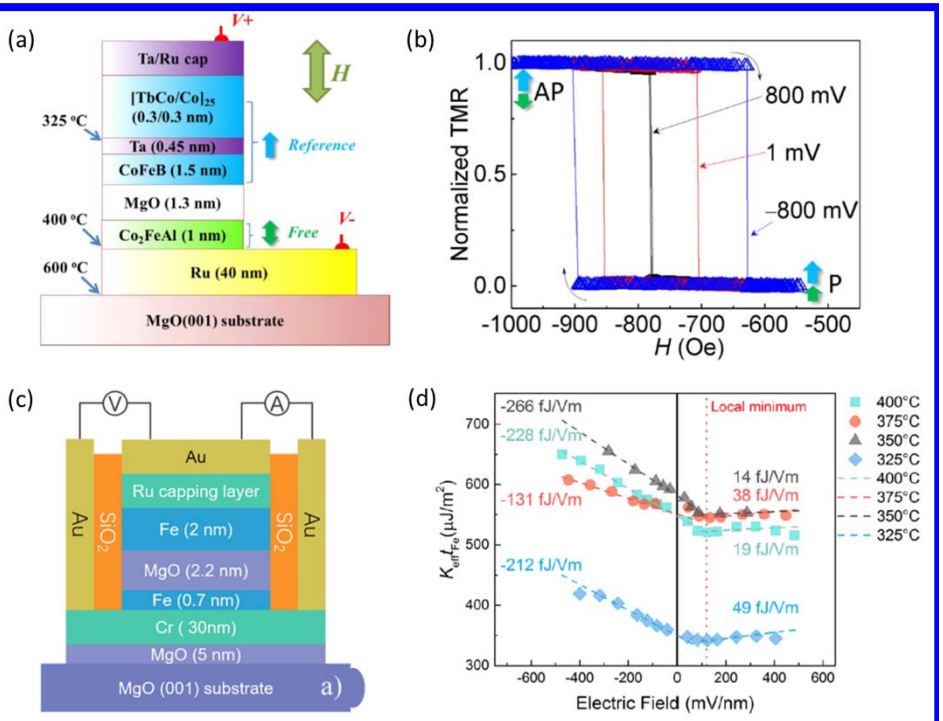
期待される研究成果：　Spintronic devices with the structure of normal metal (NM)/ferromagnet (FM)/Barrier/FM will be investigated, as shown in the illustration. When a voltage is applied, the magnetic anisotropy of the FM layer will be changed. By engineering materials and interfaces in the structure, the electronic band structures and spin-orbit interactions can be manipulated. In a well-designed heterostructure, a large voltage or electric field effect on the magnetic anisotropy of FM layers could be expected.



研究プロジェクト名：　Voltage control of magnetic anisotropy in magnetic heterostructures (磁気ヘテロ構造における磁気異方性の電圧制御に関する研究)

概要：Voltage control of magnetic anisotropy (VCMA) in magnetic heterostructures is one of key technologies for achieving energy-efficiency electronic devices. Here, we report the first demonstration of the VCMA effect in epitaxial Ru/Co_2FeAl (CFA)/MgO heterostructures. A VCMA coefficient of 108 fJ/Vm for the CFA film was achieved at room temperature (RT). Also, the VCMA was studied in an ultrathin Fe(001) monocrystalline layer sandwiched between Cr and MgO. A large coefficient of the electric field effect of more than 200 fJ/Vm was observed for the Fe layer at RT.

研究成果（実施状況）：Perpendicularly magnetized tunnel junctions with the structure of Ru/CFA/MgO were fabricated, as illustrated in Fig. (a). An effective voltage control on switching fields for the CFA layer was observed in Fig. (b). The interfacial stability was confirmed and the temperature dependence of the VCMA was investigated. Furthermore, the VCMA was studied in the structure of Cr/Fe/MgO as shown in Fig. (c). A large coefficient of VCMA of more than 200 fJ/Vm was achieved in Fig. (d). Interestingly, nonlinear behavior was found in the electric field dependence, being independent of post-annealing and measurement temperatures. The studies contribute to the progress in applications and theoretical studies on VCMA-based spintronic devices.

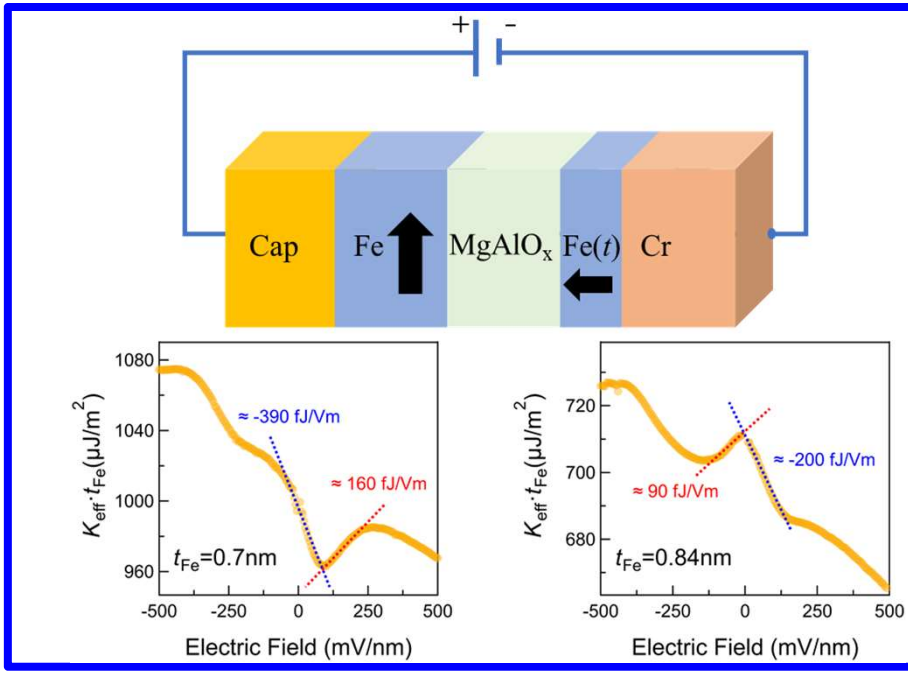


主要発表論文等：[1] Z. Wen et al., Sci. Rep. 7, 45026 (2017).
[2] Q. Xiang, Z. Wen et al., J. Phys. D: Appl. Phys. 50, 40LT04 (2017).

研究プロジェクト名：　Voltage control of magnetic anisotropy in spintronic heterostructures (スピントロニクヘテロ構造における磁気異方性の電圧制御に関する研究)

概要： Voltage control of magnetic anisotropy (VCMA) is a promising technology for achieving energy-efficient spintronic devices. In this work, we studied the VCMA effect in Cr/Fe/$MgAlO_x$ magnetic heterostructures fabricated by molecular beam epitaxy (MBE). Distinct VCMA effects were observed as a function of Fe thickness, which could be attributed to electronic structures in the heterostructure. This work may contribute to develop further large VCMA effect for spintronic devices.

研究成果（実施状況）： Voltage control of magnetic anisotropy (VCMA) in spintronic heterostructures with the structure of Cr/Fe/$MgAlO_x$/Fe was investigated, as shown in the illustration. A large VCMA effect with the maximum coefficient of -390 fJ/Vm was achieved at t_{Fe} = 0.7 nm. It is also found that the sign of VCMA effect strongly depends on the thickness of bottom Fe layer, as shown in the figures. The mechanism could be the difference in electronic structures in the heterostructure. Detailed analysis and understanding could be important for the development of further large VCMA effect.



主要発表論文等： [1] Z. Wen *et al.*, Adv. Electron. Mater. 3, 1700367 (2018).
[2] Z. Wen et al., arXiv:1902.07406