2020年度　提案書（**Web公開用**）

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研究プロジェクト名：　Influence on antiferromagnet/ferromagnet heterostructures properties on memristive switching.

概要：　We propose to study spin-orbit torque (SOT) switching in antiferromagnet/ferromagnet (AFM/FM) heterostructures, which has non-volatile analogue-like properties. We have already visualized the switching in the FM layer as well as AFM domains by means of photoemission electron microscopy (PEEM) coupled with x-ray magnetic circular and linear dichroism (XMCD and XMLD). The experiments were performed at the Diamond Light Source synchrotron in collaboration with Prof. Gambardella's group of ETH. A paper with the results is being prepared for submission. In continuation of this collaboration we plan to reveal dependence of switching on the stack structure (thicknesses of the layers) and explain it with micromagnetic simulations in Mumax3. Such an approach will explain how and why exchange bias, anisotropy, saturation magnetization of the stack influence the switching process and show a path towards its optimization for practical applications.

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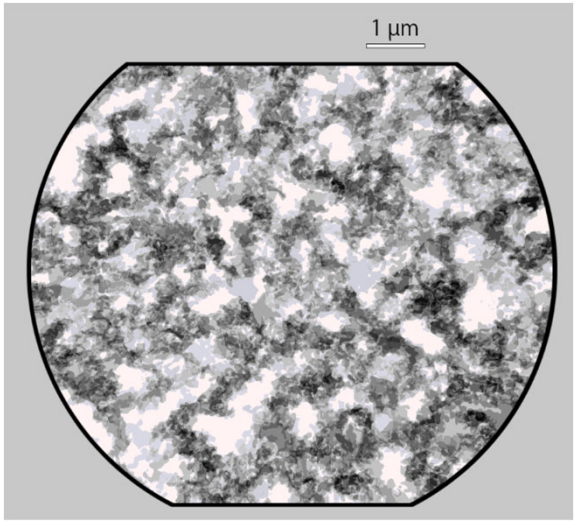
期待される研究成果：Results of this study will improve fundamental understanding of exchange bias and SOT switching and allow tuning of memristive switching in AFM/FM devices for specific needs. Combination of experimental PEEM XMCD/XMLD methods and numerical simulations allows clarifying details of the system which are below time or space resolution of any experimental method. Therefore we expect to obtain valuable information about switching dynamics in the studied material system at the nanoscale.

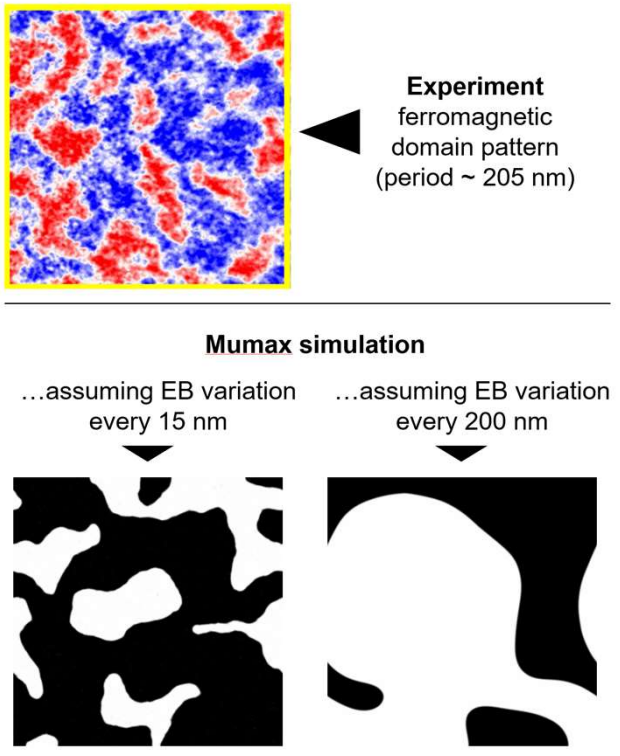


Composite image of ferromagnetic domains in PtMn/[Co/Ni] bilayer, prepared by overlaying several XMCD images. Illustrates switching properties of different FM regions.

研究プロジェクト名：　Influence on antiferromagnet/ferromagnet heterostructures properties on memristive switching

概要：　This research aims to explain the unusual mechanism of spin-orbit torque (SOT) switching in antiferromagnet/ferromagnet (AFM/FM) heterostructures. Its main features are reproducible “memristive” behavior and fine scale of domain patterns, which is not typical for FM or heavy metal/FM stacks.

研究成果（実施状況）：Previously, we explained field-free SOT switching in AFM/FM by exchange bias (EB). We also proved that the EB changes locally at 200 nm or smaller scale. Here, by means of x-ray magnetic circular and linear dichroism, and micromagnetic simulations in Mumax, we show that the actual scale of EB variation is most probably considerably smaller than FM domain size. This can be explained by the polycrystalline structure of the AFM PtMn. Transmission electron microscopy measurements show that the crystallites of AFM are around 15 nm in diameter and X-ray diffraction shows their disordered (111) orientation. Considering that spin structure in an AFM depends on its crystalline structure, these results suggest variation of Neel vector (and thus EB) at the crystalline scale i.e. ~15 nm. Combining these results in a micromagnetic simulation and comparing it to the experiment (see Figure on the right), we conclude that polycrystalline structure of the stack is the source of memristive behavior and that the latter can be tuned by addressing the crystallographic properties of the devices.



主要発表論文等：[1] G. K. Krishnaswamy, A. Kurenkov et al., Phys. Rev. Appl. 14, 044036 (2020).