【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Interdisciplinary Science and Engineering)

Title of Project : Microscopic understanding of interface spin-orbit coupling and development of perpendicular magnetic anisotropy devices

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Research Area : Applied Physics
Keyword : Spintronics, Magnetism, Surface & Interface, Ultrathin film, Spin-Orbit Coupling

【Purpose and Background of the Research】

Spin-orbit coupling (SOC) at the interfaces of magnetic heterostructures is the physical origin of interface perpendicular magnetic anisotropy that is indispensable for next generation magnetic memory technologies. It is also important for the new research fields such as electric field control of magnetism and the so-called spin-orbitronics. However, there remains a serious problem that microscopic understanding is lacking in interface SOC. As a result, there are a lot of difficulties in designing materials and predicting properties in these research fields.

In this study, we are aiming at understanding the microscopic mechanisms of interface SOC, via systematic studies in which sample preparation of atomically controlled magnetic heterostructures, spectroscopic analyses based on photoemission and XMCD, and first-principles calculations (for site-resolved spin and orbital states etc.) are combined. Our interests are also on effect of Rashba SOI in the magnetic heterostructures and novel methods to elucidate orbital states. One of the final targets is to achieve giant interface perpendicular magnetic anisotropy and its new functionalities.

【Research Methods】

An important point of this study is to make "model" heterostructures that enable us to directly compare the experimental results with the first-principles calculations. For this purpose, we employ the epitaxial growth and monoatomic layer control techniques that have been accumulated in our previous research activities.

Photoemission spectroscopy and XMCD meas-urements are mainly performed as a microscopic analysis, and we also attempt to develop a new method to determine orbital states in materials.

In first-principles calculations, atomic site-dependent spin and orbital states are analyzed for obtaining microscopic understanding of interface SOI. Further, material design and functionality prediction will also be performed.

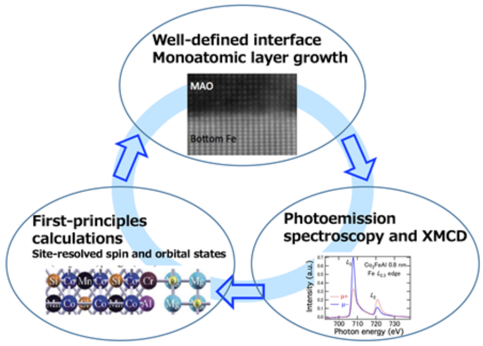

Fig. 1. Method of the study.

【Expected Research Achievements and Scientific Significance】

Understanding of the microscopic mechanisms of interface SOC is expected to obtain sufficiently. It contributes to the progress of related new and important fields. We also expect to attain giant magnetic anisotropy and its sensor/memory devices.

【Publications Relevant to the Project】

- J. W. Koo et al., "Large perpendicular magnetic anisotropy at Fe/MgO interfaces", Appl. Phys. Lett. **103**, 192401 (2013):
- J. Okabayashi et al., "Perpendicular magnetic anisotropy at the interface between ultrathin Fe film and MgO studied by angular-dependent X-ray magnetic circular dichroism", Appl. Phys. Lett. **105**, 122408 (2014):
- Y. Miura et al., "A first-principles study on magnetocrystalline anisotropy at interfaces of Fe with non-magnetic metals", J. Appl. Phys. **113**, 233908 (2013).

【Term of Project】 FY2016-2020

【Budget Allocation】 145,000 Thousand Yen

【Homepage Address and Other Contact Information】

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