Project No. 02415

Report form of Joint Research Project at ZAIKEN (FY2024)

Title of Project	Doped alloys and halide perovskites for multifunctional applications		
Priority Area	III-B(Energy saving & Structures), III-C(Energy saving & Properties)		
	Continuation of FY2023		
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Institution	Vietnam National University, University of Engineering and Technology	**title**	Professor

Aim of the research project

The aim of this project is to develop new materials with advanced properties applicable in the field of 4R (Reduce, Reuse, Recycle, Replace) & Energy saving, as outlined below:

(1) Materials preparation:

- The new materials will be prepared using heavy ion implantation technique provided by a Pelletron 5SDH-2 Linear Accelerator and solution-based processes recently installed at the Vietnam National University.

(2) Materials characterization:

- Characterization will be carried out at Waseda university, Tokyo, Japan. Specifically, structural, optical and magnetic properties will be analyzed using: X-ray diffraction, Raman and IR spectroscopy, and Superconducting Quantum Interference Device (SQUID) measurements. The materials under investigation include gold alloys, rare-earth $LaFe_{13}$ type alloys, and/or doped halide perovskite crystals.

The expected outcomes include (4R & Energy saving):

- Changes in the structure and properties of materials under various experimental factors are expected to contribute to advanced management techniques of environmental pollution, reduced energy consumption, energy saving and generation.

Contents and results of the research

According to the research plan specified in this research proposal, we have carried out the following materials preparation and characterization:

(1) Thin films of gold (Au) were prepared using mechanical lamination technique, and vacuum sputtering techniques on quartz substrates, and subsequently ion-implanted using a Pelletron 5SDH-2 linear accelerator at an ion energy of 830 keV (at Vietnam National University). The implanted ions include hydrogen (atomic H), hydrogen (H) plus atomic oxygen (O), tin (Sn), copper (Cu), aluminum (Al) and lanthanum (La).

(2) The structural characterization (X-ray diffraction measurements), the optical characterization (UV-Vis, IR and Raman) and the magnetic measurements (VSM and SQUID) (at Waseda University).

Along with experimental works, we have also studied the physics of observed phenomena by theoretical simulations by using ab initio techniques.

The typical results are shown in two figures below. Fig.1 shows the responses of the pure Au, and the H-implanted samples in the magnetic field. Fig. 2 compares the magnetization of the pure Au and the doped (H, O) one.

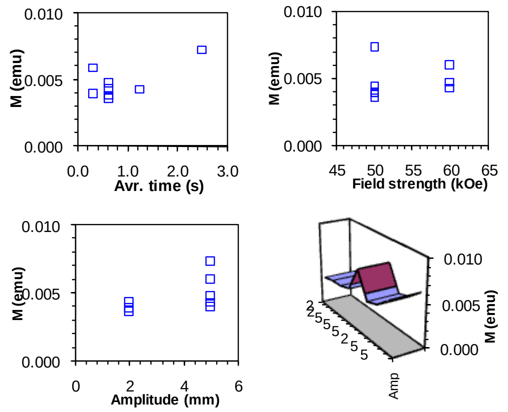

Fig. 1 Magnetization of pure Au (left) and Au:H (right) samples under various experimental conditions including the applied field strength

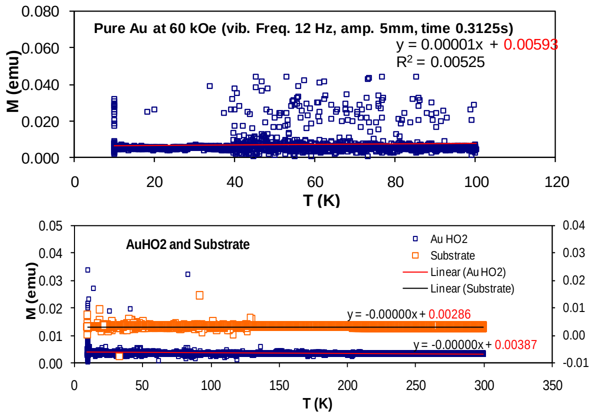

Fig. 2 Magnetization responses of pure Au sample versus Au:H+O sample in the magnetic field strength of 60 kOe

It is interesting to observe that these results are different from that measured previously in 2023 by VV Hiep et al. (also supported by this project), which showed the magnetic fluctuation below 70K, suggesting possible ferromagnetic behavior at low T. However, these results confirm the paramagnetic nature of both pure and ion-implanted samples. Another difference is that the magnitude of magnetization shown here is sufficiently larger than the ones reported in the previous measurements by VV Hiep et al.

Outputs of the project (publications, presentations, patents)

We are currently summarizing the measured data and plan to present them at the coming international conferences, e.g., 8th International Symposium on Frontiers in Materials Science, and then publish them in one of the high-impact international journals in the field of materials science.

This research was conducted in collaboration with Dr. Nguyen Duy Thien and Dr. Vuong Van Hiep