Microwave-Field-Induced Magnetization Excitation and Magnetization Switching of an Antiferromagnetically Coupled Magnetic Bilayer with Perpendicular Magnetization

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I. Background

Antiferromagnetically coupled (AFC) media that consists of two antiferromagnetically coupled magnetic layers has been explored for magnetic recording [1]. Because the AFC media reduces the dipolar interaction, it improves the reliability of writing and the stability of data. In microwave-assisted magnetic recording (MAMR), which is a candidate for next-generation magnetic recording [2,3], the dipolar interaction raises other concerns. MAMR utilizes large-amplitude ferromagnetic resonance (FMR) excitation in media magnetization to assist writing, and the dipolar interaction leads to the distribution in FMR frequency and the collective magnetization excitation in multiple grains. In this respect, AFC media is considered to be advantageous for MAMR [4,5]. In this study, we fabricate an AFC magnetic dot consisting of two Co/Pt multilayers and investigate magnetization excitation and switching in a microwave field.

II. Experimental setup

Figure 1 shows the experimental setup. A magnetic film consisting of two Co/Pt multilayers with a Ru layer between them is deposited. The two magnetic layers are designed to have different anisotropy by controlling the Co thickness, and the one with higher anisotropy is referred to as a hard layer and the one with lower anisotropy is referred to as a soft layer. This magnetic film is then patterned into dots of two different size (a larger dot for magnetization excitation and a smaller dot for magnetization switching). Magnetization excitation and switching of the magnetic dot is studied by applying a *z*-direction magnetic field (H_z) from an external electromagnet and an in-plane circularly polarized microwave field from two coplanar waveguides fabricated on top of the magnetic dot. The detailed experimental setup is described in Ref [6].

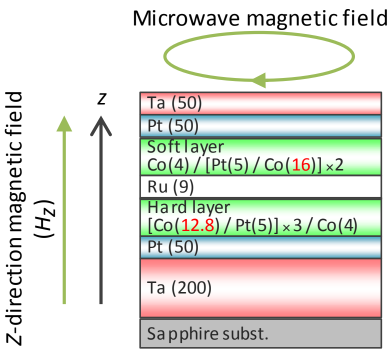

Fig. 1. Stacking structure of the magnetic film consisting. Thicknesses are given in angstroms

III. AHE-FMR measurement of the AFC magnetic dot

Figure 1 shows the anomalous Hall effect (AHE) voltage of the AFC magnetic square dot with a side length of 500 nm. In the remanent state, an antiferromagnetic configuration is realized. By applying a microwave field, an increase or decrease of the AHE voltage appears, indicating that the FMR excitation of the magnetic dot occurs. For the counterclockwise (CCW) microwave field, the decrease of the AHE voltage due to the FMR excitation of the soft layer appears at H_z = 0 and + 4 kOe because CCW is the rotation direction of the FMR excitation of the +*z*-direction magnetization. The dip is wider in the antiferromagnetic configuration at H_z = 0 kOe than in the ferromagnetic configuration at H_z = + 4 kOe. The different width may be attributed to the interaction between the hard and soft layers. For the clockwise (CW) microwave field, the increase of the

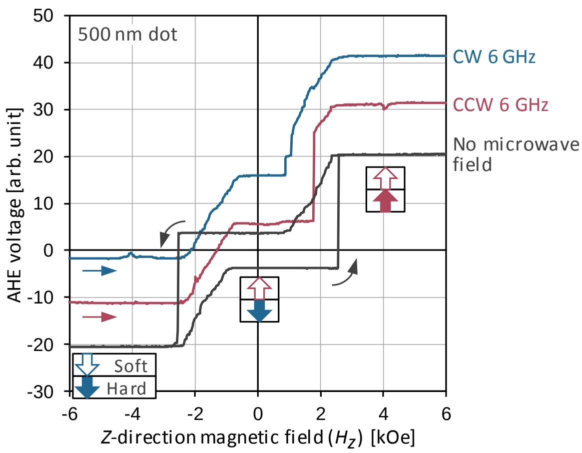

Fig. 2. AHE voltage versus H_z obtained without a microwave field and with a microwave field rotating CCW and CW.

AHE voltage due to the FMR excitation of the soft layer at H_z = – 4 kOe and assisted switching of the hard layer occurs at H_z = + 1 kOe.

IV. Microwave-assisted magnetization switching of an AFC magnetic dot

Figure 3 shows the switching field of the hard layer (H_{sw}) as a function of the microwave field frequency (f_{rf}) obtained for an AFC magnetic circular dot with a diameter of 80 nm. The rotation direction of the microwave field is mostly CW except for the plot depicted by cross in which the rotation direction is CCW. For the microwave field amplitude (H_{rf}) range of 43 – 170 Oe, H_{sw} decreases almost linearly as f_{rf} becomes higher and suddenly increases at a critical frequency. As H_{rf} increases, the microwave assistance effect increases, and a large H_{sw} decrease to approximately 1 kOe is demonstrated. For H_{rf} = 213 Oe and f_{rf} = 12 – 14.5 GHz, a part of the hard layer reverses, resulting in a magnetic domain configuration. This switching behavior is similar to that reported for a single layer perpendicular magnetic dot [3,6]. When the microwave field rotates CCW, FMR excitation of the soft layer is expected. However, no significant change in H_{sw} is observed, showing that the soft layer excitation has little effect on hard layer switching. The H_{sw} decrease for CCW and f_{rf} = 3 – 5 GHz shows the f_{rf} dependence similar to that in the CW microwave and is attributed to the fact that the polarization is not perfectly circular and a small CW component exists. These results show that the large microwave assistance effect is obtained for the AFC bilayer, which is not hindered by the additional soft layer.

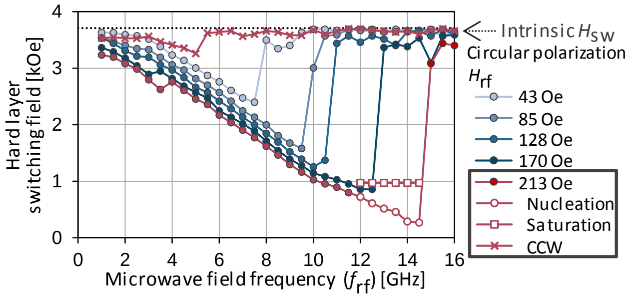

Fig. 3. H_{sw} versus f_{rf} obtained by applying a circularly polarized microwave field.

Reference

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