MICROWAVE-ASSISTED MAGNETIZATION SWITCHING OF ANTIFERROMAGNETICALLY COUPLED MAGNETIC BILAYER WITH PERPENDICULAR MAGNETIZATION

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I. INTRODUCTION

Antiferromagnetically coupled (AFC) media that consists of two antiferromagnetically coupled magnetic layers has been explored for magnetic recording [1]. Because the stray fields from the two magnetic layers cancel each other, AFC media can reduce the dipolar interaction between magnetic grains, improving the reliability of writing and the stability of data. The antiferromagnetic coupling can be introduced by inserting thin layer of nonmagnetic material such as Ru, Ir, and AFC granular perpendicular media has been demonstrated in which a thin Ru layer is inserted without breaking the granular structure [2]. In microwave-assisted magnetic recording (MAMR), which is a candidate next-generation magnetic recording, the dipolar interaction raises additional concerns [3,4]. In MAMR, large ferromagnetic resonance (FMR) excitation in media magnetization is utilized to assist writing, and the dipolar interaction leads to the distribution in FMR frequency and the collective magnetization excitation of multiple grains. In this respect, AFC media is considered to be advantageous for MAMR[5]. In this study, we fabricate an AFC magnetic dot consisting of two Co/Pt multilayers and investigate its switching behavior in a microwave field.

II. EXPERIMENTAL

Figure 1 shows the experimental setup. A magnetic film consisting of two Co/Pt multilayers and a Ru layer 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 patterned into a dot with a diameter of 80 nm. Switching behavior of the AFC dot is studied by applying a *z*-direction magnetic field (H_z) and an in-plane microwave field. Switching of the AFC dot is detected by anomalous Hall effect (AHE). The detailed experimental setup is described in Ref [6].

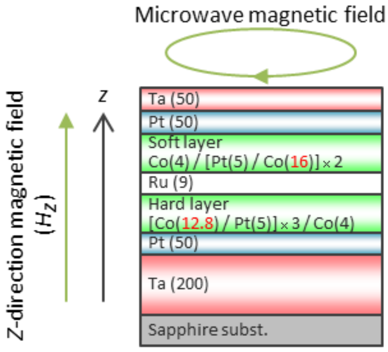

Fig. 1. Stacking structure of the magnetic film consisting of two antiferromagnetically coupled magnetic layers. Thicknesses are given in angstroms

III. RESULTS AND DISCUSSION

Figure 2 shows the AHE voltage obtained by sweeping H_z. At around $H_z = 0$ Oe, the soft layer reverses because of the antiferromagnetic coupling, and the antiferromagnetic configuration is realized. The switching *z*-direction magnetic field (H_{sw}) of the hard layer is 3.7 kOe. Next, a circularly polarized microwave field is applied to induce the microwave assistance effect. Figure 3(a) shows the dependence of H_{sw} on the microwave field frequency (f_{rf}). The rotation direction of the microwave field is mostly

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clockwise (CW) except for the plot depicted by cross. The hard layer reverses from the $-z$ to $+z$ direction. Because the rotation direction of the FMR precession of the $-z$-direction magnetization is CW, FMR excitation is induced and H_{sw} decreases. For H_{rf} = 43 – 170 Oe, H_{sw} decreases almost linearly as f_{rf} becomes higher and suddenly increases at a critical frequency. As the microwave field amplitude (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, the hard layer partially reverses, resulting in a magnetic domain configuration. This switching behavior is similar to that reported for a single layer perpendicular magnetic dot [4,6]. When the microwave field rotates counterclockwise (CCW), FMR excitation of the soft layer occurs because the rotation direction of the FMR precession of the $+z$-direction soft layer is CCW. 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 there is a small CW component. These results show that the microwave assistance effect is obtained for the AFC bilayer, which is not hindered by the additional soft layer.

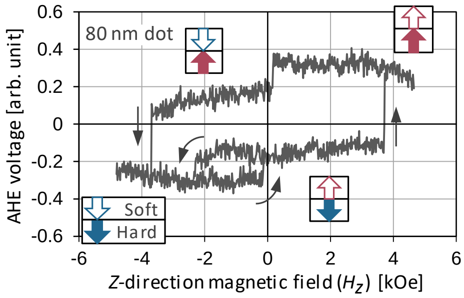

Fig. 2. AHE voltage versus H_z.

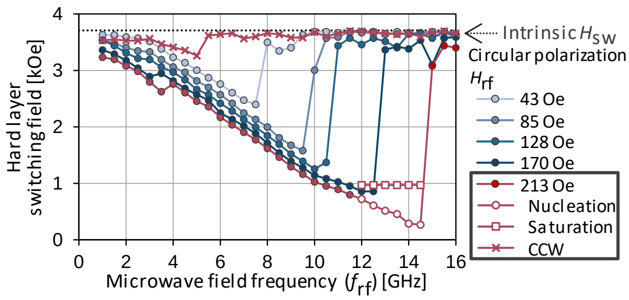

Fig. 3. H_{sw} versus f_{rf} obtained by applying a circularly polarized microwave field.

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