MICROWAVE-ASSISTED MAGNETIZATION SWITCHING FOR A 2-μm Co/Pt DOT

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I. INTRODUCTION

Microwave-assisted magnetization switching (MAS), which greatly reduces the switching field of recording bits with the help of an rf magnetic field h_{rf}, is promising technique to increase recording density in a hard-disk drive. So far, studies based on the simulation have revealed that a circularly-polarized h_{rf} had an advantage over a linearly-polarized h_{rf} in terms of MAS efficiency [1,2]. In experiments, Suto et al. recently reported MAS for a circularly-polarized h_{rf} [3]. For the actual device application the comparison of MAS for a linearly- and circularly-polarized h_{rf} is imperative, but it is not well evaluated. We aimed to evaluate MAS efficiency for both linearly- and circularly-polarized h_{rf}. In this study, we fabricated Co/Pt dot samples with perpendicular magnetic anisotropy and studied MAS properties through the anomalous Hall effect.

II. EXPERIMENTS

A stacking structure of the sample is as follows; sub./Ta 3.0/Ru 6.0/Pt 2.0/[Co 0.24/Pt 0.16]$_3$/Co 1.7/[Pt 0.16/Co 0.24]$_3$/Pt 0.3/Ru 2.0 (thickness are in nm). The effective magnetic anisotropy field of the film was tuned by inserting a thin Co film in-between the Co/Pt multilayer part to be 4.0 kOe. The Co/Pt single dot with 2-μm in diameter was fabricated by using electron beam lithography and Ar-ion etching. The Ta/Ru underlayer was fabricated to form a Hall cross bar. After covering SiO_2, Ti 5 nm/Au 200 nm was deposited to make an rf line. Figure 1 shows an optical microscope image of the sample with the measurement circuit. Magnetization direction of the dot is detected by a Hall voltage through the anomalous Hall effect [4].

III. RESULT AND DISCUSSION

Typical experimental result is shown in Fig. 2. For this sample, as a first step, linearly-polarized h_{rf} was applied with the rf power of 8 dBm, which corresponds h_{rf} of 25 Oe (estimated from the electromagnet calculation). After magnetization direction of the dot was set to the negative direction, the magnetic field was swept toward the positive direction. When the rf frequency (f_{rf}) was set to be between 3 GHz and 7 GHz, the switching field (H_{sw}) was reduced with the minimum to be 440 Oe at 6 GHz, while there was no change in H_{sw} for f_{rf} <3 GHz and f_{rf} >6 GHz. H_{sw} as a function of f_{rf} are plotted in Fig. 3. It shows that the H_{sw} monotonically reduces with increasing f_{rf} up to a critical frequency (6 GHz). Then, H_{sw} vs. f_{rf} was investigated under various rf power (Fig. 3). The result indicates that H_{sw} is lowered when the high rf power is applied, which would be beneficial to the effective switching. However, this behavior is quite different from a previous report [5]. Although the reason of the discrepancy has been unclear, our result can be explained by the domain-wall motion which occurs at relatively low field because the dot size is enough large to induce it.

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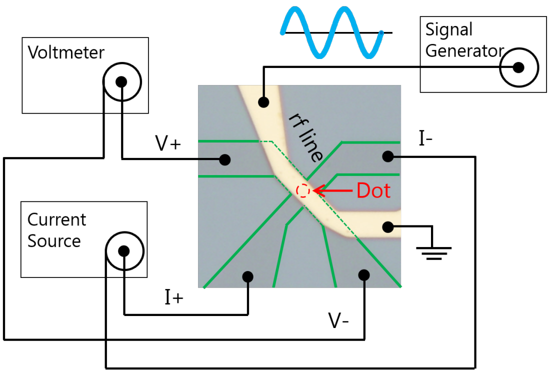

Figure 1 Optical microscope image and the measurement circuit.

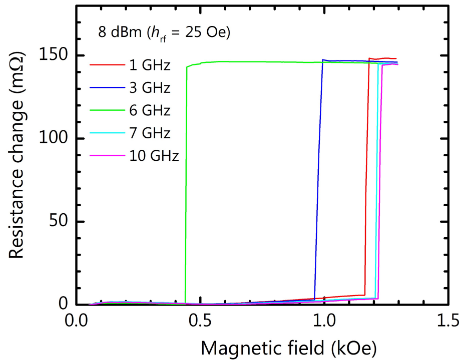

Figure 2 Example of the MAS experiment. RF power of 8 dBm (h_{rf} = 25 Oe) is injected in the rf line. Hall resistance is calculated by dividing the Hall voltage by injected current. The vertical axis shows Hall resistance change from Hall resistance at 0 Oe.

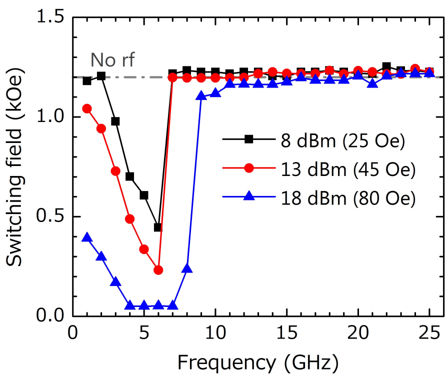

Figure 3 Switching field as a function of rf frequency under various rf power.