# Spin-orbit-torque induced magnetization switching for an ultra-thin MnGa grown on NiAl buffer layer

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## 1. Introduction

Spin-orbit-torque (SOT) induced magnetization switching has recently attracted much interest as an important basic technology for next-generation spintronic devices. MnGa is a promising electrode material for such spintronic devices owing to relatively large perpendicular magnetic anisotropy (PMA), relatively small saturation magnetization, and relatively high spin polarization. However, since it is not easy to fabricate ultra-thin MnGa layer with clear PMA, demonstration of the SOT magnetization reversal has been limited to for MnGa grown on CoGa-buffered MgO substrate [1], or on GaAs substrate [2]. In this study, we observed clear PMA and demonstrated the SOT magnetization reversal for a 1-nm-thick MnGa grown on a NiAl buffer layer.

## 2. Experimental Methods

A layer structure consisting of (from the substrate side) MgO buffer (10 nm)/NiAl buffer (3 nm)/ MnGa (1 or 2 nm)/Ta (5 nm)/MgO cap (2 nm) was deposited on a (001)MgO single-crystal substrate. A NiAl (MnGa) layer was grown at room temperature and then annealed at 540 (400)°C. The layer structure was processed into Hall devices with a 10-µm-wide channel. The magnetization of MnGa was investigated by the anomalous Hall effect (AHE).

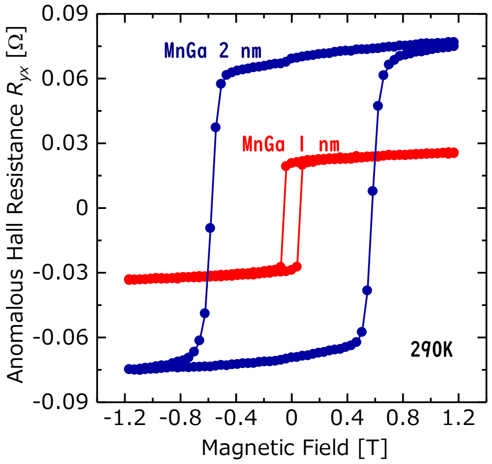


Fig. 1. Anomalous Hall resistance $R_{yx}$ for NiAl/MnGa/Ta stack as a function of out-of-plane magnetic field.

## 3. Results and Discussion

Figure 1 shows AHE signals of the fabricated device. Clear hysteresis loop was observed even for a 1-nm-thick MnGa, indicating that the NiAl buffer layer is useful for attaining ultrathin MnGa with a clear PMA. Figure 2 shows normalized anomalous Hall resistance for a 1-nm-thick MnGa as a function of pulse current $I_p$ with the duration of 1 s. An in-plane magnetic field $\mu_0 H_x$ = ±0.1 T was applied along the current direction for deterministic switching. A clear change in the anomalous Hall resistance was observed at $I_p \cong \pm 15$ mA, which is a clear indication of the SOT switching of MnGa due to the spin current generated in Ta.

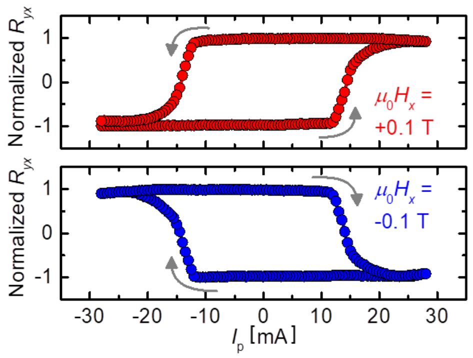


Fig. 2. Normalized $R_{yx}$ as a function of pulse current $I_p$ with the duration of 1 s under $\mu_0 H_x$ = ±0.1 T.

**References**

1) R. Ranjbar et al., Jpn. J. Appl. Phys. **55**, 120302 (2016).
2) K. Meng et al., Sci. Rep. **6,** 38375 (2016).