Low frequency noise of Hall voltage in ferromagnetic Fe-Sn Hall devices

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With a broader range of applications of magnetic-field sensors in automatization of vehicles and electronics, the Hall magnetic-field sensor based on the ordinary Hall effect in semiconductor heterostructures has been widely employed [1]. We have recently demonstrated that ferromagnetic Fe-Sn nanocrystalline sputtered films exhibit a sizeable sensitivity for the detection of magnetic-field based on large anomalous Hall effect (AHE) at room temperature [2]. In the sensing application, a noise of output signals, which limits the minimum detectable field (detectivity), should be examined in addition to the sensitivity. The noise of the Hall voltage (V_H) in ferromagnetic Hall devices might consist of both electrical and magnetic origins. In this study, we characterize sensitivity and detectivity in Hall devices based on 4-nm-thick Fe-Sn nanocrystalline films by measuring the magnetic field dependence of V_H and its spectral density, respectively.

The measurements of V_H and its spectral density were performed using a digital voltmeter and a spectrum analyzer as presented in Fig. 1(a). Figure 1(b) shows V_H as a function of the out-of-plane magnetic field ($\mu_0 H$) for different input voltage V_{in}. The V_H-$\mu_0 H$ curve exhibits a linear function without hysteretic behavior. The magnetic-field sensitivity, defined as a slope of the V_H-$\mu_0 H$ curve, is 17 mV/T for V_{in} = 0.6 V, which is comparable to Si [3]. Detectivity spectrum extracted from spectral density of V_H for V_{in} = 0.6 V at zero magnetic field shows presence of 1/f noise and thermal noise (Fig. 1(c)). The detectivity at the thermal noise region is estimated as 0.3 μT/Hz$^{1/2}$ [4], which is also comparable to Si [3]. The large sensitivity and low detectivity of AHE-based Hall voltage demonstrates a high potential of Fe-Sn nanocrystalline films for a versatile Hall sensor.

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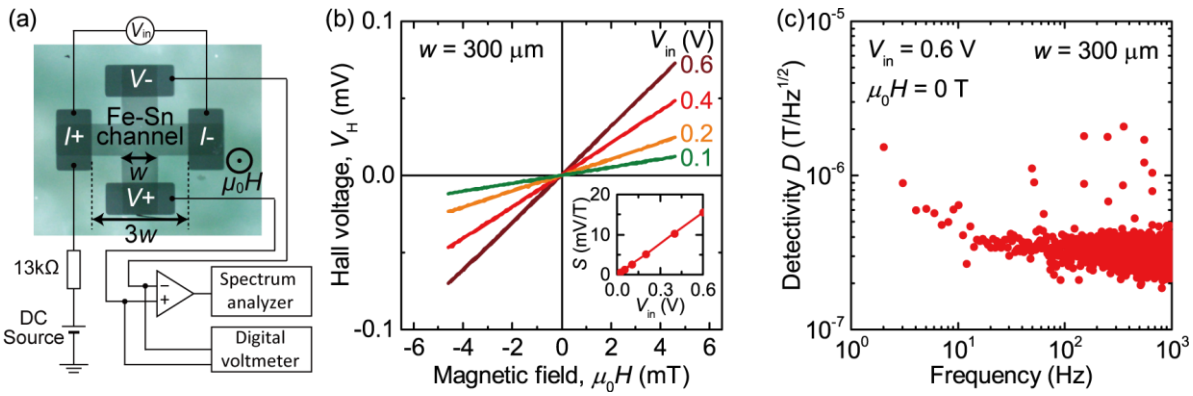

Fig. 1(a) Setup of Hall effect and noise measurements in a Hall device based on Fe-Sn nanocrystalline films. (b) Hall voltage (V_H) as a function of perpendicular magnetic field at different input voltage V_{in}. Inset shows V_{in} dependence of magnetic-field sensitivity (S). (c) Detectivity spectrum D for V_{in} = 0.6 V at zero magnetic field.