Spin-charge conversion in $Bi_{1-x}Sb_x$ layer

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Spin-charge conversion in nonmagnetic materials by means of the inverse spin Hall effect (ISHE) or the inverse Rashba-Edelstein effect (IREE) is the central topics in the recent spintronics studies[1,2], because it enables highly efficient spin-charge conversion without utilization of ferromagnetic materials. Since a large spin-orbit coupling generally enables highly efficient spin-charge conversion, bismuth (Bi) is a pivotal material in the spin-charge conversion studies[3,4]. Actually, a large IREE was realized in Bi / Ag interfaces[5]. Bi_2Se_3 based topological insulators also exhibited highly efficient spin-charge interconversion. Here, we focus on $Bi_{1-x}Sb_x$ alloys. $Bi_{1-x}Sb_x$ alloys exhibit a wide variety of characteristics. For example, whereas pure Bi (x=0) is a semimetal material with a Dirac fermion, $Bi_{1-x}Sb_x$ alloys with x=0.07-0.22 are three dimensional topological insulators. Interestingly, semimetal $Bi_{1-x}Sb_x$ alloys (x=0-0.07) and topological insulator $Bi_{1-x}Sb_x$ alloys (x=0.07-0.22) have the same crystal structure, which enables a systematical investigation of spin-charge conversion properties without change in the crystal structure.

In this study, we investigated spin-charge conversion efficiency in $Bi_{1-x}Sb_x$ alloys by using spin pumping. A schematic illustration of the sample is shown in Fig. 1. $Bi_{1-x}Sb_x$ was deposited on top of a ferrimagnetic insulator, yttrium iron garnet ($Y_3Fe_5O_{12}$, YIG) epitaxial layer by using thermal evaporation. Spin current was injected into the $Bi_{1-x}Sb_x$ layer from the YIG layer under the ferrimagnetic resonance (FMR) conditions. The injected spin current was converted into an in-plane charge current due to the ISHE or IREE. A typical result of the converted charge current in the $Bi_{1-x}Sb_x$ layer as a function of the external magnetic field measured at room temperature, where Sb concentration was x=0.10 is shown in Fig. 2. A clear converted charge current was obtained. Magnetic field angle dependence of the charge current showed a cosine dependence, indicating successful spin injection into the $Bi_{1-x}Sb_x$ layer. In the presentation, we will discuss Sb concentration dependence of efficiency of the spin-charge conversion.

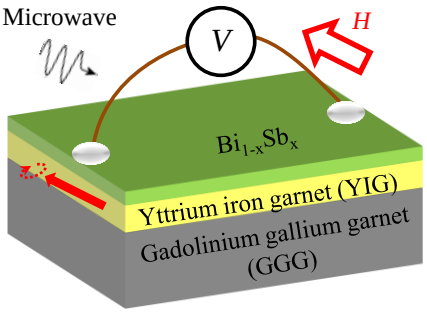

Fig. 1 A schematic of $Bi_{1-x}Sb_x$/YIG device for spin pumping measurements.

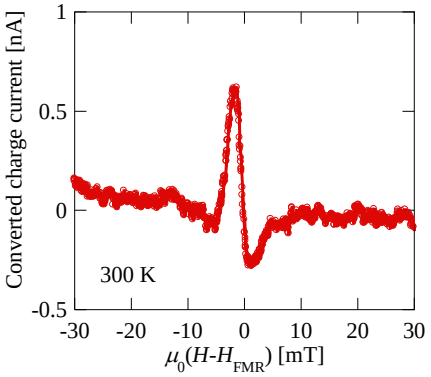

Fig. 2 A typical result of converted charge current as a function of external magnetic field.

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