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研究課題名（和文）antiferromagnetic magnon spin valve

研究課題名（英文）antiferromagnetic magnon spin valve

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研究成果の概要（和文）：反強磁性絶縁体のスピン透過を外部から操作することに成功した。
Neelベクトルを回転させる磁場。 この研究で新しい現象「spin colossal magnetoresistance」が確立された。
 この研究はまた絶縁体ベースのスピン流回路の開発のための基礎を築く。 さらに、重金属／反強磁性絶縁体二層におけるＳＭＲの磁場角度依存性を解析的に計算する。

研究成果の学術的意義や社会的意義
我々は、反強磁性絶縁体に新しい効果、巨大スピン磁気抵抗を発見した。 これは全絶縁体スピン流回路への実質的な進歩であり、これは動作中のエネルギーコストがはるかに低く、それ故にグリーン社会に不可欠な装置である。 スピン流制御のメカニズムも我々の研究でよく理解されており、それはさらなるデバイス開発の基礎を築くものである。

研究成果の概要（英文）：We succeed to manipulate the spin transmission of an antiferromagnetic insulator by external
magnetic field which rotates the Neel vector. A new phenomenon "spin colossal magnetoresistance" is established in this study. This work also lays the foundation for the development of insulator-based spin current circuit. In addition, the magnetic field angle dependence of the SMR in a heavy metal/antiferromagnetic insulator bilayer is calculated analytically.

研究分野：Spintronics

キーワード：antiferromagnet　spin Hall effect　SMR

１．研究開始当初の背景

Spin valve is the most important and basic device structure for spintronics, which is applied in the TMR devices. Another most attractive device design based on the spin valve structure is the spin transistor, which was proposed by Datta and Das . It holds the potential to replace the conventional electron-based transistors and great effort has been devoted to its development. However, the Datta-Das type spin field-effect transistor is found to be very hard to realize. The main reason is that effective gate voltage control of coherent electron spin current transport are different to realize. So far, the most successful demonstrations still work at very low temperature, which is far from commercial applications. Recently, our work shows magnon in antiferromagnetic insulator can be spin current carrier, which indicates the possibility of magnon-based spin valve.

２．研究の目的

We aim to realize an antiferromagnetic insulator (AFMI) based magnon spin valve. In this new type of spin valve, the spin current is carried by magnons instead of electrons, and the spin current can be turned “ON” and “OFF” by the orientation of the Neel vector of the AFMI. In this work, we will establish the prototype device design for AFM magnon spin valve, which opens the possibility for AFMI-based spin transistor.

３．研究の方法

The spin-current transmission in Cr2O3 was studied by using atrilayer device that sandwiched a Cr2O3 thin film between a magnetic insulator YIG and a heavy metal Pt layer . Here YIG serves as a spin current source. By using a temperature gradient, ∇ T, along the out-of-plane direction z, the spin Seebeck effect (SSE)　generates a spin accumulation at the interface of YIG/Cr2O3, which drives a spin current into the Cr2O3 layer. Spin currents, transmitted through the Cr2O3 layer to the Pt interface, are converted into a measurable voltage via the inverse spin Hall effect (ISHE).

４．研究成果

1. The spin transmission of Cr2O3 is found to have a sharp peak around the Neel temperature as shown in Figure 1e. The antiferromagnetic phase corresponds to the spin nonconductor,

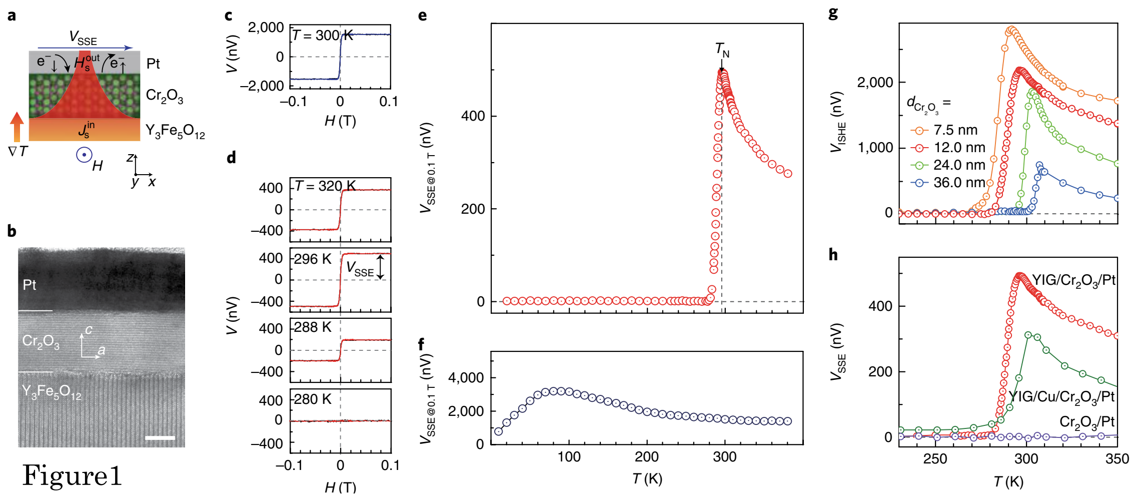

Figure1

and the paramagnetic phase corresponds to the spin conductor phase.

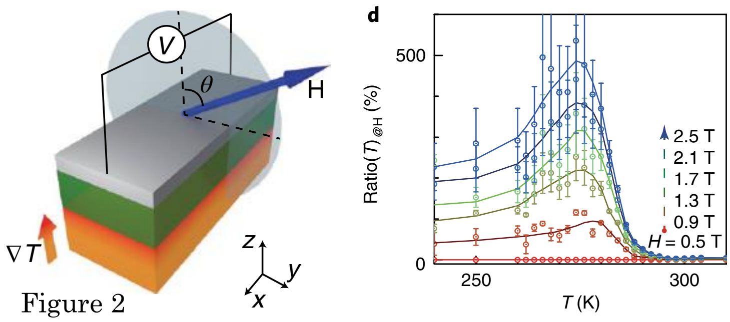

Figure 2

To realize the control of the spin current On/Off switching in our device, a magnetic field with an out-of-plane tilting angle is applied during the spin Seebeck measurement, and it is found that the spin transmission shows a modulation over 500% in the phase transition regime shown in Figure 2. This effect is named as “spin colossal magnetoresistance” in our paper.

2. We calculated the SMR field angle dependence in uniaxial antiferromagnetic materials. The results in Figure 3 show that the Neel vector will rotate for some angles even when the magnetic field is below the spin-flop field. It is very important for us to understand the Neel vector orientation under external field. The condition for biaxial antiferromagnetic material is also calculated. Our work suggests that it is feasible to use the SMR as a probe of the antiferromagnetic anisotropy for insulating materials.

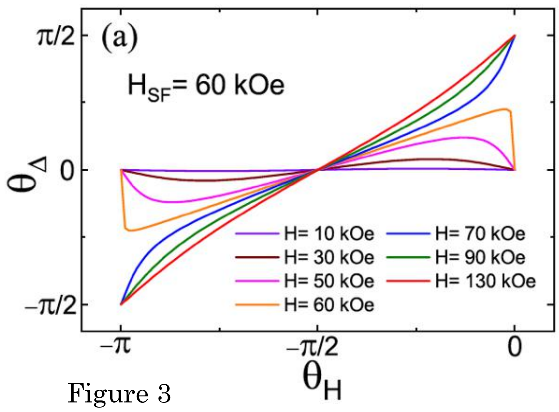

Figure 3

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〔図書〕（計　0　件）

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国内外の別：

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〔その他〕
ホームページ等

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