（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。 ）

CROSS TOKAI **Experimental Report** J-PARC	承認日 Date of Approval 2016/05/30 承認者 Approver Dai Yamazaki 提出日 Date of Report 2016/05/30
課題番号 Project No. 2016A0047 実験課題名 Title of experiment Neutron-induced spin pumping in compensated ferrimagnets 実験責任者名 Name of principal investigator Ken-ichi Uchida 所属 Affiliation Tohoku University	装置責任者 Name of Instrument scientist Dai Yamazaki 装置名 Name of Instrument/(BL No.) BL-17 Polarized Neutron Reflectometer (SHARAKU) 実施日 Date of Experiment 2016/5/16-18

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Pt/$Gd_3Fe_5O_{12}$ (GdIG) bilayer film on $Gd_3Ga_5O_{12}$ (GGG) substrate (size: 15 mm × 15 mm × 0.5 mm)

2. 実験方法及び結果 （実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

Before the beam time, in Tohoku University, we measured the temperature dependence of the spin Seebeck effect (SSE) in the Pt/GdIG sample to check its quality. As shown in Fig. 1, we observed clear SSE signals at the temperatures ranging from 10 K to 300 K. Importantly, the SSE signals exhibit sign changes at a magnetic compensation temperature ($T = T_1$) and a magnetic ordering temperature for Gd^{3+} ion ($T = T_2$), which is in good agreement with the results by Geprägs *et al.*, Nat. Commun. **7**, 10452 (2016). Based on the SSE data, we determined experimental conditions, such as magnetic-field sweep and temperature ranges, for the measurements of the neutron-induced spin pumping.

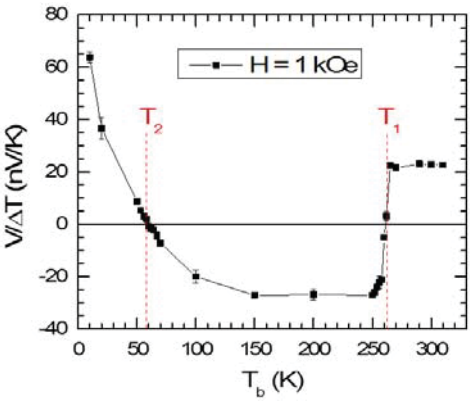

Figure 1: Temperature dependence of the SSE in the Pt/GdIG sample.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

In the Pt/GdIG sample, if neutron beams excite spin waves in the GdIG film and the excited spin waves drive the spin pumping, a spin current is generated in the Pt layer. This neutron-induced spin current is converted into an electric field due to the inverse spin Hall effect (ISHE) in the Pt layer owing to the strong spin-orbit interaction. To detect the ISHE induced by the neutron-induced spin current, we measured an electric voltage between the ends of the Pt layer under open-circuit conditions while applying a neutron beam and an external magnetic field to the Pt/GdIG sample. The sample surface was set to be normal to the beam line to accept neutrons as many as possible (see Fig. 2). We investigated the magnetic field dependence of the voltage at the temperatures ranging from 10 K to room temperature. The temperature of the sample was controlled by using a closed-cycle helium refrigerator.

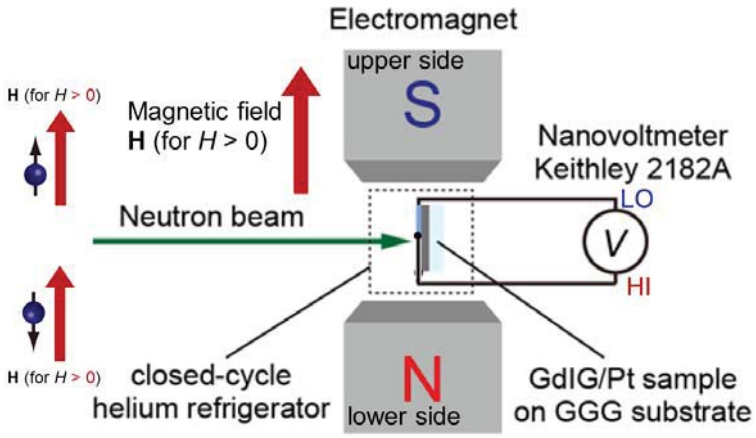

Figure 2: Experimental configuration.

Figure 3 shows the voltage in the Pt/GdIG sample as a function of the magnetic field, measured with irradiating unpolarized or polarized neutrons (as examples, the data at T = 60 K and 30 K are shown). Unfortunately, we could not observe clear ISHE signals at all the experimental conditions. This is probably because the incident neutron flux is too small to generate measurable spin currents and ISHE voltage. By using the obtained experimental results, we will estimate the upper limit of the neutron-induced spin-current contributions.

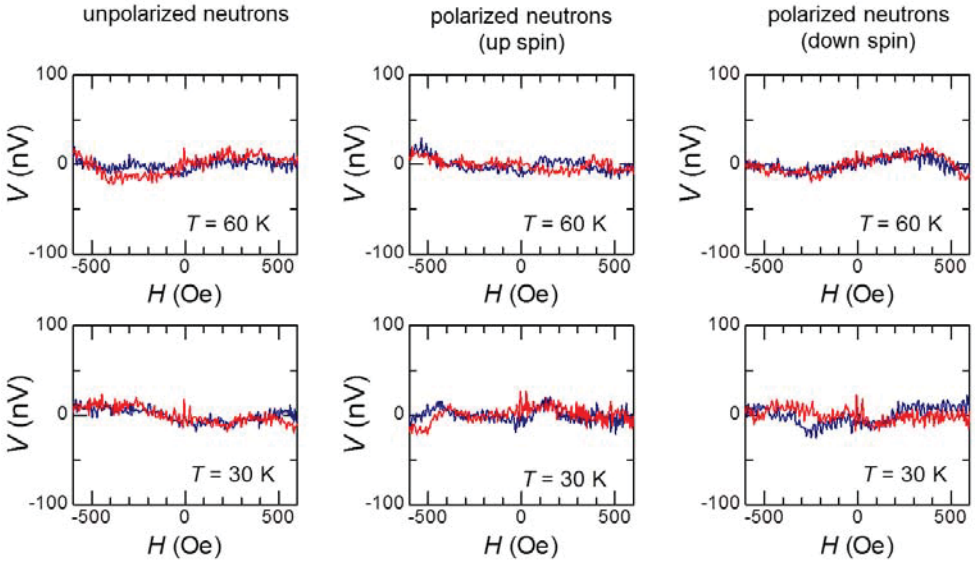

Figure 3: Magnetic field dependence of the voltage in the Pt/GdIG sample at T = 60 K and 30 K under unpolarized or polarized neutron irradiation.