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利用課題名(日本語) :面内伝導型スピンバルブトランジスタにおけるスピン依存伝導と電流変調
Program Title (English) : Spin-dependent transport and current modulation in a current-in-plane spin-valve field-effect transistor
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1. 概要(Summary)

A spin metal-oxide semiconductor field-effect transistor (spin MOSFET), in which the source and drain electrodes are composed of ferromagnetic materials, has been intensively studied, aiming at future electronics applications [1,2]. Some experimental demonstrations of lateral and vertical spin MOSFETs have been reported thus far [3-6]; however, for both lateral and vertical spin MOSFETs, there still remain problems to overcome towards practical applications in the present status. Here, we propose an alternative device, a current-in-plane spin-valve field-effect transistor (CIP-SV-FET), which comprises a ferromagnet / nonmagnet / ferromagnet trilayer and a gate electrode. This device can offer a functionality similar to that of spin MOSFETs due to the spin-valve effect and current modulation using a gate electric field. Also, the device performance is not affected by spin relaxation in the channel transport, which is a crucial issue in spin MOSFETs.

2. 実験(Experimental)

【利用した主な装置】

8 インチ汎用スパッタ装置

【実験方法】

We fabricated a ferromagnetic-semiconductor GaMnAs-based CIP-SV-FET. The trilayer structure was grown on a lattice-relaxed $In_{0.17}Al_{0.83}As$ buffer layer, and thus the magnetic easy axes of the GaMnAs layers are perpendicular to the film plane. We measured the Hall resistance (RHall) and sheet resistance (Rsheet) under an external magnetic field μ0H applied perpendicular to the film plane. In the process of establishing the fabrication procedures, we used ULVAC SIH-450 and other parts of the fabrication processes and measurements were done in the laboratory.

3. 結果と考察(Results and Discussion)

Rsheet was modulated both by the magnetization configuration through the spin-valve effect (0.17%) and by the gate voltage (14%) at 36 K. Furthermore, we successfully demonstrated electric-field-assisted magnetization reversal of the upper GaMnAs layer[7].

4. その他・特記事項(Others)

[1] S. Sugahara and M. Tanaka, Appl. Phys. Lett. **84**, 2307 (2004).[2] M. Tanaka and S. Sugahara, IEEE Trans. Electron Devices **54**, 961 (2007).[3] R. Nakane *et al.*, Jpn. J. Appl. Phys. **49**, 113001 (2010).[4] T. Sasaki *et al.*, Phys. Rev. Appl. **2**, 034005 (2014).[5] T. Tahara *et al.*, Appl. Phys. Express**8**, 113004 (2015).[6] T. Kanaki *et al.*, Appl. Phys. Lett. **107**, 242401 (2015).[7] D. Chiba *et al.*, Science **301**, 943 (2003). This work was supported by Grants-in-Aid for Scientific Research, the Project for Developing Innovation Systems of MEXT, and Spintronics Research Network of Japan. Part of this work was carried out under the Cooperative Research Project Program of RIEC, Tohoku University. T. Kanaki acknowledges the financial support from JSPS through the Program for Leading Graduate Schools (MERIT).

5. 論文・学会発表(Publication/Presentation)

(1) Toshiki Kanaki, Tomohiro Koyama, Daichi Chiba, Shinobu Ohya, and Masaaki Tanaka, *Appl. Phys. Lett.* 109, 152403 (2016).

(2) Toshiki Kanaki, Tomohiro Koyama, Daichi Chiba, Shinobu Ohya, PASPS9, 10th August, 2016.

(3) 金木俊樹、小山知宏、千葉大地、大矢忍、田中雅明, 応用物理学会第 76 回秋期大会, 平成 26 年 9 月 14 日(発表日).

6. 関連特許(Patent)

なし。