Spin Transport Across the Ferromagnetic Metal/Semiconductor Interface

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Spin-polarised current transport across ferromagnetic (FM) metal/semiconductor (SC) structures is a key ingredient for the realisation of spintronic devices. Our group has extensively studied such processes by utilising optical spin orientation in GaAs to create a population of spin polarised electrons which subsequently undergo spin 'filtering' at the FMSC interface, i.e., their transmission probabilities depend on their spin orientation relative to the magnetisation in the FM layer [1, 2]. We present here an overview of our work to date and show how photoexcitation can be used as a powerful tool for a variety of studies of the critical parameters that control spin transport across these interfaces. Studies on heterostructures with different FM materials and tunnel barriers (Schottky, AlGaAs and AlOx) have revealed that electron tunnelling is the dominant spin dependent transport process across the interface [1]. A detailed study of Fe/AlOx barrier/GaAs samples with varying AlOx layer thickness revealed a spin filtering efficiency increasing with barrier width. Our combined measurements emphasise the critical importance of both the FMSC interface and the tunnel barrier for achieving efficient spin transport.

Recently, in a new approach, the photoexcitation experiment was used to investigate the effect of the polarised electron population on ferromagnetic resonance (FMR). Light-induced exchange coupling and spin accumulation excited in GaAs was observed by FMR in Fe/GaAs Schottky contacts. The FMR spectra offer a way of quantifying the efficiency of spin transport across these interfaces.

This work is supported by EPSRC. T.T. would like to thank JSPS for a Postdoctoral Fellowship.

REFERENCES

Development of Silicon-Based Spintronic Materials and Devices

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To utilize spintronic materials in silicon technologies, we are now focusing our efforts on the following three research issues. We will show the recent achievements in the conference.

(1) Synthesis of a silicon carbide (SiC)-based ferromagnet: A good possibility that the material shows the ferromagnetic behavior was theoretically predicted in a previous report. For the 4H-SiC host, we obtained the result that the majority Mn atom was incorporated into the interstitial site in the host lattice and no ferromagnetic behavior was detected [1]. When employing the 3C poly-type, on the other hand, the possibility that a Si atom in the 3C-SiC lattice was substituted with Mn atom was experimentally confirmed.

(2) Fabrication of Fe3Si/CaF2/Fe3Si heterostructures: We succeeded in the optimization of the growth condition to obtain a very flat FeSi surface by employing the low temperature MBE growth followed by the post-anneal process at 250 °C, although the roughness of the FeSi surface was not able to be suppressed before this research project was started. This result enabled us to fabricate the magnetic tunnel junction (MTJ) having an epitaxial heterostructure of Fe3Si/CaF2/Fe3Si on Si [2].

(3) Nonvolatile change of Schottky barrier between Pt and TiOx: TiOx is one of the promising spintronic materials and a candidate of high-k dielectric in silicon technologies. The initial current-voltage characteristics of the Pt/TiOx junction show rectifying behavior originated from the Schottky junction formed between TiOx and the Pt electrode [3]. This Schottky-junction behavior can be switched to Ohmic one by applying the voltage pulse across the interface, and the switching effect is non-volatile.

The works of (1) and (2) were supported partly by a Grant-in-Aid for Scientific Research in Priority Area, Creation and Control of Spin Current, MEXT, Japan.

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