Recent Progress in Silicon-based Spintronics Devices

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Spin-dependent transport phenomena in semiconductor have been attracting much attention from both the fundamental and the practical points of view. The devices based on such phenomena have a possibility to archive continuous performance improvement of conventional ICT devices. Among them, spin-MOSFETs [1] are expected as one of the promising candidates for beyond-CMOS devices. Even in the case of spin MOSFETs, silicon is attractive as a channel material because it has the advantage in terms of good spin coherence (= weak spin-orbit interaction).

To realize silicon-based spintronics devices, it is necessary to perform a series of processes consisting of "spin injection, spin transport (modulation), spin detection" in electrical method. For investigation of these spin related properties, multi-terminal lateral spin valve (LSV) devices are extremely useful. It is widely recognized it should be demonstrated completely by spin-valve effect measurement and Hanle effect measurement, using nonlocal (4-terminal) and local (2-terminal) geometries.

Especially in recent years, remarkable progresses have been made in the field of silicon-based spintronics. First example is the observation of spin output signal at room temperature. It has already been reported by several research groups [2, 3, 4] and most of them have utilized FM/MgO/*n*-Si system (= ferromagnetic metal electrode, MgO barrier and *n*-type degenerate silicon channel). Second example is the modulation of the spin output signal by the gate voltage application at room temperature. [5, 6] It has been achieved in FM/MgO/*n*-Si (*n*-type non-degenerate silicon channel) system with back-gate electrode of SOI structure. These progresses have led to the further understanding of fundamental spin related physics, such as spin drift effect, and the further improvement of spin output voltage (over 1 mV). [7]

Although silicon spintronics devices have advanced steadily for practical application, technological issues to be solved still are abound. Among them, improvement of spin injection efficiency is strongly desirable. In order to overcome these issues, even now research and development of silicon-based spintronics devices have been carried out energetically.

Reference

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