RESEARCH ON ELECTRICALLY AND THERMALLY DRIVEN SPIN-DEPENDENT TRANSPORTS IN FERROMAGNETIC/NONMAGNETIC HYBRID NANOSTRUCTURES

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論 文 名　：RESEARCH ON ELECTRICALLY AND THERMALLY DRIVEN SPIN-DEPENDENT TRANSPORTS IN FERROMAGNETIC/NONMAGNETIC HYBRID NANOSTRUCTURES
（強磁性/非磁性体複合ナノ構造における電気的・熱的スピン依存伝導に関する研究）

区　　分　：甲

論 文 内 容 の 要 旨

Spin current, a flow of spin angular momentum, provides a new insight into the electron transports in a solid state and is now understood as a key quantity in the operation of the spintronic devices. Laterally configured ferromagnetic/nonmagnetic multi-terminal hybrid structures enable us to create a spin current without accompanying a charge current, namely pure spin current by mean of nonlocal spin injection technique. The pure spin current efficiently transmits the spin information with the absence of the Joule heating and allows us to observe novel spin-related phenomena such as spin Hall effect and spin Seebeck effect owing to the reduction of the spurious signals induced by the charge current. However, the application feasibility of the pure spin currents was quite low because of their extremely low generation efficiency in spite of its high energy efficiency for propagating the spin information. Thus, the drastic enhancement in the generation efficiency of the pure spin current should be achieved. For this purpose, in the present thesis, novel methods for the efficient generation and manipulation of the pure spin current have been developed.

Firstly, the existence of the thermal current was confirmed even in the nonlocally induced pure spin current. The thermal current was found to induce the large thermoelectric effect under the high bias current even in the nonlocal configurations using the conventional ferromagnetic electrodes. Secondly, a significant enhancement of the efficiency in the electrical generation of the pure spin current has been demonstrated by using spin-polarized ferromagnetic electrodes based on polycrystalline CoFeAl. Moreover, the CoFeAl electrodes were found to generate the pure spin current by using the heat rather than using the electricity because of its favorable band structure for the thermal spin injection. Then, by mixing the electrical and thermal generation of the pure spin current, a highly efficient generation of the pure spin current has been achieved. In addition, by extending the efficient thermal spin injection, a novel method for detecting the spin direction has been demonstrated. Finally, in order to generate a giant pure spin current, two methods, using multi-terminal spin injectors and nano-pillar-shaped spin injector, have been demonstrated.

These innovative demonstrations may open a new route for spin-device integration and its applications, leading to the realization of functional spin devices utilizing pure spin currents with an extremely low power consumption.