Room temperature spin dependent potentials in a quantum well structure

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The spin field effect transistor (spin-FET), proposed by Datta and Das [1], is one of the fascinating concepts for next generation devices due to low power consumption, high speed, and nonvolatility. For developing Spin-FET, spin transport efficiency in a quantum well structure is crucial factors. Previous works [2, 3] have reported spin injection into semiconductor quantum well, however, the spin injection efficiency is insufficient to operate spin-FET at room temperature. In this research, we experimentally observed spin dependent electrochemical potentials in the non-local geometry at room temperature.

We utilized the inverted High Electron Mobility Transistor (HEMT) with a 2 nm In As active layer. The channel size of 8 μm was defined by conventional Ar-dry etching. Previous works [2, 3] used etching process for top contact between spin injector and the semiconductor channel. In this research, we deposited $Ni_{81}Fe_{19}$ magnetic electrodes (FM) at the side of the InAs quantum well channel. The junction area between FM1 (FM2) and the InAs channel is only 0.5 μm × 2 nm (1μm × 2 nm) which is much smaller than that of conventional contact.

The potential difference between parallel and antiparallel alignments of two ferromagnetic electrodes (FM1 and FM2) was clearly detected in the non-local geometry up to room temperature. The detected signal is 1.2 Ω which is large enough to operate spin-based devices. Using the hysteresis behaviors of two ferromagnetic electrodes, we also detected four different potential levels. From these four states, this device can be applied to spin logic and multi-level memory devices.

References

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