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Fabrication of spin injection system using a new type of Al_2O_3 barrier on GaAs Two-Dimentional Gas layer

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1. Introduction

Spin injection from a ferromagnet into a semiconductor is a major challenge of spinelectronic devices. Low transmission barrier is crucial factor for the efficient spin injection, therefore oxide barrier is commonly used for the transmission layer between the ferromagnet and semiconductor.[1] Native oxide is not good enough for the tunneling barrier as a interfacial layer. In this study we utilize a novel method for growing Al_2O_3 layer on the top of two dimensional electron gas layers. Al0.98Ga0.02As layer is deposited on insulating GaAs layer in MBE chamber without breaking vacuum and then inserted into furnace instantly.

2. Experiments

Native oxides of $Al_xGa_{1-x}As$ have attracted attentions as an insulating layer of various semiconductor devices because of reproducibility and uniformity. The formation of $Al_xGa_{1-x}As$ is possible using modern growth technology with advanced control of the thickness. Therefore, many semiconductor devices have been demonstrated with these oxides [2]. Especially, native oxides of $Al_{0.98}Ga_{0.02}As$ are promising due to superior structural properties and process relativity over those of AlAs during oxidation [3]. In this experiment, we utilize a novel method for growing Al_2O_3 layer on the top of two dimensional electron gas layers as shown in Fig. 1.The 2.7 nm-thick $Al_{0.98}Ga_{0.02}As$ layer was oxidized in an open tube furnace, where water vapor was introduced with N_2 carrier gas by 100 cc/min. The sample was kept at 460 °C during 12 hours in the furnace to oxide the $Al_{0.98}Ga_{0.02}As$ layer around entire sample.

AlAs 27Å→ AlOx (t: 24~25Å)
GaAs 5.6Å
n+ $Al_{0.3}Ga_{0.7}As$ 400Å
$Al_{0.3}Ga_{0.7}As$ 200Å
GaAs 0.5 μm
(50Å GaAs /50Å $Al_{0.5}Ga_{0.5}As$) × 20
GaAs 0.8μm
S.I. GaAs (undoped substrate)

Fig1. Schematic structure of AlOx on GaAs HEMT structure

3. Results and Discussions

In order to verify the tunneling characteristic, CoFe was deposited on substrate described earlier. While voltage is applied between the two ferromagnetic electrodes, the current is measured on same electrodes. We assumed that all current flows through the two dimensional layer. Fig 2. shows voltage-current characteristics of ferromagnet/oxide/2-DEG/oxide/ferromagnet geometry. When the applied voltage is less than 4V, the current is very low due to the tunneling barrier. Above 4V the tunneling current suddenly increase. Generally CoFe-GaAs contact forms schottky barrier, but this results shows conventional tunneling behavior. Therefore, the I-V curves clarify that AlOx layer was formed without leakage current.

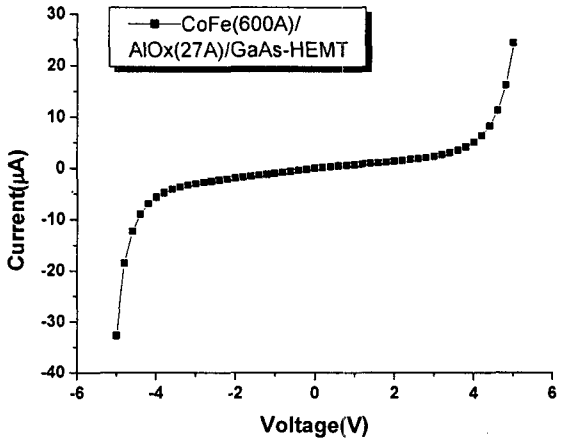

Fig2. V-I characteristics of ferromagnet-oxide-GaAs 2DEC junctions

4. References

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