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Sub-Micron Vertical Double Magnetic Barrier Device

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Since, it is possible for magnetic barriers to exhibit new effects, [1] much research has been done on lateral magnetic barrier systems. [2, 3] In lateral magnetic barrier structures, however, the induced magnetic field is small and edge effects, which make the physics complicated, are inevitable. For achieving a large induced magnetic field and removing edge effects, a vertical magnetic barrier system is proposed.

The proposed vertical magnetic barriers system is shown in Fig.1. This structure is similar to that of the sub-micron vertical resonant tunneling single electron transistor reported by D. G. Austing et al. [4] It consists an n^+-GaAs column channel, source electrode, drain electrode and 0.5 μm-high layered gate metal. The column channel has a radius of 0.34 μm, a height of 0.8 μm, an electron concentration of $1x10^{18}$ cm^{-3}, and an electron mobility of 1500 cm^{-2}/Vs. The layered gate metal is composed of 50-nm-thick Titanium, 150-nm-thick Dysprosium, 100-nm-thick Titanium, 150-nm-thick Dysprosium and 50-nm-thick Titanium layer. The electric field produced by the gate metal changes the radius of the channel which leads to a change in the drain current, and the magnetic field induced by the gate metal alters the drain current. Dysprosium has the largest magnetic polarization, Js, of 3.7T amongst the simple natural metal.

The magnetic polarization of Dysprosium induces a magnetic filed in the GaAs channel according to equation $B= J\,(h/2a)$, here B, J, h, and a are the induced magnetic filed, magnetic polarization, thickness of Dysprosium layer and radius of the column. Since the radius of the gate metal (30μm) is 90 times larger than a, fringing effects are ignored.

The induced magnetic field, B, is estimated from the magnetic polarization data shown in Fig.2. B is 0.8 T (h/a = 150/340) in the saturated region (external magnetic field is more than 3T) and it is 0.1 T with no external field.

The magnetoconductance of the double magnetic barrier device measured at T=0.3K is shown in Fig. 3. The hysteresis reflects the hysteresis characteristic of the gate metal. The Shubnikov de Haas oscillation and magnetic barrier confinement effect, however, have still not been observed due to low electron mobility. Suitable layer structures are required for the column channel.

References

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Figures.

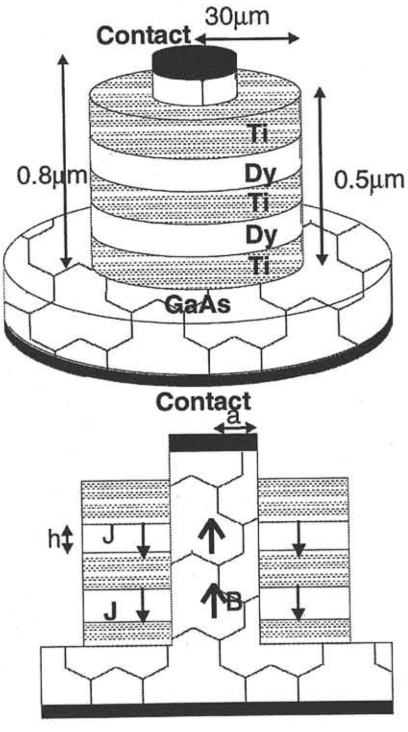

Fig. 1 Schematic diagram of the double magnetic barrier device (perspective view and cross section).

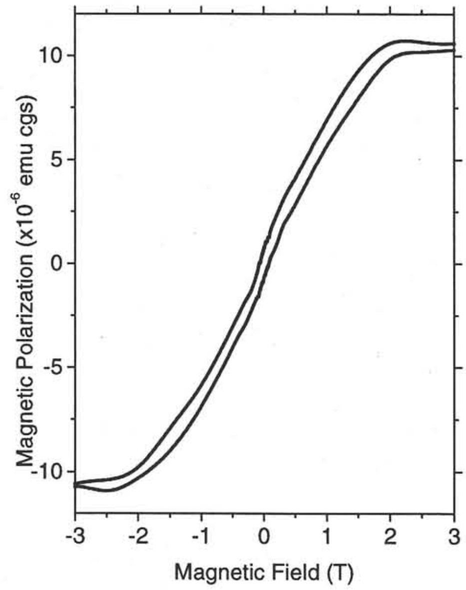

Fig. 2 Magnetic polarization of Dysprosium gate metal. Saturated value corresponds to 3.7T.

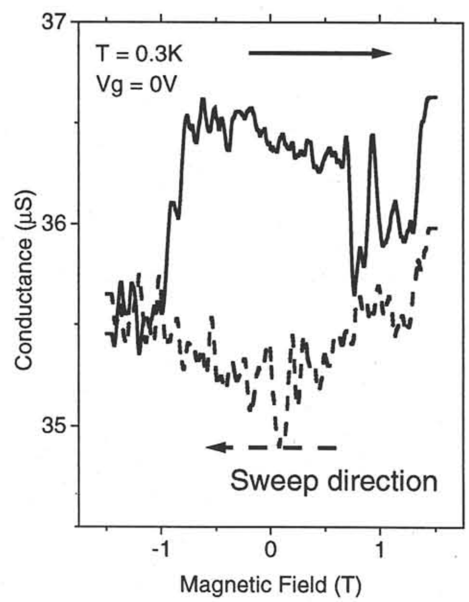

Fig. 3 Magnetoconductance of double magnetic barrier device. Hysteresis is observed according to the gate metal hysteresis characteristics.