Growth of InMnAsSb/InSb heterostructures with mid-infrared light-induced ferromagnetic properties

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III-V-based diluted magnetic semiconductor (DMS) is a class of new semiconductor alloy which combines the semiconducting and magnetic properties [1]. Carrier-induced ferromagnetism, which is one of the fundamentally and technologically important phenomena of DMS, has been reported in the (In,Mn)As/GaSb heterostructures [2]. This unique behavior is expected to apply for optoelectronic information storage such as sensor-memory devices. However, in the case of InMnAs/GaSb heterostructures the wavelength of the light is limited to the wavelength range of shorter than the band gap of GaSb (< 1.55 μm).

In this paper, we propose InMnAsSb/InSb new heterostructures which can operate even in the mid-infrared region and describe the growth of these heterostructures and their properties.

Figure. 1 shows the expected band lineup for the InMnAsSb/InSb heterostructure. This heterostructure is expected to operate even in the wavelength range of 2 – 6 μm. The InMnAsSb/InSb heterostructures were grown by MBE on InAs(100). Elemental In and Mn were used as group III and II sources, and thermally cracked metalorganic source TDMAAs and elemental Sb were used as group V source. The substrate temperature was 250 – 280°C.

X-ray diffraction measurement showed the successful growth of InMnAsSb. Raman scattering measurement showed that the InMnAsSb phonon mode from the sample grown at 250°C is stronger than that from the sample grown at 280°C, as shown in Fig. 2. This result shows the better crystalline quality of the sample grown at 250°C.

In order to confirm the photo-induced change in magnetization, we have used a SQUID magnetometer equipped with a light source whose wavelength region is longer than 2μm. Figure. 3 show the temperature dependences of magnetization for the InMnAsSb grown at (a) 250°C and (b) 280°C before and after light irradiation under the magnetic field of 300G. Before light irradiation, the samples exhibited paramagnetic behavior throughout the temperature range of 60 ~ 300K. When the sample was irradiated with light under a weak magnetic field, an enhancement in magnetization was clearly observed. This mechanism is explained that the photo-generated holes are accumulated in the InMnAsSb layer due to large built-in electric field in InMnAsSb and InSb layers, and that the carrier-induced ferromagnetism occurs.

In the conference, the detailed data for the InMnAsSb/InSb heterostructures will be presented.

[1] H. Munekata, H. Ohno, S. von Moln r, A. Segm ller, L.L. Chang, and L. Esaki, Phys. Rev. Lett. 63, 1849 (1989)

[2] S. Koshihara, A. Oiwa, M. Hirasawa, S. Katsumoto, Y. Iye, C. Urano, H. Takagi, and H. Munekata, Phys. Rev. Lett. 78, 4617 (1997)

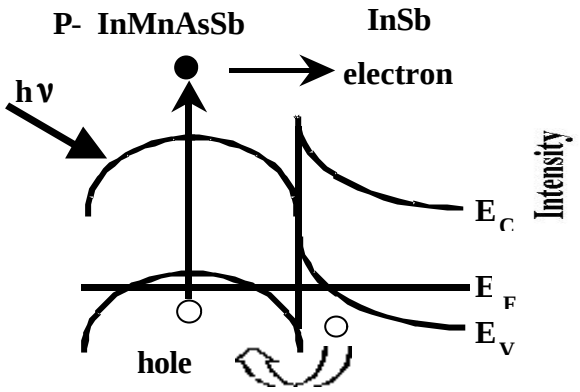

Fig.1 Band lineup for the InMnAsSb/InSb Heterostructure.

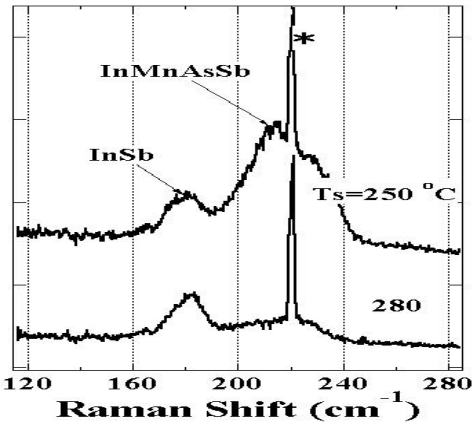

Fig.2 Room temperature Raman spectra for InMnAsSb grown at 250℃ and 280℃.

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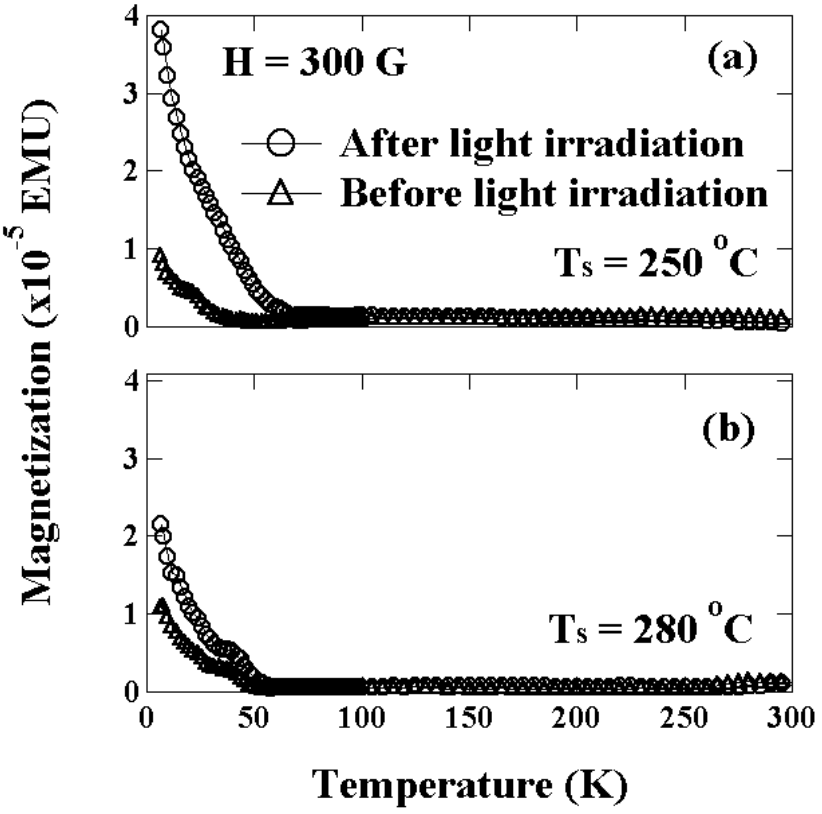

Fig.3 Temperature dependence of enhanced magnetization of InMnAsSb grown at (a) 250℃, (b) 280℃ under the magnetic field of 300G.