# 2 次元磁性トポロジカル絶縁体に向けた MBE 法による Mn 添加 InAs/GaSb ヘテロ接合の作成

## Mn doped InAs/GaSb grown by MBE toward 2D magnetic topological insulator

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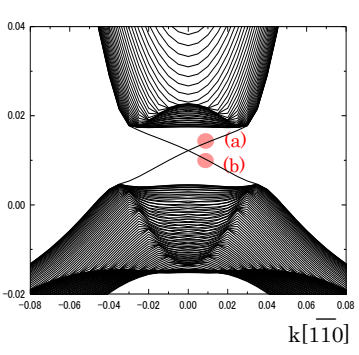
Quantum anomalous Hall (QAH) systems, which have been realized in magnetically doped thin film topological insulators, are of great interest because it can produce dissipationless conduction without applying an external magnetic field. Although QAH effect was experimentally confirmed in $(Bi, Sb)_2Te_3$ doped with Cr in 2013 for the first time, it requires extremely low temperature as low as 30 mK to realize the QAH system[1]. By analyzing the band structure using ARPES and observing the appearance of magnetic domains using a magnetic force microscope, the reason why temperature is extremely low is still under devate. Meantime, it is theoretically predicted that QAH system can be achieved in Mn doped InAs/GaSb QW system at 30 K in 2014 [2], however experimental demonstration has not been done yet. Our electronic structure calculations based on a 8 band k・p model demonstrated that QAH systems having the bulk energy gap as large as 15meV can be achieved in magnetically doped InAs/GaAs QW systems[3]. (Fig.1) In this study, to achieve the theoretical estimation, the heterojunctions of $In_{0.91}Mn_{0.09}As$ (20 nm) / $Ga_{0.99}Mn_{0.01}Sb$ (20 nm)/AlSb (500 nm) were grown on GaAs (001) substrates by low temperature molecular beam epitaxy. Anomalous Hall effects measured by Van der Pauw method reveal that the sample is p-type ferromagnetic semiconductor with Tc at around 14K and easy magnetization axes are perpendicular magnetic anisotropy, which is essential to achieve the edge state on the <110> and <1-10> cleaved surfaces. (Fig.2)

By optimizing the sample configurations, STM observation on the cleaved surface to demonstrate edge states will be also examined[4].



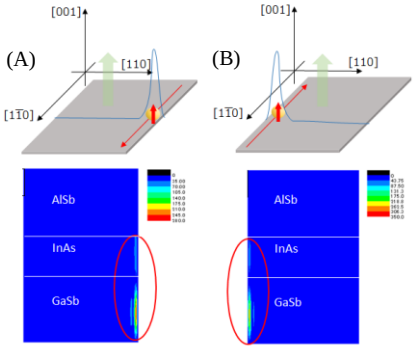




Fig.1. Electronic structure calculated by k・p 8 band model. Periodic boundary conditions are put in the vertical direction. (a) and (b) are edge states. There are chiral edge states around the sample. (A) corresponds to (a), shows that the electronic state moving in the positive direction along <1-10> direction and (B) shows the opposite.

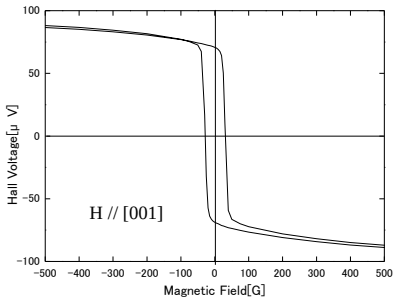



Fig.2.
Hall voltage measured at 10K. InMnAs/GaMnSb/AlSb shows its easy magnetization axes are perpendicular to the surface.

References:
[1] Cui-Zu Chang et al., Science **340**, 12 (2013)
[2] Qing-Ze Wang et al., Phys. Rev. Lett. **113**, 147201 (2014)
[3] The 78th JSAP Autumn Meeting [7p-PB7-54]
[4] The 78th JSAP Autumn Meeting [8a-A413-12]