Two-dimensional topological insulators (2D-TI) are a novel class of materials which are insulating in the bulk with unique one-dimensional (1D) channels at the edge. These 1D edge states are helical, namely the spin and the momentum directions locked to each other, and therefore are protected from backscattering. HgTe/CdTe [1] and InAs/GaSb [2] quantum well (QW) systems are known as 2D-TI. Especially, the InAs/GaSb QW system attracts much attention because of its fairly large energy gap. At appropriately designed well thickness of this system, the InAs conduction band and the GaSb valence band are anti-crossed and inverted at the hetero-interface to open hybridized mini-gap where helical edge channels are expected to form. These edge channels have been confirmed by electric measurements [3]. In this presentation, we report on scanning tunneling microscopy/spectroscopy (STM/STS) observations of InAs/GaSb heterojunctions.

We calculated electronic band structures by a 8-band $k\cdot p$ model, taking into account band-bending caused from charge carrier transfer around hetero interface, shown in Fig. 1. Figs. 1(a) and (b) represents bulk states and edge states around mini-gap, respectively. In order to confirm the unique surface states in this system by cross sectional STM/STS measurements, we have prepared a QW sample, AlSb(10nm)/InAs(12nm)/GaSb(9nm)/AlSb (10nm), by molecular beam epitaxy on a n-doped InAs (001) substrate. The samples cleaved in UHV are observed by a low temperature (78K, 4.5K) STM system with a W-tip in UHV ($<1 \times 10^{-10}$Torr). Figs. 2(a) and 2(b) show typical STM and STS image of cleaved surface over an InAs/GaSb hetero-structure, respectively. Fig. 2(c) shows line profiles of STS images obtained at various sample bias voltages. Furthermore, we have measured more detailed profiles around mini-gap at 4.5K to grasp edge states features. In the presentation, we will make a comparison between calculated local density of states profiles and STS profiles including edge states at the energy around hybridized mini-gap.

References