Molecular Beam Epitaxy of Near Surface $InAs_xSb_{1-x}$ Quantum Wells for Topological Quantum Computation

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Topological quantum computation based on Majorana Zero Modes (MZMs) promises to be a reliable approach to fault tolerant quantum computation due to the predicted topological protection of the Majorana fermions.[1] This topological protection is considered to be directly proportional to the energy of the induced topological gap in the topological superconductor created by the application of an in-plane magnetic field to a 1D chain of electrons coupled to a superconductor.[2] The g-factor of the host semiconductor and the electron mobility being the two key parameters, leading to enhanced topological gaps.

In this work, we report on the Molecular Beam Epitaxy (MBE) growth of $InAs_xSb_{1-x}$ (0.4>x>0.2) quantum wells strained to $Al_{0.3}InSb$ barrier layers. Due to band gap bowing, certain compositions of $InAs_xSb_{1-x}$ (centered around x ≈0.36) are predicted to have a higher g-factor and lower electron effective mass than either of the constituent binary compounds of InAs and InSb. Such compositions of InAsSb are hence ideal candidates for hosting MZMs providing a substantial enhancement in the topological protection. Until now, the demonstration of near surface InAsSb quantum wells had remained a challenge with InAs being the material of choice for 2D scalable designs.[3,4]

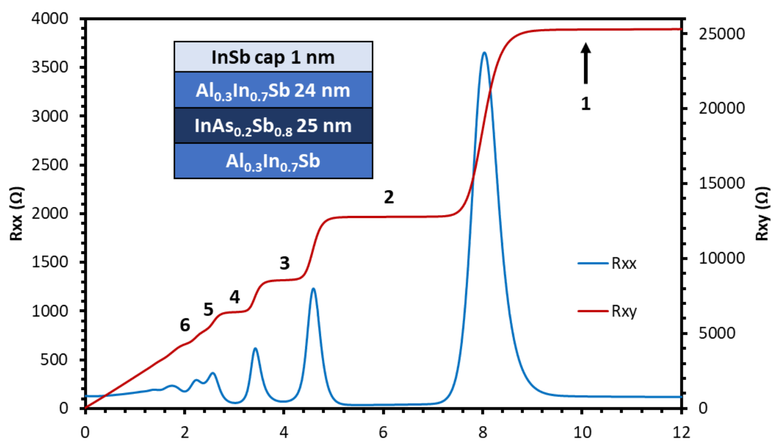

Fig. 1. Magneto-transport measurements of InAsSb QW at 2K

Quantum well structures were grown on GaSb and InSb substrates to study the effect of interfacial strain (4.6% compressive from GaSb and 1.6% tensile from InSb) while the depth of the quantum well from the surface was varied to study the effect of surface pinning on the 2D electron density. A systematic reduction in sheet carrier density was observed with reducing depth from the surface, which also correlated to a reduced doping efficiency of n-type dopants near the surface, indicating the presence of a surface depletion layer.

This understanding of the surface pinning of the InAsSb QW/InAlSb system is now expected to aid in the development of the next generation structures, paving the way for the use of InAsSb 2DEGs with superconducting epitaxial Aluminum as a platform for topological quantum computation.

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[3] J. Shabani, *et. al.*, Phys. Rev. B 93, 155402 (2016)
[4] H. J. Suominen, *et. al.*, arXiv:1703.03699 (2017)

Supplementary Information

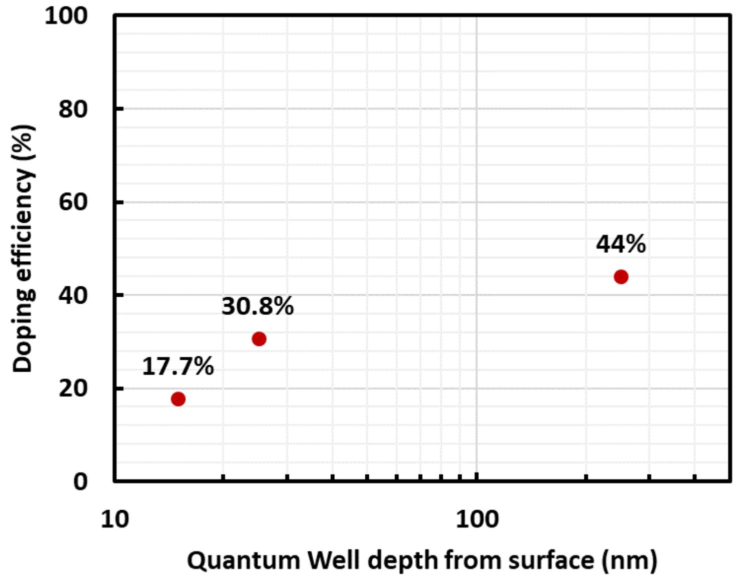

Fig. 2. Plot of doping efficiency of n-type Silicon dopants vs. depth of a 25nm wide InAsSb QW on GaSb substrate. As the QW is brought closer to the surface, the doping efficiency reduces, indicating the presence of a surface depletion layer (negative charges). This would indicate the fermi-level at the surface is pinned within the gap of the sermiconductor.

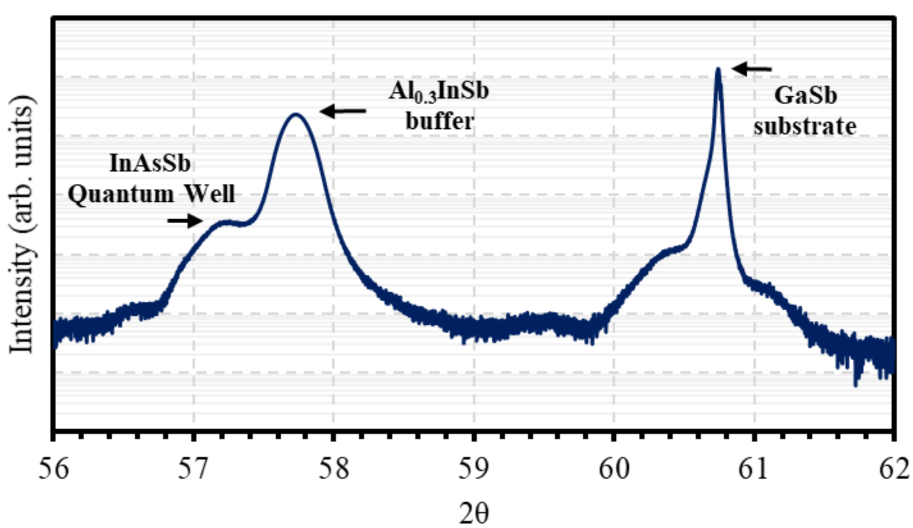

Fig. 3. X-Ray diffractogram of an InAsSb QW grown on an $Al_{0.3}InSb$ barrier layer on a GaSb substrate. The diffraction peak for the QW corresponds to a compostion of $InAs_{0.2}Sb_{0.8}$. This diffractogram in conjuction with *in-situ* Reflection High Energy Electron Diffraction (RHEED) indicates that the quantum well is strained compressively on the $Al_{0.3}InSb$ buffer/barrier layer.