Understanding Inherent Structural Defects and Chemical Distribution at Topological Superconductor-Semiconductor Interfaces and Heterostructures Using Electron Microscopy

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Abstract

In the zoo of quantum systems that might disrupt the storage and manipulation of information, topological superconductors have received significant interest for their potential application in quantum computing, mainly due to their capacity to harbor non-Abelian states and provide fault-tolerant computation. One of the possible platforms for topological superconductivity is the interface between a superconductor and a semiconductor (SS)[1] with strong spin-orbit scattering[1] – where topological qubits are manifested. However, epitaxially interfacing two dissimilar materials such these, generate inherent challenges in the form of grain boundaries (GB arrow in Fig. 1), grain misorientations (grains G1/G2 in Fig. 1), atomic distortions across the SS interface (circle in Fig. 1), which might be detrimental to the device performance. Additionally, precise control of the semiconductor heterostructure interfaces and their chemical distribution is also needed to improve electron mobility and device performance. Thus, identifying and understanding these inherent structural defects at the multiple interfaces of these hybrid devices, and connecting our findings with growth process, might contribute to better performance of such hybrid devices. Here we explore a combination of electron and ion microscopy together with advance image processing and mathematical modelling using Python libraries to understand structural properties at the SS interface, quantify roughness and chemical distribution across the semiconductor heterostructure interfaces. Our findings deliver metrology parameters to assess the quality of hybrid systems and highlight the relationship between such parameters and growth conditions.

References

[1]] L. Fu, C.L. Kane, Phys. Rev. Lett **100** (2008) 096407

Figures

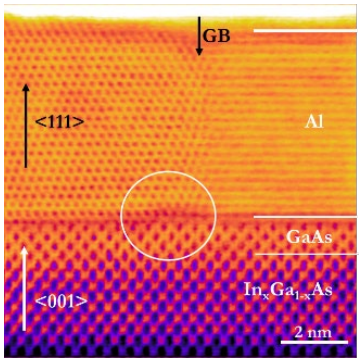

Figure 1: Color added cross-sectional HRSTEM image at the SS interface. Two Al (111) grains (G1,G2) divided by GB creating a distortion at the SS interface. G1 is parallel to the electron beam, and G2 has a small rotation respect to G1.