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“Understanding inherent structural defects, chemistry, and electronic structure in topological superconductor and semiconductor heterostructures interfaces using advanced electron microscopy”

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 platforms proposed to host topological superconductivity is the interface between a superconducting metal and a semiconductor (SS)1 with strong spin-orbit scattering – where topological qubits are manifested. However, epitaxially interfacing two dissimilar materials, such a superconductor metal and a semiconductor heterostructure, inherent challenges emerge in the form of grain boundaries, grain misorientations, atomic distortions across the SS interface, which might be detrimental to the device performance. Additionally, precise control of the semiconductor heterostructure interfaces and their chemical distribution across the interface is also needed to improve electron mobility and device performance. Thus, identifying and understanding these inherent structural defects at the multiple interfaces of this hybrid devices, and connecting our findings with growth process, might contribute to the performance improvement of topological qubits. Here we explore a combination of electron and ion microscopy together with advance image processing and mathematical modeling using Python libraries to understand structural properties at the SS interface, and quantify roughness and chemical distribution across the heterostructure interfaces. Our findings deliver metrology parameters to assess the quality of semiconductor heterostructure and highlight the relationship between such parameters and growth conditions.

Biography: Rosa E Diaz is a Research Scientist at Birck Nanotechnology Center in Purdue University. For the last 15 years, she has been interested in performing research at the interface between materials science and electron microscopy. Currently, her research focuses on structural and chemical characterization of hybrid quantum structures for application in topological quantum computing. Before arriving at Purdue University, she held a group leader position at Okinawa Institute of Science and Technology in Japan where she worked developing binary and ternary nanoparticle systems for catalytic and biomedical application. She also held a postdoctoral research associate position at Brookhaven National Laboratory with Prof. Eric Stach where she worked on in-situ transmission electron microscopy with a variety of environments. She obtained a PhD in Materials Science and Engineering from Arizona State University where she worked on the growth of III-V semiconductor nanowires and thin films under the supervision of Prof. Subhash Mahajan.



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