Semiconductor – Superconductor Nanowire Epitaxy
Growth, characterization and applications

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Semiconductor-metal interfaces are key elements in nanostructured electronics and device architectures. One of many important examples, which are the focus of this work, is in the search for materials suitable for topological quantum information, where semiconductor (SE) nanowires with high spin orbit coupling coupled to a superconducting (SU) phase constitute some of the most promising candidates. I will present a method to overcome some of the most important concerns in the field (such as obtaining a superconducting hard gap proximitized in the semiconductor and at the same time being able to gate the potential in the semiconductor), by epitaxially growing a uniform and coherent semiconductor-superconductor heterostructure nanowires. In particular, by using molecular beam epitaxy, we realize epitaxial growth of InAs//Al nanowire heterostructures, which we show can form highly ordered interfacial match, giving coherent $InAs \,||\, Al$ interfaces throughout the NWs, without introducing defects or impurities. These findings are highly relevant for the development of high performance and reliable devices with detailed electronic structure required for low temperature quantum experiments and applications

I discuss the details of the growth mechanisms of the SE//SU nanowire hybrids and show examples of both different types of structures and their promising electrical properties.

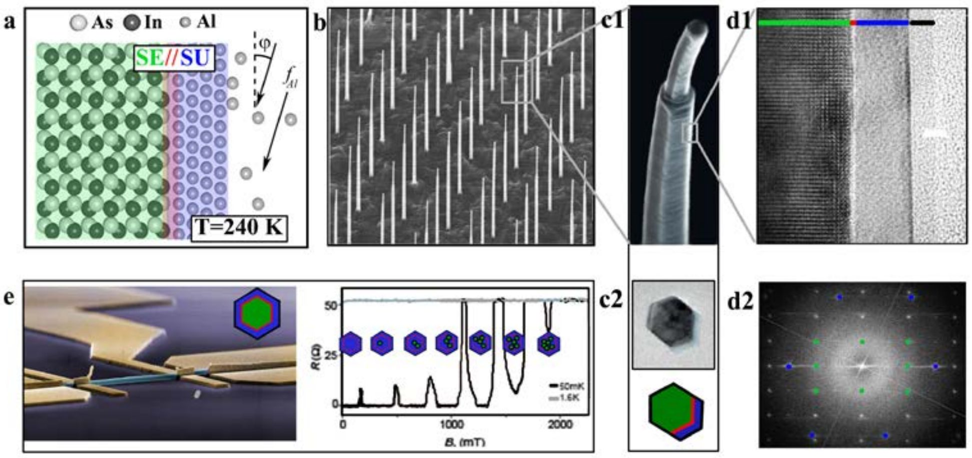

Figure 1 a) An illustration of the atomically smooth thin film Al growth on the InAs facets, a process which takes place at low temperatures and thin layers. The Al atoms arrive at the vapor-solid interface from a uniform beam flux. b) Array of $InAs \,||\, Al$ hybrid structures as grown on the substrate. The bending of the structures, is seen more clearly in the zoom in c1), where the cross sectional TEM image in c2) shows that the Al is only grown on two facets. d) A zoom on the InAs//Al interface showing the crystallographic bicrystal orientation at the interphase boundary, as indicated by the FFT in d2). E) An example of full shell superconducting devices, which show 'little park peaks' in the supercurrent as a function of the axial magnetic field, due to the cylindrical shape of the superconductor.