Development of a Semiconductor-Superconductor Hybrid 2DEG with In-situ Nb and NbTi.

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Semiconductor-superconductor hybrid structures ranging from quasi 1D-nanowires to 2D electron gases (2DEG) have recently emerged as a platform to study interaction between confined electronic states in the semiconductor and superconductivity [1, 2]. Studying states that result from this coupling, such as Andreev Bound States (ABS), requires transparent interfaces between the semiconductor and superconductor. Most of the state-of-the-art experiments rely on MBE-grown InAs combined with in-situ deposited epitaxial Al films [3]. More recently, promising results were shown using other superconductors, e.g., Sn [4], Pb [5] or Nb [6], which offer a larger operating range in temperature and magnetic field. In this project, we have developed a new hybrid material combination based on Nb and NbTi as the superconductor. We implemented a novel method to deposit an in-situ Nb/NbTi thin film by magnetron sputtering on a shallow InAs 2DEG using a thin Al interlayer to avoid intermixing. Guided by STEM analysis, we optimised the material stack to form highly crystalline interfaces obtaining a well-defined epitaxial relationship. Furthermore, transport measurements of Josephson junctions fabricated from this material show an induced gap of around 1.0 meV, only 2 times smaller than bulk Nb. Our results highlight the crucial role played by the interface in determining the performance of hybrid systems and introduce a new methodology for maximizing the semiconductor-induced gap.

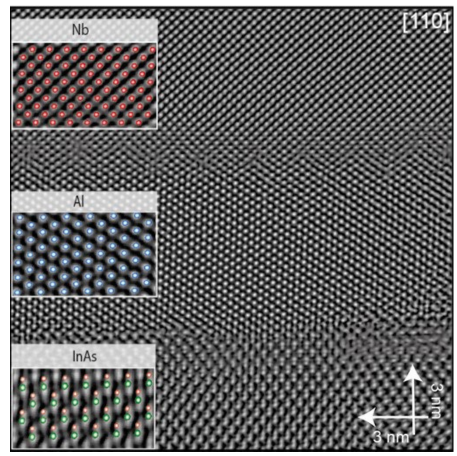

Figure 1. Scanning Transmission Electron Microscopy image showing the local epitaxy of the developed semiconductor-superconductor hybrid material.

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