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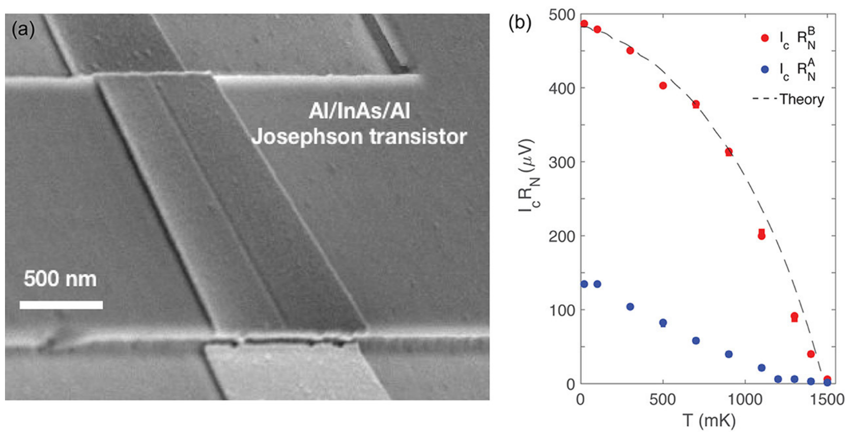
Transparent superconductor-semiconductor Josephson junction forms a three-terminal device that can be tuned via gate voltages.



High-quality Josephson junctions can serve as building blocks to enable a wide range of device architectures in many applications—ranging from Josephson field effect circuits for quantum computing to engineering topological excitations.

As part of a long push to realize transparent superconductor-semiconductor interfaces, Maher et al. report overcoming the difficult challenge of controlling this interface that stems from combining two materials with different crystal structures. The group achieved a “pristine” or defect-free semiconducting quantum well near the surface and showed that Al-InAs super-semi structures exhibit unprecedented Josephson junction quality.

These hybrid superconductor and semiconductor devices could explore the macroscopic superconducting properties of the superconducting leads with the microscopic degrees of freedom of the semiconductor, according to the authors. In semiconductors, spin-orbit interaction, density, and conductivity can be tuned using gate voltages, which gives access to a variety of exotic transport regimes and device functionalities. In hybrid systems, the properties of the induced superconductivity can be controlled within the semiconductor to study the supercurrent transport.

As for potential applications, the current leading technology in many device architectures has been based on superconductor-insulator tunnel junctions. These devices feature two terminals with their properties locked with thickness of the insulator. In comparison, the new semiconductor-based Josephson junctions form a three-terminal device with tunable properties via the application of gate voltages. These devices can compete in all applications with tunnel junctions, as well as create new possibilities for low-power logics.

Source: “Superconducting proximity effect in epitaxial Al-InAs heterostructures,” by William Mayer, Joseph Yuan, Kaushini S. Wickramasinghe, Tri Nguyen, Matthieu C. Dartialh, and Javad Shabini, *Applied Physics Letters* (2019). The article can be accessed at https://doi.org/10.1063/1.5067363.

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