DNA self-assembled nanowires serve as templates for superconducting NbN

An international research group has used the innate properties of DNA to achieve a materials science application. As reported in *AIP Advances* (<https://aip.scitation.org/doi/10.1063/5.0029781>), Lior Shani of Bar-Ilan University and colleagues used a DNA origami nanowire template to produce highly conducting wires of superconducting niobium nitride (NbN). The researchers established a relationship between temperature and resistance of the nanowires.

DNA origami nanowires were used as templates to deposit NbN. The resistance of the fabricated material did not approach a zero value because of the nanometer-width of the wires as would be expected for superconductors. The NbN-coated nanowires decreased the low temperature resistance resulting from quantum phase slips (QPSs), which result in phase/charge fluctuations for superconducting materials. QPSs result in phase coherence fluctuations that effect dissipation of transfer.

Analyses of the NbN-coated DNA nanowires showed a clear temperature (low temperature for superconductivity) dependence of the wires at zero field. This provided multiple

information: superconducting transition $T_c \sim 5$ K, thermally activated phase slips (TAPSs) region between ~ 4 and 5 K that indicates a temperature higher than the energy barrier between states, a QPS region below ~ 4 K where there is weak to no temperature dependence, and a sudden drop at ~ 4 K. Also, this allowed equations to be defined for both TAPS and QPS identified regions that can explain the behavior observed as to the temperature effect. The researchers attribute the weak temperature dependence at the QPS region to a combined effect of QPS and charge imbalance, which is common for superconductors.

Characterization showed that an increase in the magnetic field results in an initial decrease in resistance, hence exhibiting negative magnetoresistance (NMR) until reaching a minimum at a field H_{min} , which increases onward. According to the researchers, “The NMR effect is more pronounced as the temperature decreases.” The resulting trend dictates that at low fields, the decrease in charge imbalance decay length (Λ_Q) with the field dominates resulting in NMR, and at high fields, the increase in rate of phase slips (Γ_{PS}) with the field dominates, resulting in positive magnetoresistance. These two processes compete to determine the behavior of magnetoresistance; some equations are employed to define these terms.

The researchers conclude that the large NMR presented by their NbN-coated DNA nanowires is due to the nanowires’ short length. This research leads the way into possible applications as interconnects in nanoelectronics and exhausting DNA origami’s flexibility to fabricate three-dimensional (3D) architectures as this array allows for nanoscale bending into 2D and 3D shapes.

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Schematic illustration of a NbN-coated DNA nanowire suspended above a SiN/SiO₂ channel. Credit: *AIP Advances*.

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