The origin of bias independent conductance plateaus and zero bias conductance peaks in Bi2Se3/NbSe2 hybrid structures

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Abstract

Superconducting proximity effect in topological insulator and superconductor hybrid structure has attracted intense attention in recent years in an effort to search for mysterious Majorana fermions in condensed matter systems. Here we report on the superconducting proximity effect in a Bi2Se3/NbSe2 junction fabricated with an all-dry transfer method. Resulting from the highly transparent interface, two sharp resistance drops are observed at 7 K and 2 K, respectively, corresponding to the superconducting transition of NbSe2 flake and the superconducting proximity effect induced superconductivity in Bi2Se3 flake. Experimentally measured differential conductance spectra exhibit a bias-independent conductance plateau in the vicinity of zero bias below 7 K. As temperatures further decrease a zero bias conductance peak emerges from the plateau and becomes more enhanced and sharpened at lower temperatures. Our numerically simulated differential conductance spectra reproduce the observed bias-independent conductance plateau and zero bias conductance peak and show that the superconducting proximity effect in topological surface states is much stronger than that in the bulk states of Bi2Se3. The Superconducting proximity effect induced superconducting gap for the topological surface states of Bi2Se3 is comparable to that of NbSe2 and gives rise to the observed bias-independent conductance plateau below 7 K. In contrast, the superconducting proximity effect induced superconducting gap for the bulk states of Bi2Se3 is an order of magnitude smaller than that of NbSe2 and superconducting topological surface states. These weakly paired bulk states in Bi2Se3 give rise to the zero bias conductance peak below 2 K. Our study has clearly unveiled the different roles of topological surface states and bulk stats in the superconducting proximity effect, clarified the physical origin of the induced features, and shined light on further investigation of superconducting proximity effect and Majorana fermion in topological insulator and superconductor hybrid structures.

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