Towards Two-Dimensional Superconductivity of $NbSe_2$ Monolayers in Van-der-Waals SnSe-based Superlattices

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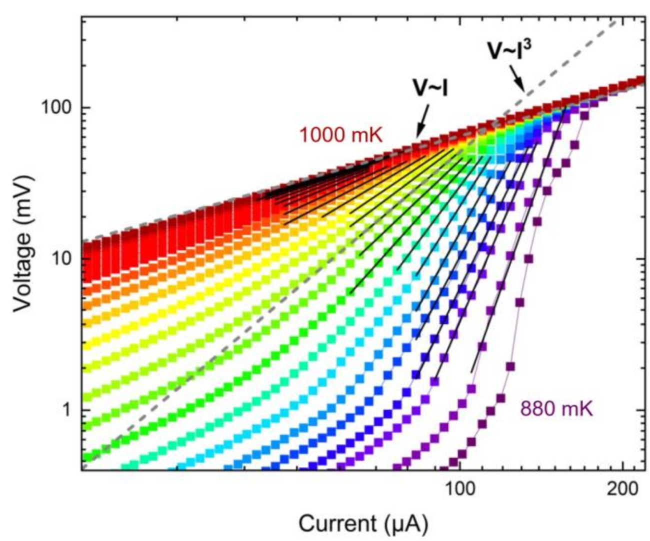
Layered transition-metal dichalcogenides (TMDCs) as ultrathin layers are popular materials, because they exhibit a wide range of electric transport properties [1], including two-dimensional (2D) superconductivity [2]. The ability to stack single layers of different semiconducting–superconducting compounds has spurred the study of new properties arising from proximity effects between adjacent layers [3, 4]. A new approach to understanding the interplay between the layers are ferecrystals, which are a Van-der-Waals bound composites of superconducting layers and semiconducting spacers [4]. Our recent studies addressed the question of dimensionality of the superconducting layers and of the role played by changes in structure and bandstructure of the semiconducting spacer layers in the coupling between these superconducting layers [5-8].

In this work we examine the collapse of the superconducting state of a $[(\mathrm{SnSe})_{1+\delta}]_3[\mathrm{NbSe}_2]_1$ ferecrystal in terms of the critical current, temperature, and magnetic field. We determine both the in-plane and out-of-plane Ginzburg-Landau coherence lengths and observe the effects on the current-voltage-characteristic by the formation of vortices. These effects are analysed in terms of a Berezinskii-Kosterlitz-Thouless transition and the formation of phaseslip lines, both signatures of 2D superconductivity. The latter also explains an anomaly in the temperature dependence of the critical currents.



Current-voltage characteristics of the ferecrystal $[(\mathrm{SnSe})_{1+\delta}]_3[\mathrm{NbSe}_2]_1$ as a function of bath temperature near the superconducting transition at $T_c \approx 975$ mK. $V \sim I^3$ is a signature for the BKT transition at $T \approx 940$ mK.

References

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