Superconductivity in 2D $NbSe_2$ Field Effect Devices

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Two dimensional transition metal dichalcogenides (TMD) have become an increasing area of interest since the isolation of graphene. These materials exhibit a variety of electronic ground states, such as superconducting, semiconductor and metallic, and the electronic behavior of monolayer TMDs differs from that of bulk materials due to changes in their band structure.

Niobium diselenide commonly exists in two crystalline forms, 2H and 4H, depending on the stacking of the niobium diselenide molecular layers. In 2H-$NbSe_2$, one layer of niobium atoms is sandwiched between two layers of selenide atoms which have coordination numbers of 6 and 3 respectively. It is a superconductor with a T_c of 7.2K but recent studies have found T_c to decrease upon decreasing the thickness of the 2H-$NbSe_2$ flake [1]. Here we report on 2H-$NbSe_2$ field effect transistors made from few layer flakes and measure their resistive superconducting transitions as a function of applied gate potential and layer thickness [2].

Resistance measurements on all 2H-$NbSe_2$ flakes showed several superconducting transitions which were attributed to disorder in stacking between layers. Flakes thinner than eight molecular layers were not found to be conducting in our experiments. The onset T_c of thicker flakes was found to be only slightly lower than the bulk value, and reduced slightly for positive gate voltages (electron doping).

These preliminary results show that the superconducting critical temperature of these 2D materials can be tuned in our field effect transistors and we are now extending our studies to higher doping levels and a broader range of TMD materials.

References

[1] N. E. Staley, J. Wu, P. Eklund, Y. Liu, L. Li, Z. Xu, Physical Review B, 80 (2009) 184505.
[2] M. S. El-Bana, D. Wolverson, S. Russo, G. Balakrishnan, D. Mck Paul, S. J. Bending, Superconductor Science and Technology, **26** (2013) 125020.

Figures

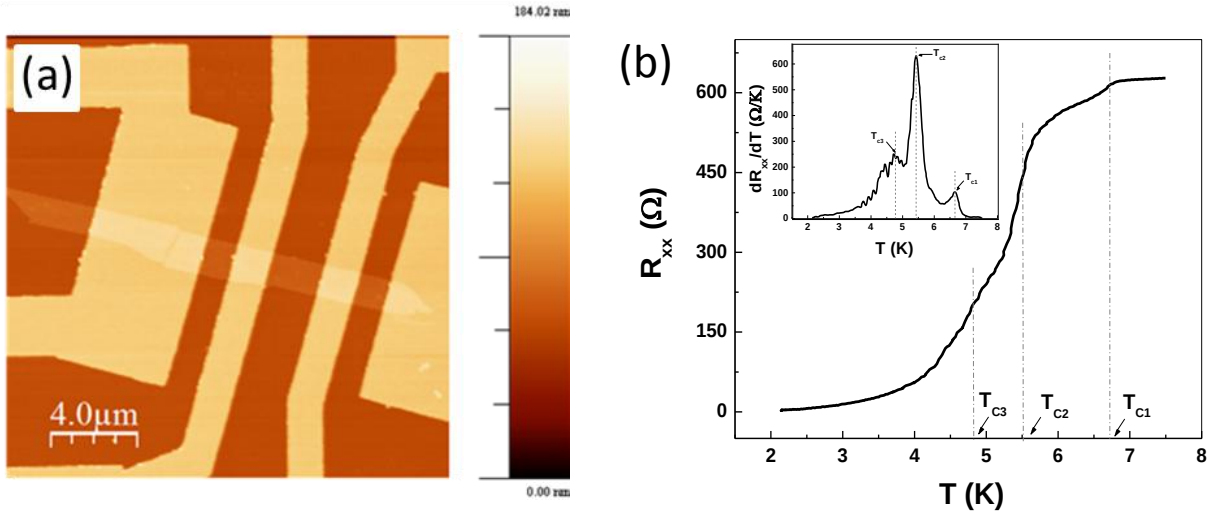

Figure 1. (a) AFM image of a $NbSe_2$ flake with Cr/Au contacts (b) Resistance versus temperature curve showing three distinct superconducting transistions in a 10.37 nm flake.