Tunable doping of 2D materials by physisorbed self-assembled networks

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One key challenge for two-dimensional materials is to tune its charge carrier concentration, i.e., controlling p- and n-type doping. An attractive approach in this respect is offered by controlled physisorption on the surface of well-ordered self-assembled networks.[1] We report how this approach results in tunable doping of graphene and few-layer MoS_2.[2,3] We used self-assembled networks of alkyl-amines with varying chain length. As seen in figure 1, the doping density can be modulated by controlling the number of the strongly n-type doping amine groups in contact with the surface. As revealed by scanning tunneling and atomic force microscopy, this number/density is governed by the length of the alkyl chain which acts as a spacer within the self-assembled network. The modulation of the doping level was also demonstrated using Raman spectroscopy and through electrical measurements on field effect transistors, see figure 2. This supramolecular functionalization approach offers new possibilities for controlling the properties of graphene and other two-dimensional materials at the nanoscale

References

[1] K. S. Mali et al., Nanoscale, 7 (2015) 1566
[2] R. Phillipson et al., Nanoscale, 8 (2016) 20017
[3] C.J. Lockhart de la Rosa et al., Applied Physics Letters, DOI: 10.1063/1.4972781

Figures

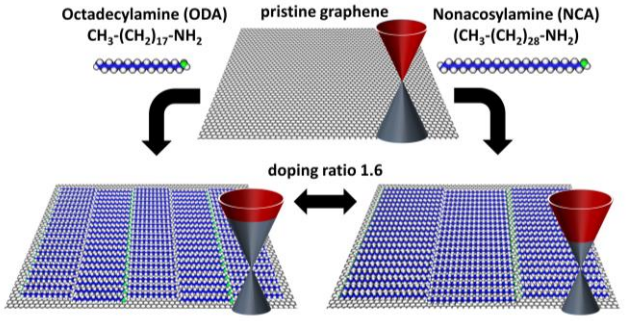

Figure 1: Schematic illustration of the concept of tunable doping by controlling the density of dopant moieties on the surface using self-assembled networks.

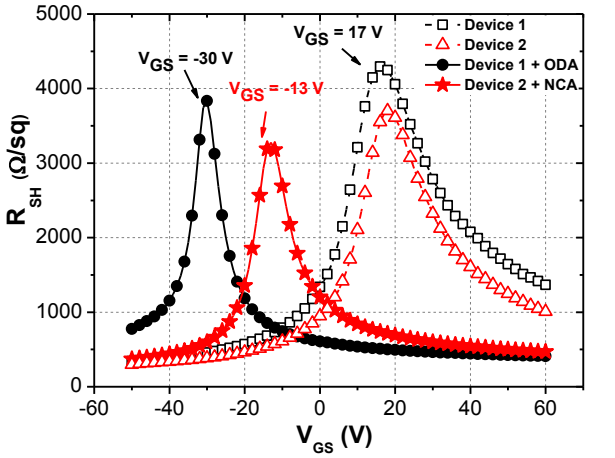

Figure 2: Transfer curves of graphene FETs before and after functionalization with alkyl amines with different chain length. The ratio of the shifts of the K-points for the two molecules (1.5) corresponds to the density of the amine groups on the graphene surface.