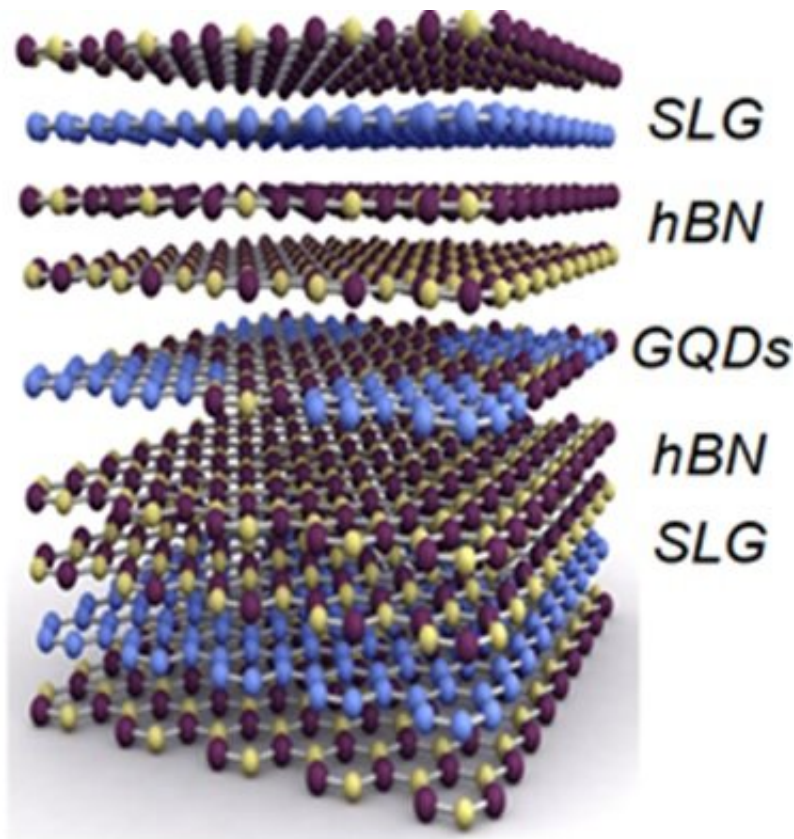


# Graphene quantum dots for single electron transistors

March 7 2019

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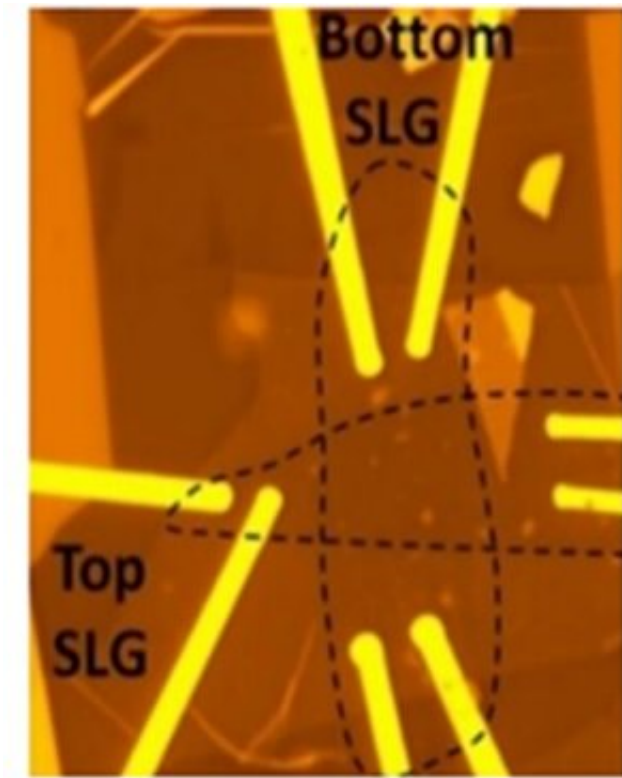
The schematic structure of the devices Credit: Davit Ghazaryan

Scientists from the Higher School of Economics, Manchester University, the Ulsan National Institute of Science & Technology and the Korea Institute of Science and Technology have developed a novel technology that combines the fabrication procedures of planar and vertical

heterostructures in order to assemble graphene-based single-electron transistors of excellent quality.

This technology could considerably expand the scope of research on two-dimensional materials by introducing a broader platform for the investigation of various devices and [physical phenomena](#). The manuscript is published as an article in *Nature Communications*.

In the study, it was demonstrated that high-quality [graphene](#) quantum dots (GQDs), regardless of whether they were ordered or randomly distributed, could be successfully synthesised in a matrix of monolayer [hexagonal boron nitride](#) (hBN). Here, the growth of GQDs within the layer of hBN was shown to be supported catalytically by the platinum (Pt) nanoparticles distributed in between the hBN and supporting oxidised silicon ( $\text{SiO}_2$ ) wafer, when the whole structure was treated by the heat in the methane gas ( $\text{CH}_4$ ). Due to the same lattice structure (hexagonal) and small lattice mismatch ( $\sim 1.5$  percent) of graphene and hBN, graphene islands grow in the hBN with passivated edge states, thereby giving rise to the formation of defectless [quantum dots](#) embedded in the hBN monolayer.

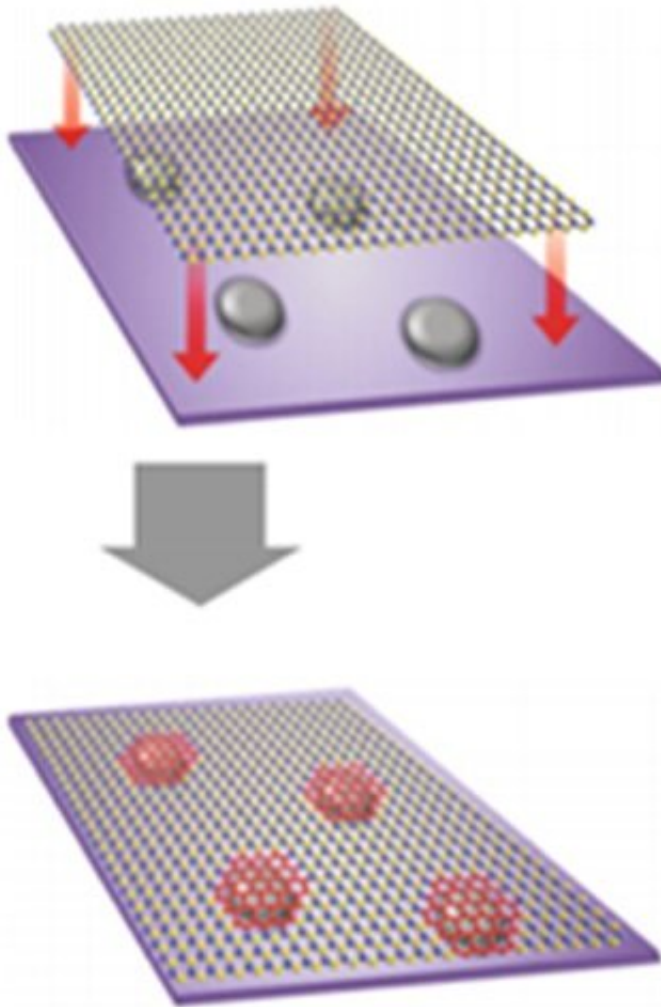


Optical micrograph (100X) of one of the devices with the highlighted layers of graphene electrodes Credit: Davit Ghazaryan

Such planar heterostructures incorporated by means of standard dry-transfer as mid-layers into the regular structure of vertical tunnelling transistors were studied through tunnel spectroscopy at low temperatures (3He, 250mK). The study demonstrated the location where well-established phenomena of the Coulomb blockade for each graphene quantum dot manifests as a separate single electron transmission channel.

"Although the outstanding quality of our single electron transistors could be used for the development of future electronics," explains study co-author Davit Ghazaryan, associate professor at the HSE Faculty of Physics, and Research Fellow at the Institute of Solid State Physics

(RAS). "This work is most valuable from a technological standpoint as it suggests a new platform for the investigation of physical properties of various materials through a combination of planar and van der Waals heterostructures."



The growth of graphene quantum dots within the hBN matrix Credit: Davit Ghazaryan

**More information:** Gwangwoo Kim et al, Planar and van der Waals heterostructures for vertical tunnelling single electron transistors, *Nature Communications* (2019). [DOI: 10.1038/s41467-018-08227-1](https://doi.org/10.1038/s41467-018-08227-1)

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