Electrically Contacting Self-Assembled PbS Nanocrystals Using Graphene

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Using molecular junctions as electrical components often implies low scalability and complex fabrication: horizontal architectures generally require costly and sequential processes such as electron-beam lithography [1], whilst vertical stacking arrangements using metal evaporation can damage the molecules or cause short circuits [2]. Recent architectures with molecular self-assembled monolayers (SAMs) and graphene have enabled to molecular tunnel junctions to be built with a yield of 90% [3]. Here, we use graphene to make arrays of ~1μm² junctions contacting SAMs of PbS nanocrystals (5nm diameter) as quantum dots to obtain films with more complex low-dimensional transport characteristics. Our junctions exhibit Coulomb blockade [1,5] in the nanocrystals (Fig. 2) with a yield above 40% before optimisation, thus demonstrating single-electron effects in a robust and scalable architecture. The design is adapted for electron-beam lithography to contact areas down to nanometre sizes. This enables a comparison of transport over a large range of nanocrystal numbers, from single digits up to tens of thousands. Statistical analysis and topographical imaging allow us to investigate the conduction parameters in these complex films.

References

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Figures

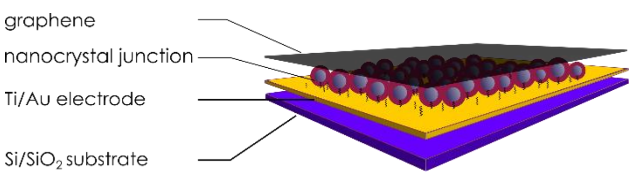

Figure 1: Self-assembled PbS nanocrystal junction. The nanocrystals form a dense monolayer supporting the graphene top electrode.

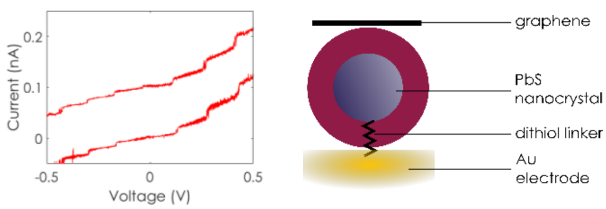

Figure 2: Left: *I-V* measurements of a self-assembled PbS nanocrystal junction exhibiting a Coulomb staircase (curves are offset vertically for clarity). Right: Detail of a self-assembled PbS nanocrystal contacted as a quantum dot.