Graphene as a cluster sensor: detecting size-specific charge transfer and oxidation of few-atom Au_n

Jeroen E. Scheerder
S. Liu, V.S. Zharinov, N. Reckinger, J.-F. Colomer, H.-P. Cheng, E. Janssens and J. Van de Vondel

Laboratory of Solid-State Physics and Magnetism, KU Leuven, Leuven, Belgium

jeroen.scheerder2@kuleuven.be

Graphene's high susceptibility to adsorbed (nano-)particles makes it of great interest for sensing applications, and it provides schemes to tailor graphene's properties for example for spintronics and catalysis. Ultra-small metallic clusters are interesting candidates in this perspective. Their physico-chemical properties, which greatly differ from the element's single atom or bulk characteristics, strongly depend on the exact number of atoms. It is expected that these size-specific cluster properties will transpire in graphene's electronic properties. Thus on the one hand, graphene can act as a sensor to clusters, while on the other, the virtually endless possibilities to tune a cluster's properties, greatly expands the opportunities for graphene-based cluster devices.

In order to bring these fascinating low-dimensional systems together, we introduced size-selected few-atom metal gold clusters as adparticles to graphene devices, in a novel technical realization which offers high control over the type of clusters and deposition parameters [1].

Moreover [2], we demonstrate the binding of molecular oxygen to Au_n clusters deposited on graphene (Figure 1). This is an important aspect of the catalytic behaviour of these ultrasmall Au clusters. Furthermore, size-specific charge transfer can be resolved in these systems (Figure 2). To the best of our knowledge, there has been no prior realization of a device, in which the rich size-dependence of few-atom clusters is transpired in its properties.

References

[1] J.E. Scheerder *et al, Nanoscale* **9**, 10494 (2017)
[2] J.E. Scheerder *et al, in preparation*

Figures

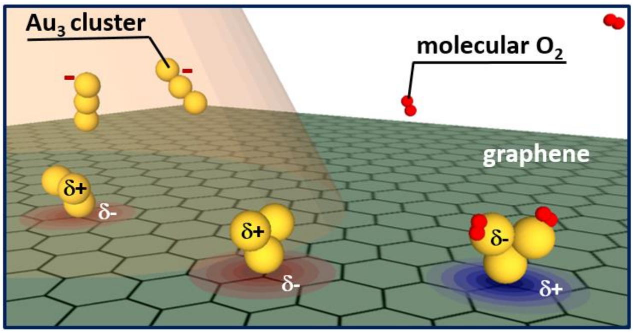

Figure 1: Schematic overview of the experiment, where size-selected Au_3 clusters are deposited on graphene, followed by in-situ oxygen adsorption. The resulting graphene-cluster charge transfer is detected electronically.

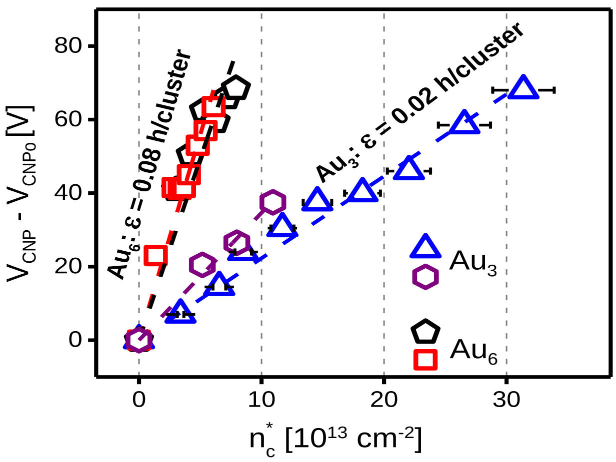

Figure 2: Doping of oxidized Au_3 and Au_6 clusters, detected as a shift in graphene's charge neutrality point as a function of the deposited cluster density. Reproduced experiments on different devices reveal size-specific effects, quantified by the doping efficiency ε.