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Novel technique used to study graphene's response to air

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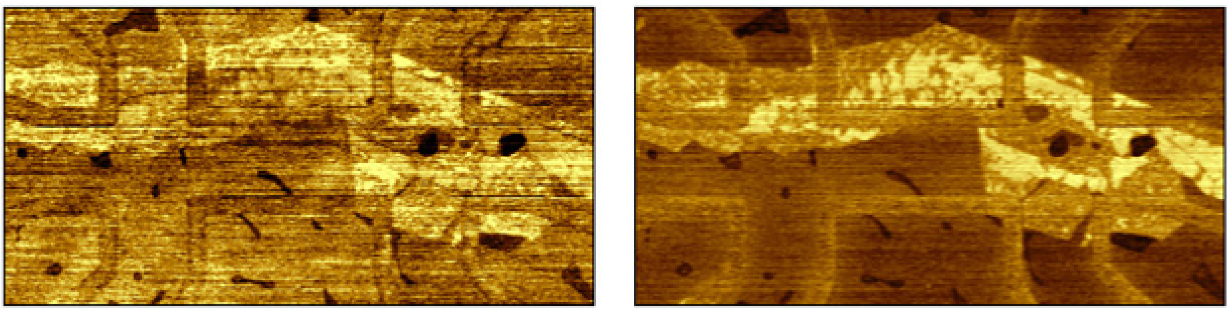

Local surface potential maps for synthetic air (left) and ambient air (right), with the same relative humidity of 40%. The scan size is 6×3 micrometres squared.

An international team of scientists led by the National Physical Laboratory (NPL) has performed novel measurements of graphene's electrical response to synthetic air, exposing a distinct knowledge gap that needs to be bridged before the commercialisation of graphene-based gas sensors.

Early gas detection is crucial in many fields, including environmental protection, medical diagnosis and national defence. Graphene, the 'wonder-material' consisting of a two-dimensional layer of carbon atoms, has attracted much attention for its potential gas sensing applications.

When the surface of graphene is bared to certain chemicals, those chemicals either donate or withdraw electrons from graphene, causing a change in the electrical resistivity. Graphene is incredibly sensitive to this process, in fact it is so sensitive that just a single molecule of nitrogen dioxide can cause a measureable change. A graphene-based gas sensor would use these electrical changes to detect the target chemical.

However, it is not that simple. Gas sensors need to be exposed to the environment in order to detect the target species, but graphene is sensitive to such a wide variety of chemicals that its electrical resistivity changes significantly in ambient air alone. This makes it difficult to differentiate between the changes that are caused by the target gas and those caused by the natural environment.

In a new study, a group of scientists from NPL, Chalmers University of Technology and the US Naval Research Laboratory have used a novel technique to examine the effects of ambient air on graphene in a controlled environment in order to characterise its response.

The researchers investigated the effects of nitrogen, oxygen, water vapour and nitrogen dioxide (in concentrations typically present in ambient air) on epitaxial graphene inside a controlled environmental chamber. All measurements were taken at NPL by applying Kelvin probe force microscopy whilst simultaneously performing transport (resistance) measurements. This novel combination gave researchers the unique ability to connect the local and global electronic properties together, a task that has proven to be difficult in the past.

The study, published in 2D Materials, experimentally showed that the combination of gases used does not fully replicate the effects of ambient air; even at concentrations higher than those found in the typical atmosphere, there is a large difference in graphene's response. This result contradicts past literature, which has mainly attributed the changes in graphene's electronic properties to these gases. And it raises the question: "What mystery chemicals are causing this significant response?"

It is clear that, while graphene-based gas sensors have great potential, there is still a lot of research to be done. Further exploration is needed to find the missing link between the effects seen in controlled laboratories and the effects seen in ambient air. Researchers are also interested in studying methods to optimise the devices by narrowing the sensitivity to specific target species, such as chemical functionalisation.

More information: Vishal Panchal et al. Atmospheric doping effects in epitaxial graphene: correlation of local and global electrical studies, *2D Materials* (2016). DOI: 10.1088/2053-1583/3/1/015006

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