Research team achieves high-resolution 2D imaging for graphene devices under high pressure

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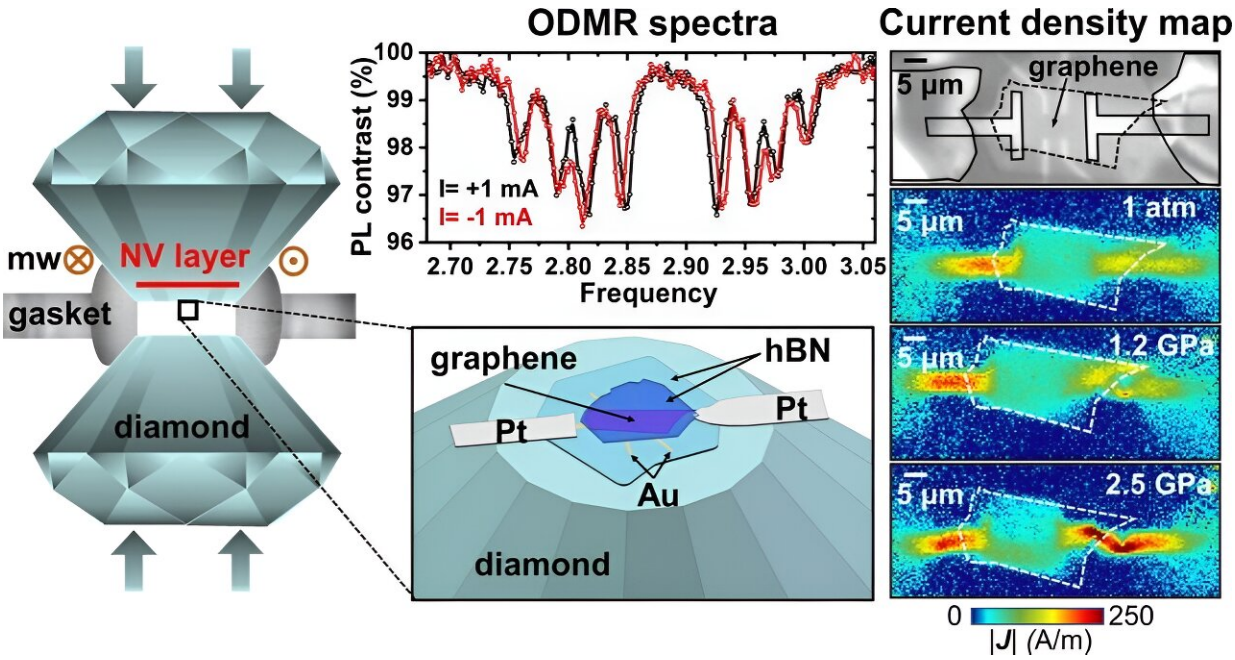

Current Density Imaging and Evolution of 2D hexagonal boron nitride (hBN)-graphene-hBN Devices Under High Pressure. Credit: *Nano Letters* (2024). DOI: 10.1021/acs.nanolett.4c00780

A research team led by Prof Zhang Zengming from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences (CAS) has combined nitrogen-vacancy (NV) centers in

diamond with a diamond anvil cell (DAC) to achieve non-invasive, high-resolution two-dimensional imaging of current density and pressure gradient for graphene devices under high pressure.

The team's study is published in *Nano Letters*.

Many two-dimensional materials exhibit rich electronic properties under high pressure, such as pressure-induced superconductivity and topological phase transitions in twisted bilayer graphene (tBLG). However, traditional resistance measurements overlook crucial spatial information such as topological edge currents, impurities, and defects, which play pivotal roles in many intriguing physical phenomena.

Existing magnetic imaging techniques, such as superconducting quantum interference devices (SQUID), are limited by complex experimental conditions and finite spatial resolution, making them challenging to implement under high pressure. Therefore, there is an urgent need to develop experimental devices capable of non-invasive, high-resolution imaging of current density in two-dimensional devices under high pressure.

NV centers in diamond have been widely used to achieve two-dimensional current density imaging under ambient pressure due to their high sensitivity and spatial resolution. Moreover, combining NV centers with DAC enables high-resolution magnetic imaging under high pressure. Building upon this, the research team successfully combined NV centers with DAC to achieve non-invasive, high-resolution imaging of two-dimensional current density under high pressure.

Additionally, they reconstructed the two-dimensional vector current density using the vector magnetic field mapped by the near-surface NV center layer in the diamond. The current density images accurately and clearly depicted the complex structure of compressed graphene under

high pressure, such as the formation of cracks and holes, and the flow of current. The extracted pressure spatial distribution map of the graphene device under high pressure provides a reasonable explanation for the non-uniformity of current density, such as variations in contact resistance and thickness.

This finding presents a new avenue for exploring electronic transport and conductivity changes in two-dimensional materials and electronic devices under high pressure, as well as for non-destructive evaluation of semiconductor circuits.

More information: Cheng Zhong et al, High Spatial Resolution 2D Imaging of Current Density and Pressure for Graphene Devices under High Pressure Using Nitrogen-Vacancy Centers in Diamond, *Nano Letters* (2024). DOI: 10.1021/acs.nanolett.4c00780

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