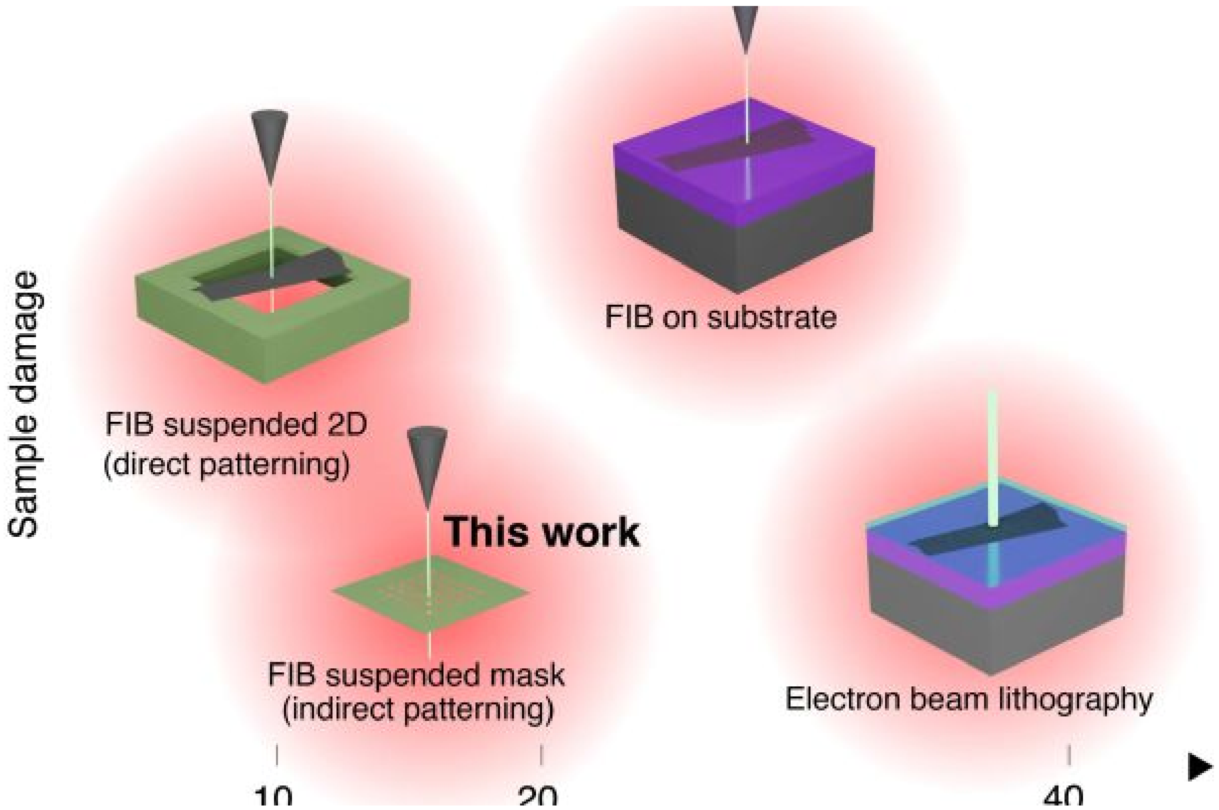

A novel nanofabrication technique for patterning periodic structures achieves record resolution

An international team of researchers from ICFO and NIMS has developed a new solution for patterning periodic nanostructures that goes beyond the spatial resolution of standard techniques, enabling the realization of very short-period superlattices in 2D materials.

December 07, 2022

Miniaturizing patterned features in optoelectronics is one of the main goals of nanofabrication research efforts for several decades now. Electron beam lithography has been so far one of the most common widespread nanopatterning fabrication techniques in academic research but it poses certain limitations. An alternative to this technique is the helium-focused ion beam (He-FIB) milling approach for direct patterning of features. Although it achieves a very high resolution, it presents two major limiting factors: ion implantation in the substrates and damage in the patterned material due to secondary collisions.

In a recent study published in **Nature Communications**, ICFO researchers David Barcons Ruiz, Hanan Herzig Sheinfux, Rebecca Hoffmann, Iacopo Torre, Roshan Krishna Kumar, Lorenzo Vistoli, Adrian Bachtold, led by ICREA Professor Frank Koppens, in collaboration with researchers from the National Institute for Materials Science (Japan), have reported on a new technique based on ultra-thin suspended etching masks that are implemented to pattern periodic nanostructures. By using this new strategy, they have been able to fabricate graphite electrodes to engineer high-quality graphene superlattices.

The new technique uses ultra-thin suspended membrane, made of poly-crystalline silicon, which have been previously milled with an He-FIB. With the use of a polymer-based stamp, the membrane (working as a mask) is transferred onto a graphite flake. The final pattern is copied from the mask to the substrate byreactive ion etching. Finally, the mask is remove from the sample. "As a demonstration of the capabilities of our technique, we patterned a triangular lattice with a period as small as 16 nm and hole diameters down to 8 nm", the researchers highlighted.

To test their new technique, the researchers fabricated two patterned graphite gate electrodes, which were integrated into two single-layer graphene devices to engineer superlattice (SL) potentials. The fabricated electrodes had a square lattice pattern but with a different period: 47 nm in one device and 18 nm in the other. The research team conducted electronic transport measurements, demonstrating superlattice features typical to moire, such as satellite peaks due to the cloned Dirac cones, Hofstadter butterfly spectrum, and Landau fans emerging from the satellite peaks.

This new solution opens the door "towards the realization of a very short period superlattices in 2D materials, but with the ability to control lattice symmetries and strength. This can pave the way for a versatile solid-state quantum simulator platform and the study of correlated electron phases", they concluded.

Original article

Barcon Ruiz, D., Herzig Sjeinfux, H., Hoffmann, R., Torre, I., Agarwal, H., Krishna Kumar, R., Vistoli, L., Taniguchi, T., Watanabe, K., Bachtold, A., Koppens, F. H.L. (2022) Engineering high quality Graphene superlattices via ion milled ultra-thin etching masks. **Nature Communications**, 13:6926.