High quality graphene from nickel

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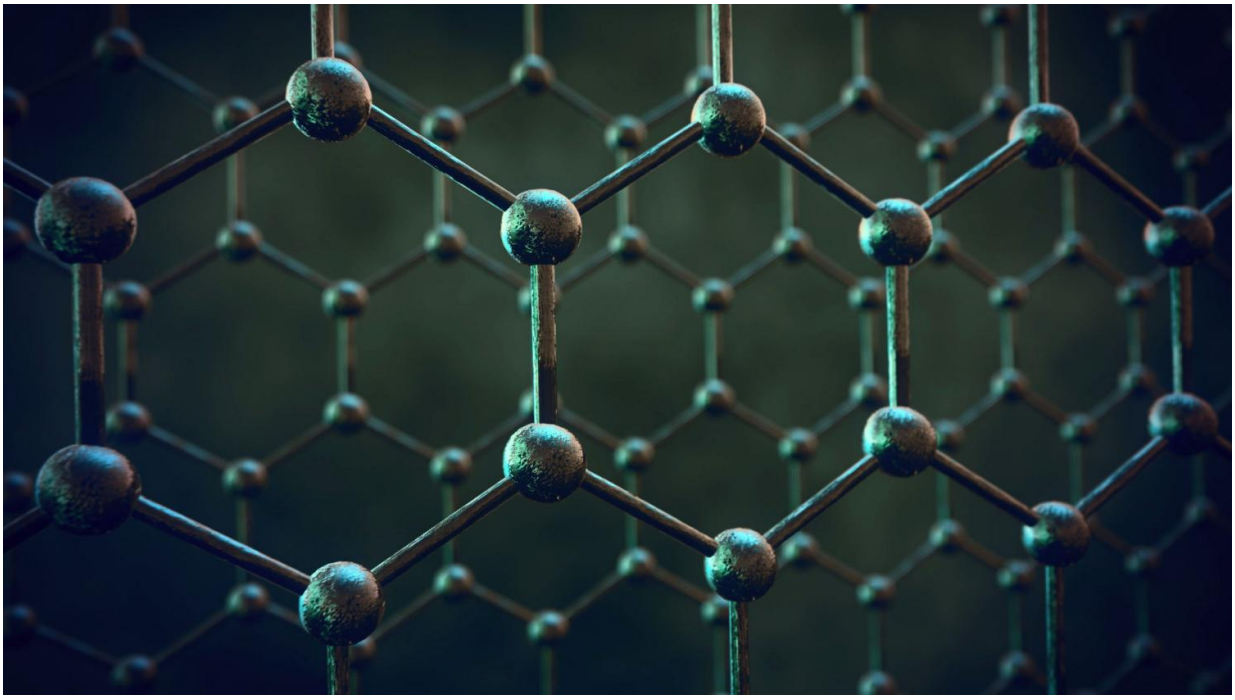

This visualisation shows layers of graphene used for membranes. Credit: University of Manchester

A study published in *Science* reports the catalytic action of nickel in the growth of graphene sheets. The research, carried out by Iom-Cnr and the University of Trieste, provides new strategies to improve the industrial production of this material characterized by exceptional properties

Graphene is a two-dimensional material composed of a single layer of

carbon atoms. It is flexible like plastic and exhibits a mechanical resistance 100 times higher than steel. Thus, it is considered ideal for multiple uses in industrial and technological fields. However, it is difficult to produce, making its use extremely expensive.

The study, conducted in Trieste (Italy) by the Istituto officina dei materiali of the Italian National Research Council (Iom-Cnr) and by the Department of physics of the University of Trieste identifies the mechanism of graphene growth on the surface of nickel, opening up new possibilities in production technologies.

"We know that individual atoms are always present on metal surfaces, where they can freely move around and participate in many of the processes that take place there," explains Cristina Africh, of Iom-Cnr. "In our study, we have shown that on a nickel surface, the mobile metal atoms act as catalysts, facilitating the formation of graphene."

The scientific team was able to record this process in real time, revealing the behavior of individual surface atoms by means of a high-speed scanning module developed in the recent years in collaboration with Elettra-Sincrotrone Trieste and recently improved thanks to European funding.

"With a scanning tunneling microscope," says Laerte Patera, "we filmed what happens at the edge of the graphene sheet during its growth, at a temperature of about 450 degrees Celsius, collecting up to 60 images per second, a frame rate much higher than those used in cinematography or in television and perceived by the human eye."

"From the videos, it is clear that the growth process takes place line by line, like a knitting machine weaving a thread to form a piece of cloth. At the microscopic level, the individual nickel atoms perform the same function as the machine needle, adding new stitches to the edge of the

fabric in an ordered sequence," explains Giovanni Comelli from the University of Trieste. "Numerical simulations clarify all details of the experimental results and clearly explain the role played by nickel adatoms which, by temporarily attaching themselves at the graphene edges, allow the inclusion of new carbon atoms."

"In addition to its relevant scientific value, this result is of considerable interest for applications, since one of the most widely used methods currently employed for industrial production of graphene makes use of a nickel substrate to grow graphene layers characterized by few defects at a reduced production cost," concludes Africh. "Understanding the details of the growth mechanism, so far unknown, is therefore fundamental to define a strategy for the development of new and more efficient graphene production processes at the industrial level."

More information: Laerte L. Patera et al. Real-time imaging of adatom-promoted graphene growth on nickel, *Science* (2018). DOI: 10.1126/science.aan8782

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