New insights advance atomic-scale manufacturing

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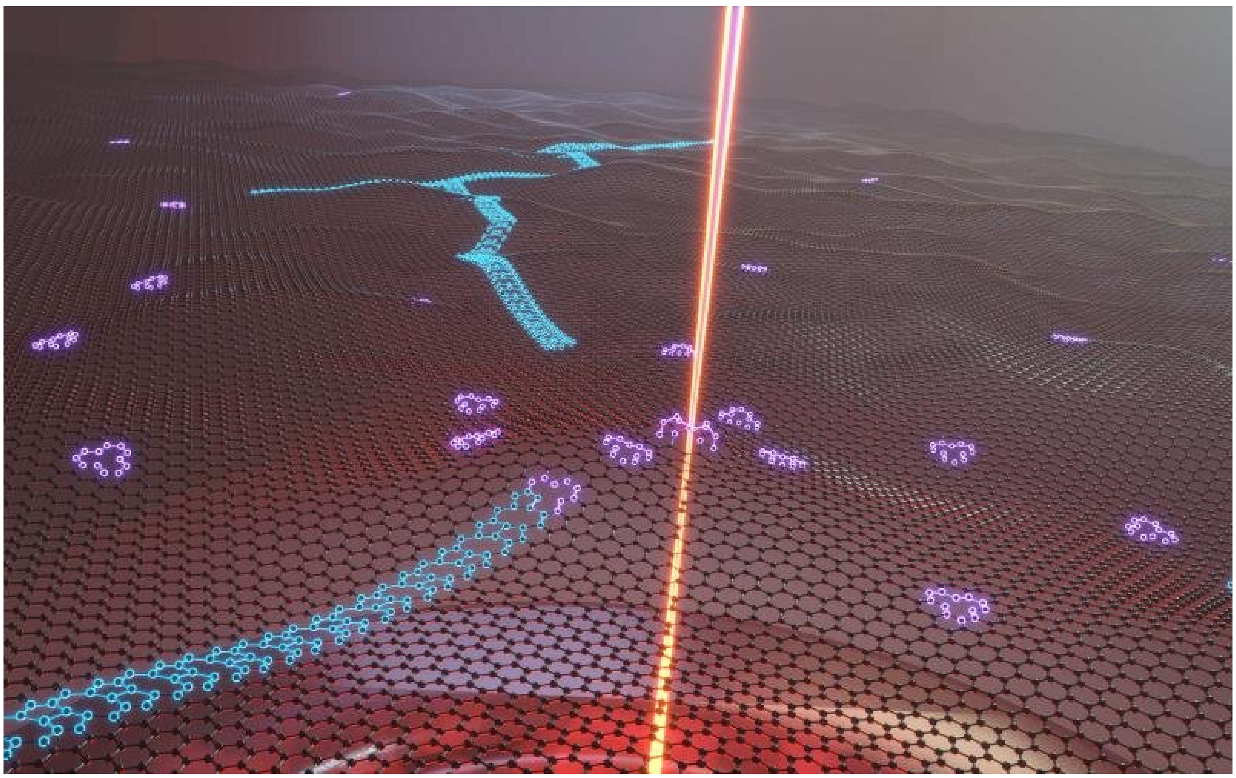

When an electron beam drills holes in heated graphene, single-atom vacancies, shown in purple, diffuse until they join with other vacancies to form stationary structures and chains, shown in blue. Credit: Ondrej Dyck/ORNL, U.S. Dept. of Energy

Oak Ridge National Laboratory researchers serendipitously discovered when they automated the beam of an electron microscope to precisely drill holes in the atomically thin lattice of graphene, the drilled holes closed up. They expected the heat to make atoms easier to remove, but they saw the opposite effect.

"Graphene appeared impervious to the electron beam," said Ondrej Dyck, who co-led the study with Stephen Jesse at ORNL's Center for Nanophase Materials Sciences. Jesse added, "It heals locally, like the (fictitious) liquid-metal T-1000 in the movie Terminator 2: Judgment Day."

Theory-based computations performed on the lab's Summit supercomputer, led by ORNL's Mina Yoon, explained the quasi-metal's healing ability: Single atomic vacancies zip through the heated graphene until they meet up with other vacancies and become immobilized.

"Similar processes are likely to extend to other 2D materials," Dyck said.

"Controlling such processes could help us realize graphene's promise for quantum information science," said Jesse.

The study is published in the journal *Carbon*, and the researchers are applying this new knowledge to guide creation of atomic-scale devices.

More information: Ondrej Dyck et al, The role of temperature on defect diffusion and nanoscale patterning in graphene, *Carbon* (2022). DOI: 10.1016/j.carbon.2022.09.006

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