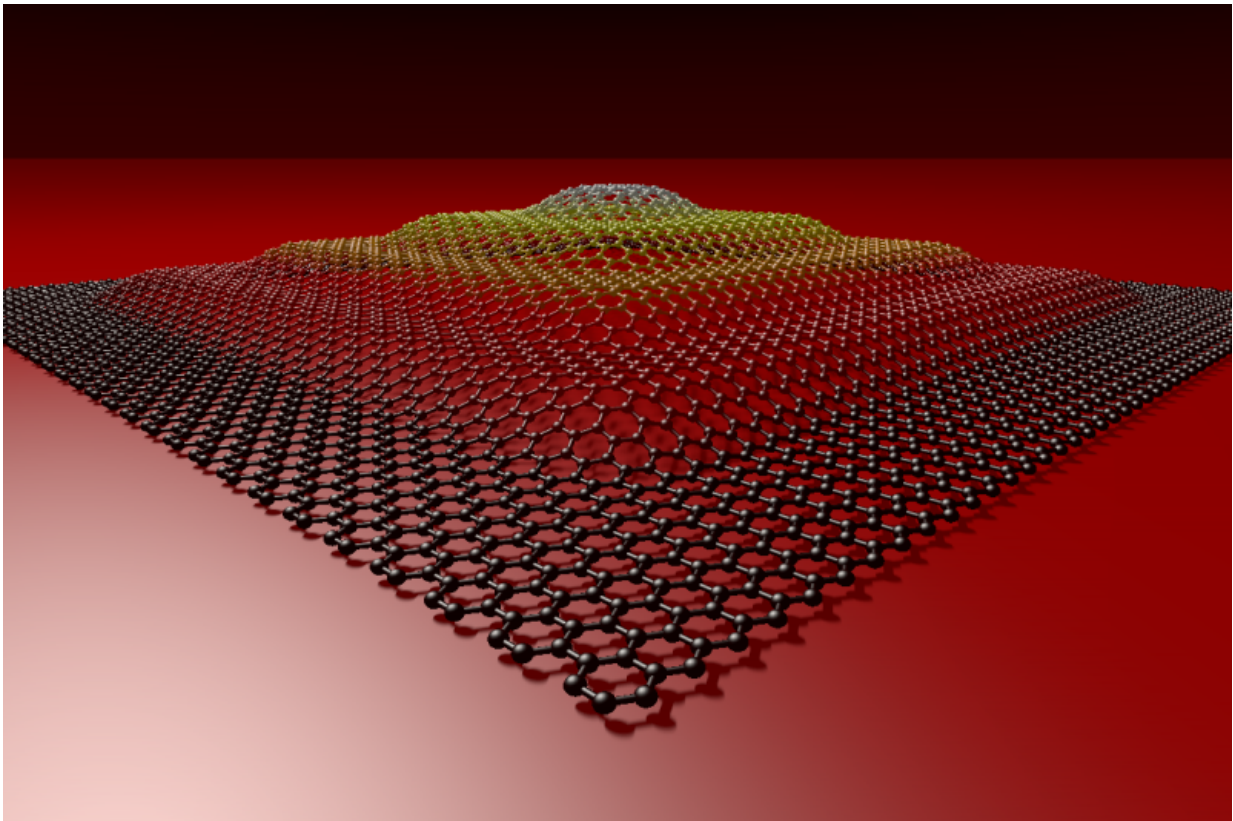


Graphene forged into three-dimensional shapes

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Credit: Academy of Finland

Researchers from Finland and Taiwan have discovered how graphene, a single-atom-thin layer of carbon, can be forged into three-dimensional objects by using laser light. A striking illustration was provided when the

researchers fabricated a pyramid with a height of 60 nm, which is about 200 times larger than the thickness of a graphene sheet. The pyramid was so small that it would easily fit on a single strand of hair. The research was supported by the Academy of Finland and the Ministry of Science and Technology of the Republic of China.

Graphene is a close relative to graphite, which consists of millions of layers of graphene and can be found in common pencil tips. After graphene was first isolated in 2004, researchers have learned to routinely produce and handle it. Graphene can be used to make electronic and optoelectronic devices, such as transistors, photodetectors and sensors. In future, we will probably see an increasing number of products containing graphene.

"We call this technique optical forging, since the process resembles forging metals into 3-D shapes with a hammer. In our case, a laser beam is the hammer that forges graphene into 3-D shapes," explains Professor Mika Pettersson, who led the experimental team at the Nanoscience Center of the University of Jyväskylä, Finland. "The beauty of the technique is that it's fast and easy to use; it doesn't require any additional chemicals or processing. Despite the simplicity of the technique, we were very surprised initially when we observed that the [laser beam](#) induced such substantial changes on graphene. It took a while to understand what was happening."

"At first, we were flabbergasted. The experimental data simply made no sense," says Dr Pekka Koskinen, who was responsible for the theory. "But gradually, by close interplay between experiments and computer simulations, the actuality of 3-D shapes and their formation mechanism started to become clear."

"When we first examined the irradiated graphene, we were expecting to find traces of chemical species incorporated into the graphene, but we

couldn't find any. After some more careful inspections, we concluded that it must be purely structural defects, rather than chemical doping, that are responsible for such dramatic changes on graphene," explains Associate Professor Wei Yen Woon from Taiwan, who led the experimental group that carried out X-ray photoelectron spectroscopy at the synchrotron facility.

The novel 3-D graphene is stable and it has electronic and optical properties that differ from normal 2-D graphene. Optically forged graphene can help in fabricating 3-D architectures for [graphene](#)-based devices.

More information: Andreas Johansson et al. Optical Forging of Graphene into Three-Dimensional Shapes, *Nano Letters* (2017). [DOI: 10.1021/acs.nanolett.7b03530](https://doi.org/10.1021/acs.nanolett.7b03530)

Provided by Academy of Finland

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