The Advanced Photon Source

Transformation of Graphite into Hexagonal Diamond

A new study by Washington State University (WSU) researchers using the U.S. Department of Energy's Advanced Photon Source (APS) answers longstanding questions about the formation of a rare type of diamond formed during major meteorite strikes. The discovery could help planetary scientists use the presence of hexagonal diamond at meteorite craters to estimate the severity of impacts.

Hexagonal diamond or lonsdaleite is harder than the type of diamond used in an engagement ring and is thought to be naturally made when large, graphite-bearing meteorites slam into Earth. Scientists have puzzled over the exact pressure and other conditions needed to make hexagonal diamond since its discovery in an Arizona meteorite fragment half a century ago.

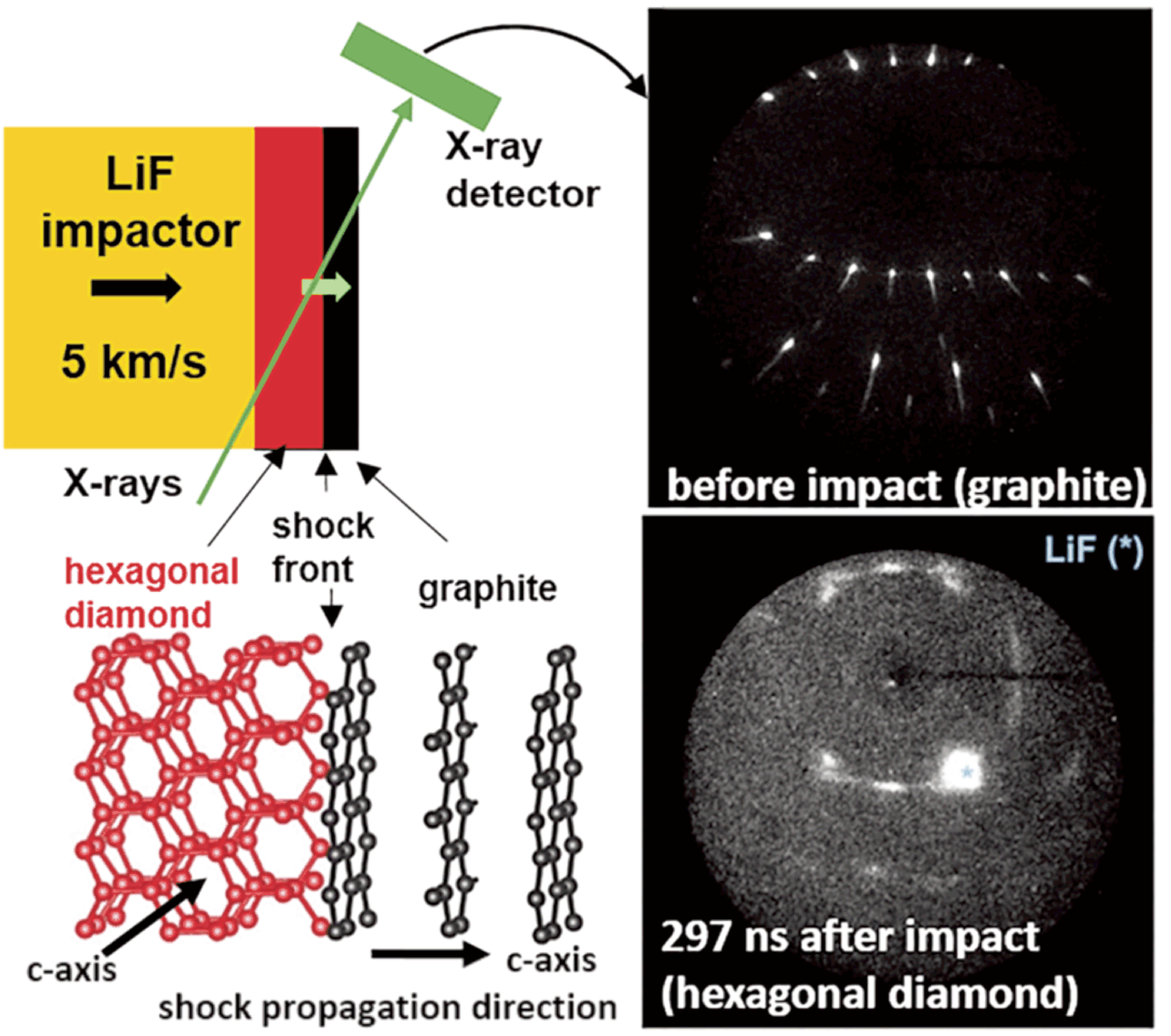
The team of WSU researchers has for the first time observed and recorded the creation of hexagonal diamond in highly oriented pyrolytic graphite under shock compression, revealing crucial details about how it is formed. The research was carried out at the WSU-led Dynamic Compression Sector (35) of the APS. The DCS is a first-of-its-kind experimental facility that links different shock wave compression capabilities to synchrotron x-rays. The WSU team was able to take x-ray snapshots of the transformation of graphite to hexagonal diamond in real-time.

The researchers found that the crystalline structure of a highly oriented form of graphite transforms to the uncommon hexagonal form of diamond at a pressure of 500,000 atmospheres, around four times lower than previous studies had indicated.

To obtain their results, the researchers shot a lithium fluoride impactor at 11,000 mph into a 2 mm thick graphite disk. They then used pulsed, high-brightness synchrotron x-rays from the APS and *in situ* x-ray diffraction to take snapshots every 150 billionths of a second, while the shockwave from the impact compressed the graphite sample. Their work unambiguously demonstrated that the graphite sample transformed into the hexagonal form of diamond before being obliterated into dust.

The next step in the research will be to investigate under what conditions pure hexagonal diamond can be recovered after shock compression.

See: Stefan J. Turneaure, Surinder M. Sharma, Travis J. Volz, J. M. Winey, Yogendra M. Gupta*, "Transformation of shock-compressed graphite to hexagonal diamond in nanoseconds," Sci. Adv. **3** eaao3561 (27 October 2017).



Experimental configuration and results.

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Call for APS General-User Proposals

The Advanced Photon Source is open to experimenters who can benefit from the facility's high-brightness hard x-ray beams.

General-user proposals for beam time during Run 2018-2 are due by Friday, March 2, 2018.

Information on access to beam time at the APS is at http://www.aps.anl.gov/Users/apply_for_beamtime.html or contact Dr. Dennis Mills, DMM@aps.anl.gov, 630/252-5680.

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