

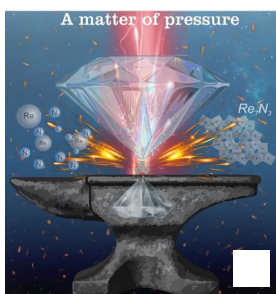
[← Back to overview](#)

University of Bayreuth, Press Release Nr. 7/2022 - 11 May 2022

Traveling to the centre of planet Uranus: Materials synthesis research and study in terapascal range for the first time

Jules Verne could not even dream of this: A research team from the University of Bayreuth, together with international partners, has pushed the boundaries of high-pressure and high-temperature research into cosmic dimensions. For the first time, they have succeeded in generating and simultaneously analyzing materials under compression pressures of more than one terapascal (1,000 gigapascals). Such extremely high pressures prevail, for example, at the center of the planet Uranus; they are more than three times higher than the pressure at the center of the Earth. In Nature, the researchers present the method they have developed for the synthesis and structural analysis of novel materials.

Theoretical models predict very unusual structures and properties of materials under extreme pressure-temperature conditions. But so far, these predictions could not be verified in experiments at compression pressures of more than 200 gigapascals. On the one hand, complex technical requirements are necessary to expose material samples to such extreme pressures, and on the other hand, sophisticated methods for simultaneous structural analyses were lacking. The experiments published in Nature therefore open up completely new dimensions for high-pressure crystallography: materials can now be created and studied in the laboratory that exist – if at all – only under extremely high pressures in the vastness of the universe.



Structures and properties of materials at extremely high pressures and temperatures are still largely "terra incognita". Prof. Leonid Dubrovinsky and his research partners use a laser-heated two-stage diamond anvil cell they constructed for the synthesis of materials in the terapascal range (1000 gigapascals). In situ single crystal X-ray diffraction is used for the simultaneous structural characterization of the materials.

© Timofey Fedotenko.

"The method we have developed enables us for the first time to synthesize new material structures in the terapascal range and to analyze them in situ – that is: while the experiment is still running. In this way, we learn about previously unknown states, properties and structures of crystals and can significantly deepen our understanding of matter in general. Valuable insights can be gained for the exploration of terrestrial planets and the synthesis of functional materials used in innovative technologies," explains Prof. Dr. Dr. h.c. Leonid Dubrovinsky of the Bavarian Geoinstitute (BGI) at the University of Bayreuth, the first author of the publication.

In their new study, the researchers show how they have generated and visualized in situ novel rhenium compounds using the now discovered method. The compounds in question are a novel rhenium nitride (ReN_3) and a rhenium-nitrogen alloy. These materials were synthesized under extreme pressures in a two-stage diamond anvil cell heated by laser beams. Synchrotron single-crystal X-ray diffraction enabled full chemical and structural characterization. "Two and a half years ago, we were very surprised in Bayreuth when we were able to produce a superhard metallic conductor based on rhenium and nitrogen that could withstand even extremely high pressures. If we apply high-pressure crystallography in the terapascal range in the future, we may make further surprising discoveries in this direction. The doors are now wide open for creative materials research that generates and visualizes unexpected structures under extreme pressures," says the study's lead author, Prof. Dr. Dr. h.c. Natalia Dubrovinskaia from the Laboratory of Crystallography at the University of Bayreuth.

Together with the Bavarian Geoinstitute (BGI) and the Laboratory of Crystallography at the University of Bayreuth, numerous other research partners were involved in the research work published in Nature: the University of Cologne, the University of Linköping, the German Electron Synchrotron DESY in Hamburg, the European Synchrotron Radiation Facility in Grenoble and the Center for Advanced Radiation Sources at the University of Chicago.

Publication:

Leonid Dubrovinsky et al.: Materials synthesis at terapascal static pressures. Nature (2022), DOI: 10.1038/s41586-022-04550-2 // <https://www.nature.com/articles/s41586-022-04550-2>

Photo for Download

 [Prof. Dr. Dr. h.c. Leonid Dubrovinsky and Prof. Dr. Dr. h.c. Natalia Dubrovinskaia, University of Bayreuth.](#)

Photo: UBT / Chr. Wiffler



Prof. Dr. Dr. h.c. Natalia Dubrovinskaia
Laboratory for Crystallography
University of Bayreuth

Phone: +49 (0)921 / 55 -3880 or -3881
E-mail: Natalia.Dubrovinskaia@uni-bayreuth.de



Prof. Dr. Dr. h.c. Leonid Dubrovinsky



Phone: +49 (0)921 / 55 -3736 or -3707
E-mail: Leonid.Dubrovinsky@uni-bayreuth.de

Webmaster: christian.wissler@uni-bayreuth.de

Social networks



Visit Universität Bayreuth on the UniNow App



Frequently visited pages

[Recent press releases](#)

[Information regarding COVID-19](#)

[Work at the university](#)

[Cafeteria, Frischraum, and Coffee Bars](#)

[Study programme finder](#)

[Programme coordinators \(PDF, in German\)](#)

[Advising & Service Network for students](#)

[Events calendar](#)

[Organizational structure](#)

