# Squashing Silane into Metal

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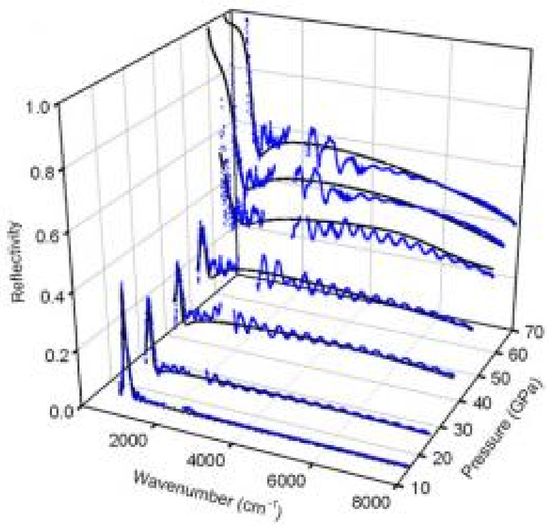


Room-temperature infrared reflectivity spectra of SiH4 at selected pressures up to 67.2 GPa. The blue squares are the measurement results. The solid lines represent model fits to the data. The small gap in the spectrum near 2000 cm-1 is due to diamond anvil absorption.

(PhysOrg.com) -- Squeeze it hard enough and hydrogen, the most abundant and lightest element in our Universe, strangely takes on a metallic nature. During this state, as it loses hold of its electrons, hydrogen is believed to display unique characteristics including high-temperature superconductivity and properties that could be useful in developing new methods of energy production using nuclear fusion and alternative fuels. Creating this drastic phase change, however, is difficult, requiring extremely high temperatures and pressures.

As a result, efforts to actually form and detect solid metallic hydrogen have been elusive. Recently, though, a team of researchers from the Carnegie Institution of Washington, South China University of Technology, and the University of Western Ontario, used the NSLS to study silane, a hydrogen-rich compound, to learn more about the leader of the period table.

“Recent studies have suggested that the metallization pressure of group IVa hydrides like methane, silane, and germane might not be not as high as it is for pure hydrogen,” said Xiaojia Chen, a physicist at the Carnegie Institution of Washington and South China University of Technology. “We thought silane would be good system to study in order to get a look at this phase transition at a pressure at which it’s easier to confirm the material’s changes.”

Most scientists believe that the recipe for creating metallic hydrogen involves heating it to 3000 degrees Kelvin (a little hotter than 2,700 degrees Celsius) and exposing it to about 1.4 million atmospheres of pressure (140 GPa). By comparison, the pressure inside the core of the Earth is 380 GPa. These conditions, however, are very difficult to reach and record in a laboratory.

Using two silane samples, the researchers found far less demanding pressure requirements for metallization: about 60 GPa. Their experiment offers the first example for the metallization of an IVa hydride. Members of this periodic group contain hydrogen that is already compressed in naturally occurring compounds.

In order to conduct the experiment, the researchers placed their silane samples in a special apparatus called a diamond anvil cell, a device that uses the polished faces of two diamonds to apply extremely high pressure. By applying a range of pressures and measuring the results through infrared reflectivity experiments at beamline U2A, the group found that silane undergoes three phase transitions before becoming opaque at 27-30 GPa. Above 60 GPa, the material shows an increase in reflectivity, indicating pressure-induced metallization.

Their results were published in the January 8, 2008 edition of the Proceedings of the National Academy of Sciences and confirmed by a group using electronic resistance measurements later that year.

Next, the researchers want to investigate the pressure dependence of the superconducting transition temperature of metallic silane and its structure at high pressure. They also hope to study the properties of another compound, germane, which is predicted to switch to a metallic state at even lower pressures than silane.

“There’s great interest in these materials in terms of energy applications and in trying to better understand many planets,” Chen said. “Some planets are mostly made of hydrogen in a very pressurized state just like what we make at the synchrotron. Understanding how this element functions in such an extreme condition could have a wide variety of implications.”

Other authors involved in the study include Muhtar Ahart, Alexander Goncharov, Russell Hemley, Zhenxian Liu, Ho-kwang Mao, and Viktor V. Struzhkin, all from the Carnegie Institution of Washington, and Yang Song, from Carnegie and the University of Western Ontario.

Publication: X. Chen, V. Struzhkin, Y. Song, A. Goncharov, M. Ahart, Z. Liu, H. Mao, R. Hemley, "Pressure-Induced Metallization of Silane", *Proc Natl Acad Sci*, 105(1), 20-23 (2008).

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