

Solar cell compound probed under pressure

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This is a microphotograph of "wurzite" GaAs nanowire in a diamond anvil cell high pressure cavity kept at 99,000 times normal atmospheric pressure (10 gigapascals); a blue spot is from the 488 nm laser spot (about 4 μm in diameter). Credit: Wei Zhou

Gallium arsenide, GaAs, a semiconductor composed of gallium and

arsenic is well known to have physical properties that promise practical applications. In the form of nanowires and nanoparticles, it has particular potential for use in the manufacture of solar cells and optoelectronics in many of the same applications that silicon is commonly used.

But the natural semiconducting ability of GaAs requires some tuning in order to make it more desirable for use in manufacturing these types of products. New work from a team led by Carnegie's Alexander Goncharov explores a novel approach to such tuning. Their work is published in *Scientific Reports*. The research team includes Wei Zhou, Xiao-Jia Chen, Xin-Hua Li and Yu-Qi Wang of the Chinese Academy of Sciences and Jian-Bo Zhang of South China University of Technology.

Metallic substances conduct electrical current easily, whereas insulating (non-metallic) materials conduct no current at all. Semiconducting materials exhibit mid-range electrical conductivity. When [semiconducting materials](#) are subjected to an input of a specific energy, bound electrons can be moved to higher-energy, conducting states. The specific energy required to make this jump to the conducting state is defined as the "band gap." Fine-tuning of this band gap has the potential to improve gallium arsenide's commercial potential.

There are different methods available to engineer slight tweaks to the "band gap." Goncharov's team focused on the novel application of very high pressure, which can cause a compound to undergo electronic changes that can alter the electron-carrier properties of materials. It had already been demonstrated on nanowires made from one crystalline form of gallium arsenide—the cubic so-called "zincblende" structure—that the "band gap" widens under pressure.

The present research focused instead on nanowires of a less-common crystalline form—the hexagonal so-called "wurtzite" structure. The team subjected "wurtzite" gallium arsenide to up to about 227,000 times

normal atmospheric pressure (23 gigapascals) in diamond anvil cells. They discovered the "band gap" that the electrons need to leap across to also widened, although not as much as in the case of the "zincblende" crystal nanowires.

Significantly, they discovered that around 207,000 times normal atmospheric pressure (21 gigapascals), the "wurtzite" gallium arsenide nanowires underwent a structural change that induced a new phase, the so-called "orthorhombic" one, which may possibly have metallic electronic properties.

"The similarity in behavior when subjected to [high pressure](#), but resulting in significant differences in the size of the '[band gap](#)', between the two crystalline structures of gallium arsenide suggests that both types of GaAs structures could theoretically be incorporated into a single device, or even a single nanowire, and realize much more complex and useful electronic functions through interactions across the phases," Goncharov said. "We believe these findings will stimulate further research into [gallium arsenide](#) for both basic scientific and practical purposes."

Provided by Carnegie Institution for Science

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