Researchers advance solar material production

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A sample crystal of cadmium telluride material that can be used to make solar cells. Credit: WSU

A Washington State University team has developed a more efficient, safer, and cost-effective way to produce cadmium telluride (CdTe) material for solar cells or other applications, a discovery that could advance the solar industry and make it more competitive.

The researchers showed they could rapidly grow a large amount of high-purity CdTe material—a more than kilogram-sized crystal in one day—which would be considered lightning fast in the industry. The technique, which uses a high-pressure furnace to produce large amounts of the needed crystal feedstock material, is 45 % more cost effective than the industry standard and is scalable, which could make CdTe solar technology less expensive than natural gas. The crystal material produced also has better electrical properties than what is currently available.

Working in collaboration with the National Renewable Energy Laboratory (NREL) and industry partner Nious Technologies, Inc., the researchers report on their work in the *Journal of Crystal Growth*.

CdTe photovoltaics are a newer technology than popular silicon solar cells and are competitive in terms of efficiency. They also perform better in hot and humid weather. While CdTe solar cells could provide significant advantages in cost and efficiency over silicon, they currently make up less than 10 % of the solar market, mostly at the utility scale. In particular, current production methods are slow, costly, cumbersome and lack the flexibility to customize.

(l-r) Seth McPherson, Tawfeeq Kadheem Al-Hamdi, and Santosh Swain stand in front of a Bridgeman furnace used to create cadmium telluride crystal materials. Credit: WSU

"Right now there is a huge kink in raw material production," said Santosh Swain, research assistant professor with the Institute of Materials Research and a co-author on the paper. "The solar industry has steadily increased device efficiency and fabricating devices, but further efficiency gains and cost reduction require improvement in CdTe material properties."

The current manufacturing process involves cooking the CdTe material in a sealed glass tube to contain the reaction. It takes a long time, the tubes are not reusable, and the silica glass is limited in how much heat, mass, and pressure it can take. Because of concerns about the material exploding, the industry is limited in the size of crystals they can grow. To make solar cells, the crystals are then evaporated onto glass substrate to make very thin films.

The new technique uses a strong graphite crucible, and the material is cooked in a high-pressure Bridgman furnace. The high-pressure environment completely eliminates the possibility of explosions and also allows the researchers to easily add a high concentration of additional materials, called dopants, during the manufacturing process that improve the material's performance. In 2016, the WSU research team in collaboration with NREL and University of Tennessee dramatically improved CdTe technology by adding phosphorus as a dopant, overcoming a 1 Volt limit that had been pursued for six decades. For this project, the researchers added arsenic as a dopant.

Adding the highly volatile dopants during the feedstock manufacturing process also eliminates the need to dope after film deposition which can cause non uniformity issues, said Tawfeeq Al-Hamdi, a Ph.D. student and lead author on the paper.

"Doping is a key strategy," said co-author Seth McPherson. "At 80 atmospheres of pressure, you can really shove the dopants into the material, and you don't have to worry about them evaporating out of the crystal or otherwise escaping the system."

More information: Tawfeeq K. Al-Hamdi et al, CdTe synthesis and crystal growth using the high-pressure Bridgman technique, *Journal of Crystal Growth* (2020). DOI: 10.1016/j.jcrysgro.2019.125466

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