Towards more efficient, non-toxic, and flexible thin-film solar cells

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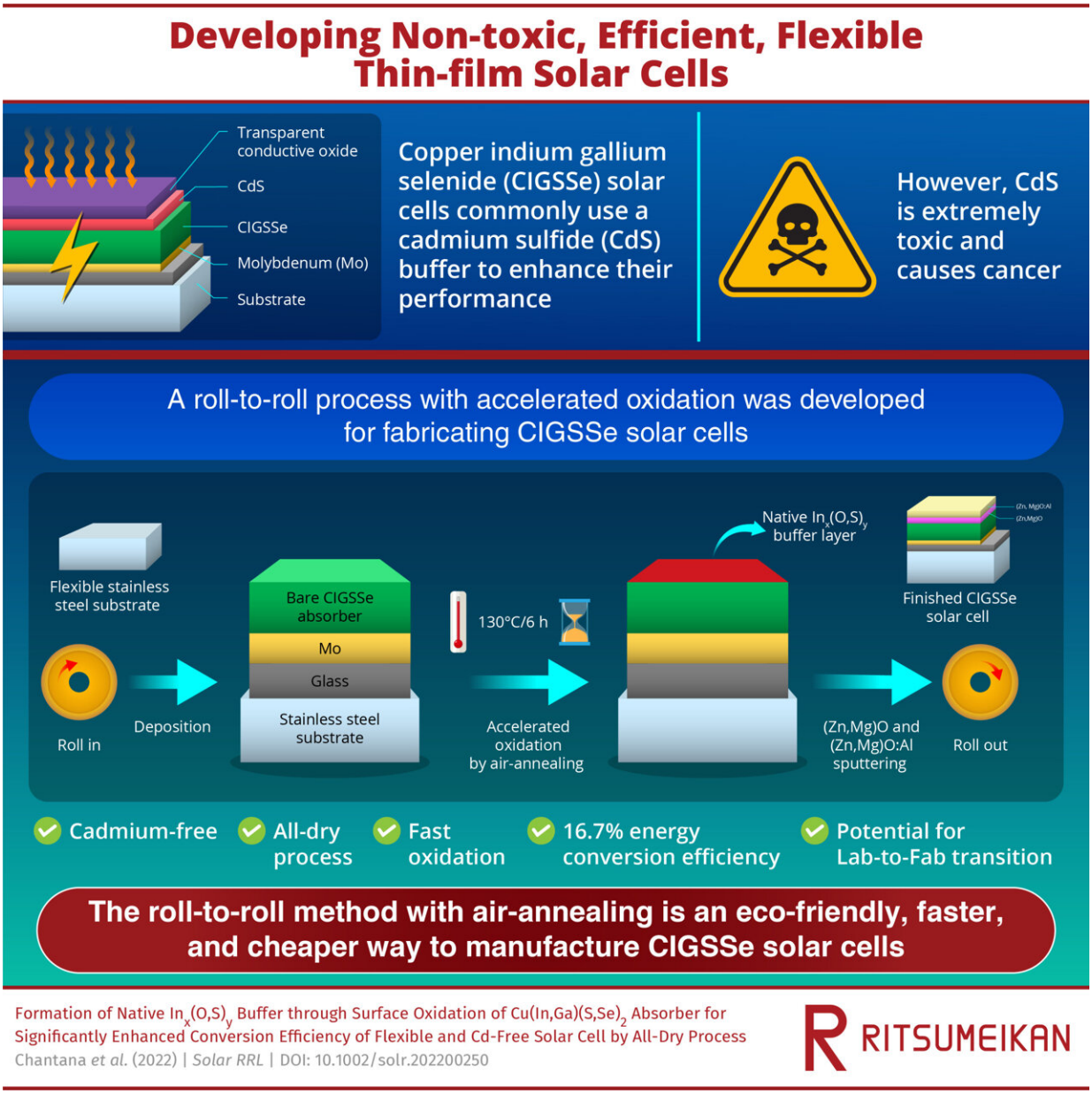

In a new study, researchers from Ritsumeikan University, Japan, have now developed an eco-friendly method that eliminates the use of toxic cadmium in the production process to produce cost-effective, efficient, and eco-friendly solar cells. Credit: Ritsumeikan University

Climate change, one of the major global concerns today, has made it clear that fossil fuels are detrimental to our environment and are not a sustainable source of energy. It is imperative to adopt clean sources of energy, and solar cells are a popular candidate on this front. While efficiency is a primary concern for solar cells, researchers have also focused on developing solar cells that are lightweight, low-cost, and flexible. However, the fabrication process itself has posed a serious environmental concern: specifically, the use of toxic materials and generation of industrial waste.

For instance, copper indium gallium selenide (CIGSe) is a thin-film solar cell that offers several advantages over traditional silicon solar cells. Thin-film solar cells are about 100 times thinner, cheaper to make, and are easier to install on rooftops and vehicles. Moreover, compared to other photovoltaic materials used in thin-film solar cells like amorphous silicon, cadmium-telluride, and organic materials, CIGSe absorbs light more strongly and can be prepared into thinner films. However, they contain a buffer layer of cadmium sulfide, which is highly toxic and carcinogenic. This makes finding alternative, non-toxic materials essential for large-scale production and installation of CIGSe panels.

For Professors Jakapan Chantana and Takashi Minemoto at Ritsumeikan University, Japan, removing cadmium from solar cells was as important as developing an eco-friendly manufacturing process that is both efficient and affordable. Addressing these issues in a new study, a research team led by them developed a strategy in which the traditional

cadmium sulfide buffer layer was replaced with a native buffer layer formed by oxidizing the surface of the $Cu(In,Ga)(S,Se)_2$ CIGSSe layer with an air-annealing process. The study was published on March 26, 2022, in the journal *Solar RRL*.

While attempts to oxidize the CIGSSe layer have been made before, the surface usually takes months to oxidize. With the new method, however, the team reduced the oxidation time to a few hours, allowing for a faster manufacturing by a "roll-to-roll" process. In this process, a CIGSSe layer is initially deposited on a flexible stainless-steel substrate. The deposition is then followed by an air-annealing process where the surface of the CIGSSe layer is oxidized to form native buffer layers of $In_x(O,S)_y$. By experimenting with different oxidation conditions, the researchers fabricated a CIGSSe solar cell with a maximum energy conversion efficiency of 16.7% after 6 hours of oxidation at 130°C.

"We have disclosed for the first time that the CIGSSe surface oxidized through an optimized air-annealing process leads to a strong enhancement in energy conversion efficiency," says Prof. Minemoto.

Although the reported efficiency is lower than that of conventional solar cells (which typically exceed 20%), the developed method manages to do away with cadmium, making the solar cells eco-friendly. "In the conventional process, cadmium is deposited on the CIGSSe layer via a chemical bath deposition process. By eliminating this step, we have created a completely dry manufacturing process that generates less waste," explains Prof. Chantana. Moreover, the process is also cost-effective.

In order to make solar energy a viable source of clean energy, solar panels must become more efficient, economical, and eco-friendly. "The method developed in our study can be scaled to large-scale manufacturing applications, which is what we need to make solar cells a

clean energy resource not only in Japan but all over the world," concludes Prof. Minemoto.

More information: Jakapan Chantana et al, Formation of Native $In_x(O,S)_y$ Buffer through Surface Oxidation of $Cu(In,Ga)(S,Se)_2$ Absorber for Significantly Enhanced Conversion Efficiency of Flexible and Cd-Free Solar Cell by All-Dry Process, *Solar RRL* (2022). DOI: 10.1002/solr.202200250

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