Solar cells, phone displays and lighting could be transformed by nanocrystal assembly method

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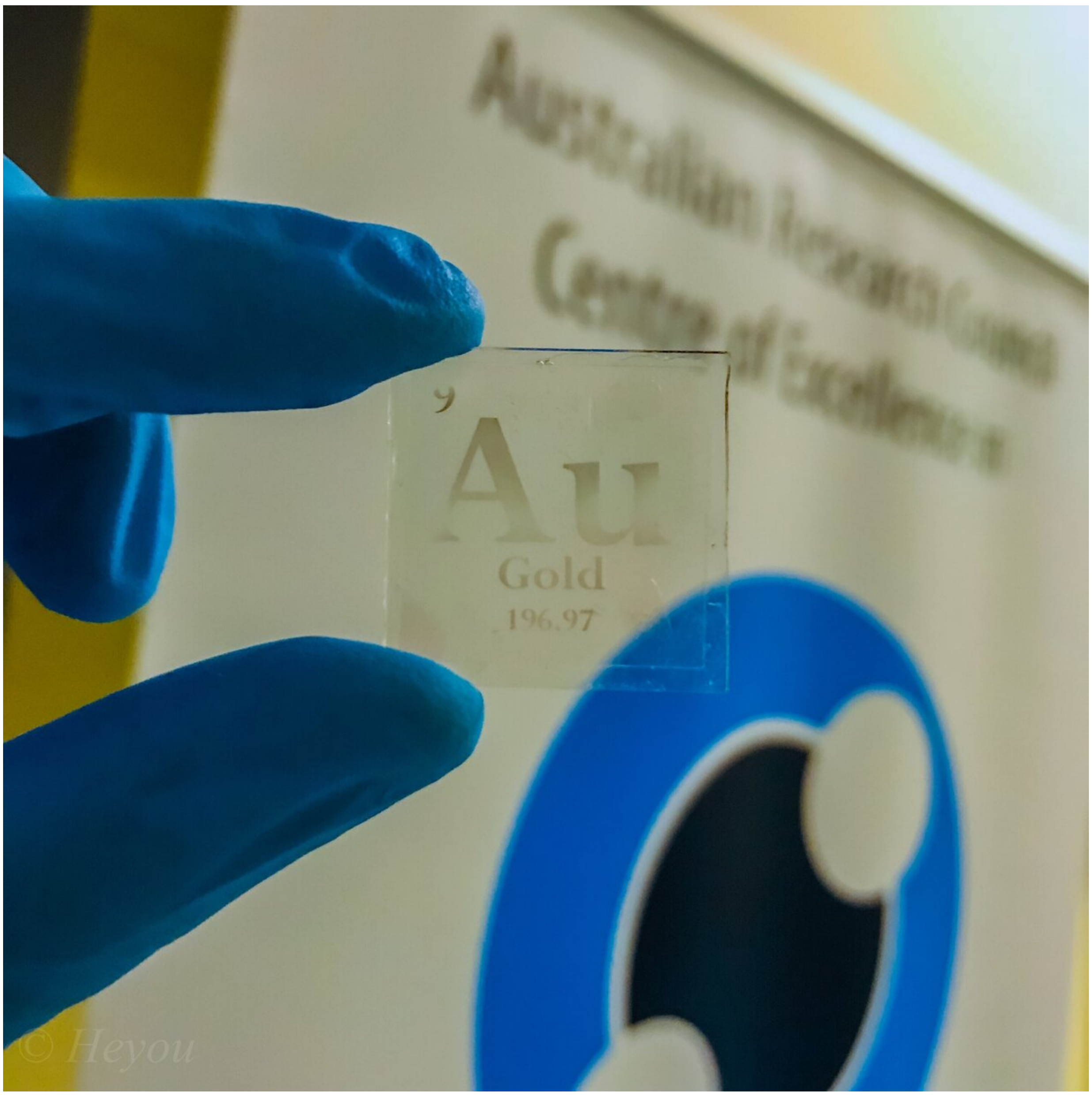

A logo of the element "Au" assembled by EPD method with gold nanoparticles. Credit: Heyou Zhang

Smart phones, tablets and laptop displays, camera lenses, biosensing devices, integrated chips and solar photovoltaic cells are among the applications that could stand to benefit from an innovative method of nanocrystal assembly pioneered by Australian scientists.

Nanocrystals have a wide range of existing and potential uses, but they are often made with wet chemical methods that present challenges when seeking to incorporate them effectively into devices.

However, researchers from the ARC Centre of Excellence in Exciton Science have demonstrated a highly efficient and controllable method to assemble single nanoparticles directly into a pre-patterned template.

They have shared the details of this technique in an article published in the journal *Advanced Materials* that reviews the state of the field and summarises their novel approach.

By applying an electric field at a certain level of strength, a technique called electrophoretic deposition (EPD), researchers at the University of Melbourne and Australia's national science agency, CSIRO, were able to create a nearly perfect single nanocrystal array using either gold nanospheres or gold nanorods.

And by tweaking the potential applied to the materials as part of this field, the researchers even discovered they were able to dictate whether the nanocrystals assemble in vertical or horizontal configurations.

Lead author Mr Heyou Zhang, a Ph.D. candidate, said: "Conventional nanofabrication methods normally produce 2-D nanostructures. With the ability to assemble in both vertical and horizontal directions and with spatial control of the nanoparticles on the surface, this method provides far more opportunities to build and manufacture nanoscale structures."

Although the manuscript focuses on assembly of gold nanocrystals, the technique has been applied to semiconductor quantum dots, magnetic nanoparticles and organic nanoparticles.

The next goal for the research is the creation of a single quantum dot "on-off" switch, which can form part of a logic gate or memory pixel for high-density information storage.

However, there is already interest from industry partners in other areas too.

"We can use assembled gold nanocrystals arrays as a plasmonic pixel, which is a colour display unit with high purity and colour saturation," Heyou said.

"It provides very distinct colour with angle or polarization-dependent properties, which has potential as a security feature or in medical imaging."

Heyou feels the approach has great potential as a universal nanomaterial assembly method.

He said: "We can use these particles to build up reconfigurable metal lenses, such as the lenses on your phone.

"The thickness of the lens on your phone camera is limited by optical geometries, but with this method you might be able to shrink it down to micrometre size."

The Centre is looking for partners to help scale-up the novel EPD process.

Senior author Professor Paul Mulvaney, director of the ARC Centre of Excellence in Exciton Science, said, "Heyou has found a novel approach to large scale fabrication for nanomaterials. This deposition method solves a fundamental roadblock for nanotechnology and creates a viable pathway for miniaturisation of both optical and electronic devices."

More information: Heyou Zhang et al. Single-Nanocrystal Arrays: Fabrication of Single-Nanocrystal Arrays (Adv. Mater. 18/2020), *Advanced Materials* (2020). DOI: 10.1002/adma.202070143

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