An innovative device studies gold nanoparticles in depth

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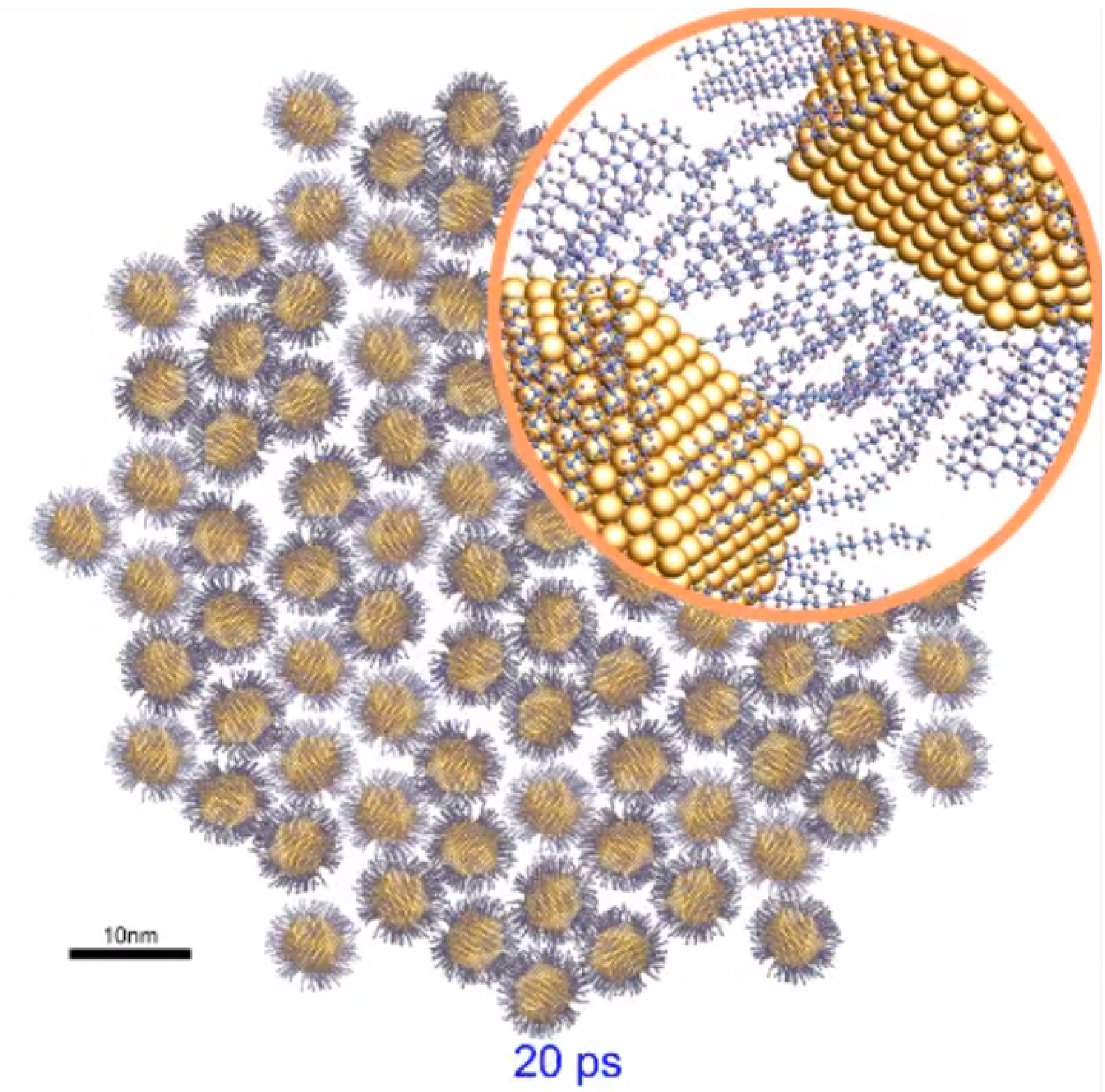

Artists have used gold nanoparticles for centuries, because they produce vibrant colors when sunlight hits them. Their unique optical-electronics properties have put gold nanoparticles at the center of research, solar cells, sensors, chemotherapy, drug delivery, biological and medical applications, and electronic conductors. The properties of gold nanoparticles can be tuned by changing their size, shape, surface chemistry etc., but controlling these aspects is difficult.

Publishing in *Nano Letters*, researchers led by Fabrizio Carbone at EPFL have made an unprecedented study into the structure of gold nanoparticles. Working with Francesco Stellacci's lab (EPFL), the researchers achieved this using a device called "small-angle time-resolved electron diffractometer", which allowed them to study the structural arrangements of gold nanoparticles at ultrafast speeds – quadrillionths of a second.

The diffractometer itself is interesting because it uses a cheap alternative to a very expensive technique: the free electron laser (FEL). The FEL uses electrons to generate X-rays that can "study" molecules down to the atomic level – in billionths of a meter. Such a powerful tool normally comes at the cost of over a billion dollars. But in 2010, researchers from the Netherlands developed an alternative method jokingly called "poor-man's FEL", which looks at materials with an electron beam of ultrafast pulses, and achieve similar results.

In this study, the researchers developed a diffractometer device that uses the "poor-man's FEL" and exploits the high sensitivity that electrons have for interacting with matter. The device can study monolayers and very thin samples containing light elements, e.g. hydrogen and carbon.

And when it comes to dense aggregates and small molecules, the small-angle time-resolved electron diffractometer can achieve the extreme sensitivity of a traditional FEL, but at a fraction of the cost: less than a million dollars.

Looking for gold

Using this approach, the EPFL researchers were able to obtain a movie in which the structural changes of gold nanoparticles triggered by light were captured with atomic resolution in both time and space.

These experiments show that ligand molecules attached to gold nanoparticles can self-assemble and order themselves into preferential orientations, which is central for creating ordered nanostructures. Even more striking was the discovery that that light itself can induce such ordering phenomena, providing a unique tool for controlling the physics of gold nanoparticles, with great potential for optoelectronic applications such as organic photovoltaic (OPV) solar cells etc.

The study provides proof-of-concept evidence that the small-angle time-resolved electron diffractometer enables the systematic investigation of structural properties of nano-assembled materials". The authors expect this to bear significantly onto multiple applications, including signal processing, biology and even future drug delivery.

More information: Giulia Fulvia Mancini et al. Order/Disorder Dynamics in a Dodecanethiol-Capped Gold Nanoparticles Supracrystal by Small-Angle Ultrafast Electron Diffraction, *Nano Letters* (2016).
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