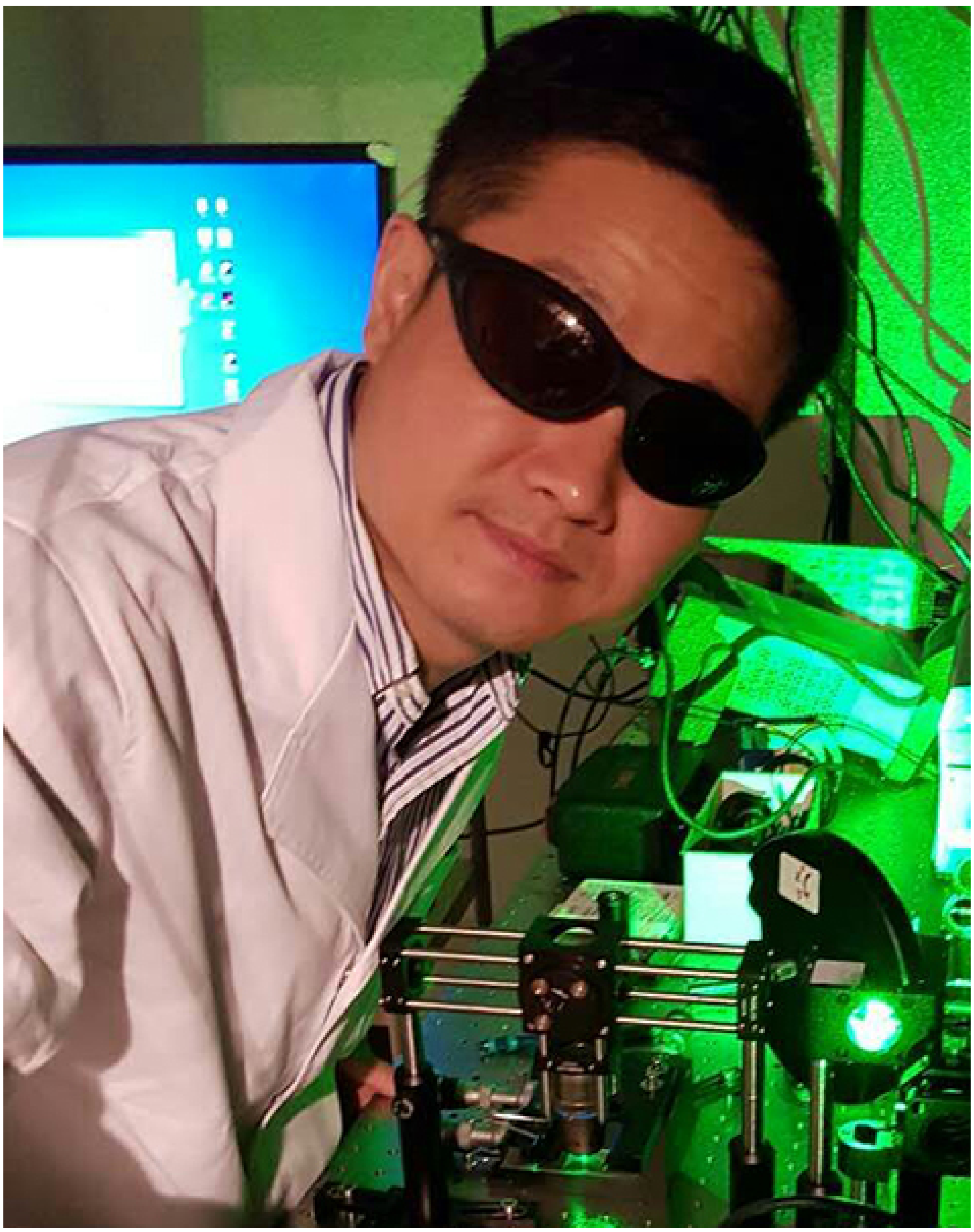
Tiny particles with a big, cool role to play in microscopy

February 23 2017



Professor Dayong Jin. Credit: University of Technology, Sydney

Researchers at UTS, as part of a large international collaboration, have made a breakthrough in the development of compact, low-cost and practical optical microscopy to achieve super-resolution imaging on a scale 10 times smaller than can currently be achieved with conventional microscopy.

This discovery overcomes two obstacles – cost and heat – that limit the development of super-high-resolution imaging for biological and biomedical researchers to be able to do detailed examination of live cells and organisms.

The research team's findings, reported in *Nature*, show that bright luminescent nanoparticles can be switched on and off using a low-power infrared laser beam.

Professor Dayong Jin from UTS, a lead researcher on the project, said the use of a low-powered laser beam was the key to resolving the twin bottleneck problems of cost and heat.

"Currently, in order to switch each individual pixel on and off for super-resolution imaging, you need a bulky laser with lots of power," Professor Jin said.

"The high-powered laser means you end up with very expensive equipment, typically over $1 million. And with such a high-powered laser shining on a fragile biological sample, the sample essentially becomes 'cooked'.

"Significantly reducing the power requirement removes the need for bulky and expensive lasers and makes it much more biocompatible."

The use of lamp-like nanoparticles for super-resolution bio-imaging is a relatively recent development which has attracted widespread attention internationally. The nanoparticles act as molecular probes to light the sub-cellular structures. However, fundamental limitations of light restrict the minimum size of image pixels to about 200nm, about half of one excitation wavelength and insufficient to visualise many biological structures of interest.

This new research shows that nanoparticles down to 13nm in size, possibly even smaller, can be visualised in a new form of optical nanoscopy where unwanted luminescence is suppressed by a low-power infrared laser.

Professor Jin was joint winner of the 2015 Eureka Prize for Excellence in Interdisciplinary Scientific Research for his work developing nanocrystals known as Super Dots and is director of the UTS Initiative for Biomedical Materials and Devices (IBMD). He and his students and collaborators have been working on nanoscale photonics technology for several years.

"We are interested in conducting solution-focused research that offers potential for industry. We identify the key problems in the field, find a solution and move on to the next steps towards technology translation," Professor Jin said.

"To do that, you need to find the right partner with complementary skills, build a relationship based on trust and carry that with persistence as we have done over the six years it has taken to complete this research."

He said this new tool opens opportunities to understand how the life machine works, in a non-invasive way, hopefully leading to a better understanding of antibiotic resistance pathogens and diseases, and the immune system.

Professor Jim Piper, of Macquarie University and the ARC Centre of Excellence for Nanoscale BioPhotonics, was a co-researcher on the Nature study. He said the research findings were exciting because these nanoparticles have "unique properties that will allow researchers to see deeper and more clearly at the cellular and intra-cellular level – where proteins, antibodies and enzymes ultimately run the machinery of life".

"What we've done is illustrate that tiny nanoparticles offer substantial potential as a new generation of luminescent probes for optical nanoscopy. This opens up an entirely new avenue in the study of live biological processes."

Associate Professor Peng Xi from Peking University, a leading researcher in super-resolution microscopy, said, "After the Nobel prize in 2014, the attention of the super-resolution community has been focused on the development of techniques that are live-cell compatible. Our newly developed rare-earth nanoparticles decrease the requirement for high-power laser by two to three orders of magnitude, which enables the wide application of this technology in live cells and dramatically decreases the cost and complexity of the system."

The research for "Amplified stimulated emission in upconversion nanoparticles for super resolution nanoscopy" was conducted by scientists at UTS, Macquarie University, Peking University and Shanghai Jiao-tong University.

More information: Yujia Liu et al. Amplified stimulated emission in upconversion nanoparticles for super-resolution nanoscopy, *Nature* (2017). DOI: 10.1038/nature21366

Provided by University of Technology, Sydney