Media Release

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NEW NANOPARTICLE DISCOVERY TO AID SUPER-RESOLUTION IMAGING

Researchers at the ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP), Macquarie University, the University of Technology Sydney (UTS), Peking University and Shanghai Jiao-tong University have made a breakthrough in the development of practical super-resolution optical microscopy that will pave the way for the detailed study of live cells and organisms, on a scale 10 times smaller than can currently be achieved with conventional microscopy.

Reported in *Nature,* the international team of researchers has demonstrated that bright luminescent nanoparticles can be switched on and off using a low-power infrared laser beam, and used to achieve images with a super resolution of 28nm (about 1/36 the wavelength of light).

The scientific breakthrough, which uses luminescent nanocrystals with the chemical element Thulium added at high concentration, involves creation of a unique excitation condition whereby the signals can be optically modulated via either spontaneous emission pathway or stimulated emission pathway.

Professor Jim Piper, leader of the research team at Macquarie University and the ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP), sees these nanoparticles as having new unique properties.

“These allow researchers to see well beyond normal limits of standard microscopes,” Professor Piper said. “It will let you see deeper and more clearly at the cellular and intra-cellular level—where proteins, antibodies and enzymes ultimately run the machinery of life.”

Professor Dayong Jin from UTS, a lead researcher on this project, said using a low-powered laser beam solves two problems that currently limit super-resolution imaging for users.

"Significantly reducing the power requirement removes the need for bulky and expensive lasers," he said. "The heat generated by high-powered lasers also destroys fragile biological samples, so reducing the power makes it much more biocompatible.

"We are interested in conducting solution-focused research that moves the field to another level," Professor Jin said. "In order to do that, you need to find the right partners and collaborators, build a relationship, and carry that with persistence.

"Our collaborative approach and our shared vision, over a six-year period, has made the difference in this breakthrough in creating new biomedical methods via the integration of biomedical materials and devices."

Associate Professor Peng Xi at Peking University, a leading researcher in super-resolution microscopy, and also a Partner Investigator of the CNBP and an Honorary Professor at UTS 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 decreases the requirement for high power laser by 2-3 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 use of nanoparticles for bio-imaging is a relatively recent development which has attracted widespread attention internationally. Typically, the nanoparticles are placed in biological samples and then "excited" by the light of a confocal microscope. The nanoparticles act as tiny "lamps" which show where they are located. However, fundamental limitations of light restrict the minimum size of images to about 200nm, insufficient to visualise many biological structures of interest. By contrast 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.

“A particular problem of current ‘stimulated emission depletion’ microscopy is that high laser power is required to suppress emission from normal dyes and this can damage the biological samples that we are trying to look at—obviously not ideal when trying to make a diagnosis,” said Professor Piper. “Our nanoparticles are unique in that luminescence can be amplified and modulated with commonly available low-power semiconductor lasers.”

Professor Piper is excited by the research: “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 in greater detail, to ultimately help us to understand how the body works at the nanoscale - this is the key goal of the CNBP.”

Professor Jin said super-resolution imaging opens a lot of opportunities to understand how the life machine works, hopefully leading to a better understanding of antibiotic-resistant pathogens and diseases, and the immune system.

“This will be important for the design of new drugs to treat diseases and superbugs that are resistant to current antibiotics.”

The research for ‘Amplified stimulated emission in upconversion nanoparticles for super resolution nanoscopy’ was undertaken by scientists at the ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP), Macquarie University, the University of Technology Sydney, Peking University and Shanghai Jiao-tong University.

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IMAGES AVAILABLE:

Seeing images at super resolution https://flic.kr/p/RuMvsC
Professor Jim Piper, CNBP Leader at Macquaire University https://flic.kr/p/zNksqB
Prof Dayong Jin at his laboratory at UTS Science. Image by Anna Zhu. https://flic.kr/p/QU2ZoQ

ABOUT CNBP:

The Centre for Nanoscale BioPhotonics (CNBP) is an Australian Research Council Centre of Excellence led by the University of Adelaide, with research focussed nodes also at Macquarie University and RMIT University. A $40m initiative, the CNBP is focused on developing new light-based imaging and sensing tools, that can measure the inner workings of cells, in the living body.
http://cnbp.org.au/

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