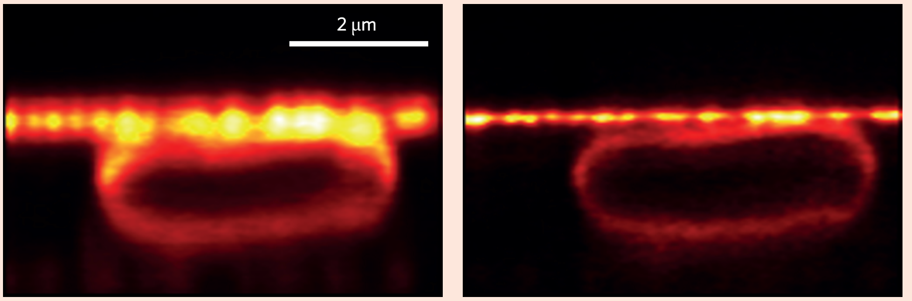
NOBEL PRIZE IN CHEMISTRY

Seeing the nanoscale

Microscopy and nanotechnology, convention tells us, should not mix. The prefixes on the words themselves give some indication of their intrinsic disparity — a factor of one thousand separates the micro- and the nano-worlds. The 2014 Nobel Prize in Chemistry has been awarded to Stefan Hell, William Moerner and Eric Betzig for helping to bridge this gap with their development of super-resolved fluorescence microscopy.



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Light is perhaps our most important connection with the world around us. Seeing is believing, or so they say, and direct visual observation remains our most trusted means of scientific discovery and experimental verification. But light has its limits. Diffraction means that a lens cannot focus a ray to a spot smaller than between one third and one half of the wavelength. This is just a few hundred nanometres for a conventional visible-light microscope: good enough to image whole cells, but not to get a detailed view of what is going on inside them.

In 1994, Stefan Hell began developing a concept that he thought could beat this limit called stimulated emission depletion (STED) microscopy. Hell's idea was to take advantage of fluorescence quenching — a reduction in the intensity of light emitted from a molecule when it is exposed to too much laser light. One laser stimulates fluorescence while a second quenches all emission except for that at the centre of the focus spot. In 2000, Hell experimentally demonstrated a STED microscope with a focus spot six times smaller than that imposed by the diffraction limit. He and his team were able to image an *Escherichia coli* bacterium at a resolution not possible in a conventional microscope (pictured; the image on the left was obtained with standard confocal resolution and the image on the right with the axial resolution improved by STED; T. A. Klar *et al.*, *Proc. Natl Acad. Sci. USA* **97,** 8206–8210; 2000).

Around a similar time, William Moerner was trying to isolate the emission from single molecules. He dispersed the green fluorescent protein from a jellyfish in a gel and was able to collect light from just one protein when the protein–protein separation was greater than the diffraction limit. In 1997, Moerner used this approach to discover that the emission from these proteins blinks on and off. In 2006, Eric Betzig harnessed this effect for imaging. He and his co-workers combined molecules that emitted light of different colours and superimposed images taken over time while the emitters switched on and off. They used this single-molecule microscope to image intracellular proteins with a nanometre resolution.

STED and single-molecule microscopy are already reaping rewards. The three Nobel laureates themselves have used their techniques to better understand brain synapses, cell division in embryos and the proteins associated with Huntington's disease. But the real testament to the importance of their work is the extent to which the methods have now been adopted and improved by their colleagues around the world, and the promise of fundamental discoveries yet to come.

DAVID GEVAUX

Corrected after print: 6 November 2014

OPTOMECHANICS

Photons that pivot and shuttle

Self-oscillation and shuttling of photons between distinct cavities in a photonic see-saw provide unexpected opportunities in nano-optomechanics.

Heedeuk Shin and Peter T. Rakich

In the past few years, micro- and nanoscale systems have enabled controllable coupling between photons and acoustic phonons in a variety of forms[1,2]. Quantum[3,4] and classical nonlinear interactions[5], produced by coupling between tightly confined optical and mechanical modes, have spawned a flurry of activity in the field of optomechanics. Recent experiments have demonstrated the versatility of such device physics; optomechanical interactions have been used to implement schemes for cooling of phonon modes, optomechanical memory, signal delay and self-oscillation[1,2,6].

The rapidly growing field of optomechanics has produced a host of device topologies that have enabled strong photon–phonon coupling. These include optomechanical systems based on suspended mirrors, membranes, microtoroids, nanobeams, microspheres, microdisks, waveguides and photonic crystals[2]. To control such interactions with ever greater fidelity, both ultralow-loss phonon modes

Correction

In the version of the News & Views article 'Nobel Prize in Chemistry: Seeing the nanoscale' originally published (*Nature Nanotech.* **9,** 878; 2014), the name of the Nobel Prize winner Eric Betzig was misspelt. Corrected in the online versions after print 6 November 2014.