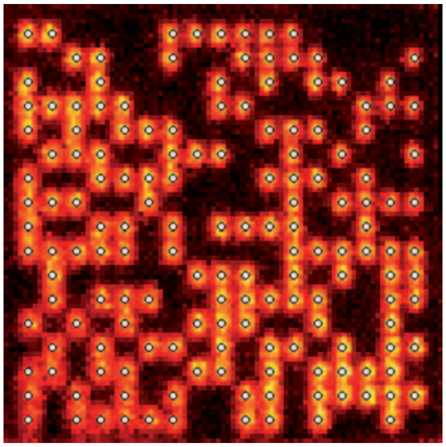
IMAGING

Super-resolution at low light

Nature **478,** 204–208 (2011)



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Although stimulated emission depletion (STED) microscopy is a popular super-resolution imaging scheme, its requirement for light of a modest intensity limits its use in most practical applications. Now, by employing a reversibly switched enhanced green fluorescent protein (rsEGFP), scientists at the Max Planck Institute for Biophysical Chemistry in Göttingen, Germany, have reported an STED-like imaging scheme that makes it possible to image living tissue at resolutions of less than 40 nm using light intensities a million times lower than those of STED. The concept behind this achievement is the use of reversible saturable optical fluorescence transitions (RESOLFT) — a technique that improves imaging resolution by exploiting fluorophores that can be photoswitched between their emissive 'on' and non-emissive 'off' states. Although this technique has been known for some time, finding suitable fluorophores that can be switched many times without significant degradation has been problematic. The importance of this most recent work is the discovery of a suitable fluorophore — rsEGFP — which can be switched thousands of times from its 'on' state (using 405 nm light) to its 'off' state (using 491 nm light). The researchers also showed that the scheme could have applications in data storage as well as biological imaging. They wrote and read 270,000 letters as digital ASCII code onto a 17 μm × 17 μm area of a microscope slide covered in a 1-μm-thick layer of rsEGFP. Each data bit measured around 500 nm in diameter, and after 6,600 read–write cycles the average fluorescence signal representing the data bit '1' reduced by around 35%, which suggests that approximately 15,000 read–write processes should be possible. *OG*

PLASMAS

Collisionless shockwaves

New J. Phys. **13,** 093001 (2011)

A team of researchers from China and Japan have used the Shenguang II laser in Shanghai to demonstrate counter-propagating laser plasmas that can pass smoothly through one another without causing collisions. The Shenguang II is capable of delivering 2.0 kJ of energy over a period of 1 ns at a wavelength of 351 nm. The researchers split the facility's eight laser beams into two branches that illuminated two points on a Mylar foil. The laser spot diameters of 150 μm equate to intensities of around 5.7×10^{15} W cm^{-2}. The use of 70 ps duration probe pulses at a wavelength of 526 nm, together with an interferometer, enabled a series of images to be collected during the process. The interaction became collision-free when the plasmas were of a sufficiently low density and high flow velocity, which was achieved by appropriate choice of laser energy, target thickness and spot separation. The team hopes that analogies of this technique with astrophysical plasma phenomena might help to investigate phenomena such as the behaviour of supernova remnants. *DP*

OPTOMECHANICS

Probing quantum states

Proc. Natl Acad. Sci. USA **108,** 16182–16187 (2011)

Despite recent progress in the field of optomechanics, probing the quantum state of mechanical resonators remains a significant challenge. Now, using short optical pulses, Michael Vanner and colleagues from Austria, the UK, Germany and Australia have shown that they can fully reconstruct an oscillator's quantum states of mechanical motion. In their proposed implementation, a pulse of duration much less than the mechanical period of the oscillator, which is an optomechanical Fabry–Pérot cavity operating at 1,064 nm with a length of 4λ and an amplitude decay rate of 2.5 GHz, is incident upon the oscillator. The radiation–pressure interaction between the pulse and the cavity generates entanglement, resulting in a correlation between optical phase and mechanical position and thus transferring momentum from the optical pulse to the mechanical oscillator. Access to the system's quantum-mechanical states is obtained by observing the distribution of phase noise for strong light pulses at various times throughout a mechanical period. A time-domain homodyne detection scheme determines the phase — and thus the mechanical position — of the field emerging from the cavity. The researchers say that the scheme can also be applied to other systems, such as trapped ions and superconducting resonators. *RW*

ULTRAFAST LASER OPTICS

Laser-induced emission

Appl. Phys. Lett. **99,** 103504 (2011)

The laser-induced field emission of electrons from sharp metallic tips could lead to the development of ultrafast electron microscopy and compact free-electron lasers. So far, however, the maximum electron bunch charge from such tips has been around 10^3 electrons per laser pulse, and this must be increased to 10^7 before practical applications can be realized. Anna Mustonen and co-workers from the Paul Scherrer Institut

SPECTROSCOPY

Femtosecond ultrasonic spectroscopy

Appl. Phys. Lett. **99,** 051913 (2011)

Acoustic waves in the gigahertz–terahertz range are useful for studying lattice dynamics and manipulating electron–phonon and photon–phonon coupling in condensed matter. However, performing broadband ultrasonic experiments at frequencies of up to 1 THz is still a challenge. Now, Yu-Chieh Wen and co-workers from National Taiwan University, Academia Sinica and National Cheng Kung University in Taiwan have developed ultrabroadband ultrasonic spectroscopy. The researchers measured the acoustic attenuation coefficient of a 22-nm-thick vitreous SiO_2 film deposited on a 7-nm-thick GaN layer by plasma-enhanced chemical vapour deposition. They grew a 3-nm-thick $In_{0.14}Ga_{0.86}N$/GaN single quantum well (SQW) under the GaN layer by metal–organic chemical vapour deposition. The indium content of the SQW was chosen to reduce reflections of acoustic pulses at the boundary between the SQW and GaN. The atomically flat boundaries of each layer also reduced roughness-induced phonon scattering. Illuminating the surface with laser pulses (wavelength 410 nm and pulse width 200 fs) caused the generation of acoustic pulses through the piezoelectric effect. The temporal spectrum of the transmission exhibited two characteristic dips at 3.3 ps and 11.2 ps, which were acoustic echoes reflected from the two interfaces of the SiO_2 film. The researchers analysed these echoes to obtain an acoustic attenuation coefficient of 180–650 GHz. *NH*

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