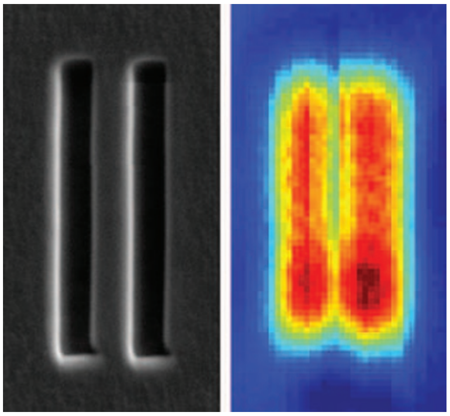
SUPER-RESOLUTION IMAGING

Beyond the limit

Nature Mater. **11,** 432–435 (2012)



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Over the past decade, researchers have put a significant amount of effort into the realization of optical imaging at resolutions beyond the diffraction limit. However, current techniques either require the lens to be very close to the object, suit only certain samples or suffer from significant losses, thus impeding their use in practical devices. Nikolay Zheludev and co-workers from the University of Southampton and the University of Bristol in the UK have now developed a super-resolution imaging technique that focuses laser light to a subwavelength spot by tailoring the interference between a large number of beams diffracted from a nanostructured mask. The researchers report a super-resolution of $\lambda/6$, although in principle the device has no physical resolution limit. This technique suits imaging at any wavelength, but requires the object to be no more than tens of micrometres away from the mask. *JB*

NONLINEAR OPTICS

Fixed-point attractor

Phys. Rev. A **85,** 031806(R) (2012)

The effects of nonlinear periodic structures on the temporal behaviour of optical pulses are not well understood, and measurements so far have not taken into account the phase dynamics of the pulse. Now, using frequency-resolved optical gating measurements based on second-harmonic generation, Darren Hudson and co-workers from the USA and Canada have studied the impact of nonlinear waveguide arrays on the full electric field of an ultrashort pulse as a function of both input chirp and average power. They experimentally showed that, at a sufficiently high peak power (24 mW), the chirp and average power of an ultrashort pulse after propagating through a 6-mm-long nonlinear waveguide array can be independent of the input chirp and power. In particular, increasing the average power of the input pulses moves the attraction towards an average fixed output power of 4.55 mW and a chirp of 16,600 fs^2, which, interestingly, occurs for both normal and anomalous input chirp. The researchers attribute this effect — which they classify as a phase-space fixed-point attractor involving intensity and chirp — to the interplay between dispersion and temporal reshaping of the pulse. The findings allow a pulse to be shortened and dechirped without detailed knowledge of the input pulse, which may be of use in telecommunications. *RW*

NONLINEAR OPTICS

Plasmons versus photons

Phys. Rev. Lett. **108,** 136802 (2012)

Nicolai Grosse, Jan Heckmann and Ulrike Woggon from the Technische Universität Berlin have investigated the roles played by various optical modes during enhanced second-harmonic generation inside a metal-nanofilm-covered prism. Employing the Kretschman geometry caused the modes in the prism to be excited when the tangential component of the incident beam's wavevector was equal to the wave number of the modes guided along the metal film. The researchers used *k*-space spectroscopy to separate different modes according to their wavenumber and varied the angle of incidence to determine the contribution of each mode to the second-harmonic generation signal. As expected, the main second-harmonic generation peak coincided with the resonant excitation of a plasmonic mode and hence a higher local electric field to drive the process. The researchers hope that this particular spectroscopic set-up will be useful for investigating nonlinear interactions in more complex nanometallic structures. *DP*

SEMICONDUCTORS

Quasi-permanent change

Appl. Phys. Lett. **100,** 132106 (2012)

Precise control over the surface properties of semiconductor nanomaterials is essential for their use in many optoelectronic applications. Porous semiconductors are particularly appealing for use as biochemical sensors, owing to their large surface areas and high aspect ratios. Terahertz time-domain spectroscopy can be used to investigate electron transport in semiconductor nanomaterials, as long as the material's properties are not permanently changed by the photoexcitation. J. Lloyd-Hughes and co-workers have now shown that photoexcitation causes a quasi-permanent increase in the conductivity of a nanoporous InP honeycomb, with the conductivity remaining high for one hour after photoexcitation. The researchers used terahertz time-domain spectroscopy to measure the transmission of InP porous membranes with varying donor density and orientation, and employed X-ray photoemission spectroscopy to examine the charge density and composition of the surface states. The electron density varied for different surface pinning energies, which suggests that photoexcitation may reduce the density of the surface states. This effect could be useful in materials processing because it offers a clean, dry and area-selective way of quasi-permanently altering the conductivity of a porous semiconductor. However, the researchers stress that further work will be

LASERS

Less-than-one-photon success

Nature **484,** 78–81 (2012)

Laser oscillators based on ultranarrow atomic transitions are predicted to be capable of operating in the 'super-radiant regime' with spectral purities many orders of magnitude higher than those of conventional lasers. To realize super-radiant operation with a linewidth of <1 mHz, it is crucial for a source to operate in the 'no-photon' limit, where it has an average intracavity photon number of less than 1. Now, by employing spontaneous synchronization of more than a million ^{87}Rb atomic dipoles in an optical cavity, Justin Bohnet and colleagues from JILA, the National Institute of Standards and Technology and the University of Colorado at Boulder in the USA have demonstrated a Brillouin super-radiant laser that is sustained by as few as 0.2 photons on average inside the cavity. The work explores a novel regime of optical laser physics in which the optical cavity is replaced by a highly coherent collective atomic dipole acting as a high-*Q* oscillator. Laser operation is achieved by synchronizing the emission from the rubidium atoms in unison, hence increasing the emission rate by a factor of 10,000. The low intracavity photon number isolates the collective atomic dipole from the environment, which reduces the laser's sensitivity to noise. The researchers say that such super-radiant lasers could be useful for improving the stability of atomic clocks and the precision of measurement science. *RW*