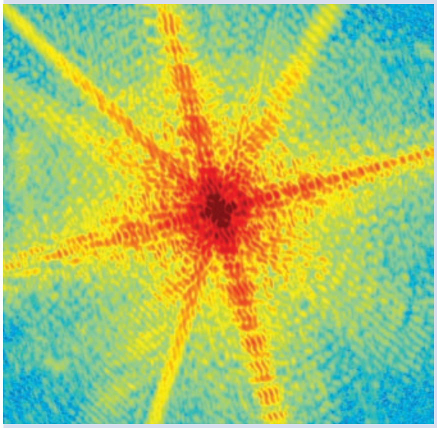
SOFT X-RAY MICROSCOPY

On the table



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Proc. Natl Acad. Sci. **105,** 24–27 (2008)
Richard Sandberg and colleagues in the USA have now developed a soft X-ray microscope that is small enough to fit on a table top and can resolve features as small as 70 nm.

Soft X-rays have a wavelength of just a few or a few tens of nanometres and are traditionally generated using very large systems, such as synchrotrons or free-electron lasers. In recent years, however, the size of soft X-ray sources has been reduced dramatically. Sandberg *et al.* have now taken advantage of these smaller devices to create a soft X-ray microscope that can fit on an optics bench just 1.2 m × 2.4 m in size. The radiation is focused by a series of multilayer mirrors and is diffracted as it passes through the sample. The diffraction pattern, measured by a CCD camera, can then be used to construct an image of the sample. The team create soft X-ray light at a wavelength of 46.9 nm using an argon plasma in a narrow capillary. With it, they can resolve features down to 70 nm in size, just one and a half times the wavelength.

OPTICAL FORCES

Whispers in tune

Appl. Phys. Lett. **91,** 231102 (2007)
A group of researchers in Turkey have demonstrated that a laser beam can spectrally tune the whispering-gallery modes of microdroplets over tens of nanometres and that the effect is reversible. The technique may have applications in optical communications systems as tunable optical switches or filters.

The researchers stabilized a microdroplet of glycerol and water solution, containing rhodamine B molecules at a 50-micromolar concentration, on a superhydrophobic surface, which strongly repels water. They then focused a continuous-wave Nd^{3+}:YVO_4 laser at the droplet centre and used the gradient force of the beam's light field to tune the microdroplet geometry. At the same time, a continuous-wave solid-state green laser was focused at the equator of the microdroplet to excite fluoresence spectra, which were recorded using a CCD and monochromator.

As the droplet was held to the surface, the gradient force from the laser light caused the spheroid to elongate so that the equatorial diameter decreased by as much as 2.4 μm, from 6.5 μm to 4.1 μm, thus altering the resonance frequency of the whispering-gallery mode by up to 30 nm. When the laser was removed the droplet recovered its spherical form with almost no hysteresis.

Previous efforts to tune microdroplets had only achieved a spectral shift of 1 nm, and the deformation was uncontrolled. The researchers see no fundamental limitation to extending the tuning range of microdroplets even further.

BIOPHOTONICS

Biochip refractometer

Appl. Phys. Lett. **91,** 243901 (2007)
The refractive index of a living cell is related to a number of cell properties, such as its size, mass and composition, and thus can act as an indicator for cell abnormalities or disease. For example, the refractive index of red blood cells may indicate an abnormal percentage of haemoglobin, a sign of iron-deficiency anaemia or thalassaemia. However, until now measurement of the refractive index of cells has required tackling complex algorithm analysis and bulky equipment, which is prone to deform the cell. Now a collaboration of researchers in Singapore has devised a simple, precise and non-contact single-living-cell refractometer.

The researchers fabricated a biochip on a polydimethylsiloxane slab, which housed inlets for both the cells and buffer liquids and a pair of single-mode fibres containing Bragg gratings. The fibres were positioned so that their ends were 20 μm apart and formed an optical cavity. When 1,550-nm laser light was shone down the fibres, the cavity provided a non-contact trap for the cell. A bright LED with a central wavelength of 1,275 nm was used to monitor the cavity properties — the refractive index was measured by the resonance shift in the spectrum of light transmitted along the two fibres. The researchers measured the refractive index of Madin–Darby canine kidney cells to be 1.383 ± 0.001 — a precision twice that possible with previous measurements using a Fabry–Pérot based method. The device is also simple, easily fabricated and allows label-free detection and sorting.

NONLINEAR OPTICS

A quicker response

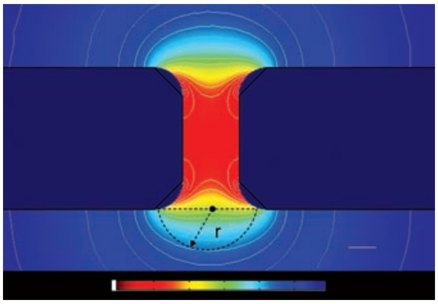
Opt. Express **15,** 17761–17771 (2007)
To achieve faster all-optical switching in semiconductor microstructures, a shorter carrier lifetime — the average time it takes for minority carriers to recombine — is imperative. The response time of previous switching approaches based on the free-carrier nonlinearity from two-photon absorption in semiconductors, such as silicon and gallium arsenide, is limited by lifetimes of hundreds of picoseconds. Now, Kazuhiro Ikeda and colleagues from the University of California, San Diego, have found that amorphous silicon is a promising candidate for faster switching operation.

The researchers measured the free-carrier nonlinearity in amorphous silicon films and observed enhanced nonlinearity. They attribute this effect to the presence of midgap localized states that promote the recombination of minority carriers leading to a shorter lifetime.

To exploit this effect, the team fabricated a composite rib waveguide consisting of amorphous and crystalline silicon. They show that their structure exhibits a free-carrier nonlinearity of 4 cm GW^{-1} — seven times larger than a similar all-crystalline silicon waveguide, and an improved free-carrier lifetime of about 300 ps. The researchers also fabricated a ring resonator made of the composite structure and obtained a free-carrier lifetime of about 30 ps. Although this value is not much lower than similar devices made of crystalline silicon, mainly owing to the roughness of the structure, the results do demonstrate the potential of using amorphous silicon in optical switching devices.

COLLOIDAL QUANTUM DOTS

Filling the gap



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Opt. Express **15,** 17163–17170 (2007)

Getting the most out of nanoscale photonic integrated circuits requires a detector with suitable dimensions. Now, scientists at the University of Washington have presented an elegant answer. Michael Hegg and Lih Lin use colloidal nanocrystal quantum dots to create a near-field photodetector for subdiffraction nanophotonic integrated circuits. The quantum dots used have highly tunable emission and absorption wavelengths and flexible surface chemistry suitable for many self-assembly processes.

To fabricate the detector, the scientists first create a small gap (1.5–25 nm) between two 50-nm-wide gold electrodes, on an organic polymer layer. They then drop-cast CdSe/ZnS nanocrystal quantum dots, with a nominal size of 5.2 nm, into the gap. For a device with a 25-nm nanogap, the team measured a detection sensitivity of 62 pW and a maximum responsivity of 2.7 mA W^{-1}. The scientists also found that the signal-to-dark current ratio increases linearly with gap size and that higher responsivity can be achieved in a smaller device area. Their approach provides an alternative photodetection approach for nanophotonics integrated circuits. In addition, the scientists hold the opinion that the simple, flexible drop-casting process can be easily used for other self-assembled and solution-processed components of nanophotonic integrated circuits.

OPTICAL STORAGE

Safe and sound

Science **318,** 1748–1750 (2007)

In the field of optical communications, it is important to be able to temporarily store incoming information so that it doesn't all arrive at the same time. Although this is very simple to achieve with electronic signals, light is far more difficult to manipulate. Now, however, Zhaoming Zhu and co-workers from Duke University and the University of Rochester in the USA have come up with an elegant technique that can delay pulses of light by over 10 ns. They do this by converting optical pulses travelling along an optical fibre into sound waves.

In their approach, data travels along the optical fibre as a series of pulses with a wavelength of 1.55 μm, while a strong laser pulse at a slightly different wavelength propagates in the opposite direction. If the difference in the wavelengths of the counter-propagating pulses is just right, then some of the energy of the data pulses is converted into an acoustic wave. A similar process is used to retrieve the data. The storage time is limited by the lifetime of the acoustic vibrations. After being stored for 12 ns, 2% of the data signal could still be retrieved, and this could be improved by using a more appropriate fibre material.

Although a number of alternative techniques for optical storage have been shown in the past, the method used by Zhu *et al.* has the important advantage that it works at any signal wavelength: all that is required is to select an appropriate wavelength for the write and read laser pulses.

ATTOSECOND PHYSICS

Ionizing action

Phys. Rev. Lett. **99,** 233001 (2007)

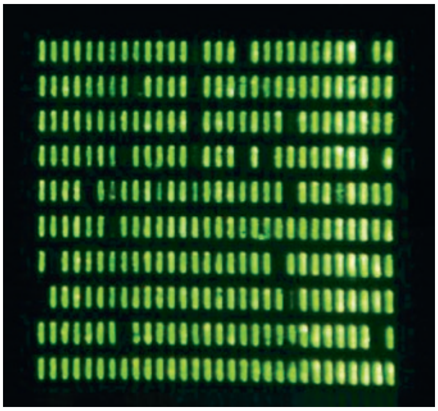
Attosecond pulses are useful for controlling electron dynamics inside atomic and molecular systems on very fast, subfemtosecond timescales. Using attosecond light to generate attosecond electron wave-packets, researchers in Sweden and the USA have now shown that they can control when ionization in a helium atom occurs, as well as its probability, with attosecond precision.

Until now attosecond pulses had been used to control the time at which ionization occurs but not its likelihood. Johnsson *et al.* use a train of UV attosecond pulses to excite helium atoms in the presence of an infrared field. The attosecond pulses, which are produced by high-order-harmonic generation in xenon, are phase-locked to the infrared field; their energy (23 eV) is lower than the ionization threshold of helium. By controlling the delay between the infrared field and the field of the attosecond pulses, it is possible to control the number of helium ions produced.

The unprecedented control demonstrated in this experiment arises from interference between electron wave packets generated by different attosecond pulses. With further work, this study should pave the way for detailed insights into electron wave-packet dynamics in driven atomic and molecular systems.

DISPLAY TECHNOLOGY

Driven by nanowires



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Nano Lett. doi: 10.1021/nl072538+ (2007)

An enticing prospect for future flat-panel-display technology is the development of displays that are flexible and transparent. With this goal in mind, Sanghyun Ju and colleagues based in the USA have demonstrated flexible active-matrix organic LED (AMOLED) displays that are driven by simple, mass-producible nanowire electronics and are optically transparent.

Although AMOLED displays have previously been demonstrated, these have incorporated thin-film transistors based on low-temperature polysilicon or amorphous silicon, and they have been opaque and not well-suited for flexible displays. Nanowire transistors, on the other hand, are ideal because of their transparency, small size, electrical behaviour and fast switching properties, not to mention the fact that they can be produced at a low temperature. These devices have one or more semiconductor nanowires as the active-channel region.

Ju *et al.* present transparent AMOLED displays in which the switching and driving circuits are comprised solely of nanowire transistor electronics. Indium oxide nanowires are used for the active channels, along with a self-assembled nanodielectric as the gate insulator and polymer organic LEDs. The 2 mm × 2 mm displays offer an optical transmittance of 72% and a brightness of over 300 cd m^{-2}, and could be used in hand-held applications or integrated onto plastic substrates.