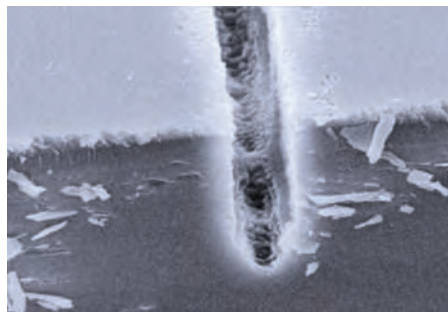


LASER MACHINING

Faster fabrication

Opt. Express **18**, 566–574 (2010)



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For inscribing micro- and nanostructures in glass, femtosecond non-diffracting Bessel beams offer the advantage of much faster processing times compared with Gaussian beams, according to François Courvoisier and co-workers from Université de Franche-Comté in France and Macquarie University in Australia. The researchers fabricated channels with diameters of 2 μm , lengths of 40–80 μm and aspect ratios of up to 40 using Bessel beams with a conical angle of 10° , a central spot diameter of 1.5 μm at full-width half-maximum and a depth of focus of 150 μm at full-width half-maximum. They also identified an energy range of 6.8–8 μJ where high-quality, taper-free structures can be written without the need to translate the sample along the direction of the channel. As the processing time is dependent only on the number of shots required to drill the channel, this method is much faster than Gaussian-beam-based techniques, which require a low translation speed for the sample. Courvoisier and co-workers attribute the success of this scheme to the nonlinear filamentation stability of the Bessel beam propagation, and suggest that it will undoubtedly simplify the fabrication of, for example, microfluidic channels for lab-on-chip applications and DNA analysis.

LIGHT DETECTION

Extending absorption

Adv. Mater. **22**, 647–650 (2009)

Optoelectronic materials that absorb light in the near- to mid-infrared range are essential for many applications, including optical data communications and contrast-enhanced imaging. However, most of these materials are based on expensive III–V semiconductor technology and are not easy to integrate with standard silicon-based CMOS technology. Now, Gebhard Matt and colleagues from Austria and France have demonstrated a silicon-based

heterojunction that has strong absorption in the wavelength range of 1.12–2.25 μm . The heterojunction consists of a spin-coated layer of the C_{60} derivative PCBM on top of a boron-doped p-Si wafer. Current–voltage characteristics typical of standard photovoltaic devices were observed. Neither of these materials independently demonstrates strong absorption in the near- to mid-infrared wavelength range, which makes the observed photocurrent particularly interesting. The team attributes the photoresponse and current–voltage characteristics of the heterojunction to a particular optical transition from the valence band of p-Si to the LUMO level of the PCBM.

PLASMONICS

Free-space excitation

Phys. Rev. Lett. **103**, 266802 (2009)

Surface plasmons always have a slower phase velocity than light waves in the adjacent bulk media — if this were not the case, they would leak away from the surface. This fact also means that their excitation cannot typically be achieved by illumination of a flat surface. Now, Jan Renger and colleagues from Spain and the USA have provided the first demonstration of direct surface plasmon excitation on flat surfaces by bulk waves. The key is to bridge the momentum gap between the surface plasmon–polaritons and the incident radiation. To achieve this, the team used four-wave mixing at a gold surface by overlapping two beams of laser pulses: 4.5- μm -diameter spots from a 200-fs Ti:Sapphire laser at a wavelength of 800 nm, and an optical parametric oscillator providing pulses of a similar duration at

a wavelength of 707 nm. The generated plasmons were scattered away from the surface by gratings and the radiation routed into a fibre-coupled spectrometer. Resonant angles of excitation confirmed that plasmons were indeed generated. The researchers say that the energy and momentum of the plasmons can be chosen by appropriate laser energies and excitation angles in the scheme. The obvious advantages of this free-space excitation approach are that no additional fabrication is required and that no losses are introduced by new materials.

MICROSCOPY

Photons help electrons

Nature **462**, 902–906 (2009)

By exploiting the interactions between electrons and photons, Brett Barwick and colleagues from Caltech in California, USA, have imaged evanescent electromagnetic fields at nanometre spatial scales and femtosecond temporal scales. Their approach involves splitting 220-fs, 1,038-nm pulses into two ‘arms’; one is frequency-doubled and used to optically excite the nanostructure, whereas the other is frequency-tripled and used to generate electrons at a photocathode source. The team overlapped the femtosecond single-electron packets with the optical pulses, resulting in the absorption of integer multiples of photons by the electrons. These electrons were then accelerated to ~ 200 keV, and energy filtering allowed determination of the local electric field distribution. Samples investigated included multiwalled carbon nanotubes of ~ 140 nm diameter and silver nanowires of ~ 100 nm diameter. This method, coined ‘photon-induced near-

ENVIRONMENTAL OPTICS

Sunburn myth dispelled

New Phytol. **185**, 979–987 (2010)

It is a widely held belief in horticulture that plants should not be watered in the midday sun. One of the reasons given is the risk of leaf burn resulting from the focusing properties of small water drops that form on the surface of leaves. Scientists in Hungary and Germany have now performed a series of optical experiments with Acer and Gingo leaves to test this assumption. Gábor Horváth and co-workers conclude that although it is indeed possible for sunlight glass spheres (diameters of 2–10 mm) to cause serious leaf burn, the situation is highly unlikely to occur for water drops on smooth, hairless plant leaves. The researchers explain that the main reason for the lack of damage is that — unlike a glass sphere — a water drop usually only forms a weak lens, owing to its typical ellipsoidal shape and the refractive index of water, and so usually has a focal region that falls far below the surface of the leaf. However, for leaves with hydrophobic wax hairs, such as floating ferns, spheroid-shaped water drops can form suspended above the leaf surface, resulting in a higher risk of burning. The researchers say their analysis suggests that claims made about sunburn due to the formation of water drops on human skin should therefore be treated with a healthy dose of scepticism.

field electron microscopy, may have many applications for imaging electromagnetic fields in all fields of photonics, but seems especially appealing to those interested in nanostructures and plasmonics.

QUANTUM DOTS

Independent tuning

Appl. Phys. Lett. **95**, 243107 (2009)

Self-assembled quantum dots (QDs) embedded in an optical nanocavity are potentially useful for quantum information processing. It is difficult, however, to couple two QDs to a single nanocavity mode in a cavity quantum electrodynamical system, owing to the linewidth mismatch between the two closely spaced QDs and the cavity modes. Now, Hyeonul Kim and co-workers from the USA and the Netherlands have proposed a simple technique that allows the frequencies of individual QDs to be tuned. Their method relied on the use of GaAs photonic crystal membrane structures containing two embedded $\text{In}_{0.4}\text{Ga}_{0.6}\text{As}$ QD layers. The QDs were located in the three-point defects of the photonic crystal, which had a lattice constant and hole radius of 240 nm and 74 nm, respectively. By applying a d.c. voltage of 1.33 V onto only one of the QD layers, the emission line of that particular QD layer was shifted by over 1 nm, leading to an overlap with the cavity mode. Kim and his colleagues are confident that strong coupling effects such as the generation of tripartite quantum states can be achieved by further optimization of their technique.

OPTICAL MATERIALS

UV resistance

Opt. Lett. **35**, 10-12 (2010)

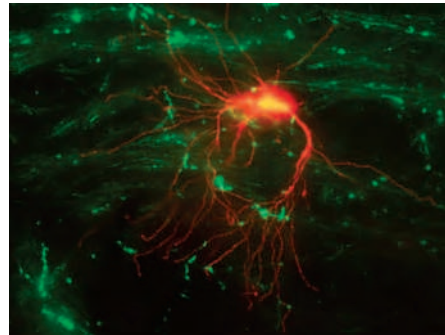
Although lithium niobate is a useful material for integrated optics and nonlinear photonics, photorefractive — laser-induced optical damage — hinders its applications in the UV region. Now, Fucui Liu and co-workers from Nankai University in China have carried out a systematic investigation into the UV-range damage resistance of lithium niobate doped with zirconium. For comparison, three kinds of lithium niobate were grown by the Czochralski method: Zr-doped, MgO-doped and congruent pure lithium niobate. Two-wave mixing techniques were used to measure both the increase in refractive index when irradiated by 351 nm light and the decrease in refractive index when irradiated by 532 nm light. The researchers found that the Zr dopant was the most efficient for preventing optical damage

at UV wavelengths, and a sample with 2.0 mol% Zr dopant was reported to have a damage resistance threshold of 10^5 W cm^{-2} .

NEUROSCIENCE

Light and headaches

Nature Neurosci. **13**, 239-245 (2010)



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Many migraine sufferers experience photophobia — an abnormally high sensitivity to light — during intense migraine episodes. Rodrigo Nosedá and his colleagues have now identified the neural mechanism responsible for this painful phenomenon. By examining a group of blind migraine sufferers, the researchers determined that those who had lost their optic nerves or both of their eyes did not suffer from photophobia. They then conducted various electrophysiological neuronal tests in rats. Through their experiments, the researchers concluded that the neuronal activity of the nociceptive pathway — which causes the pain experienced during migraine headaches — is regulated by retinal photo-activation. This is induced by signals from light-sensitive retinal ganglion cells that converge on the dura-sensitive neurons in the brain, which are responsible for migraine pain.

BIOPHOTONICS

Neural silencing

Nature **463**, 98-102 (2010)

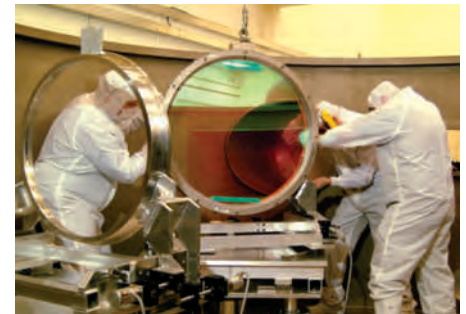
Multicoloured lights are capable of silencing brain activity, according to findings reported by Brian Chow and co-workers at the Massachusetts Institute of Technology in the USA. The researchers introduced light-driven proton pumps — proteins embedded in cell membranes that transport molecules in and out of the cells — to neurons in the brain. These proton pumps respond to illumination with specific colours of light; the two pumps chosen for this experiment — Arch and Mac — were sensitive to yellow-green and blue-green light, respectively. The team showed

that irradiating the neurons with either yellow or blue light caused protons to be removed from the cell, which inhibited neural activity. They also discovered that light-driven proton pumps were able to mediate significantly higher photocurrents (approaching 900 pA) than light-driven chloride pumps. Furthermore, Arch-mediated currents were shown to recover from yellow light illumination within a matter of seconds — much faster than any of the other proton pumps previously tested. The researchers suggest that their findings could lead to experiments where two or more neural projections from a single site in the brain could independently be silenced during analysis, which could lead to a greater understanding of the underlying causes behind brain activity and more effective treatments for neural disorders.

PLASMA PHYSICS

Collisionless shocks

Phys. Rev. Lett. **103**, 255001 (2009)



RUTHERFORD APPLETON LABORATORY

Emissions of plasma from supernovae, gamma-ray bursts and relativistic jets often interact with the surrounding interstellar medium through relativistic collisionless shocks. Despite the importance of these shocks and their associated instabilities to a large number of astrophysical situations, there is currently no single, complete analytical theory to describe them. Karl Krushelnick and his co-workers from the UK, Greece and Germany have now achieved the first laboratory demonstration of such ultrahigh-velocity shockwaves by focusing 350-TW, 1-ps laser pulses with energy in the range of 200–350 J onto the edge of a low-density helium gas jet target. The resulting electrostatic shock propagates into the surrounding helium gas, and has three distinct stages. In particular, the researchers found that the third stage of the shock — known as the blast wave — was unlike any laser-generated blast wave previously demonstrated in the laboratory because thin-shell perturbations were found to grow without fragmentation of the blast front.