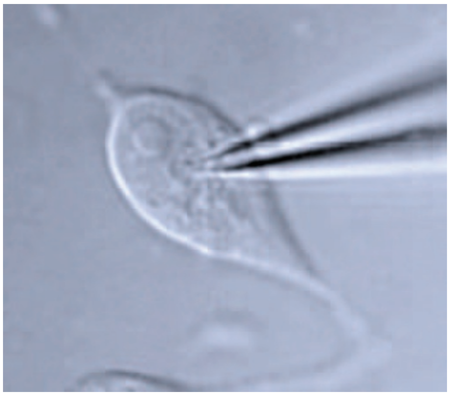
NEUROPHOTONICS

Quantum-dot control

Biomed. Opt. Express **3,** 447–454 (2012)



© 2012 OSA

The ability to switch and control electrical signals in the brain would help researchers tackle many of the outstanding questions in neuroscience. Katherine Lugo and co-workers from the University of Washington in the USA have now demonstrated an optical control scheme that uses quantum dots to control cellular activity and signalling. Optically exciting a quantum dot creates an electric dipole moment that can perturb the ion channel signalling capability of any cells nearby. The advantage of this approach is its flexibility: quantum dots can be activated and deactivated simply by turning on and off the excitation light, and can also be selectively bound to specific biological targets by modifying their surface chemistry. The researchers demonstrated the remote switching of cellular activity in cultured prostate cancer cells on CdTe quantum dot films, as well as cultured neurons on CdSe quantum-dot films and CdSe quantum-dot probes under excitation at wavelengths of 430 nm and 550 nm, respectively. They observed that these effects began to appear at an intensity rate of 10^7 photons per square micrometre per second. *RW*

SEMICONDUCTOR LASERS

Pushing the mid-infrared

Appl. Phys. Lett. **100,** 041109 (2012)

The only semiconductor lasers currently capable of accessing mid-infrared wavelengths above 2.3 μm — a range that is particularly important for trace-gas optical detection — are those based on GaSb. Alternative InP-based devices, which offer the benefits of being cheaper, exhibiting lower thermal conductivity and relying on more established technology, are limited to an upper wavelength of around 1.75 μm. Stephan Sprengel and co-workers have now demonstrated room-temperature lasing at 2.55 μm in an InP-based GaInAs/GaAsSb type-II quantum-well laser operating in pulsed mode. The device employs compressive strain in both the GaInAs and GaAsSb regions, together with carrier confinement provided by electron- and hole-blocking layers made from AlAsSb and AlGaInAs, respectively. Whereas previous attempts exploited superlattice active regions, the device demonstrated by Sprengel and co-workers employs W-shaped active regions to benefit fully from the reduced density of states of the quantum confinement. The researchers also demonstrated continuous-wave lasing at 2.31 μm for temperatures of up to 0 °C. Although the device is still in the early stages of development, the researchers say that growth optimization and additional advances in design are expected to improve laser performance and extend operation further into the mid-infrared. *JB*

X-RAYS

Inner-shell atom laser

Nature **481,** 488–491 (2012)

X-ray free-electron laser (FEL) facilities provide pulses of soft and hard X-rays that are bright and short but suffer from unstable emission spectra. Nina Rohringer and colleagues from the USA and Germany have now found a way to improve the fluctuating spectrum, noise and limited coherence of an FEL. The team used the FEL at the Linac Coherent Light Source in the USA to pump a hard-X-ray atom laser and obtain narrowband and coherent output. The team used 40–80 fs pulses with photon energies of around 960 eV (wavelength of 1.28 nm) to illuminate a neon gas with a 1–2 μm spot size and thus produce a plasma column of core-excited ions. Amplified stimulated emission occurred at the front of the plasma column when photons emitted from previously excited atoms encountered atoms prepared in an excited state due to the FEL pulse. The researchers detected atomic radiation at 849 eV (wavelength of 1.45 nm) using a grating spectrometer and a CCD. To confirm exponential amplification of the X-rays along the gain medium, the researchers doubled the FEL energy from 0.12 mJ to 0.24 mJ, which increased the output by four orders of magnitude. Single-shot experiments provided a peak output of around 1.1 μJ and an effective gain coefficient of approximately 70 cm^{-1}. *DP*

OPTICAL CLOCKS

Stable transfer

Appl. Phys. Express **5,** 022701 (2012)

By phase-locking two independent clock lasers to a common optical frequency comb, scientists in Japan have successfully transferred the high stability of a master clock laser to a slave clock laser, which usually exhibits inferior performance. The team, from the National Institute of Information and Communications Technology (NICT) and the Japan Science and Technology Agency, say that the technique will prove useful for applications related to optical frequency standards and ultraprecise spectroscopy. The 729 nm

EXCITONS

Nanotube answer

Phys. Rev. B **85,** 045428 (2012)

In metallic materials, free electrons can screen the Coulomb interaction between an electron and a hole, thereby preventing the formation of an exciton. Furthermore, the observation of photoluminescence in metallic materials is difficult because of the ultrafast non-radiative decay of photoexcited electrons and holes due to electron–electron scattering and photon-mediated relaxation processes. Takeshi Koyama and co-workers from Nagoya University and the National Institute of Advanced Industrial Science and Technology in Japan believe they have now found evidence of exciton formation in metallic single-walled carbon nanotubes (SWNTs). The researchers used femtosecond time-resolved luminescence spectroscopy to measure the photoluminescence. The device provided a central excitation photon energy of around 1.55 eV and a time resolution of 10 fs. The researchers prepared samples enriched with both metallic and semiconducting SWNTs by using the density gradient ultracentrifugation procedure. They attributed the peak in photoluminescence — around 1.4 eV — to the metallic-SWNT-enriched samples. They also implemented transient photoabsorption measurements to record the time evolution of band bleaching around 1.4 eV. The difference in temporal behaviour between the photoluminescence and absorption signals strongly suggests that the photoluminescence peak was excitonic in nature. The exciton lifetime of 40 fs indicates that a large exciton binding energy leads to a relatively stable exciton state in the presence of metallic electrons. *NH*