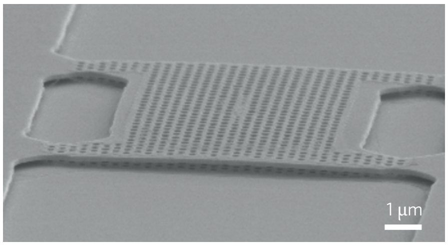
QUANTUM EMITTERS

Fully tunable

Appl. Phys. Lett. **107,** 141109 (2015)



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For emitters inside cavities, control over the wavelength of the emitter and the cavity modes is important for bringing both into resonance with each other and exploiting effects such as Purcell enhancement. Maurangelo Petruzzella and co-workers from The Netherlands, Denmark and the UK have now reported a method for accomplishing this in a solid-state system. Their semiconductor device supports independent electrical control of both the emitter and the cavity. The device consists of low-density InAs quantum dots embedded in the upper membrane of two parallel mechanically reconfigurable photonic crystal membranes. A p–i–n diode realized across the top membrane governs the energy of the quantum dots and thus their emission wavelength via the quantum-confined Stark effect. A second p–i–n diode connected to the bottom membrane controls the cavity resonance through capacitive force-induced displacement of the membrane. By combining Stark tuning of quantum dots with nanoelectromechanical actuation of the cavity, reversible wavelength tuning of the emitter over 7.5 nm and a mode shift of the cavity over 8.5 nm are achieved. As a result, a single exciton transition is brought into resonance with the cavity mode allowing a tenfold enhancement of its spontaneous emission. *RW*

GRAPHENE

Terahertz modulator

ACS Photon. http://doi.org/83z (2015)

An integrated device that can strongly modulate the intensity of terahertz (THz) waves could prove useful for various applications of terahertz photonics, including high-bit-rate free-space communications, imaging and sensing. Now, a graphene-based device with 100% modulation depth and a response speed of 110 MHz has been successfully integrated with a surface-emitting THz quantum cascade laser featuring a concentric circular grating. The large strength of the modulation is due to a strong interaction of the graphene with the laser field. The device was made by researchers from Nanyang Technological University, University of Leeds, Singapore Institute of Manufacturing and Hong Kong Polytechnic University. The broadband nature of graphene's absorption spectrum means that the approach reported here could, in principle, be scaled to other wavelength regions, such as the mid-infrared. *OG*

SILICON PHOTONICS

Two-qubit logic gate

Nature **526,** 410–414 (2015)

Attempts to make quantum information processors practical to manufacture have concentrated on the use of solid-state platforms based on superconducting or semiconductor materials. However, owing to the difficulties of coupling qubits and dephasing problems, semiconductor systems trail behind superconducting systems in terms of performance. Now, Menno Veldhorst and co-workers from the University of New South Wales, Australia and Keio University, Japan have demonstrated a two-qubit logic gate based on single spins in silicon. The device has a double-quantum-dot structure fabricated on a ^{28}Si epilayer with a residual ^{29}Si concentration of 800 ppm. The quantum dot qubits are individually controlled by electrically tuning the electron spin resonance frequency using the Stark shift. The spin states of qubits are manipulated by a microwave pulse. The measurements were conducted at 50 mK. A Ramsey experiment showed the dephasing time of a single-spin qubit was around 100 µs. The two-qubit gate was realized by using controlled-phase operations combined with single-qubit operation. When the phase difference is π between two qubits with different antiparallel states, clear anticorrelation is observed in the two-spin probabilities, which demonstrates the operation of a CNOT gate. The small size of the gate and the fact that it can be made by standard CMOS technology offers the prospect of realizing a large-scale quantum processor. *NH*

FREE-ELECTRON LASERS

Two-colour operation

Phys. Rev. Lett. **115,** 184801 (2015)

Free-electron lasers (FELs) use magnetic undulators to 'wiggle' electron bunches, creating photons whose parameters are highly tunable. Ying Wu and colleagues from the USA, Russia and China have now reported two-colour operation in a ring-based FEL. Using three undulators and dual-band dielectric mirrors they achieved simultaneous lasing at 720 nm in the near-infrared and 360 nm in the ultraviolet. Importantly, the arrangement yielded a similar level of gain at each wavelength, which is a challenging task. The ability to keep one lasing wavelength fixed while tuning the other is also important for exploitation of two-colour FELs. The ultraviolet lasing wavelength was able to be held at 360.05 ± 0.04 nm while the infrared lasing wavelength was swept (with 5-nm step size) from 675 nm to 735 nm. The team also achieved a fixed infrared wavelength of 720.00 ± 0.09 nm during ultraviolet wavelength tuning from 374 nm to 350 nm. *DP*

TERAHERTZ PHOTONICS

Compact accelerator

Nature Commun. **6,** 8486 (2015)

Optical schemes for charged particle acceleration are highly desirable. Usually such schemes, the most popular being the laser-driven wakefield accelerator, rely on intense femtosecond laser sources with demanding properties. Now, an international collaboration of scientists from the US, Canada and Germany have demonstrated that the use terahertz (THz) pulses could perhaps ease requirements with the report of a THz-driven linear accelerator for electrons. The team report how an optically generated 10 µJ THz pulse centred at 0.45 THz was able to accelerate electrons along a 3-mm-long circular-profile dielectric waveguide with a copper outer wall. In this proof-of-principle experiment the energy of the accelerated electrons is boosted by 7 keV, but it is expected that the use of more intense THz sources would be able to provide GeV m^{-1} acceleration gradients. The development of ultracompact THz accelerators that support extremely short electron bunches would potentially prove valuable for free-electron lasers, linear colliders and X-ray science. The single-cycle THz pulses used in the experiments were generated by optical rectification of 1.2 mJ, 1.03 µm laser pulses with a repetition rate of 1 kHz. A segmented waveplate was used to transform the polarization of the THz pulses from a linear to a radial polarization, prior to them being coupled into the waveguide, to accelerate 60 keV electrons emitted from an electron gun. *OG*

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