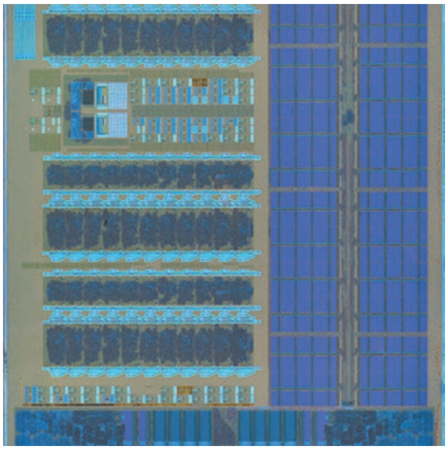
MICROPROCESSORS

Electronic–photonic chip

Nature **528,** 534–538 (2015)



NATURE PUBLISHING GROUP

A long-standing goal of the photonics and semiconductor industries is the dense integration of optical components into electronic microprocessor chips to overcome bandwidth and power density limitations of electrical connections. However, fabrication incompatibilities mean that chip-scale integration of photonics and electronics has so far remained limited. Now, Chen Sun, Mark Wade, Yunsup Lee, Jason Orcutt and colleagues in the USA have demonstrated integration of 70 million transistors and 850 photonic components in a chip that exploits the electronics for logic operations and optics for rapid communication with the memory. The system houses a RISC-V microprocessor and a separate 1 MB random access memory and was shown to be capable of three-dimensional graphics rendering. Communication between the microprocessor and the memory by optical means was demonstrated over arbitrary distances (for example, up to 20 m by fibre). A 1,183-nm wavelength solid-state laser provides a light source for integrated modulators made from 10-mm-diameter ring-resonators. The full-duplex communication between memory and microprocessor runs at 2.5 Gb s^{-1} in each direction, for an aggregate of 5 Gb s^{-1}. The team notes that 55 Gb s^{-1} should be possible without additional fibres, by using multiple wavelengths simultaneously. As processor load can affect the chip temperature (by up to 8 K in the present case), and thus affect operation of the optical transmitters and receivers the team implemented a thermal-tuning feedback circuit to control ring modulator microheaters, alleviating the temperature variation issue. *DP*

SINGLE-PHOTON SOURCES

Quantum dot microlenses

Appl. Phys. Lett. **108,** 021104 (2016)

Single-photon sources based on semiconductor quantum dots (QDs) are promising platforms for future quantum hardware. However, the achievement of modulation speeds exceeding the GHz range is limited by the intrinsic radiative lifetime of the QD optical transition. Now, Alexander Schlehahn and co-workers from Technische Universität Berlin in Germany and Technion-Israel Institute of Technology have demonstrated the generation of a single-photon pulse train at a 1 GHz repetition rate by electro-optically exciting InGaAs QD microlenses embedded in a GaAs layer. The QD microlenses were electrically addressed by an integrated microprobe needle and excited by a continuous-wave diode laser emitting at 651 nm. When electrical pulses with a width of 8.2 ns and amplitude of 3 V were applied to the QD microlenses, a pronounced pulsed emission triggered by the rising edge of the electrical pulse was observed. The non-classical nature of the photon pulse train was proved by intensity autocorrelation measurements. In combination with resonant excitation schemes, this holds promise for the realization of efficient, ultrafast sources of indistinguishable photons. *NH*

LIGHT SOURCES

Cascaded OPOs

Opt. Express **23,** 33460–33465 (2015)

Cascaded optical parametric oscillators (OPOs) covering a broad spectral range from 5.8 to 18 μm have been demonstrated by Andrey Boyko and co-workers from Germany, Russia and Sweden. The first stage of the cascade is an OPO composed of a Rb-doped periodically poled $KTiOPO_4$ crystal, which was excited by a 1.064 μm laser with a pulse width of 8 ns to generate signal (S_1) and idler (I_1) beams. Subsequently, the S_1 beam excited the second OPO, composed of a $AgGaSe_2$ (AGSe) crystal, to generate another set of signal (S_2) and idler (I_2) beams. The second OPO had a single-resonant cavity set-up for the S_2 beam, while the first OPO had a double-resonant cavity set-up for both the S_1 and I_1 beams. To achieve highly efficient wavelength conversion, the international team prepared two AGSe samples — one cut for short-wavelength conversion (5.8–8.3 μm) and the other for long-wavelength conversion (8–18 μm). The overall external conversion efficiency from the 1.064 μm pump laser was around 4% and is limited by the effective second-order nonlinear optical coefficient and the transparency of the AGSe crystals. *NH*

FREQUENCY COMBS

Soliton boost

Science **351,** 357–360 (2016)

On-chip microresonator-based frequency combs have been demonstrated before, but the challenge remains in achieving broadband coherent combs. Such a device would be attractive for frequency metrology and spectroscopy. Now, by exploiting soliton Cherenkov radiation in the presence of higher-order dispersion, Victor Brasch and colleagues from EPFL, Switzerland have generated a fully coherent optical frequency comb spanning two-thirds of an octave and whose phase can be stabilized to the sub-hertz level. Their experimental platform is based on an integrated silicon nitride optical microresonator with a thickness of 800 nm and a diameter of 238 μm, embedded in SiO_2. It is continuous wave-pumped at 1,560 nm and dispersion engineered with an anomalous group velocity dispersion for wavelengths around 1,500 nm. When pump power is at 2 W, soliton Cherenkov radiation is generated, appearing as a sharp feature around 1,930 nm in the optical spectrum. *RW*

SOLAR CELLS

Guanidinium benefit

Nano Lett. **16,** 1009–1016 (2016)

Adding the chemical element guanidinium to perovskite solar cells can enhance charge-carrier lifetime and the cell's open circuit voltage, report researchers from the University of California at Los Angeles. It is known that non-radiative charge-carrier recombination at grain boundaries limits the performance of these solar cells and thus a means for eliminating this phenomenon is highly desirable. The team describe how guanidinium-based additives serve to passivate recombination centres at grain boundaries leading to superior performance with cell power conversion efficiencies greater than 17% and an open circuit voltage of 1.1 V. It is believed that the guanidinium ions suppress formation of iodide vacancies in the perovskite material and that their hydrogen bonding capabilities passivate iodine species at grain boundaries. *OG*

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