PHASED ARRAYS
Dense integration
Nature **493,** 195–199 (2013)

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Phased arrays — groups of antennas, each of which has its phase individually controlled — are useful for beam steering and imaging applications and are commonly used in the radiofrequency domain. So far, only one-dimensional or small-scale two-dimensional arrays have been produced for use in optics, with a maximum of 4 × 4 antennas. Now, Jie Sun and co-workers from MIT in the USA have not only set a new record for the number of antennas in an array, but have also shown that the antennas can be densely integrated on a small (576 × 576 μm^2) silicon photonics platform. By using a 300-nm complementary metal–oxide–silicon (CMOS) foundry and 193-nm optical immersion lithography, the team fabricated a phased array of 64 × 64 antenna units. Each unit occupied 9 × 9 μm^2 and consisted of an optical coupler, a phase shifter and gratings. Experimental results demonstrate that suitable control of the antennas' phase can produce sophisticated far-field radiation patterns. The team has also shown how phase tuning of an 8 × 8 array of nanoantennas can be used to realize dynamic beam steering and shaping. Potential applications lie within communications, LADAR, three-dimensional holography and biological sciences. *RW*

RESONATORS
Low-loss phased arrays
Opt. Express **21,** 1344–1352 (2013)

Transmission of light through, or reflection from, subwavelength arrays of metallic resonators has received renewed attention with several studies showing the possibilities for wavefront engineering and beam steering. A similar trick has long been used to great effect in the radiofrequency and microwave ranges. However, it is well known that metallic resonators and metamaterials can result in large losses for optical waves. Now, Longfang Zou and colleagues from the University of Adelaide and RMIT University in Australia propose a low-loss solution based on what they call dielectric resonator arrays. The resonators are designed to operate in the visible range and consist of small cylinders of TiO_2 on silver substrates. The researchers claim that much of the optical energy in the resonator is stored in the dielectric part, and hence loss in the metal is reduced. The designed non-uniform planar array elements impart desired phase shifts across the wavefront, allowing the angle of reflection to be varied. The team created linear six-element sub-arrays on a ~40 × 40 μm^2 surface containing 126 × 126 resonator elements that efficiently deflected an optical beam with a wavelength of 633 nm. *DP*

IMAGING
In vivo tracking
Nano Lett. **13,** 980–986 (2013)

Fluorophores or quantum dots can be used to temporally track the locations of proteins and other species in a biological cell. However, photobleaching or blinking can limit tracking times to seconds, whereas many cellular processes occur over minutes or even hours. Also, a larger spatial tracking range is desired along with methods that permit many probes to be simultaneously observed in parallel. Now, Bram van den Broek and colleagues from Leiden University in the Netherlands have achieved parallel 3D tracking of gold nanorods in living cells using multifocal two-photon microscopy. Gold nanorods have the advantage that they do not blink or bleach, simplifying the tracking process. Two-photon luminescence has previously been used for 2D particle tracking in living cells, but its extension to three dimensions is not trivial as the usual procedure of serial laser scanning and read-out can be slow compared with cell dynamics. To resolve this problem, the team used a multifocal scanning microscope with a rapid CCD-based read out. Individual gold nanorods were localized with a sub-10-nm resolution and followed in three dimensions for over 30 min. *DP*

LASER COOLING
Semiconductor success
Nature **493,** 504–508 (2013)

Optical refrigeration, also known as laser cooling, is being explored as a solid-state technology for reducing the temperature of small devices and samples. This approach relies on using optical emission at a shorter wavelength than an incident pump laser to extract thermal energy in the form of phonons from a suitable material system. It has been demonstrated in rare-earth-doped glasses, but net cooling in semiconductors has remained elusive. Now, Jun Zhang and co-workers from Nanyang Technological University in Singapore report cooling by up to 40 K from room temperature and by 15 K from 100 K by pumping cadmium sulphide (CdS) nanobelts with 514 nm or 532 nm light with a power in the milliwatt range. The cooling effect, which has an estimated efficiency of the order of 1–2%, is attributed to strong coupling between excitons and longitudinal optical phonons in CdS, which allows resonant annihilation of several longitudinal optical phonons in a luminescence up-conversion process. According to the researchers, the demonstration indicates that group II–VI semiconductors have a promising future for cooling applications. *OG*

SOLAR CELLS
Nanowire efficiency boost
Science **339,** 1057–1060 (2013)

Solar cells based on an array of semiconductor nanowires instead of a continuous planar design can, in principle, reduce the amount of material required to construct a photovoltaic module. However, so far, the performance of nanowire cells has been considerably poorer than that of their flat counterparts. Now, Jesper Wallentin and co-workers from Sweden, Germany and China have fabricated an InP nanowire array cell with a power conversion efficiency of 13.8%, which is comparable to those of the best planar InP devices. Although the 180-nm-diameter InP nanowires in their device cover only about 12% of the cell's surface, resonant light-trapping effects give an optical-to-photocurrent conversion efficiency that is six times higher than that predicted by simple ray optics. Furthermore, their nanowire cell's open-circuit voltage, a critical parameter in solar cells, is superior to that of the planar design, reaching 0.906 V, despite a 30 times higher surface-to-volume ratio. The research team says sample tests showed that the efficiency of their best devices degraded less than 0.5% over a period of six months. They also point out that the design should be scalable to wafer-sized cells and may also be useful for constructing photodetectors. *OG*