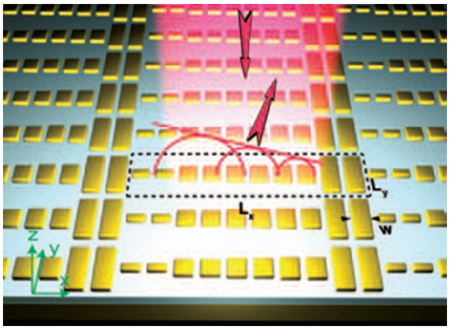
METAMATERIALS

Tailoring reflection

Nano Lett. **12,** 6223–6229 (2012)



When it comes to designing man-made structures with unusual or desirable optical properties, one popular goal is the realization of three-dimensional bulk metamaterials. However, thin surfaces with custom-designed optical properties are potentially useful too. Now, Shulin Sun and colleagues from Taiwan and China have fabricated a gradient metasurface from an array of nanoantennas whose properties vary across the sample. The surface is an efficient reflector of near-infrared light whose angle of reflection can be tailored by adjusting the gradient of the metallic structures. In addition, the researchers shifted operation to shorter wavelengths than previous experiments by reducing the size of the features that make up the surface. The metasurface is made from a 130-nm-thick gold reflecting plane coupled with gold rod antennas on an upper layer with a 50-nm-thick MgF spacer. The phase of the reflected or scattered field is engineered by varying the lengths of the antenna rods across the sample. The rod length determines the resonant frequency and hence the phase imparted to the scattered field from each point on the reflector. The structure operates across a wide wavelength range of 750–900 nm, owing to the broad resonance of lossy low-Q-factor resonators and to the gradient of the antennas' resonant frequencies across the sample. The researchers hope this approach will be useful for applications such as optical absorbers and optical mode couplers. *DP*

BIOPHOTONICS

Optical breath sensor

Biomed. Opt. Express **3,** 3325–3331 (2012)

A photonic-crystal fibre interferometer that can function as an optical breath sensor and is safe to use inside a magnetic resonance imaging scanner could prove to be a useful alternative to electronic sensors in hospitals. The face-mask device works by optically sensing the change in air humidity when the patient exhales. A 1-mm-long photonic crystal fibre inside the mask is filled with agarose, whose refractive index is highly sensitive to humidity. This sensitivity causes changes in the optical path length inside a fibre interferometer and thus a rise or fall in the output signal, thereby providing a real-time indicator of the patient's breathing pattern. The researchers behind the invention, from the Dublin Institute of Technology in Ireland, say that before clinical trials can take place the device must be modified so that the patient's eyes are protected from the laser light. Furthermore, the sensor will need to be protected from contamination in case the patient coughs or sneezes. *OG*

ENDOSCOPY

Scanner-free

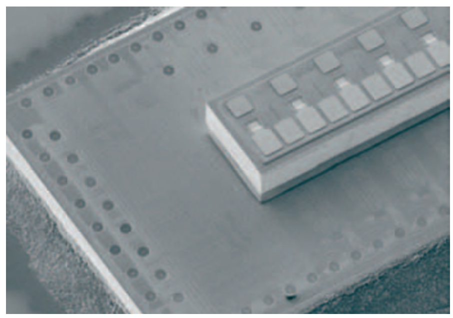
Phys. Rev. Lett. **109,** 203901 (2012)

Today's endoscopes collect high-resolution images via hundreds or thousands of individual optical fibres, which results in a bulky design with limited accessibility. The use of multimode fibre, although able to support numerous independent spatial modes, is hampered by wave distortions induced by the fibre. Youngwoon Choi and colleagues from Korea and the USA have now demonstrated endoscopic imaging using a single multimode optical fibre. They reconstructed a real image from the scrambled image transmitted by the multiple modes of light propagating down a single, 1-m-long multimode optical fibre with a 200-μm-diameter core, 15-μm-thick cladding and a 0.48 numerical aperture. Their trick was to characterize the input–output response of the fibre by recording its transmission matrix. To overcome wave distortions, the researchers employed methods of speckle imaging and turbid lens imaging. The resulting multimode fibre functioned as a self-contained, flexible three-dimensional imaging device that did not require a scanner or a lens. The researchers obtained a high spatial resolution of 1.8 μm and a field-of-view of around 200 μm. *RW*

INTEGRATED CIRCUITS

Stacking optoelectronics

Opt. Express **20,** B386–B392 (2012)



Demands for ever-faster data communication are driving the development of compact optoelectronic chips capable of handling more data channels. Pinxiang Duan and researchers at Eindhoven University of Technology and the firm TE Connectivity in the Netherlands have presented what they believe is a cost-effective way of creating compact stacked optoelectronics devices. Their work, which they apply to a vertical-cavity surface-emitting laser array transmitter, involves a new fabrication approach for stacking optoelectronic dies on complementary metal–oxide–semiconductor (CMOS) integrated circuits. The researchers bonded an optoelectronic die on top of a CMOS integrated circuit chip with a photoresist 'ramp' to connect the ~220 μm step between the optoelectronic and CMOS integrated circuit components. They claim that the lithographic approach they used to forge the required electrical connection can be scaled to wafer production and that the process is fully CMOS compatible. The researchers have

QUANTUM COMMUNICATIONS

Convenient key distribution

Phys. Rev. X **2,** 041010 (2012)

It would be economically advantageous and incredibly convenient if both data transmission and quantum key distribution could take place over a single optical fibre. However, this has so far proved problematic because the Raman scattered noise arising from the intense data signal can easily contaminate the low-intensity quantum signal. Now, Ketaki Patel and co-workers from Toshiba Research Europe and Cambridge University in the UK have shown that a temporal filtering technique allows the coexistence of quantum key distribution and gigabit-per-second data communications over a single fibre at distances of up to 90 km, with secure bit rates three orders of magnitude higher than those of current quantum key distribution schemes. The researchers found that time gating can filter out the forwards and backwards Raman scattering because the Raman photons reach the detector at random times with respect to the regularly pulsed quantum signals. The researchers therefore operated their InGaAs avalanche photodiodes with synchronized temporal filtering in order to enhance the quantum-signal-to-Raman-noise ratio by a factor of ten. They then removed any residual Raman photons by employing a conventional narrow bandpass filter. *NH*