used to couple pump light to the waveguide with very small modal cross-section. If a state-of-the-art spot-size converter were to be used with the waveguide, this loss could be reduced to less than 1 dB. In addition, the slow-light pulse in this experiment was 1.5 ps wide, corresponding to a wavelength bandwidth of 2 nm. If the full bandwidth of 10 nm measured for slow light is fully used to launch a shorter pulse, the peak intensity is five times higher for the same time-averaged power. These two improvements would potentially improve the efficiency by several orders of magnitude, if nonlinear losses were suppressed.

Another direction for future research is to reduce the nonlinear losses, in particular that of free carriers. Silicon has an absorption-edge wavelength of 1.11 μm, so two-photon absorption is unavoidable for pump wavelengths around 1.55 μm as the absorption occurs with pump wavelengths up to twice the absorption-edge wavelength. However, the free-carrier absorption of excited carriers by two-photon absorption is usually more severe in terms of the absorption itself and the heating induced. It can be avoided by shortening the carrier lifetime to less than the repetition period of the pulses, which is possible by applying an electric field and/or doping non-radiative recombination centres.

Despite the low conversion efficiency, the work by Corcoran *et al.* is an interesting observation that offers increased functionality and new opportunities for the fields of photonic crystals, slow light and silicon photonics. Looking ahead, not only third-harmonic generation but also other various types of wavelength conversion, nonlinear all-optical modulation and switching, formation of optical solitons and so on will be areas worth pursuing. ❐

Toshihiko Baba is at the Department of Electrical and Computer Engineering, Yokohama National University, Yokohama 240-8501, Japan.
e-mail: baba@ynu.ac.jp

References

1. Corcoran, B. *et al. Nature Photon.* **3,** 206–210 (2009).
2. Joannopoulos, J. D., Johnson, S. G., Winn, J. N. & Meade, R. D. *Photonic Crystals Molding the Flow of Light* 2nd edn (Princeton Univ. Press, 2008).
3. Baba, T. *Nature Photon.* **2,** 465–473 (2008).

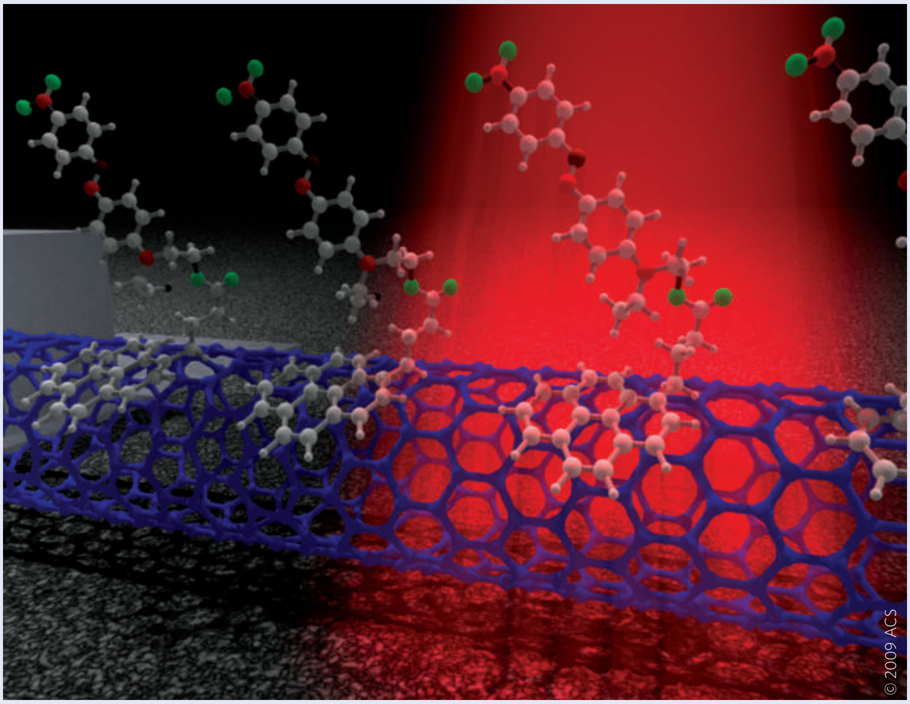
NANOPHOTONICS

Nanoscale colour detector

By attaching light-absorbing molecules to carbon nanotube field-effect transistors, scientists in the United States have fabricated nanoscale optoelectronic detectors that are sensitive to different colours of visible light (*Nano Lett.* doi:10.1021/nl8032922; 2009).

Xinjian Zhou and colleagues from Sandia National Laboratories took single-walled carbon nanotubes and functionalized them with azobenzene chromophores to create molecularly engineered photosensitive materials. In the scheme, the chromophores serve as photoabsorbers and the nanotubes act as an electronic read-out system.

The carbon nanotubes had diameters in the range of 0.8–2 nm, and were prepared in a well-dispersed solution and attached to treated silicon wafers. Three different azobenzene-based chromophores having absorption maxima at 467 nm, 381 nm and 342 nm, respectively, were anchored, through strong non-covalent interactions, to the surfaces of the nanotubes, in three separate experiments.



On illuminating the nanotubes with monochromatic light with a wavelength in the visible range of 400–700 nm, the scientists observed shifts in the threshold voltage in the electrical conduction of these nanotube–chromophore hybrid field-effect transistors. The shifts correlated with the absorption spectra of the azobenzene molecules.

Zhou *et al.* confirm that the process of conversion from an optical to an electrical signal is controlled by a dipole change mechanism at the molecular level. When a chromophore absorbs photons, a change in the molecular structure of the azobenzene occurs — so-called photoisomerization — and it transforms from the ground state *trans*-configuration to the metastable excited state *cis*-configuration. This photon-induced isomerization is accompanied by a large change in the electrical dipole moment of the chromophore and modifies the electrostatic potential and thus the threshold voltage of the nanotubes.

Zhou and co-workers' colour detection scheme is not only useful for making colour photodetectors with nanoscale resolution but also gives insights into the molecular interactions between single-walled carbon nanotubes and molecules. Further improvements are expected to allow them to detect single-molecule transformation activities and extend operation to other spectral regions.

RACHEL WON