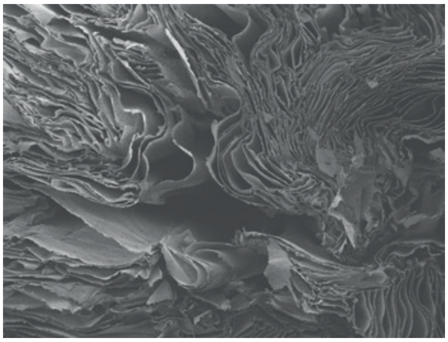
research highlights

TERAHERTZ OPTICS

Silk foam waveguides

Adv. Opt. Mater. http://doi.org/v44 (2014)



WILEY

For biomedical applications it is highly desirable to find terahertz waveguides that are biocompatible with living tissue. Now, Hichem Guerboukha at the Ecole Polytechnique de Montréal and colleagues have demonstrated silk-based THz waveguides and investigated their optical properties.

The scientists fabricated silk bulk foams from aqueous silk solution using a lyophilisation technique that they developed. Scanning electron microscopy images of the cross-section of the foams reveal an intricate flaky structure. The foams feature individual silk layers that are approximately 2-μm-thick and there is a 30–50 μm separation between layers. The silk fibroin filling factor is around 5%.

The loss and refractive index of 10-cm-long, 5-mm-diameter fibres with a silk foam core and an air cladding was measured using the cutback method. Given that the modal refractive index is constant in the 0.2–0.4 THz frequency range, the effective refractive index of the core mode was determined to be 1.058 and the propagation loss around 0.8 cm^{-1}. The modal group velocity dispersion was estimated to be less than 0.2 ps $\mathrm{THz}^{-1}\,\mathrm{cm}^{-1}$, which is smaller than that of a sub-wavelength polymer fibre. *NH*

TERAHERTZ PHOTONICS

Quantum cascade amplifier

Appl. Phys. Lett. **105,** 141102 (2014)

Scientists at the University of Cambridge in the UK have built a high-gain terahertz amplifier by adapting a 2.9 THz quantum cascade laser (QCL). An antireflective coating was deposited on the QCL's facet, which supressed optical feedback and lasing action, so that the device acted as a single-pass amplifier. The device was pumped with a separate QCL to achieve gains as large as 30 dB from a 1.33-mm-long Fabry–Pérot ridge cavity held at a temperature of 4.5 K. *OG*

OPTICAL ANTENNAS

Phase-change control

ACS Photon. **1,** 833–839 (2014)

Optically-controlled reversible switching of the resonances of optical nanoantennas is possible by covering them with a thin layer of a phase-change material, say researchers in Germany and the USA. The team, from RWTH Aachen University, SLAC National Accelerator Laboratory and Stanford University, report how femtosecond pulses from a Ti:Sapphire laser can be used to trigger amorphous-to-crystalline phase transitions in a thin film of $Ge_3Sb_2Te_6$ (GST) by heating it. Changing the structural phase of GST shifts the spectral resonance of an aluminium nanoantenna, located underneath, as the permittivity of the GST changes. In particular, the refractive index of GST changes from a value of 3.56 in the amorphous phase to 6.33 in the crystalline phase. Experiments with aluminium antennas that were 400 or 500 nm in length underneath a 50-nm-thick layer of GST show a clear change in the infrared reflection spectra. The approach means that antennas within an array can be individually addressed and independently controlled by optical excitation. It is postulated that the scheme could be useful for creating plasmonic and metamaterial devices that are reconfigurable. *OG*

SILICON PHOTONICS

Reconfigurable delays

Opt. Express **22,** 22707–22715 (2014)

A reconfigurable optical delay line on a silicon chip has been fabricated by scientists in China. Such devices are needed in all-optical networks and optical information processing systems to perform data synchronization and buffering. The device designed and built by Jingya Xie and co-workers at Shanghai Jiao Tong University is based on a cascade of eight 2 × 2 Mach–Zehnder interferometer (MZI) switches. Variable optical time delays are introduced by selecting long or short optical paths in each MZI switch as desired. In this manner, a maximum time delay of up to 1.27 ns with a 10 ps resolution is achieved. The team says that given the long lengths of waveguides required to introduce the delay, it is important to minimize waveguide propagation loss. The device was fabricated using standard CMOS processes on a silicon-on-insulator wafer and has a footprint of 7.4 × 1.6 mm (11.8 mm^2). Tests with data streams at 25 and 10 gigabits per second confirm its operation. *OG*

QUANTUM INFORMATION

Tomography by noise

Phys. Rev. Lett. **113,** 070403 (2014)

Quantum tomography is the most comprehensive tool for the quantitative evaluation of the fidelity of states that have been subject to quantum teleportation or entanglement distillation. However, methods for the reconstruction of photon number distributions require precise calibration of the measurement set-up together with minimization of noise and losses. Now, Georg Harder and co-workers from Germany, Belarus and the UK have demonstrated both theoretically and experimentally a quantum tomography system that uses thermal noise as a probe. Furthermore, only one on-off single-photon detector is sufficient for the data collection.

QUANTUM INFORMATION

Undetected imaging

Nature **512,** 409–412 (2014)

Scientists in Austria have demonstrated quantum imaging with photons that never actually interact with the imaged object. The technique is based on a quantum interference experiment with two separate down-conversion nonlinear crystals (labelled NL1 and NL2). The crystals are illuminated by the same continuous-wave 532 nm laser, and create 810 nm and 1,550 nm photons through parametric down-conversion processes. The 1,550 nm photons from NL1 are separated by a dichroic mirror, transmitted through the object, and collinearly sent to NL2 with the 532 nm laser. The 1,550 nm photons from NL1 and NL2 are then discarded and only 810 nm photons are combined at a beam splitter to cause interference. A cardboard cut-out or an etched 500-μm-thick silicon plate, which is opaque to illumination at 810 nm and highly transparent at 1,550 nm, is used as an object. The images are obtained with an electron-multiplying charge-coupled device camera with single-photon sensitivity at 810 nm. The demonstrated imaging is fundamentally different to interaction-free imaging or ghost imaging because the photons used to illuminate the object do not have to be detected at all and coincidence detection is not necessary. This enables the probe wavelength to be chosen in a range for which suitable detectors are not available. *NH*