PHOTONIC CRYSTALS

Holey light

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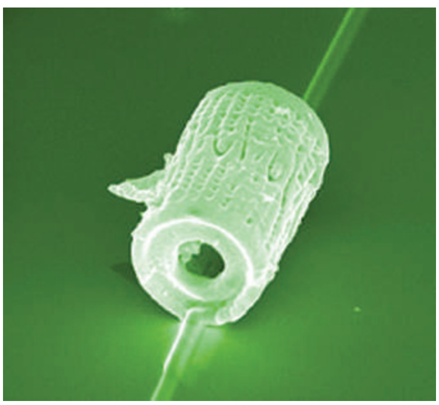
Photonic crystals are periodic structures that can manipulate the flow of electromagnetic radiation, such as light. The spacing inside the material does not allow certain wavelengths of light to propagate, the range of which is known as the photonic bandgap. This gives rise to novel optical properties that can be used in devices such as low-loss fibres. One-dimensional photonic crystals are already in widespread use and two-dimensional materials are nearing the market, but the challenge remains to make three-dimensional systems — especially on a large scale.

Now, Jiaqi Chen and co-workers at the University of Texas at Austin in the USA have made three-dimensional photonic crystals from polymeric materials using holographic lithography. With a specially designed prism, a He–Cd laser was split into four beams that overlap to generate a three-dimensional interference pattern, which can be used to pattern a photoresist. Depending on the nature of the photoresists, the regions exposed to the laser light are made to be either soluble or insoluble, and the soluble portions are washed away with solvent to produce a periodic structure.

By tuning the wavelength of the laser and using different photoresists, photonic crystals with lattice spacings of 610 nm and 820 nm were produced. These materials can operate in the 1460–1565 nm window and can be used to guide the infrared radiation that is commonly used in optical communications.

SILICON NANOSTRUCTURES

Reduce and replicate



K. H. SANDHAGE

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The silica microshells of marine algae (diatoms) are intricately patterned with nanopores and protrusions. To make replicas of these structures out of silicon — a more technologically useful material — the silica must be chemically reduced. However, this usually requires very high temperatures that would destroy the original morphology of the diatom shells.

Now, Kenneth Sandhage and co-workers at the Georgia Institute of Technology in the USA have made silicon replicas of diatom microshells by reacting them with magnesium gas at a cool (relatively speaking) 650 °C. First, a mixed solid of interconnected silicon and magnesia was obtained. Coarser grains of silicon were reoxidized to silica, and then — along with the magnesia — were dissolved in acid, leaving behind a continuous and highly porous nanocrystalline silicon structure with a high surface area.

Because its production can be readily scaled up, this new material could be used for a range of electronic, optical and sensing applications. The potential to make such devices was demonstrated by using a silicon replica of a diatom shell to sense nitric oxide gas. When one of these replicas was connected to electrodes and a voltage put across it, changes in impedance were observed on exposure to nitric oxide. Although further optimization is required, the devices are highly sensitive and have faster response times than previously reported porous silicon sensors.

NANOLITHOGRAPHY

Drawing a blank

Small **3,** 600–605 (2007)

Dip-pen nanolithography (DPN) is a powerful tool for 'writing' with molecules on surfaces. However, so far there has been no method for erasing mistakes. Now, Chad Mirkin and co-workers at Northwestern University in the USA have developed a technique that uses a conductive atomic force microscope to selectively remove regions and subsequently replace them with new molecules.

Nanosized alkanethiol features were deposited by DPN on a gold substrate and the surrounding regions filled with a monolayer of a different compound. The application of a negative bias voltage between the tip of the microscope and the surface causes molecules to desorb, and so regions of the alkanethiol can be selectively removed. The recessed areas can be refilled with a new substance, and if the conductive tip is coated with a replacement ink, this can be done in a single step with the erasing process. The tip can be coated either with the molecule used for the surrounding layer, which will effectively erase the scanned portion of the feature, or with another molecule, which will modify it.

This technique has potential, not only as a repair mechanism, but also for creating complex multiple-ink architectures that cannot be generated by standard DPN methods alone.

TOP DOWN BOTTOM UP

Joining forces

Biologists and optics researchers develop a biosensor based on DVD technology.

Penmetcha Kumar, a biologist at the Institute for Biological Resources and Functions, was interested in label-free detection of biomarkers using a type of molecule known as an aptamer and wanted to develop a diagnostic tool for use at the bedside. Elsewhere in the National Institute of Advanced Industrial Science and Technology (AIST) in Tsukuba, near Tokyo, Junji Tominaga was director of the Center for Applied Near Field Optics Research. Kumar and Tominaga met at a seminar organized by AIST in March 2005 and are currently working together to develop a 'BioDVD' that can detect ligand–aptamer interactions on a disc similar to a conventional DVD.

While Kumar's team optimized the chemistry involved in attaching the aptamers to surfaces and measured various ligand–aptamer interactions, Tominaga and co-workers developed the discs and machines to read them. The discs have a multilayer structure, containing alternating thin films of dielectric, metal and phase-changing materials, and the ligand–aptamer interactions are detected by measuring changes in the reflection intensity of the disc. The BioDVD platform is promising for a number of reasons, says Kumar: it can be mass-fabricated cheaply, it relies on simple DVD optics, it is suitable for high-throughputs, and the discs can be re-used after rinsing.

The two sides of the collaboration started by performing experiments together. "For a successful collaboration, it is important to set short-term goals and to schedule these collaborative experiments," says Kumar. "It is also important to read articles from other fields, as well as your own, because this helps you to think about how different fields are emerging. Biologists should also attend and present their work at non-biology conferences," he adds. This BioDVD project is now receiving a budget of around 10 million Japanese yen per year from a special research fund at AIST.

The definitive versions of these Research Highlights first appeared on the *Nature Nanotechnology* website, along with other articles that will not appear in print. If citing these articles, please refer to the web version.