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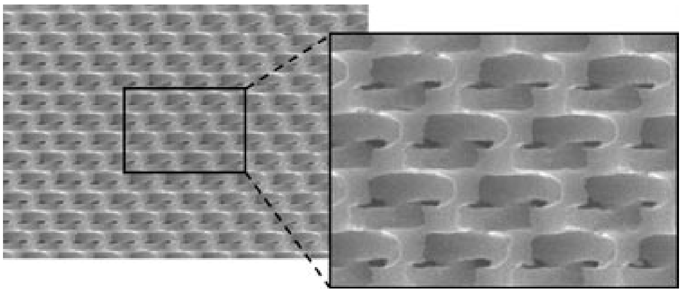
- Susumu Noda's Quantum Optoelectronics Laboratory, University of Kyoto

NEWS

Aug 19, 2009

Controlling light becomes crystal clear

A simple way to fabricate 3D photonic crystals could find applications in next-generation laser diodes, LEDs and solar cells.



Up close

Many optical scientists and engineers consider 3D photonic crystals the ideal structures for manipulating photons. To date, however, these structures have proved frustratingly difficult to make.

Now, researchers in Japan say that they have come up with a simple "top-down" approach to fabricating 3D photonic crystals, one which is compatible with existing microfabrication techniques (*Nature Materials* DOI:10.1038/NMAT2507).

"We have developed a new method to create 3D crystals that addresses existing fabrication issues and greatly simplifies the production process," Susumu Noda, a professor at Kyoto University, told *optics.org*. "What is more, by introducing a light emitter between the 3D crystals, we have demonstrated enhancement or suppression of spontaneous emission."

The Kyoto team believes that its approach will soon be commercially available and could find application in advanced photonic chips, high-efficiency LEDs, low threshold or thresholdless laser diodes, high-efficiency solar cells and quantum computing.

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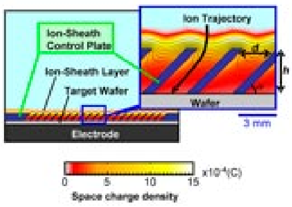
The trouble with 3D photonic crystals is the unintentional defects that invariably find their way into the structures during production. This is a particular problem when constructing crystals at optical wavelengths (the defects seriously degrade the optical quality of the crystals).



Ion trajectory

In 2000, Susumu and colleagues successfully fabricated crystals with excellent optical qualities by stacking 2D thin striped layers in what's known as a "bottom-up" approach. The trouble is, that process is complicated and time-consuming.

Now, the Kyoto team has come up with another workaround. Rather than stacking 2D layers, the group carved out a 3D woodpile structure directly by double etching at angles of ±45° with respect to the sample surface.

"We used a reactive-ion etching (RIE) technique, which is commonly used in the CMOS and MEMS fields," explained Noda. "We applied a metal plate [dubbed the ion-sheath control plate] with 45° openings to the surface of the crystal to guide the ion beam during etching."

According to Noda, the metal plate, which is a few millimetres thick, can be applied to many types of RIE facilities, which means that the technique is potentially CMOS- or MEMS-compatible. "This is crucial to enable our method to be used widely and to allow 3D photonic crystals to find practical use in the future," he noted.

In the final part of the study, the Kyoto team bonded a light emitter in the form of a single quantum well onto the crystal

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In the final part of the study, the Kyoto team bonded a light emitter in the form of a single quantum well onto the crystal
structure to demonstrate enhanced emission. The team then found that bonding a second crystal to the quantum-well layer (to effectively sandwich the quantum-well layer between two crystals) established emission suppression.

"Our results indicate that our 3D photonic-crystal structure has excellent properties regarding the control of light emission," said Noda.

The next task for the team is to deepen the etching in order to strengthen the photonic-bandgap effect and then start introducing the crystal to photonic devices.

About the author

Marie Freebody is a freelance science and technology journalist based in Bournemouth, UK.