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NPG Asia Materials research highlight | doi:10.1038/asiamat.2010.100
Published online 21 June 2010

Photonics: In the spotlight

The direction of laser beam emission can be controlled on a single chip using superimposed photonic crystals.

Control over the direction of laser beams is an important requirement for a range of applications, including commercial devices such as laser printers, DVDs and laser displays. Although there have been many attempts to achieve good on-chip control over beam direction, the cumbersome architectures employed have only allowed control over a narrow range of angles. Susumu Noda and a team of researchers from Kyoto University in Japan have now demonstrated fully electronic control of laser beam steering on a single chip using a specially designed photonic crystal structure[1].

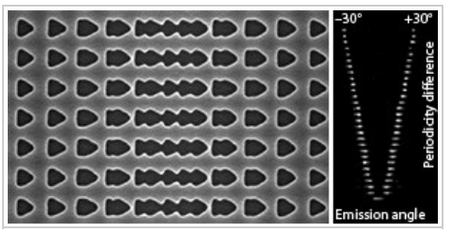

Fig. 1: Superimposing two periodic arrays of triangles with different periodicity (left) causes light to be emitted at an angle dependent on the periodicity difference (right), which can be controlled by activating specific regions of the overlying photonic crystal.

From Ref. 1 © S. Noda

Photonic crystals are artificial lattices in which the periodicity of the lattice influences the properties of light propagation. The propagation of light through such crystals can be controlled, for example, by varying the length scale of the periodic structure or introducing irregularities. Arrays of triangular holes have previously been shown to lead to strong vertical laser emission from an active light-emitting layer underneath the photonic crystal. Controlling the beam direction precisely, however, has proved difficult. “The output beam direction of semiconductor lasers has generally been controlled using external mechanical systems,” says Noda.

The researchers showed that control over the direction of vertical laser emission can be achieved by overlaying two regular photonic crystal arrays with slightly different periodicities of triangular lattice (Fig. 1). Interference effects between the structures result in emission at an angle determined solely by the difference in periodicity. Noda’s team demonstrated a broad range of emission angles, up to ±30°, by varying the periodicity of the two overlaid structures across the chip.

To select a specific emission angle, the active light-emitting layer needs simply to be activated at a particular region on the chip. This means that the position of light emission on the chip will be slightly different for each angle, but the difference is so small that from a distance this variation is negligible. Noda is very optimistic that this unprecedented flexibility will make a number of new functions possible. “Applications include mobile laser projection displays, advanced laser printers, chip-to-chip optical communication and even laser knives for medical procedures.” The researchers are already collaborating with a corporate partner in the hopes of commercializing this technology within a few years.

Reference

1. Kurosaka, Y.,[1,2] Iwahashi, S.,[1,2] Liang, Y.,[1,2] Sakai, K.,[1,2,3] Miyai, E.,[1,2,4] Kunishi, W.,[1,2,4] Ohnishi, D.[1,2,4] & Noda, S.[1,2,5]* On-chip beam-steering photonic-crystal lasers. *Nat. Photon.* **Published online:** 2 May 2010 | doi: 10.1038/nphoton.2010.118 | article

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