CURRENT NEWS

Go

Home
News
Lab & Fab Talk
Features
Recruitment
Events
CS Magazine
Solar Magazine
EuroAsia Magazine
Compound Semiconductor TV
Buyer's Guide
Advertise
Contact

aAs/InAs nanolasers inspired by brightly-
loured birds

14, 2011

sicists have developed lasers composed of a gallium arsenide membrane and indium enide quantum dots which mimic the nanostructure of bird feathers

earchers are studying how two types of nanoscale structures on the feathers of birds produce ant and distinctive colours.

The team, led by Hui Cao from the Department of Applied Physics at Yale University, have borrowed these nanoscale tricks from nature to produce new types of lasers. These results bring the promise that the lasers can assemble themselves by natural processes.

Figure 1: A male eastern bluebird (Sialia sialis, Turdidae)

Many of the colours displayed in nature are created by nanoscale structures that scatter light strongly at specific frequencies. In some cases, these structures create iridescence, where colours change with the angle of view, like the shifting rainbows on a soap bubble. In other cases, the hues produced by the structures are steady and unchanging.

The mechanism by which angle-independent colours are produced stumped scientists for 100 years; at first glance, these steady hues appeared to have been produced by a random jumble of proteins. But when researchers zoomed in on small sections of the protein at a time, quasi-ordered patterns began to emerge. The scientists found that it is this short-range order that enhances light scattering at specific frequencies to produce the distinctive hues of a bluebird's wings, for example.

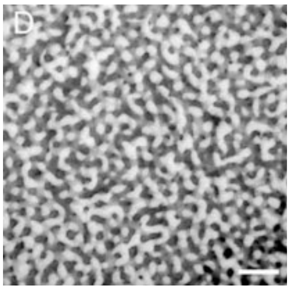

Figure 2. SEM image of a back contour feather barb from a male eastern bluebird. It exhibits a protein with channel-type nanostructure. (Scale bar = 500 nm)

Inspired by feathers, the Yale researchers created two lasers that use this short-range order to control light.

One of the lasers simulates feathers with tiny spherical air cavities packed in a protein called beta-keratin. The laser based on this model consists of a GaAs membrane full of tiny air holes that trap light at certain frequencies. InAs quantum dots embedded between the holes amplify the light and produce the coherent beam that is the hallmark of a laser.

The two-dimensional photonic amorphous structure in this laser was originally generated from computer simulations of jam packed polydisperse cylinders. The diameters of all cylinders were reduced to the same value to eliminate the size variation with the final configuration having structural disorder only in the position of the cylinders.

The computer-generated pattern was transferred to a membrane composed of a GaAs layer and $Al_{0.75}Ga0_{0.25}As$ layer grown on a GaAs substrate by MBE. Inside the GaAs layer, three uncoupled layers of InAs quantum dots, equally spaced by GaAs barriers were incorporated.

An amorphous array of air holes was fabricated in the GaAs layer by electron-beam lithography and reactive ion etching. The $Al_{0.75}Ga0_{0.25}As$ layer was then selectively etched to leave a freestanding GaAs membrane in air. The scientists fabricated patterns with different structural parameters. For example, they altered the radius of the circular air holes and the average distance between adjacent air holes.

The researchers also built a network laser using a series of interconnecting nano-channels, based on their observations of feathers whose beta-keratin takes the form of interconnecting channels in "tortuous and twisting forms." The network laser produces its emission by blocking certain colours of light while allowing others to propagate.

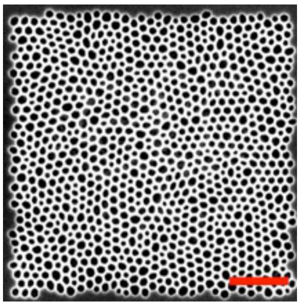

Figure 3. A network laser based on feathers with the channel-type nanostructure. This laser consists of interconnecting nano-channels (white) in a GaAs membrane. (Scale bar = 2 µm)

In both cases, the researchers found they can manipulate the lasers' colours by changing the width of the nano-channels or the spacing between the nano-holes.

What makes these short-range-ordered, bio-inspired structures different from traditional lasers is that, in principle, they can self-assemble, through natural processes similar to the formation of gas bubbles in a liquid. This means that engineers would not have to worry about the nanofabrication of the large-scale structure of the materials they design, resulting in cheaper, faster, and easier production of lasers and light-emitting devices.

One potential application for this work includes more efficient solar cells that can trap photons before converting them into electrons. The technology could also yield long-lasting paint, which could find uses in processes such as cosmetics and textiles.

"Chemical paint will always fade," says lead author Hui Cao. But a physical "paint" whose nanostructure determines its colour will never change. Cao describes a 40-million-year-old beetle fossil that her lab examined recently, and which had colour-producing nanostructures. "With my eyes I can still see the colour," she said. "It really lasts for a very long time."

This work will be presented by Hui Cao at the Optical Society's (OSA) Annual Meeting, Frontiers in Optics (FiO) 2011, taking place in San Jose, California in the presentation entitled "Bio-inspired photonic nanostructures and lasers." The talk will take place at 4 p.m. on Wednesday, 19 October 2011.

Further details of this work are available in the paper "*Control of Lasing in Biomimetic Structures with Short-Range Order*" by Noh *et al* in PhysRevLett 106, 183901 (2011).

DOI: 10.1103/PhysRevLett.106.183901

NEWS

Compound Semiconductor. The most respected, authoritative and widely read information source connecting the community since 1995 To view the latest issue of Compound Semiconductor, click here

To register free of charge to receive news via e mail on a weekly basis click here.

Search the Compound Semiconductor web site

Go

Submit your Lab & Fab article

It is imperative that CompoundSemiconductor.net remains a timely resource for this industry, so we are only interested in highlighting very recent work reported in academic papers. Therefore, please only consider writing a short piece highlighting your work if you have a journal paper that has been accepted and about to appear in press, or a paper that has been published within the last month. For further guidelines, click here.

SHARE THIS

Email this article to a friend

Connotea Cite-U-Like Del.icio.us Digg Facebook

Google Live Spaces MySpace Newsvine Reddit

Stumbleupon Technorati Twitter Yahoo! My Web

