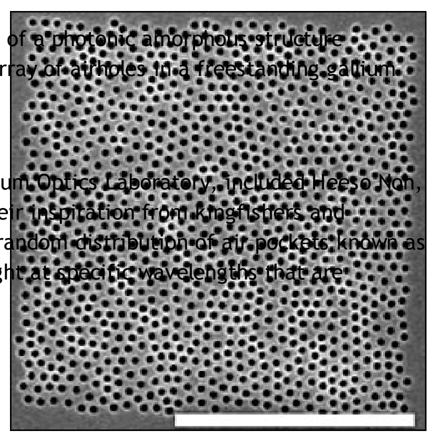
Pigment-Free Feathers Inspire Mirrorless Laser

NEW HAVEN, Conn., May 11, 2011 — Bright, colorful birds, the feathers of which get their color not from pigment molecules but from a largely random distribution of embedded air pockets, are the inspiration for a new mirrorless laser developed at Yale University.

The Rufous-collared kingfisher. (Image: Jakob Wijkema/PLoS Journals/Wikimedia Commons)

In a traditional laser, light is temporarily trapped inside a mirrored cavity, where it can be amplified by a gain medium. Although in the past 10 years researchers have developed mirrorless lasers that trap light with internal nanostructures that scatter light in different directions, these lasers were made from materials of various levels of structural organization. The system developed at Yale is the first to demonstrate that lasing in nanostructures can be improved and manipulated by short-range order.

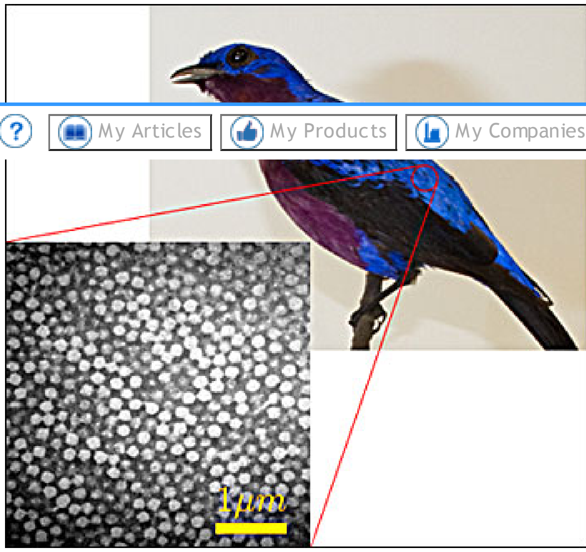
Top-view SEM image of a photonic amorphous structure consisting of a 2-D array of airholes in a freestanding gallium arsenide membrane. (Image: Courtesy of Heeso Noh)



The team of Hui Cao, director of Yale's NanoPhotonics and Quantum Optics Laboratory, included Heeso Noh, Jin-Kyu Yang, Seng Fatt Liew and Michael J. Rooks. They took their inspiration from kingfishers and parrots, whose noniridescent feathers are the result of a largely random distribution of air pockets, known as a photonic amorphous structure. These nanostructures scatter light at specific wavelengths that are determined by short-range order in the spacing between the pockets. Such structures have no long-range order.

Image of *Cotinga cotinga*, which gets its bright blue color not from a pigment in its feathers but from nanostructures composed of air pockets that scatter light at specific wavelengths that are determined by short-range order in the spacing between the pockets, as shown in the inset image. (Photo courtesy of Mario Graul)

Using this as a model, the team created biomimetic samples and investigated the lasing behavior by etching an array of roughly 150-nm-wide holes into a semiconductor film that contained quantum dots as a gain medium. When the researchers optically excited the two-dimensional device with sufficient power, it emitted laser light at a frequency that could be tuned by changing the spacing and radius of the airholes.



The work was published May 5 in *Physical Review Letters*; also an author on the paper is Glenn S. Solomon of the Joint Quantum

The research was funded by a grant from the National Science Foundation and Yale.

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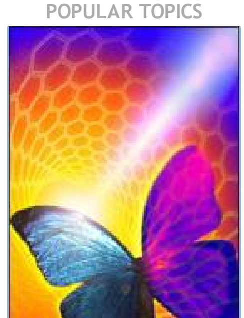

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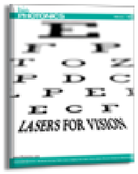

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