Engineering researchers achieve organic laser breakthrough

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(PhysOrg.com) -- Researchers at the University of Michigan have achieved a long sought-after optics phenomenon that could lead to more efficient and flexible lasers for telecommunications and quantum computing applications, among other uses.

The researchers demonstrated polariton lasing for the first time in an organic semiconductor material at room temperature. Their results are published in the June issue of Nature Photonics.

An organic material primarily contains carbon, and can sometimes have biological origin. This is in contrast to inorganic semiconductors such as silicon or gallium arsenide commonly found in modern electronic circuitry.

A polariton is not exactly a particle, but it behaves as if it were. It is a "coupled quantum mechanical state" between an excited molecule and a photon, or particle of light.

"You can think about it as two pendulums side by side tied together with a spring. They have to work together," said Stephen Forrest, principal investigator. Forrest is the William Gould Dow Collegiate Professor of Electrical Engineering, a professor in the Department of Physics and the university's vice president for research.

"This is a potential route to a whole bunch of new phenomena for new applications," Forrest said. "People have been trying to do this for about a decade—to see polariton lasing at room temperature. In my lab, my student Stephane Kena-Cohen took five years to succeed in this discovery. He had to figure out new ways to grow crystalline organic materials between highly reflective mirrors, and then to do the complicated measurements with optical pulses shorter than one-trillionth of a second."

The team is working toward building organic lasers that, like many inorganic lasers today, can be excited with electricity rather than light. So-called electrically pumped lasers are more efficient and useful than their optically pumped counterparts. But so far, organic semiconductors have been too fragile to survive exposure to the amount of electrical current necessary to get them to operate as lasers.

"We're looking at polaritons as a way to do electrical pumping of organic semiconductors at extremely low currents," Forrest said. "We still optically pumped the sample in this experiment, and the next step is to find better materials and higher quality optical cavities in order to eventually electrically pump the material into lasing."

Compared to inorganic materials, organic semiconductors offer a wider range of properties and are easier for chemists to tailor for specific purposes. Organics have untapped potential in telecommunications and computing, Forrest said.

The paper is "Room-temperature polariton lasing in an organic single-crystal microcavity." Forrest is also a professor in the Department of Materials Science and Engineering. His co-author is Stepane Kena-Cohen, a graduate student at Princeton University.

The work was conducted at the U-M Lurie Nanofabrication Facility. It is funded by Universal Display Corp. (UCD) and the Air Force Office of Scientific Research. The technology is being licensed to UCD, a

company in which Forrest is a founder and member of the scientific advisory board.

More information: Room-temperature polariton lasing in an organic single-crystal microcavity, Nature Photonics 4, 371 - 375 (2010) Published online: 18 April 2010 doi:10.1038/nphoton.2010.86

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