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Optical devices

Making simpler, cheaper organic crystals

Molecular materials could simplify the fabrication and reduce the cost of lasers

Cheap and efficient sources of light could play an important role in future communication systems. NAIST researchers have now synthesized molecular crystals that could be used in bright, but easily manufactured, laser devices[1].

Most optoelectronic light sources, such as light-emitting diodes and lasers, are made from inorganic materials such as gallium arsenide, which are expensive. Organic-molecule-based materials offer a cheaper alternative because they can be produced by solution and printing processes rather than complicated methods like the deposition of crystalline overlayers on substrates, known as epitaxy. As an added bonus, organic-based devices can be fabricated on curved or even flexible substrates.

But much development is still needed before these sources match the performance and versatility of their inorganic counterparts. An electrically powered laser made using a molecular active region is particularly challenging, for example.

Hisao Yanagi from NAIST's Quantum Material Science Laboratory, working with colleagues in Japan and Italy, have now synthesized a novel organic-molecule-based material, and demonstrated that it can produce laser light, paving the way to an electrically driven molecular source of intense optical radiation.

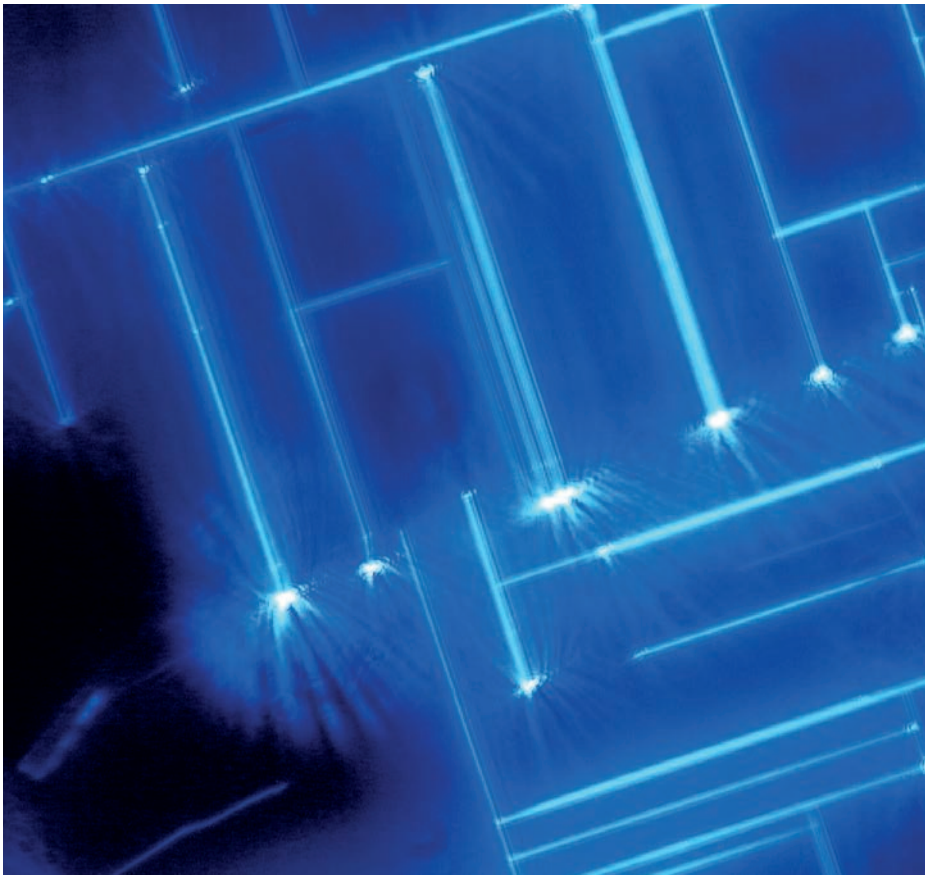
"One of the advantages of molecular materials is that their emission colour is tunable by molecular modification," explains Yanagi. "So we prepared blue-light-emitting molecular crystals and investigated their laser properties."

The researchers chose to use a molecule in a class of organic semiconductors known as thiophene/phenylene co-oligomers (TPCOs). Scientists are focusing a great deal of attention on TPCOs because they are robust and have excellent semiconducting properties.

Yanagi's team observed spectrally pure and bright emission with a wavelength of 500 nanometres when they illuminated their sample with ultraviolet radiation. This so-called optically pumped lasing is the first step in the development of electrically driven devices.

The most important part of many semiconductor light emitters is the p–n junction: an interface between a positively and negatively charged regions where the light is produced. These charge regions arise in inorganic materials because of atomic impurities. In molecular materials, however, p and n regions are created by adding 'electron accepting' or 'electron withdrawing' molecular groups to the active molecule.

Most previous TPCOs have been p-type. Yanagi and co-workers managed to create an *n*-type organic semiconductor crystal by substituting in cyano groups, creating a molecular crystal called BP1T-CN. This work is the first demonstration of optically pumped lasing in an n-type TPCO. "We next hope to fabricate light-emitting diodes with this material," says Yanagi.



NAIST researchers hope to soon fabricate light-emitting diodes based on BP1T-CN, an n-type TPCO organic semiconductor crystal, which emits bright blue light when illuminated with ultraviolet radiation.

Reference

1. Mizuno, H., Maeda, T., Yanagi, H., Katsuki, H., Aresti, M. *et al.* Optically pumped lasing from single crystals of a cyano-substituted thiophene/phenylene co-oligomer. *Advanced Optical Materials* **2**, 529–534 (2014).

More information about the group's research can be found at the Quantum Materials Science Laboratory webpage:
http://mswebs.naist.jp/LABs/optics/eng/index-e.html