Organic vortex lasers could be used in future 3-D displays

February 8 2018, by Lisa Zyga

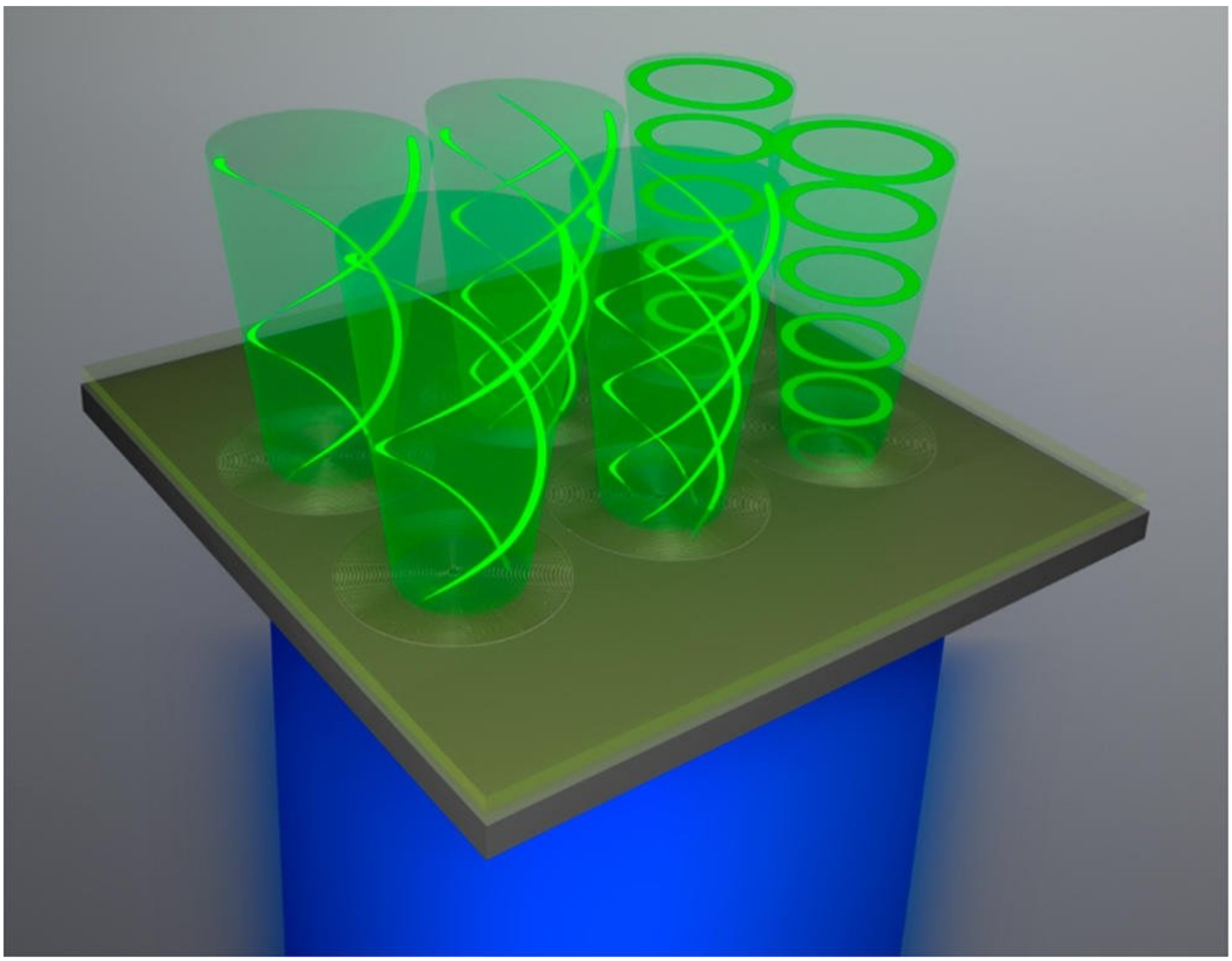


Illustration of an array of organic vortex lasers, each with a different spiral and therefore a different topological charge. Credit: Stellinga et al. ©2018 American Chemical Society

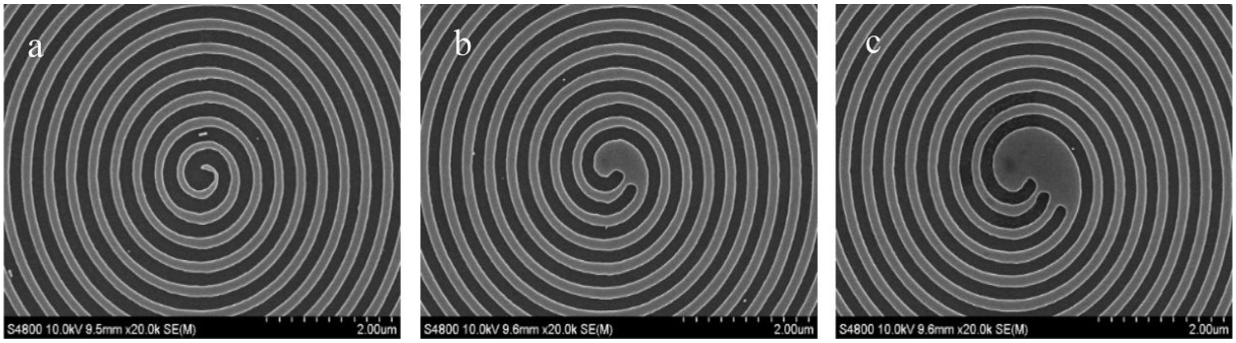
Researchers have developed a new type of organic vortex laser, which is a laser that emits a helical beam of light. In the future, miniature arrays of these vortex lasers, each with a slightly different spiral shape, may be used in applications such as 3D TV displays, microscopy, and as information carriers for visible light communications.

The researchers, led by Ifor D. W. Samuel at the University of St. Andrews and Thomas F. Krauss at the University of York, both in the UK, have published a paper on the organic vortex lasers in a recent issue of *ACS Nano*.

"Laser arrays have been demonstrated before, but not with such control over the beamshape," Krauss told *Phys.org*. "Our approach allows us to make vortex beams of controlled topological charge. We can make Airy beams or Bessel beams. Similarly, metasurfaces that generate such bespoke beams have been demonstrated before, but they have been passive elements, not active lasers."

Previously, vortex laser beams have been generated by taking a laser and using separate optical components to shape the beam, resulting in large beams. The new vortex lasers demonstrated here have a nanostructured gain medium that generates the vortex beam directly. This means that it can be scaled down into miniature beams, which can then be arranged into an array. The miniaturized version is expected to be much more useful for practical applications.

In order to generate helical light beams, the researchers designed an optical grating consisting of an Archimedean spiral. When light passes through the grating, it emerges as a helical beam. By controlling the dimensions of the spiral grating, it's possible to control the properties of the light beam.



SEM micrographs of Archimedean spirals with (a) one, (b) two, and (c) three arms. Credit: Stellinga et al. ©2018 American Chemical Society

The main way to do this is by controlling the number of "arms" the Archimedean spiral has. The number of arms is equal to the light beam's topological charge, which is the number of twists the light beam makes in one wavelength. So the larger the number of arms, the tighter the helix of the light beam. Here, the researchers demonstrated Archimedean spiral gratings with between zero (no twist) and three arms.

This new method for generating vortex lasers has advantages over previous methods in that the beams can be generated in a single step and by a single optical element (the grating). With these advantages, the researchers expect that the results will pave the way toward implementing vortex lasers in a variety of applications.

"My main interest is in organic semiconductors, which can be simply patterned to make devices like this," said Samuel, whose group provided the organic semiconductor gain material and conducted the measurements. "A long-term aim is to make such lasers electrically, rather than optically, driven. A nearer term aim is to use such lasers for sensing explosive vapor."

Krauss, whose group designed the nanostructures used in the study, is particularly interested in displays and microscopy applications.

"In displays, you could use the different vortex orders to multiplex information—for example, to project multiple images at once," he said. "Vortex beams are of interest in microscopy, so one can imagine an array of such beams for massively parallel microscopy."

More information: Daan Stellinga et al. "An organic vortex laser." *ACS Nano*. DOI: 10.1021/acsnano.7b07703