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Researchers design plasmonic cavity-free nanolaser

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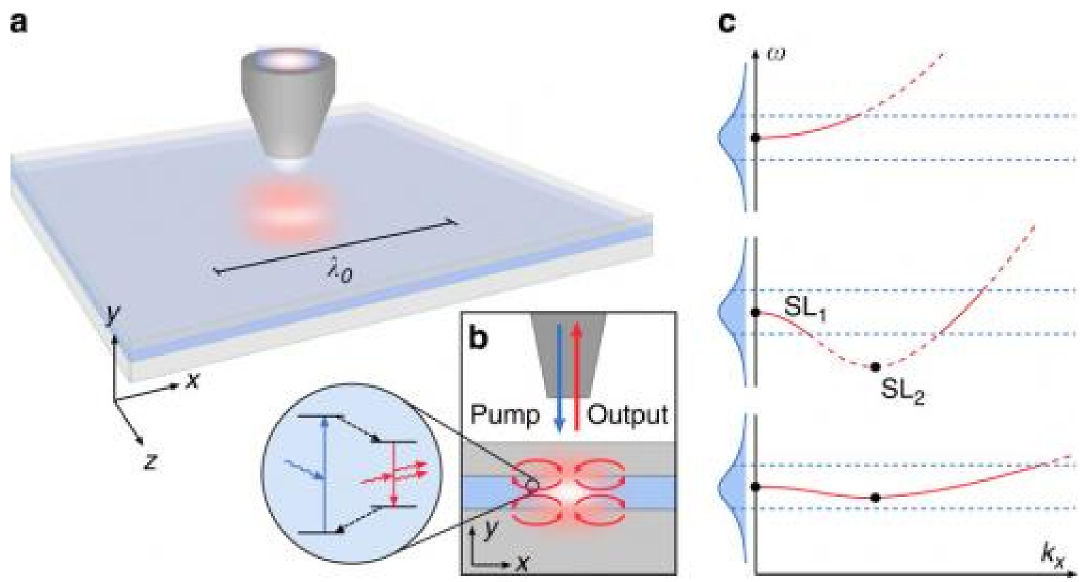

(a) The core layer of the metal-dielectric (SL) multilayer structure is filled with gain material (blue). (b) Spatially selective excitation of the homogeneous gain layer using a near-field tip leads to the formation of a subwavelength spot of inverted gain, in which the stimulated emission processes take place (inset). Photons are trapped locally in a closed-loop energy vortex (red curved arrows), enabled by an SL point, SL1, at (ω1, k1) that aligns with the peak gain. (c) A second SL point, SL2, at (ω2, k2) enforces a monotonous behaviour of the dispersion over a range of wavevectors with an average slope of (ω2−ω1)/(k2−k1). Bringing the frequencies of the SL points close together while maintaining a large distance in k-space flattens the dispersion to within the bandwidth of the gain (blue), allowing for the formation of highly localized, SL wave packets during lasing operation. Credit: *Nature Communications* 5, Article number: 4972 doi:10.1038/ncomms5972

(Phys.org) —A team of researchers at Imperial College in London has designed a new type of laser, one that could be made much smaller than today's models because it would be cavity-free. In their paper published in the journal *Nature Communications*, the team describes their idea and offer possible uses for such a laser should they be able to build one.

As most that have dabbled in the sciences are well aware, conventional lasers work by bouncing light between mirrors inside of a chamber, also known as a cavity, causing a buildup of photons of a certain type that are eventually released as a beam. While this method has worked extraordinarily well for a host of applications, there is still one area where it is lacking—applications at the nanoscale. This is because, the researchers note, the need for the cavity. In this new effort, the researchers have created a design for a very tiny laser that works without a cavity and is able to do so by taking advantage of prior research into stopping light.

The envisioned laser (the team hasn't actually built one yet) would be made by pressing two metals together, with an insulating material between them, resulting in a sandwich of sorts. Pulses of light sent through the middle part of the sandwich would reverse direction upon encountering the metal part, causing the light to become trapped in a vortex, which means it would be stopped. The researchers have found that in testing their idea, light sent into the laser would get trapped in the vortex for approximately 10 trillionths of a second before breaking free in the form of a beam of light. In addition to being cavity-free, the laser would also be able to emit laser beams with a range of frequencies.

With the design created and tested, the team is now moving towards building a prototype of the new type of laser—they believe it could be used in optics applications, perhaps as part of a computer. Others have suggested that if such a laser could be built, it could be used in such diverse applications as signaling, or even prosthetics, because it could be embedded in synthetic tissue.

More information: Cavity-free plasmonic nanolasing enabled by dispersionless stopped light , *Nature Communications* 5, Article number: 4972 DOI: 10.1038/ncomms5972

Abstract

When light is brought to a standstill, its interaction with gain media increases dramatically due to a singularity in the density of optical states. Concurrently, stopped light engenders an inherent and cavity-free feedback mechanism, similar in effect to the feedback that has been demonstrated and exploited in large-scale disordered media and random lasers. Here we study the spatial, temporal and spectral signatures of lasing in planar gain-enhanced nanoplasmonic structures at near-infrared frequencies and show that the stopped-light feedback mechanism allows for nanolasing without a cavity. We reveal that in the absence of cavity-induced feedback, the subwavelength lasing mode forms dynamically as a phase-locked superposition of quasi dispersion-free waveguide modes. This mechanism proves remarkably robust against interface roughness and offers a new route towards nanolasing, the experimental realization of ultra-thin surface emitting lasers, and cavity-free active quantum plasmonics.