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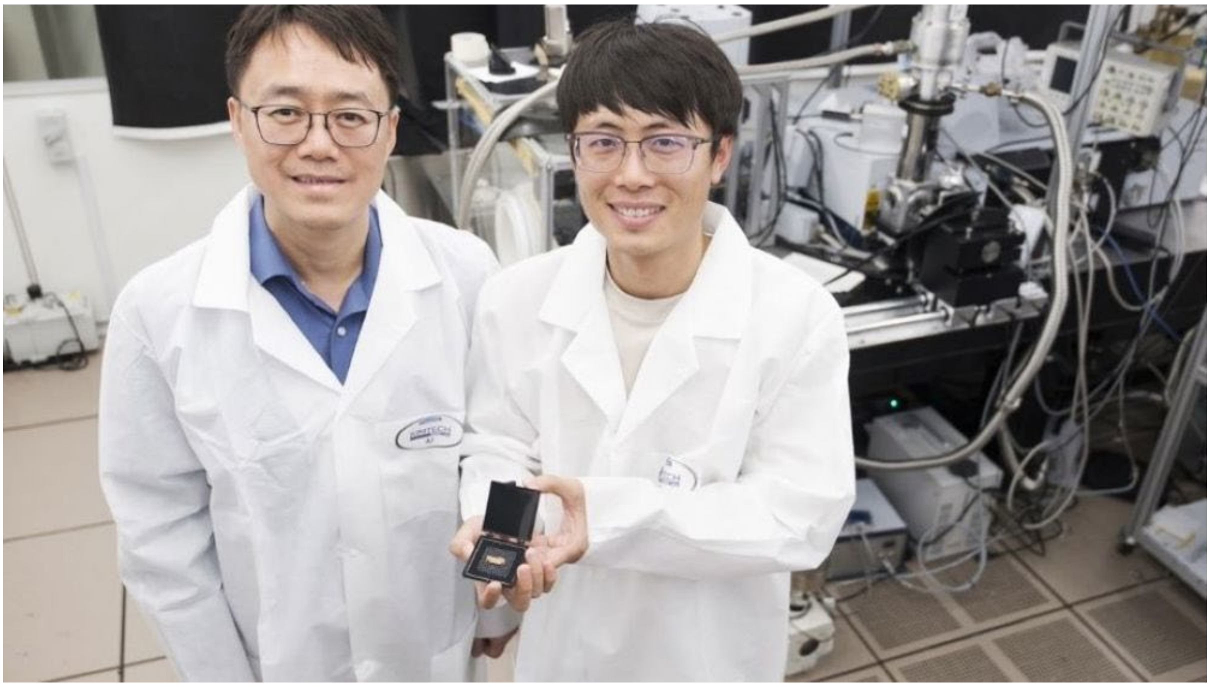
NTU leads development of ultracompact laser

An international team including researchers from Leeds University has developed a new type of ultracompact laser that is claimed to be more energy efficient and consumes less power.



Prof Wang Qijie from NTU Singapore's School of Electrical and Electronic Engineering (EEE) and School of Physical and Mathematical Sciences (left) and Dr Cui Jieyuan from NTU Singapore's EEE - NTU Singapore

Led by scientists at Nanyang Technological University, Singapore (NTU Singapore), the micrometre-sized laser emits light in the terahertz region and incorporates a design that reduces light leakage. Minimising light loss means less energy is required to operate the laser compared to other highly compact lasers.

The research is published in *Nature Photonics*.

Why lasers lose light

Ultracompact lasers have applications across various industries, particularly in small devices but their performance is hampered by the loss of light. Some of this loss occurs due to side leakage from the laser cavity. Light is also lost due to scattering caused by imperfections in the photonic crystal, which is constructed from semiconductor materials to control the propagation of light.

These loss-inducing effects are more significant in ultracompact lasers than larger lasers. In some cases, the loss of light is so severe that it prevents the lasers from working properly.

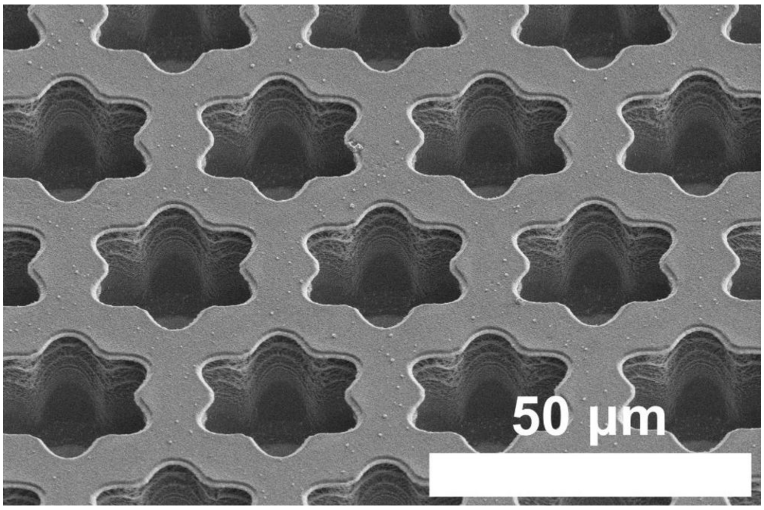
Reducing light loss in all directions

To prevent light loss, the new NTU laser harnesses flat bands and a phenomenon called multi-bound states in the continuum (BIC).

Flat bands are energy bands in the photonic crystal where light waves have near-zero group velocity. At near-zero group velocity, the energy carried by light waves remains confined within the horizontal plane of the laser cavity.

Conversely, multi BICs reduce light loss in the vertical dimension while still allowing the laser to emit sufficient light for practical use; specific wave patterns in light cancel out the parts that would usually escape. The design of the cavity also effectively minimises the loss of optical signals.

To reduce light loss due to leakage and scattering, the researchers designed a laser cavity that combines concepts from flat bands and multi BIC. They created a periodic arrangement of daisy-shaped holes in a photonic crystal consisting of a semiconductor material sandwiched between two gold layers.



Close-up view of the air holes - NTU Singapore

According to the researchers, this could potentially be the ‘ultimate’ solution to suppress light leakage from a laser cavity in three dimensions. The laser also produces a highly focused beam with minimal divergence, making it useful for optoelectronic applications.

By scaling the size of the airholes and the lattice constant – the spacing between atoms in the photonic crystal – the design can be extended to create lasers that emit other wavelengths, such as near-infrared and visible light.

“Compared to conventional ridge lasers of similar size, our design achieves roughly 30 per cent higher output power and 20 per cent lower threshold current,” said first author Dr Cui Jieyuan, a research fellow at NTU’s School of Electrical and Electronic Engineering. “It also shows much better directionality, with a beam divergence of around 15°, and maintains stable single-mode operation with a side-mode suppression ratio of approximately 25dB,”

The researchers are now working to enhance the power of the laser and integrate it into optoelectronic devices. They have also filed a technical disclosure for the innovation and are looking to collaborate with industry.

“Extending this platform to the near-infrared and visible spectrum could benefit applications such as on-chip optical interconnects, silicon photonics, optical neural networks, active optical and biomedical sensing,” said Dr Cui Jieyuan. “We are currently in the design stage and expect to demonstrate early prototypes within 1–2 years.”

https://www.theengineer.co.uk/content/news/new-energy-efficient-ultracompact-laser-developed-by-ntu