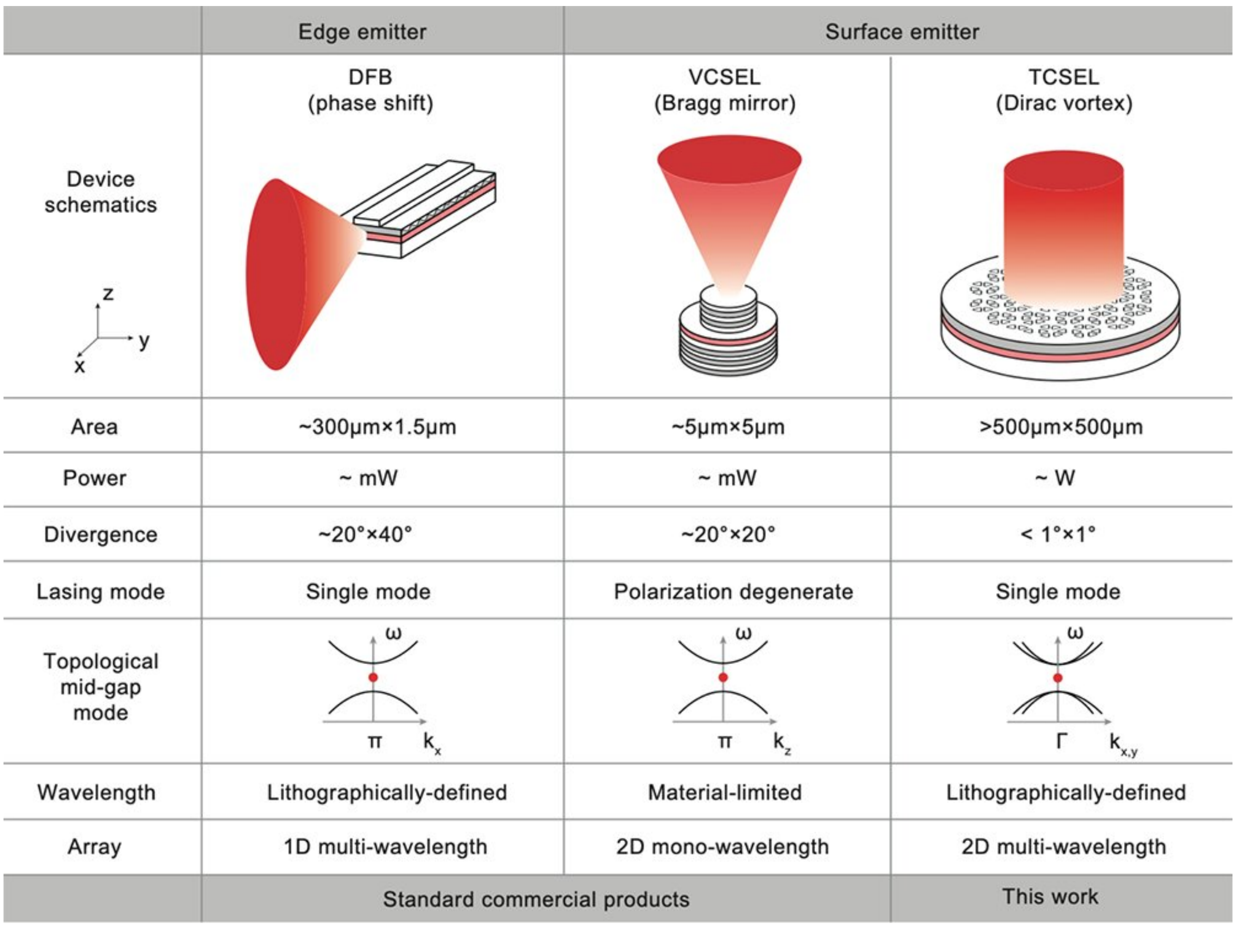
Scientists invent topological-cavity surface-emitting laser

May 5 2022, by Zhang Nannan



	Edge emitter	Surface emitter	
	DFB (phase shift)	VCSEL (Bragg mirror)	TCSEL (Dirac vortex)
Device schematics			
Area	~300μm×1.5μm	~5μm×5μm	>500μm×500μm
Power	~ mW	~ mW	~ W
Divergence	~20°×40°	~20°×20°	< 1°×1°
Lasing mode	Single mode	Polarization degenerate	Single mode
Topological mid-gap mode	ω, π, k_x	ω, π, k_z	ω, Γ, $k_{x,y}$
Wavelength	Lithographically-defined	Material-limited	Lithographically-defined
Array	1D multi-wavelength	2D mono-wavelength	2D multi-wavelength
	Standard commercial products		This work

Fig. 1. Comparison of TCSEL with mainstream commercial single-mode semiconductor lasers. Credit: Institute of Physics

Semiconductor lasers are the most widely used lasers due to their compact size, high efficiency, low cost and wide spectra. But they suffer low output power and low beam quality—two specifications difficult to improve simultaneously. For example, although a larger cavity increases power, it supports more modes to lase which decreases beam quality.

Previously, a Dirac-vortex topological cavity was demonstrated by the L01 group at the Institute of Physics of the Chinese Academy of Sciences (CAS) led by Prof. Lu Ling. It offers the best single-mode selection over the largest area. This cavity design was proposed to overcome the above-mentioned bottlenecks of semiconductor lasers and simultaneously improves the output power and beam quality.

Recently, the same team applied their topological cavity to surface emitting lasers and invented the topological-cavity surface-emitting laser (TCSEL), whose performance can far exceed that of the commercial counterparts.

According to their report published in *Nature Photonics*, TCSEL is capable of 10 W peak power, sub-degree beam divergence, 60 dB side-mode suppression ratio, and two-dimensional (2D) multiwavelength array, lasing at 1,550 nm—the most important communication and eye-safe wavelength. It can also operate at any other wavelength range and is promising for a large variety of applications, including LiDAR for face recognition, self-driving, and virtual reality.

The researchers compared TCSEL with the standard industrial products of single-mode semiconductor lasers. The distributed feedback (DFB) edge-emitting laser used in Internet communication as well as the vertical-cavity surface-emitting laser (VCSEL) enabling cell-phone facial recognition both adopt the mid-gap mode in their optimized 1D resonator designs. TCSEL continues this successful path by realizing the 2D version of topological mid-gap mode that are more suited for the planar process on semiconductor chips.

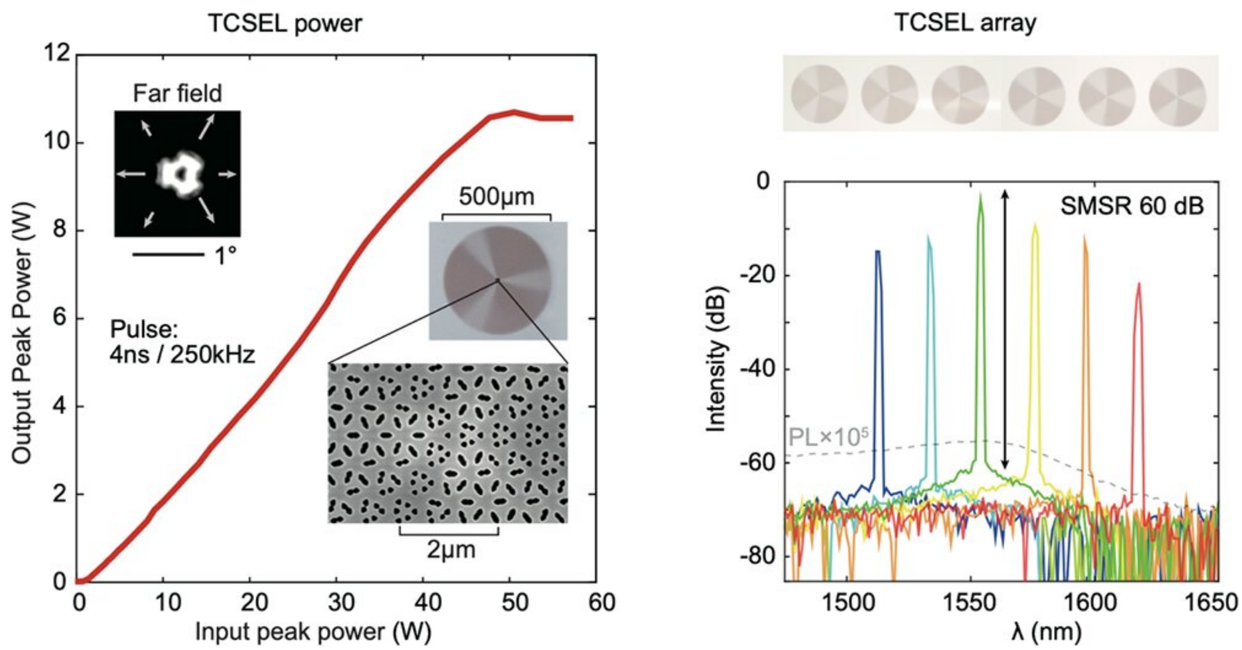


Fig. 2. TCSEL performance and array. Credit: Institute of Physics

Large area single mode is a unique feature of TCSEL, which improves the (>10 W) and beam divergence (

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