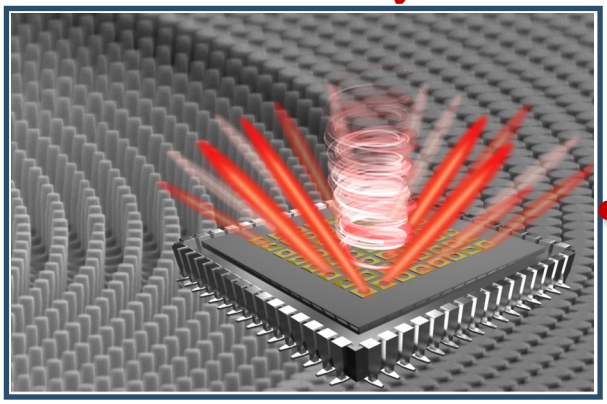
# Metasurface integrated Vertical Cavity Surface Emitting Lasers



***Programmable lasers array for wide-range dynamic beam steering.*** *The image shows a schematic of the metasurface integrated vertical surface emitting array (MS-VCSELs ). The array of MS-VCSELs is mounted onto a PCB board, indicating different deflection angles for wide-range dynamic beam steering applications. .Below, a SEM of the nanopillars forming the beam shaping metasurfaces.*

## Monolithic integration of dielectric metasurfaces with VCSELs enables arbitrary control of the laser beam profiles

Vertical-cavity surface-emitting laser (VCSEL) has experienced a soaring development over the last 30 years and become one of the most versatile laser sources for a large number of applications. The exploding development of modern optoelectronic technologies places stringent requirements for lower power consumption devices with high efficiency and more compact integrated system. However, due to the narrow aperture of the laser, their emission is generally highly divergent, spreading the signal after only few hundreds of microns from the laser source. The emerging ultra-thin flat optical structures, namely metasurfaces, offer a powerful technique to manipulate electromagnetic fields with exceptional spectral and spatial controllability, unique planar configuration, and complementary-metal-oxide-semiconductor processing compatibility, making them promising candidates for ultra-compact optoelectronic integration. Here, we demonstrate a wafer-level non-intrusive and monolithic integration that solves the issues of arbitrary beam shaping VCSELs by directly sculpturing their emitting surfaces into metasurfaces.

## Breakthroughs

Metasurface integrated Vertical Cavity Surface Emitting Lasers (MS-VCSELs): the first realization of programmable laser-array emitting with fully -arbitrary beam profiles.

## Perspectives

The arbitrary wavefront control directly at the wafer-level and the programmability of Metasurface VCSELs would significantly promote applications in various wide-field applications, such as optical fibre communications, laser printing, smartphones, optical sensing, face recognition, directional displays and ultra-compact light detection and ranging (LiDAR).



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