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Hair-width LEDs could replace lasers — and a UCSB doctoral student is helping make it happen

LEDs no wider than a human hair could soon take on work traditionally handled by lasers, from moving data inside server racks to powering next-generation displays. New research co-authored by UC Santa Barbara doctoral student Roark Chao points to a practical path forward.

“We’re talking about devices that are literally the size of a hair follicle,” said Chao, who studies electrical engineering. “If you can engineer how the light comes out, those microLEDs can start to replace lasers in short-distance data communication.”

The work builds on UCSB’s longstanding strengths in gallium nitride research and optoelectronics. Chao is co-advised by Steven P. DenBaars and Jon A. Schuller, both co-authors on the study, which also include Nobel laureate Shuji Nakamura, whose pioneering work on blue LEDs transformed global lighting and display technologies. The research was conducted in the laboratories of the DenBaars/Nakamura and Schuller groups, where teams focus on gallium nitride materials growth and nanoscale photonics.

The study, published in Optica Express, demonstrates a new micro–light-emitting diode (microLED) design that improves both efficiency and beam directionality. By laterally enclosing the emitting region with distributed Bragg reflectors, the researchers achieved roughly 20% higher optical output through air-side emission,

more than 130% higher output through the substrate side and about 30% reduced beam divergence compared with reference devices.

Beyond directing light more precisely, the redesigned microLEDs also deliver substantially higher efficiency. The team observed roughly 35% higher electrical efficiency and about 46% higher wall-plug efficiency — meaning the devices convert significantly more of the power drawn from the wall into usable light compared to conventional microLED designs.

MicroLEDs — typically 100 microns wide or smaller — are emerging as a promising alternative to lasers for short-range optical links, particularly inside data centers where heat, reliability and energy use are persistent challenges.

“The big thing with lasers is that they start having thermal issues at relatively low temperatures,” Chao said. “MicroLEDs can be driven much hotter without needing complex cooling. That means less replacement, less cost and more flexibility in data centers.”

As cloud computing and AI continue to expand, data centers must transmit massive volumes of information quickly and efficiently. Even incremental improvements in light sources can have significant economic impact.

“What’s exciting about microLEDs is that they offer multiple solutions in one package,” Chao said. “They can improve data communication, enable brighter and thinner displays, and even work for things like AR or VR — all using the same underlying technology.”

Chao began at UCSB as an undergraduate electrical engineering student in 2020 before continuing into doctoral research. He credits the university’s integrated research infrastructure — from materials growth to nanofabrication to device testing — with accelerating his work.

“You can simulate a design, grow the crystal, fabricate the device and test it — all on campus,” Chao said. “That speed from idea to experiment is what makes this place powerful.”

The findings appear in a paper co-authored by Chao, Stephen Gee, Alejandro M. Quevedo, Wesley K. Mills, Tanay Tak, Hunter S. Larson, Kent N. Nitta, Nakamura,

Schuller and DenBaars.

Tags
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