

# Full-color LEDs cut down to size

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KAUST scientists have created micrometer-scale light-emitting diodes of unprecedented small size that could be used in mobile phone screens or televisions. Credit: KAUST

Tiny light-emitting devices that can create all the colors in the rainbow are essential for the next generation of phones and screens.

Micrometer-scale light-emitting diodes ( $\mu$ LEDs) are the ideal building block for next-generation microLED displays used in head-mounted monitors, mobile phones and televisions because they are bright, respond quickly, offer longevity and consume little energy. KAUST researchers have shown that these scaled-down devices can efficiently emit light across the entire visible-light spectrum.

Just as with conventional LED displays, full-color  $\mu$ LEDs products will require arrays of blue, green and red light sources. Nitride-based alloys are a group of semiconducting materials that offer one route to achieving this because, with the right chemical mix, they can emit all three colors.

However, when nitride devices are reduced in size to micrometer scales, they become very poor emitters of light. "The main obstacle to reducing the size of the devices is the damage to the sidewalls of the LED structure generated during the fabrication process," explains Ph.D. student Martin Velazquez-Rizo. "Defects provide an electrical path for a leakage current that does not contribute to the light emission." This effect gets worse as the size of the LED shrinks, which has limited the LED size to approximately 400 by 400 micrometers.

Velazquez-Rizo, along with his colleagues Zhe Zhuang, Daisuke Iida and Kazuhiro Ohkawa, have developed bright red indium gallium nitride microlight-emitting diodes ( $\mu$ LEDs) of just  $17 \times 17$  micrometers.

The team used a thoroughly calibrated atom deposition technique to create a 10 by 10 array of red  $\mu$ LEDs. The damage to the  $\mu$ LED sidewalls was then eliminated using a chemical treatment. "We confirmed with atomic-scale observations that the sidewalls had high crystallinity after the treatment," says Velazquez-Rizo. "Performing this type of observation requires specialized tools and sample preparation." And the leader of the research Ohkawa agrees. "Without this microscope technology, we could not realize and confirm this achievement."

They observed very high output power of 1.76 milliwatts from each square millimeter on the device's surface—a notable improvement on previous devices that reported an output power of less than 1 milliwatt per millimeter square. The team then demonstrated their red  $\mu$ LEDs with green and blue indium gallium nitride  $\mu$ LEDs to create a wide color-range [device](#).

"The next step in our research is to further improve the efficiency of our  $\mu$ LEDs and decrease their lateral dimensions below 10 micrometers," says Velazquez-Rizo.

**More information:** Zhe Zhuang et al, 630-nm red InGaN micro-light-emitting diodes (

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