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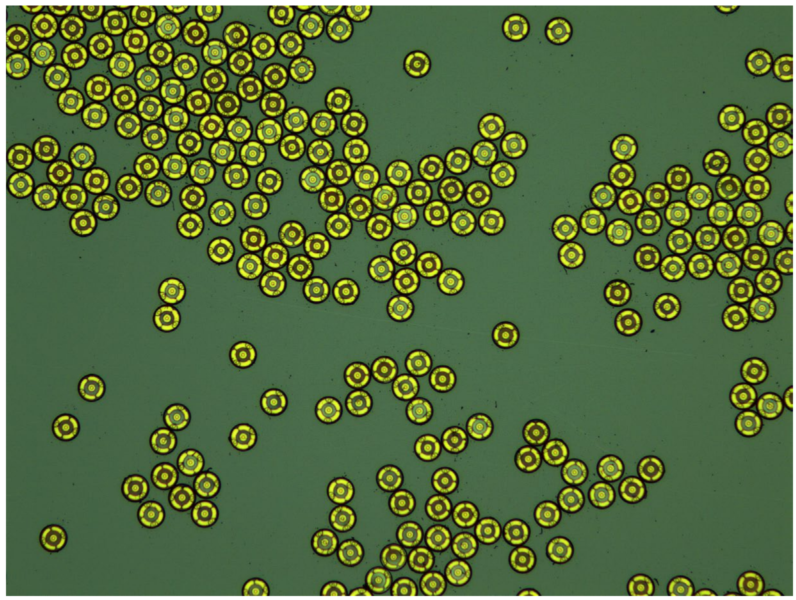
Shining a light on the future of microLEDs

Micro-light-emitting diodes – microLEDs – could be used to create the next generation of displays, for use in smartwatches and augmented reality devices, if various fabrication issues can be addressed.



Optical microscopy image of the microLED chips developed by Yoo, Jeong, Hwang and colleagues. The chips are on a silicon substrate, with all faces aligned in the same way.

Computer, television and mobile displays are today based on organic light-emitting diodes (OLEDs) and liquid-crystal displays (LCDs), which started to replace cathode-ray tubes more than 20 years ago. But OLEDs and LCDs have limitations and a range of next-generation display technologies are currently competing to replace them. One such contender is inorganic micro-light-emitting diodes, which are also known as microLEDs or μLEDs.

The development of microLEDs can be traced back to the work of Hongxing Jiang and Jingyu Lin in the late 1990s and early 2000s. As Jiang and Lin recount in a Reverse Engineering article in this issue of *Nature Electronics*, their efforts emerged from a dinner table discussion about what would happen if a gallium nitride (GaN) light-emitting diode (LED) was reduced to the microscale. Together with their team at Kansas State University (Jiang and Lin are now based at Texas Tech University), they went on to create a microdisk LED with a diameter of only 12 μm, first observing blue-light emission from the device in August 1999.

The technology has evolved rapidly since then. And as Keith Behrman and Ioannis Kymissis at Columbia University explored in a Review article back in September[1], displays based on microLEDs have a number of potential advantages over OLED displays and LCDs, including brightness, colour, lifetime and minimum pixel size. These capabilities mean that the devices could be of use in wearables, such as smartwatches, and also in near-to-eye technologies, such as augmented reality devices. But various issues – particularly around manufacturing and transfer steps – still need to be addressed before widespread adoption is likely.

Mass transfer methods are often used to manufacture microLED displays. But this requires the careful alignment of numerous devices. In an Article in this issue, Geonwook Yoo, Jaewook Jeong, Kyungwook Hwang and colleagues report a technique that can rapidly align microLEDs on the wafer scale. (See also the accompanying News & Views article on the paper.)

The approach works by engineering the top and bottom face of the microLED chips to have a different surface roughness; as a result, the van der Waals force between a substrate and the top and the bottom face is different. The chips, which are fabricated using a GaN-on-silicon technology, are deposited onto the substrate from solution, and through a fluid-assisted self-aligning transfer process, a particular face of the device can then be selectively bonded to the substrate in a specific pixel location.

The team – who are based at the Samsung Advanced Institute of Technology, Chungbuk National University, Soongsil University and Seoul National University – show that the technique can be used to accurately align 259,200 microLED chips with a transfer yield of 99.992%. They also use it to create passive-matrix and active-matrix displays, which display various computer-generated images. The images chosen include one of the layout of *The More, The Better*, a work by the artist Nam June Paik. The piece was created in 1988 and incorporates 1,003 Samsung television monitors that were made using cathode-ray tube technology.

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References

1. Behrman, K. & Kymissis, I. *Nat. Electron.* **5**, 564–573 (2022).