

Pixels smaller than grains of sand: Breakthrough paves the way for tiny displays on smart glasses

German scientists have created the world's smallest light-emitting pixel measuring just 300 nanometers, promising to bring a generation of super-small screens for smart glasses and future wearable devices. This technology paves the way for ultra-compact and energy-efficient AR/VR.

Physicists at Julius-Maximilians-Universität Würzburg (JMU) have developed the world's smallest light-emitting pixel, marking a major step towards microscopic displays for smart glasses and next-generation wearable devices.

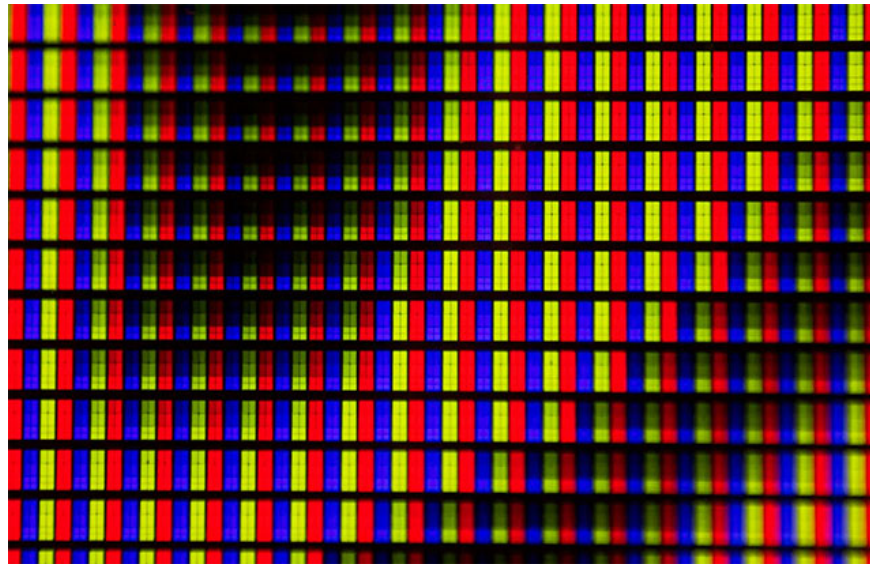
Smart glasses – devices that project digital information directly into the user's field of vision – have long been considered the cornerstone of the wearable technology of the future, but development in this field has so far been limited by bulky components and optical constraints that make efficient light emission at the microscopic scale nearly impossible.

Now, researchers at JMU have made a major breakthrough by creating tiny light-emitting pixels using optical antenna technology. Led by professors Jens Pflaum and Bert Hecht, the team has published details of the results in the journal *Science Advances*.

Display on an area of ??only 1 mm²

'By using a metal contact that allows current to flow into an organic light-emitting diode (OLED) and simultaneously amplify and emit light, we created an orange light-emitting pixel measuring just 300 x 300 nanometers. Despite being so small, it is as bright as a conventional OLED pixel measuring 5 x 5 micrometers,' shared Professor Bert Hecht.

To put that in perspective, a nanometer is one millionth of a millimeter. This means that a Full HD (1920 x 1080 pixels) display could be shrunk to fit in an area of ??just 1 mm². The display could then be integrated into the frame of smart glasses, where the emitted light would be reflected onto the lens to display information.



How OLED works

Each OLED consists of multiple ultra-thin organic layers sandwiched between two electrodes. When an electric current is applied, electrons and holes recombine, exciting organic molecules in the light-emitting layer, which in turn emit photons. Each pixel lights up independently, eliminating the need for a backlight, allowing for deeper blacks, more vibrant colors, and energy efficiency – a key factor for mobile AR and VR devices.

However, shrinking the pixel size presents a number of physical problems. '*If you simply reduce the size of a conventional OLED structure, the current will concentrate mainly at the corners – similar to the lightning rod principle*,' explains Professor Pflaum. The metal antenna in this design is made of gold, in the form of a rectangular box measuring 300 x 300 x 50 nanometers.

The strong electric fields at the corners cause the gold atoms to migrate and gradually penetrate the light-emitting material layer, forming unwanted conductive filaments. When these filaments grow too large, the pixel will short-circuit and be completely damaged.

Increased performance and expanded color spectrum

To solve this problem, the JMU team added a special insulating layer to the optical antenna, leaving only a small circular hole 200 nanometers in diameter in the center. This design prevents current from spilling over from the edges and corners, allowing the pixel to operate stably over the long term. Under experimental conditions, the first nanopixels remained stable for two weeks in a normal environment.

The team's next step is to increase the luminous efficiency from the current 1% and expand the display capabilities to the full RGB color gamut. Then there will be no barriers to creating a generation of micro-displays 'Made in Würzburg'.

With this technology, in the future, screens and projectors could be so small that they are almost invisible, enough to be integrated into any wearable device – from eyeglass frames to smart contact lenses.

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