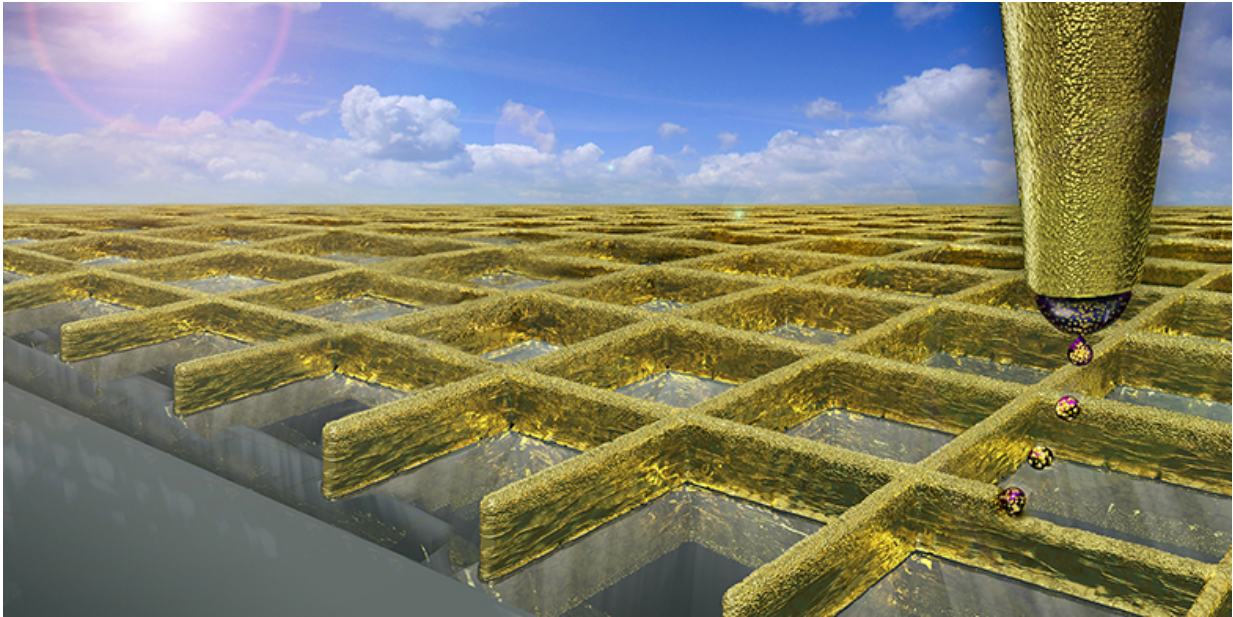


Nanowalls for smartphones

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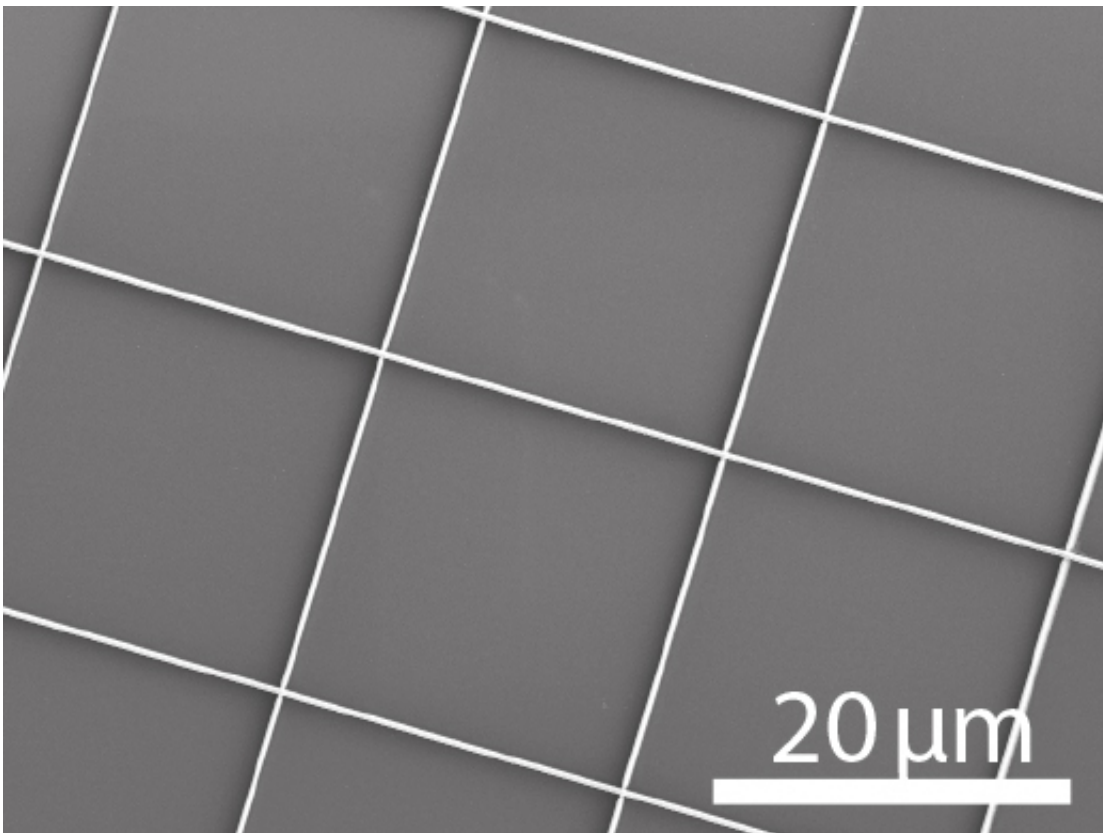
With a special mode of electrohydrodynamic ink-jet printing scientists can create a grid of ultra fine gold walls. Credit: Ben Newton / Digit Works

Researchers at ETH Zurich have manufactured transparent electrodes for use in touchscreens using a novel nanoprinting process. The new electrodes are some of the most transparent and conductive that have ever been developed.

From smartphones to the operating interfaces of ticket machines and cash dispensers, every touchscreen we use requires [transparent electrodes](#): The devices' glass surface is coated with a barely visible

pattern made of conductive material. It is because of this that the devices recognise whether and where exactly a finger is touching the surface.

Researchers under the direction of Dimos Poulikakos, Professor of Thermodynamics, have now used 3D print technology to create a new type of transparent electrode, which takes the form of a grid made of gold or silver "nanowalls" on a [glass surface](#). The walls are so thin that they can hardly be seen with the naked eye. It is the first time that scientists have created nanowalls like these using 3D printing. The new electrodes have a higher conductivity and are more transparent than those made of [indium tin oxide](#), the standard material used in smartphones and tablets today. This is a clear advantage: The more transparent the electrodes, the better the screen quality. And the more conductive they are, the more quickly and precisely the touchscreen will work.



This grid printed in gold has walls only 300 nanometres thick. Credit: Schneider J et al. *Advanced Functional Materials* 2015

Third dimension

"Indium tin oxide is used because the material has a relatively high degree of transparency and the production of thin layers has been well researched, but it is only moderately conductive," says Patrik Rohner, a PhD student in Poulidakos' team. In order to produce more conductive electrodes, the ETH researchers opted for gold and silver, which conduct electricity much better. But because these metals are not transparent, the scientists had to make use of the third dimension. ETH professor Poulidakos explains: "If you want to achieve both high conductivity and transparency in wires made from these metals, you have a conflict of objectives. As the cross-sectional area of gold and silver wires grows, the conductivity increases, but the grid's transparency decreases."

The solution was to use metal walls only 80 to 500 nanometres thick, which are almost invisible when viewed from above. Because they are two to four times taller than they are wide, the cross-sectional area, and thus the conductivity, is sufficiently high.

Ink-jet printer with tiny print head

The researchers produced these tiny metal walls using a printing process known as Nanodrip, which Poulidakos and his colleagues developed three years ago. Its basic principle is a process called electrohydrodynamic ink-jet printing. In this process scientists use inks made from metal nanoparticles in a solvent; an electrical field draws ultra-small droplets of the metallic ink out of a glass capillary. The

solvent evaporates quickly, allowing a three-dimensional structure to be built up drop by drop.

What is special about the Nanodrip process is that the droplets that come out of the glass capillary are about ten times smaller than the aperture itself. This allows for much smaller structures to be printed. "Imagine a water drop hanging from a tap that is turned off. And now imagine that another tiny droplet is hanging from this drop - we are only printing the tiny droplet," Poulikakos explains. The researchers managed to create this special form of droplet by perfectly balancing the composition of metallic ink and the electromagnetic field used.

Cost-efficient production

The next big challenge will now be to upscale the method and develop the print process further so that it can be implemented on an industrial scale. To achieve this, the scientists are working with colleagues from ETH spin-off company Scrona.

They have no doubt that once it is upscaled, the technology will bring a host of advantages compared with existing methods. In particular, it will likely be more cost-efficient, as Nanodrip printing, unlike the production of indium [tin oxide](#) electrodes, does not require a cleanroom environment. The new electrodes should also be more suitable for large touchscreens due to their higher conductivity. And finally the process is also the first to allow you to vary the height of the nanowalls directly while printing, says ETH PhD student Rohner.

Another possible future application could be in solar cells, where transparent electrodes are also required. The more transparent and conductive they are, the more electricity that can be harnessed. And lastly, the electrodes could also play a role in the further development of curved display using OLED technology.

More information: Julian Schneider et al. Electrohydrodynamic NanoDrip Printing of High Aspect Ratio Metal Grid Transparent Electrodes, *Advanced Functional Materials* (2015). [DOI: 10.1002/adfm.201503705](https://doi.org/10.1002/adfm.201503705)

Provided by ETH Zurich

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