

Researchers reproduce micro-scale 'Great Wave' painting with inkless technology

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Radical Inkless Technology produces the world's smallest "Ukiyo-e" & promises to revolutionize how we print. Credit: Kyoto University iCeMS

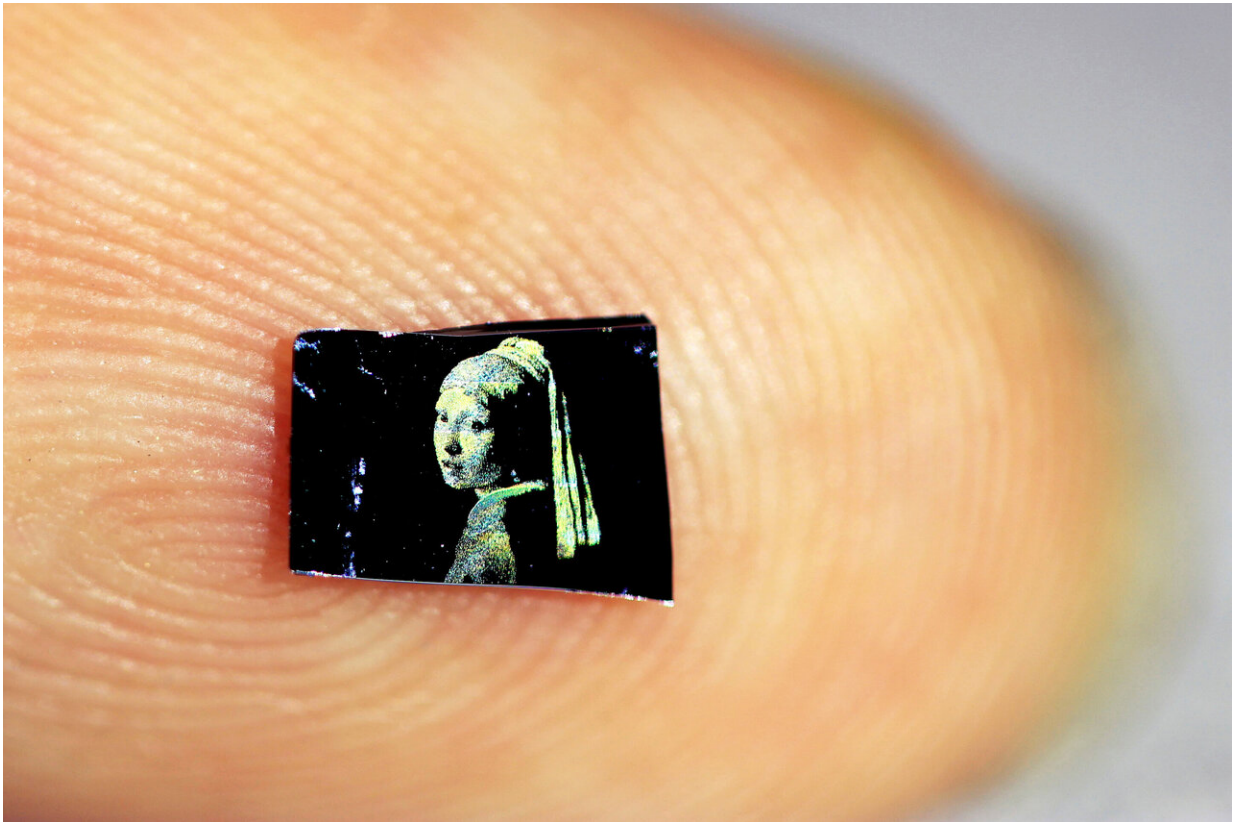
Katsushika Hokusai (1760 - 1849) is the titan of Japanese art, as revered in his homeland as are Da Vinci, Van Gogh and Rembrandt Van Rijn in

the West. Of all his famed masterpieces, the "Great Wave" stands out as the ultimate testament to his artistic genius.

Now, a team of researchers at Kyoto University has created the smallest "Great Wave" ever produced, just one millimeter in width. What's more, they created it without the use of pigments. Not only is the "Great Wave" reproduction the world's smallest, it is also the first ever printed without the use of a pigment.

Professor Easan Sivaniah of iCeMS, Kyoto University, where the research was developed, says, "Polymers, when exposed to stress—specifically, a kind of 'stretching out' at the molecular level—undergo a process called 'crazing' in which they form tiny, slender fibers known as fibrils. These fibrils cause a powerful visual effect. Crazing is what the bored school kid sees when he repeatedly bends a transparent ruler until the stretched plastic starts to cloud into a kind of opaque white."

Significantly, the iCeMS researchers realized that by controlling a process called organized microfibrillation (OM), which describes the way the microscopic [fibrils](#) form and organize in a periodic pattern, they could also control the scattering of light to create colors across the whole visible spectra from blue to red. Thus, it comprises a technique for printing that does not depend on pigment.



Pictures without ink printed at the sub-millimeter scale. Credit: Kyoto University iCeMS

Zoologists have long been familiar with this non-pigment-based color phenomenon, which they term "structural color." This is how nature produces the vivid colors seen in butterfly wings, the spectacular plumage of male peacocks, and other shimmering, iridescent birds. Some of the most spectacular wildlife on the planet is, in fact, devoid of pigmentation and depends upon light interacting with the surface structure for its mesmerizingly beautiful effect.

The OM technology allows an inkless, large-scale color printing process that generates images at resolutions of up to 14,000 dpi on a number of flexible and transparent formats. This has countless applications, for

example, in anti-forgery technology for banknotes. But as Sivaniah emphasizes that its applications go way beyond conventional printing ideas.

"OM allows us to print porous networks for gases and liquids, making it both breathable and wearable. So, for example in the area of health and well-being, it is possible to incorporate it into a kind of flexible 'fluid circuit board' that could sit on your skin or your contact lenses to transmit essential biomedical information to the cloud or directly to your health care professional."

OM is flexible technology in both the literal and figurative sense. The Kyoto University researchers have proved the technology works in many commonly used polymers such as [polystyrene](#) and [polycarbonate](#). The latter is a widely used plastic in food and medicine packaging, so there is clearly an application in food and drug safety, where security labels can be created much like a watermark to ensure a product has not been opened or sabotaged.

Masateru Ito, lead author of the paper, which was published this month in *Nature*, thinks there is more to come from the basic principles raised by this groundbreaking research. "We have shown that stress can be controlled at the submicron-length scales to create a controlled structure," he notes. "However it may be that it can also create controlled functionality. We demonstrated it in polymers, and we also know that metals or ceramics can crack. It is exciting to know if we can similarly manipulate cracks in these materials, too."

More information: Structural colour using organized microfibrillation in glassy polymer films, *Nature* (2019). [DOI: 10.1038/s41586-019-1299-8](#) , www.nature.com/articles/s41586-019-1299-8

Provided by Kyoto University

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