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# Scientists apply ancient construction methods to help fabricate modern microparticles

by Nanyang Technological University

Prototype using tongue and groove to assemble the microfluidic chip's fabrication channel. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-53016-8

Inspired by the ancient East Asian method of constructing wooden structures using a "tongue and groove" technique, Nanyang Technological University, Singapore (NTU Singapore) scientists have developed a new approach to fabricating advanced ceramic microparticles, just slightly bigger than the width of a human hair.

NTU materials scientists have used this approach to make a microfluidic chip that can produce and shape tiny ceramic microparticles with unprecedented complexity and precision. Their method is published in *Nature Communications*.

These microparticles, with various intricate shapes and precise sizes, such as ten-toothed gears or triangles with angled edges, could be used in a wide range of applications across microelectronics, aerospace, energy, and medical and mechanical engineering.

For instance, tetrahedral-shaped (four-faces) zirconium dioxide ($ZrO_2$) microparticles can alter the performance and function of terahertz emitters and receivers—often used in imaging such as for security, medical diagnostics and quality control in manufacturing.

Similarly, octahedral-shaped (eight-faces) silicon dioxide ($SiO_2$) microparticles can enhance the strength and toughness of materials, while gear-shaped ceramic particles are essential for mechanical drives.

Conventional fabrication methods, such as micromachining and laser sintering, have limitations in resolution and the ability to mass-produce such tiny, intricate shapes.

The current methods struggle with achieving sharp-edged and non-transparent microparticles due to material properties and the tiny sizes of the microparticles.

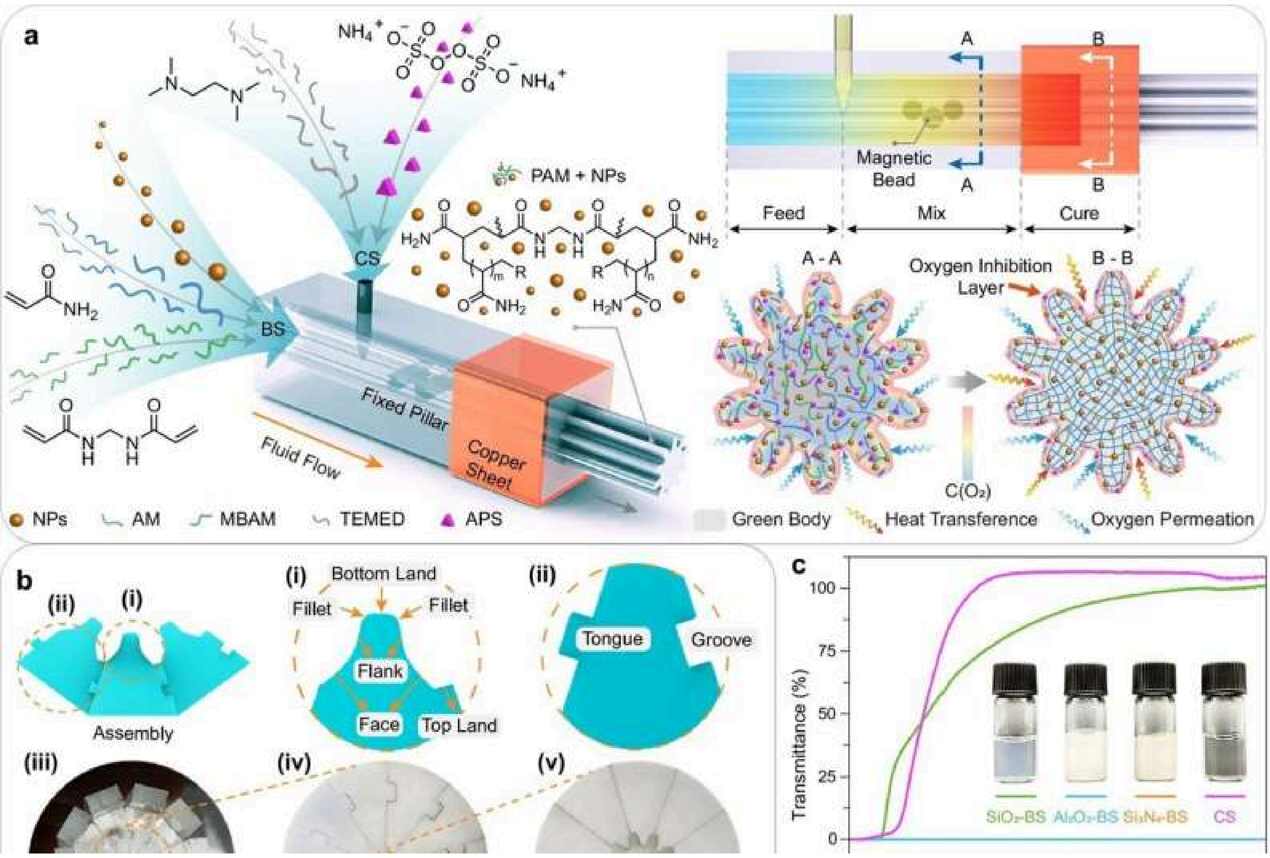
In contrast, NTU's approach effectively addresses these challenges by employing a simple three-step process.

First, the microfluidic chip is formed by molding and cutting the plastic substrate into multiple pieces, each meticulously shaped to fit into the next piece to create a hollow channel.

To ensure that the microfluidic chip's pieces are aligned precisely, each one is designed with tongues and grooves that interlock perfectly. These pieces are then assembled to create a shaped pipe-like mold, and the structure is secured using polycarbonate clamps to maintain its integrity.

Next, a special polymer solution and ceramic nanoparticles are injected into the microfluidics chip, where they are thoroughly mixed. This mixture is then cured using a heating process and crosslinked within the chip to form a solid material.

Finally, as the solidified material extrudes from the microfluidics chip—similar to how sausage is made—it is sliced to the desired thickness. This step ensures that the final product meets the specific dimensions required for various applications.




Fabrication of gear-shaped microparticles (MPs) by “one-pot microfluidic fabrication” (OPMF) system. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-53016-8

This new method significantly enhances the production rate—up to 10 times faster than current methods—and achieves unprecedented quality in the manufactured micro-ceramic particles.

The construction of the microfluidics chip was inspired by the historical building technique, known as "mortise and tenon" joinery, which uses interlocking grooves and tongues instead of nails or glue.

It was used to build palaces and residences in ancient China as early as 1000 BC, has been used in Korea since the 14th century for construction, and appears in Japanese temples. It is still prevalent in the traditional Korean "Hanok" architectural style and was used to build the Gyeongbokgung Palace in Seoul.

Lead scientist Professor Cho Nam Joon, from NTU's School of Materials Science and Engineering, highlighted the inspiration behind the technique, drawing from his background in civil engineering.

"Our approach is rooted in the ancient craftsmanship used in Korean architecture, which has long utilized precise interlocking techniques to create durable structures that lasted centuries. As a Korean, I wondered if we could apply this technique in interdisciplinary science to create stable and strong microparticles by combining it with chemistry and materials science," explained Prof Cho, also the Director, Center for Cross Economy at NTU.

"Our new microfabrication method demonstrates that it can meet the modern demands for precision and complexity as technology becomes more miniature, even at the most challenging microscale level."

The method represents a significant advancement in microscale manufacturing and exemplifies how traditional techniques can inspire contemporary technological innovations.

For the next phase of the research project, Professor Cho and his team are working to assemble these newly developed micro-parts into a working mechanism as a proof-of-concept to demonstrate the diverse use cases for different types of micromachines.

**More information:** Chenchen Zhou et al, One-pot microfluidic fabrication of micro ceramic particles, *Nature Communications* (2024). DOI: 10.1038/s41467-024-53016-8

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