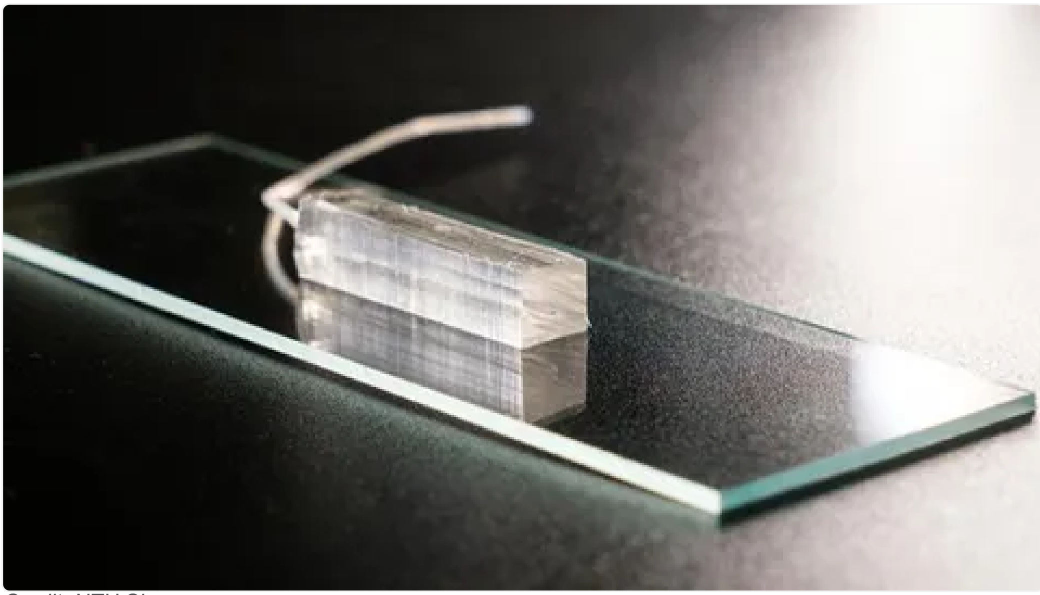
# Applying Ancient Construction Methods to Help Fabricate Modern Microparticles

NTU scientists have developed a method using ancient techniques to create advanced ceramic microparticles.

**News** Published: October 17, 2024 | Original story from Nanyang Technological University



*Credit: NTU Singapore.*

***Read time: 3 minutes***

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 the 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.

These microparticles, with various intricate shapes and precise sizes such as tentoothed 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.

Firstly, the microfluidic chip is formed by moulding 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 mould, 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 extruded the microfluidics chip – similar to how sausage is made, it is then sliced to the desired thickness. This step ensures that the final product meets the specific dimensions required for various applications.

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 utilised 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, Centre 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."

Published in Nature Communications this week, the method represents a significant advancement in microscale manufacturing and exemplifies how traditional techniques can inspire contemporary technological innovations.

Professor Kim Do-yeon, a renowned materials scientist from Seoul National University who was not involved in the paper, commented: "Prof Cho's paper demonstrates that the 'Mortise and Tenon' technique, used in construction for over a thousand years, when combined with principles from materials and chemical engineering, can create valuable building blocks. This approach will undoubtedly advance a wide range of fields, from 'Big to Small'," said Prof Kim, a former Minister of Education, Science and Technology of Korea and former President of Pohang University of Science and Technology (POSTECH).

Chemist and materials scientist Martin Pumera who is a Distinguished Professor of Chemistry at the Central European Institute of Technology Brno University of Technology, gave an independent comment on the findings: "A brilliant approach is to draw from historical wisdom and inspiration and translate it into modern science through the principles of materials and chemical engineering."

"This research exemplifies boundaryless science, where interdisciplinary collaboration unlocks new possibilities and drives innovation. The scientists here used imagination and inspiration from the past to create the future," said Prof Pumera, also a faculty member of the University of Chemistry and Technology, Prague.

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 proofof-concept to demonstrate the diverse use cases for different types of micromachines.

**Reference:** Zhou C, Liang S, Qi B, Liu C, Cho NJ. One-pot microfluidic fabrication of micro ceramic particles. *Nat Commun*. 2024;15(1):8862. doi: [10.1038/s41467-024-53016-8](https://doi.org/10.1038/s41467-024-53016-8)