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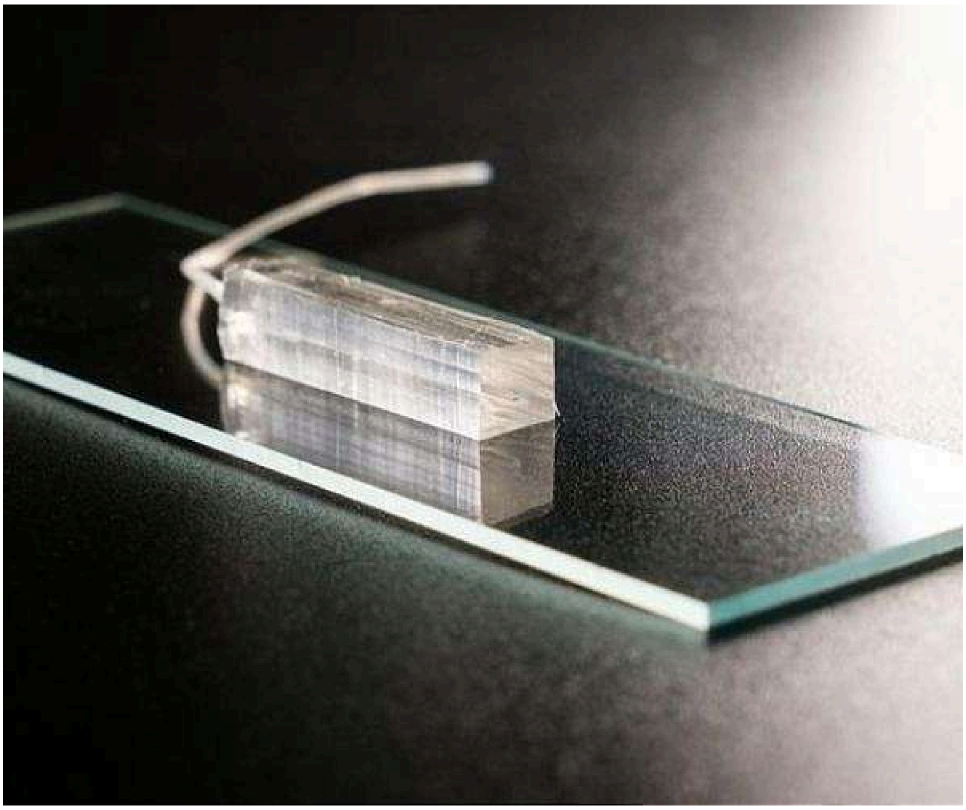
Researchers draw on ancient joinery to craft advanced ceramic microparticles



Close-up of the microfluidics device which can make square-shaped micro-ceramic particles with sharp corners.

Researchers draw on ancient joinery to craft advanced ceramic microparticles

by Simon Mansfield
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Scientists at Nanyang Technological University, Singapore (NTU Singapore), have adopted a traditional East Asian construction technique known as "tongue and groove" to fabricate modern ceramic microparticles with high precision and complexity, comparable to the width of a human hair.

The new approach, inspired by ancient wood joinery methods, has enabled NTU researchers to develop a microfluidic chip capable of producing intricate ceramic microparticles in diverse shapes and sizes, including gear-like forms and angular designs. Such microparticles hold significant potential for applications in fields ranging from microelectronics and aerospace to medical devices and mechanical engineering.

Examples include tetrahedral zirconium dioxide (ZrO_2) microparticles, which can enhance the function of terahertz imaging devices used in security, diagnostics, and manufacturing, and octahedral silicon dioxide (SiO_2) microparticles that can strengthen various materials. Gear-shaped ceramic particles also serve as crucial components in mechanical systems.

Traditional fabrication methods, such as micromachining and laser sintering, face limitations in producing microparticles with sharp edges and non-transparent properties, especially at such small scales. NTU's technique overcomes these hurdles with a streamlined three-step process.

The process begins with creating a microfluidic chip by cutting and shaping a plastic substrate into interlocking pieces, which form a hollow channel when assembled. Each piece is designed with tongues and grooves to ensure precise alignment, and the assembled chip is secured with polycarbonate clamps.

Next, a polymer solution mixed with ceramic nanoparticles is injected into the chip. The mixture undergoes a heating process to solidify, creating a solid ceramic material. Finally, the solidified material is extruded from the chip and sliced to the required thickness, achieving up to a tenfold increase in production speed and superior quality compared to existing methods.

The microfluidic chip's construction draws on "mortise and tenon" joinery, a technique used for centuries in East Asia to build wooden structures, from ancient Chinese palaces to Korean and Japanese temples.

Professor Cho Nam Joon, who led the research at NTU's School of Materials Science and Engineering, explained how his civil engineering background and Korean heritage influenced the method: "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."

Prof Cho noted that the microfabrication method addresses the increasing demand for precision as technology continues to shrink to the microscale. The study, published in *Nature Communications*, demonstrates a new frontier in microscale manufacturing.

Professor Kim Do-yeon, a materials scientist from Seoul National University, commented on the research: "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'."

Chemist and materials scientist Martin Pumera from the Central European Institute of Technology added: "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."

Looking ahead, Professor Cho and his team aim to assemble the newly fabricated micro-parts into functional micromachines, demonstrating the versatility of the technology in practical applications.

Research Report: One-pot microfluidic fabrication of micro ceramic particles