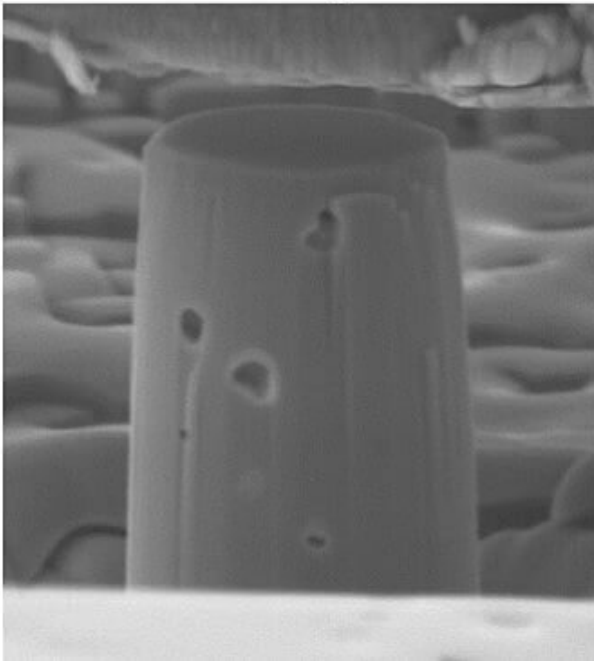


# New technique to improve ductility of ceramic materials for missiles, engines

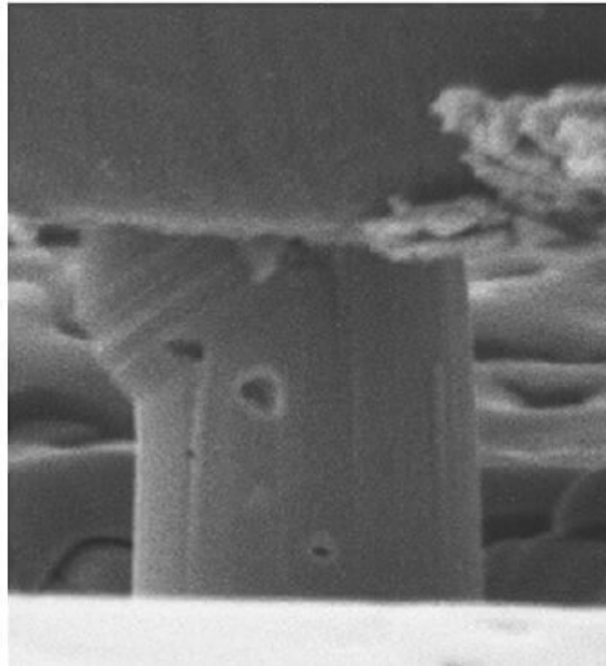
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Before compression



After compression



Purdue University researchers have developed a new process to help overcome the brittle nature of ceramics and make it more durable. Credit: Purdue University/Chris Adam

Something as simple as an electric field could soon make wartime missiles or drinking mugs easier to produce and more resilient for fracture.

Items such as drinking mugs, missile heads, thermal barrier coatings on engine blades, auto parts, electronic and optic components are commonly made with ceramics.

The ceramics are mechanically strong, but tend to fracture suddenly when just slightly strained under a load unless exposed to high temperatures.

Purdue University researchers have developed a new process to help overcome the brittle nature of ceramics and make it more ductile and durable. The Purdue team calls the process "flash sintering," which adds an electric field to the conventional sintering process used to form bulk components from ceramics.

"We have been able to show that even at room temperatures, ceramics sintered with the electric field surprisingly deform plastically before fracture when compressed at high strain," said Haiyan Wang, the Basil S. Turner Professor of Engineering in Purdue's College of Engineering.

A study published in *Science Advances* demonstrates that applying an [electric field](#) to the formation of ceramics makes the material almost as easily reshaped as metal at room [temperature](#). The Purdue team specifically applied its technique to titanium dioxide, a widely used white pigment.

"Nanotwins have been introduced in various metallic materials to improve strength and ductility. However, there are little prior studies that show nanotwins and stacking faults can significantly improve the plasticity of ceramics," said Jin Li, a postdoctoral fellow and researcher on the research team.

The significantly enhanced room temperature ductility in [titanium dioxide](#) is attributed to the unusually high-density defects, such as

stacking faults, twins and dislocations, formed through the flash sintering process.

"The existence of these defects remove the need for defect nucleation in ceramics, which typically requires a large nucleation stress, greater than the fracture stress of ceramics," Wang said.

Li, the first author of the article from Purdue, said, "Our results are important because they open the door for using many different ceramics in new ways that can provide more flexibility and durability to sustain heavy loads and high temperatures without catastrophic brittle failure."

Improved plasticity for ceramics means more mechanical durability during operation at relatively low temperatures. The sample also could withstand almost as much compression strain as some metals do before cracks started to appear.

"These ductile ceramics find many technologically important applications," said Xinghang Zhang, professor of materials engineering and co-principle investigator on the research team. "It can be applied to defense operations, automobile manufacturing, nuclear reactor components and sustainable energy devices."

**More information:** Jin Li et al, Nanoscale stacking fault–assisted room temperature plasticity in flash-sintered TiO<sub>2</sub>, *Science Advances* (2019). [DOI: 10.1126/sciadv.aaw5519](https://doi.org/10.1126/sciadv.aaw5519)

Provided by Purdue University

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