3D-printed micro-trusses point the way toward stronger high-temperature ceramics

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Video Abstract

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Abstract

3D-printed with microscale precision, these tiny architectural marvels could be the key to making high-temperature ceramics less vulnerable to fracture. The implications could span across the numerous areas these materials are used, from aerospace to tissue engineering. The blueprint for these hardy structures is reported in the Journal of Materials Research Volume 33, Issue No. 3, earning honors as the 2018 JMR Paper of the Year. Researchers built the miniature trusses layer by layer using a technique called projection microstereolithography. In this process, a UV-light pattern is scanned across a polymer bath composed of photo-active ceramic building blocks. The silicon-based polymer solidifies at every point traced by the UV beam. Subsequent heating in a high-temperature furnace activates the polymer structures, baking off volatile organics, to produce silicon oxycarbide structures. The team then put these structures to the test. Able to suspend red-hot steel, the lattices proved several times stronger than their solid counterparts. More importantly, the team discovered that the lighter the trusses were made, the stronger they became. That result may seem counterintuitive, but it makes sense when considering the fracture mechanics of ceramics. Under stress, ceramics break before they deform. That's due to the formation of fatal defects like cracks. But shrinking reduces the probability of forming these defects, as smaller feature sizes provide fewer opportunities for defects to arise. This so-called size effect can be appreciated in the trend toward thinner engineering structures throughout the world. And now it appears that the same effect could prove as useful for structures a million times smaller. Further research is still needed to fully explain the boosted strength of the team's tiny structures. Given the widespread applications of high-temperature ceramics, their findings could pave the way toward better and stronger materials for construction on numerous scales.