WPI MATERIALS SCIENCE & ENGINEERING

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MTE SEMINAR

Fabricating ceramics with embedded microchannels using an integrated additive manufacturing and laser machining method

Abstract
We demonstrate the feasibility of an innovative method to fabricate flexibly embedded microchannels in bulk ceramics of complex geometries. This innovative method is an integration of extrusion freeforming (EFF) and picosecond (PS) laser machining. The bulk ceramic green body of complex geometries was fabricated using the extrusion method. After one green layer was extruded, in-plane microchannels with variable cross-section sizes and aspect ratios were fabricated using a picosecond laser. After the microchannels were fabricated, a cover layer was extruded. The green state processed structures ceramics were pressurelessly sintered to a bulk density of ~94%. In this paper, sinuous channels, channel networks, and patterns have been demonstrated. Vertical channels can also be drilled using the picosecond laser layer-by-layer with uniform diameters. The wall between the neighboring channels can be as thin as ~60 μm without any observable defects after firing. With the correct paste rheology, the cover layer did not sag into the microchannels and the bonding between layers was excellent. We did not observe any debonding between layers. During extrusion, the gaps between the adjacent filaments can be eliminated by controlling the filament spacing and the distance between needle tip and substrate. After firing, microchannels did not distort or collapse. The laser can cut through multiple layers without damage to the bonding between layers. Due to the uniform shrinkage during pressureless sintering, the green shapes of the microchannels were well preserved.

Bio:
Dr. Peng is currently an associate professor of MSE at Clemson University. He received his Ph.D. at Georgia Institute of Technology, and M.S. and B.S in Tsinghua University. Dr. Peng's research is focused on the advanced processing of ceramics and material thermodynamics, kinetics and properties. The materials of interest include the structural and high temperature ceramics for the extreme environments, high performance sensors for medical and health applications and extreme environment monitoring, materials for renewable energies, and processing and characterizing nuclear materials. The current research projects are focused on additive manufacturing of ceramics, thermnal and environmental barrier ceramic coatings, nuclear fuel fabrication, high performance sensors, ceramic nanofibers and composites, smart materials, sintering of ultra-high temperature ceramics, and the high-temperature oxidation resistance of borides and carbides. Dr. Peng has extensive materials research experience. He has published 41 peer-reviewed journal papers, with a total citation of 693, and is the leading or corresponding author of several highly cited papers in his field. He is now serving as a member of advisory board of Bulletin of American Ceramic Society, officer of Basic Science Division of ACerS. He also organizes and serves as session chairs of professional conferences such as Fiber Society Conference and MS&T.