A new technique for the 3-D printing multimaterial devices

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An Eiffel Tower-like 3D structure printed using the researcher's method. Credit: Hensleigh et al

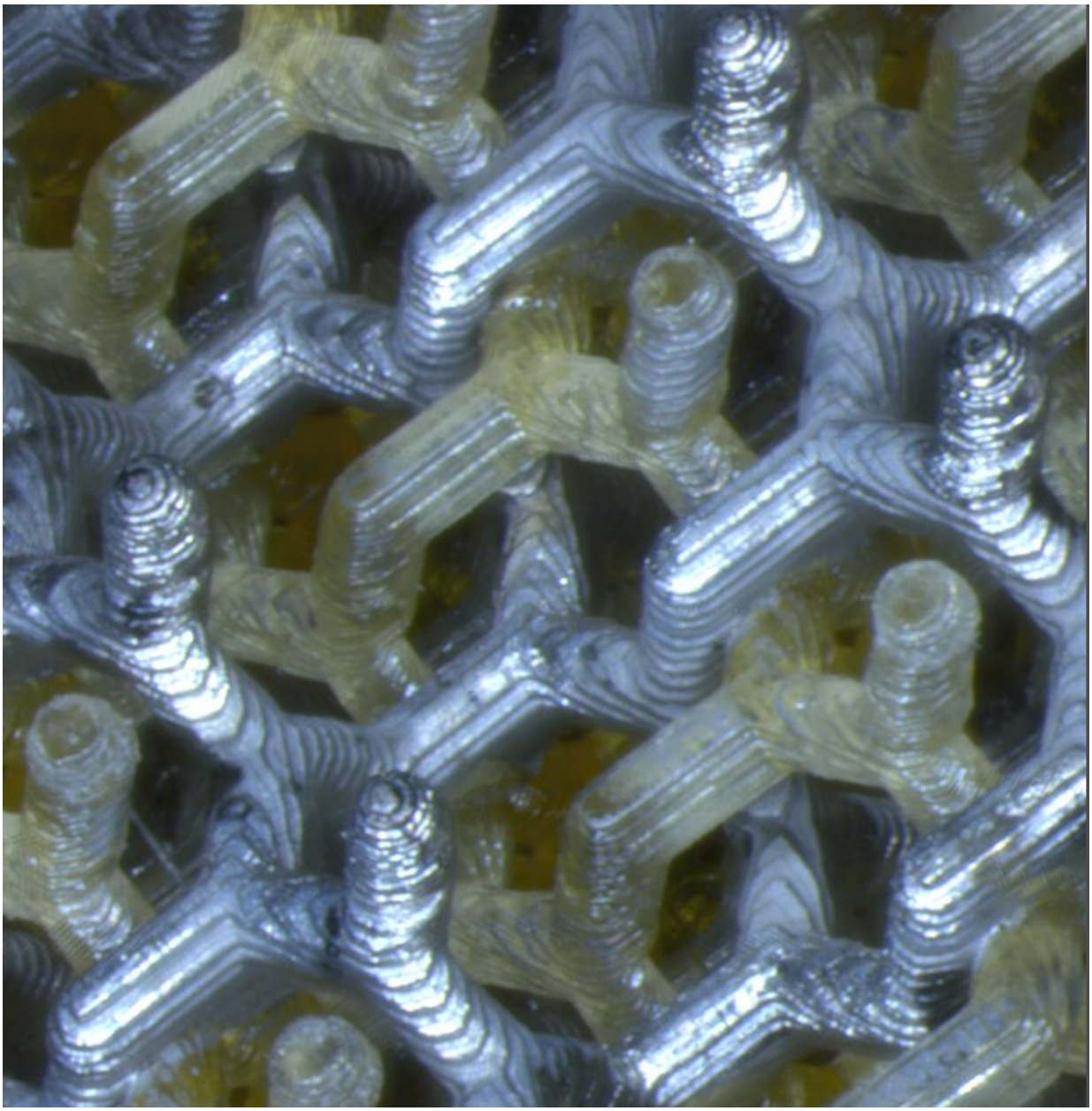
Three-dimensional printing techniques could potentially be used to fabricate a variety of objects with complex geometries, including

electronic components. Most 3-D printing approaches developed so far, however, have merely proved effective for producing non-functional materials, as printing more sophisticated structures, including electronic devices, would require several stages of production and more demanding procedures.

Researchers at the University of California Los Angeles, Virginia Tech, and the Air Force Research Laboratory have recently devised a new 3-D printing approach to produce electronic devices made of different materials. Their approach, presented in a paper published in *Nature Electronics*, enables the 3-D printing of complex electronic structures in a single step.

"Current electronic devices, including integrated circuits, antennas and sensors, are limited to 2-D planner patterns," Xiaoyu Zheng, one of the researchers who carried out the study, told Phys.org. "There is, however, a growing demand for non-planar 3-D devices or circuits, sensor arrays and antennas on curved surfaces, or packed in complex 3-D shapes and architectures. However, no existing method can efficiently achieve this."

Most existing 3-D printing approaches use a process known as 'aerosol jetting' and/or direct writing techniques. These methods generally entail multiple printing steps, embedding procedures and intricate ink formulations.



A 3D gyroid-based 3D structure printed using the researchers' method. Credit: Hensleigh et al.

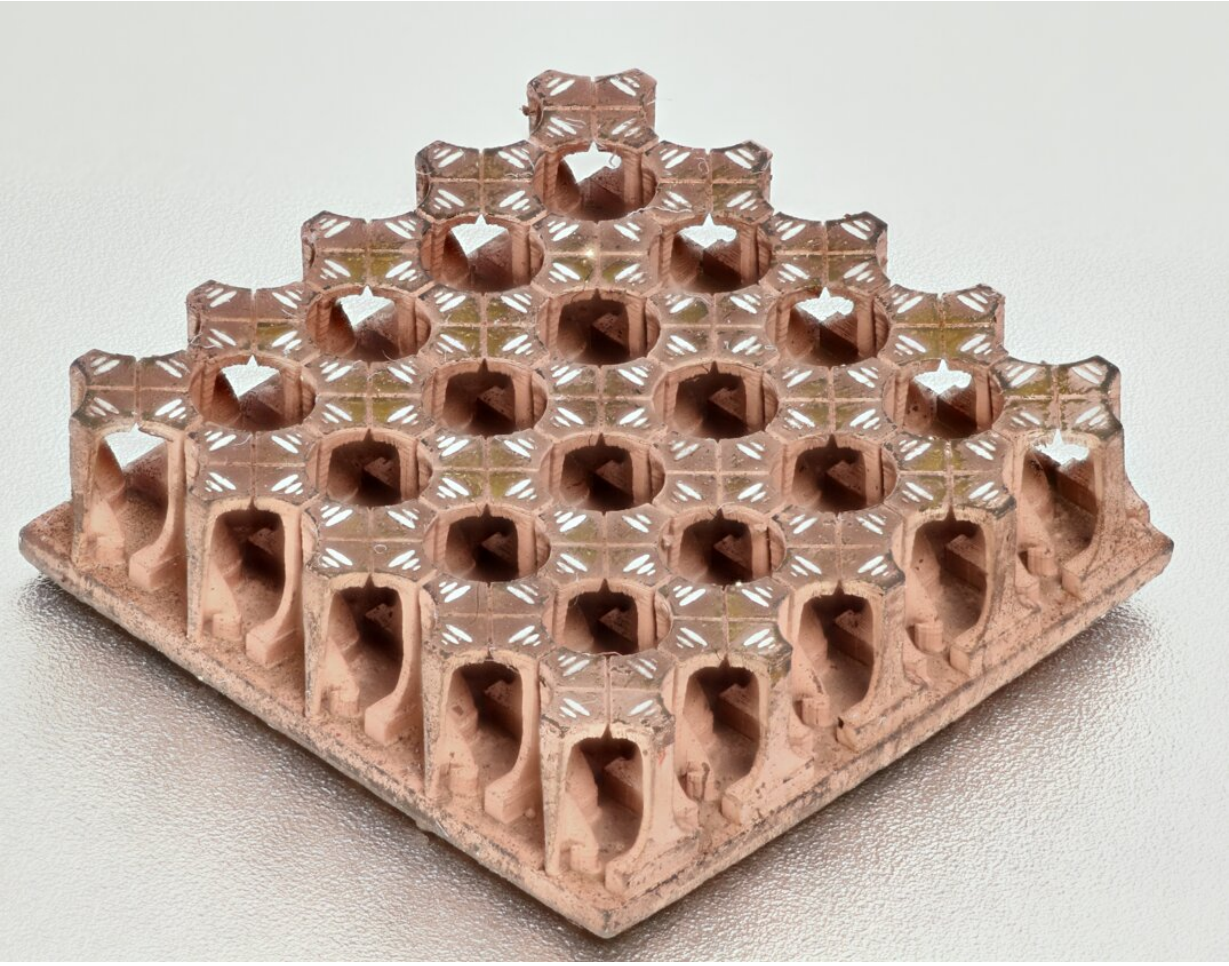
In some cases, they also require the integration of multiple printing methods, which prolongs fabrication times considerably. As a result,

these techniques are far from ideal for the high-speed production of functional electronics and complex 3-D structures.

Zheng and his colleagues devised an approach that could overcome the limitations of these previously developed 3-D printing techniques. Their method volumetrically deposits several functional materials within arbitrary 3-D layouts, creating electronic devices in a single printing step.

"We report a strategy to rapidly create arbitrary multi-material electronic devices by selectively controlling the location and type of surface charges on a 3-D printed object, which can then be used to deposit functional materials based on localized electrostatic attraction," Zheng said. "Metallic contacts can be selectively deposited at predefined locations, creating electronic circuits and electrodes with feature sizes below 10 μm and at rates of 26,000 mm^2 h–1—many times faster than other methodologies such as multi-process printing (11 mm^2 h^{-1}), ink writing (113 mm^2 h^{-1}) or aerosol jet printing (5,600 mm^2 h^{-1})."

The new 3-D printing technique introduced by Zheng and his colleagues prints devices or materials composed of 3-D dielectric/conducting arrays and unique circuit patterns. In addition, it can be easily adapted to produce a variety of topologies and 3-D architectures, and could thus potentially enable the large-scale fabrication of antenna arrays for 5G communications, prosthetics and neuron probes.



An antenna printed using the researchers' method. Credit: Hensleigh et al.

To demonstrate the effectiveness of their method, the researchers used it to print artificial fingertips for tactile sensing and shape sensing, achieving highly promising results. In the future, their approach could facilitate the automated production of compact, multi-material electronic devices over short period of time.

"We now plan to expand the build volume of our method while shrinking feature sizes, and incorporate multiple conducting, dielectric and functional materials into the system," Zheng said. "We are also working

with industrial collaborators on smart materials, sensors and all-in-one devices. One major area we are focusing on is the fabrication of antenna arrays for RF communications."

More information: Ryan Hensleigh et al. Charge-programmed three-dimensional printing for multi-material electronic devices, *Nature Electronics* (2020). DOI: 10.1038/s41928-020-0391-2