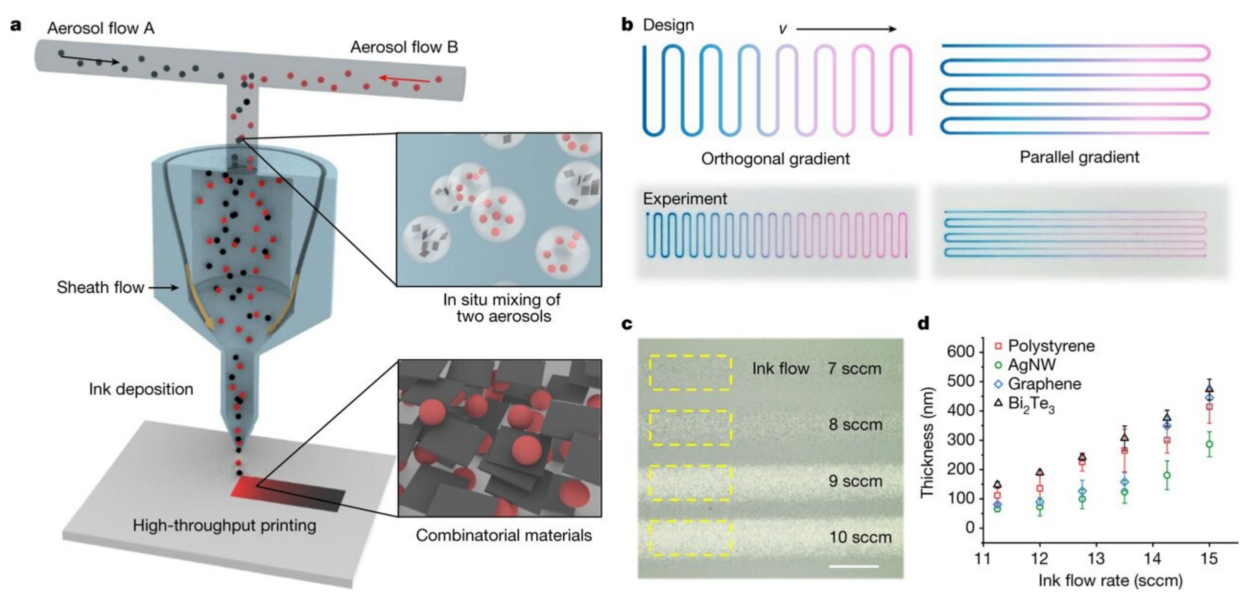
Novel 3D printing method a 'game changer' for discovery, manufacturing of new materials

May 15 2023, by Karla Cruise



The design strategy of HTCP. a, Schematic illustration of the combinatorial printing method based on in situ aerosol mixing. b, Orthogonal and parallel gradient printing design strategies, and corresponding printed gradient patterns using blue ink (food dye Blue 1) and red ink (rhodamine B), demonstrating a compositional–modulation feature. c, Optical microscopy images showing the impact of aerosol ink flow rate on the deposited materials. Scale bar, 100 µm. d, Printed material thickness versus flow rate of various inks (polystyrene, AgNW, graphene and Bi_2Te_3). Error bars represent s.d. from four experimental replicates. sccm, standard cubic centimeters per minute. Credit: *Nature* (2023). DOI: 10.1038/s41586-023-05898-9

The time-honored Edisonian trial-and-error process of discovery is slow and labor-intensive. This hampers the development of urgently needed new technologies for clean energy and environmental sustainability, as well as for electronics and biomedical devices.

"It usually takes 10 to 20 years to discover a new material," said Yanliang Zhang, associate professor of aerospace and mechanical engineering at the University of Notre Dame.

"I thought if we could shorten that time to less than a year—or even a few months—it would be a game changer for the discovery and manufacturing of new materials."

Now Zhang has done just that, creating a novel 3D printing method that produces materials in ways that conventional manufacturing can't match. The new process mixes multiple aerosolized nanomaterial inks in a single printing nozzle, varying the ink mixing ratio on the fly during the printing process. This method—called high-throughput combinatorial printing (HTCP)—controls both the printed materials' 3D architectures and local compositions and produces materials with gradient compositions and properties at microscale spatial resolution.

His research was just published in *Nature*.

The aerosol-based HTCP is extremely versatile and applicable to a broad range of metals, semiconductors and dielectrics, as well as polymers and biomaterials. It generates combinational materials that function as "libraries," each containing thousands of unique compositions.

Combining combinational materials printing and high-throughput characterization can significantly accelerate materials discovery, Zhang said. His team has already used this approach to identify a semiconductor material with superior thermoelectric properties, a promising discovery for energy harvesting and cooling applications.

In addition to speeding up discovery, HTCP produces functionally graded materials that gradually transition from stiff to soft. This makes them particularly useful in biomedical applications that need to bridge between soft body tissues and stiff wearable and implantable devices.

In the next phase of research, Zhang and the students in his Advanced Manufacturing and Energy Lab plan to apply machine learning and artificial intelligence-guided strategies to the data-rich nature of HTCP in order to accelerate the discovery and development of a broad range of materials.

"In the future, I hope to develop an autonomous and self-driving process for materials discovery and device manufacturing, so students in the lab can be free to focus on high-level thinking," Zhang said.

More information: Minxiang Zeng et al, High-throughput printing of combinatorial materials from aerosols, *Nature* (2023). DOI: 10.1038/s41586-023-05898-9

Provided by University of Notre Dame