Research team explores a novel way to fabricate preforms for composites

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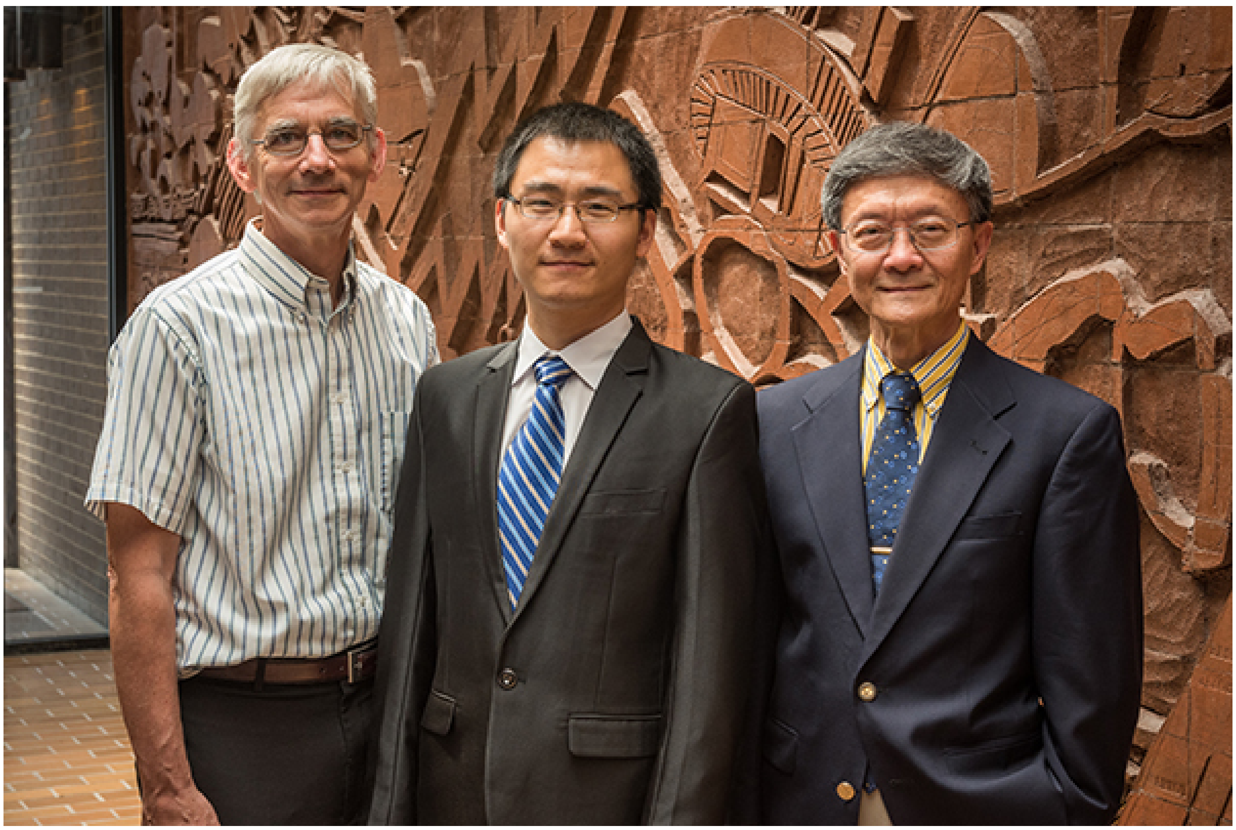

Michael Keefe, Zhenzhen Quan and Tsu-Wei Chou are part of an international team of researchers that is examining the feasibility of using additive manufacturing to produce 3D preforms.

In the 1967 movie The Graduate, young Benjamin Braddock gets a nowfamous one-word piece of advice about the future from a family friend: plastics.

At about the same time, the University of Delaware's Tsu-Wei Chou, then a graduate student at Stanford University, sought advice from his adviser about future research directions. His answer contained two words: composite materials.

Chou followed his adviser's suggestion and went on to become a pioneer in advanced composites, working over the years with a wide variety of materials and processes. Almost five decades later, he is still on the hunt for innovations that will make advanced composites more affordable, reliable and functional.

His latest breakthrough builds on work he did in the 1980s and '90s on textile structural composites. This technology applies braiding, weaving, knitting and stitching techniques to produce 3D reinforcements, which are then combined with a binder, or matrix, to make complex shapes.

While textile structural composites offer such advantages as structural integrity, damage tolerance and cost-effectiveness, some fundamental technological barriers remain in their manufacture, which can lead to inconsistencies in performance.

Now Chou, Pierre S. du Pont Chair of Engineering at the University of Delaware, is part of an international team of researchers that is examining the feasibility of using additive manufacturing to produce 3D preforms.

Their work is documented in a paper published in the web version of *Materials Today* on May 23.

Additive manufacturing, also broadly known as "rapid prototyping" and "freeform fabrication," is a process in which an object is built up layer by layer from a computerized model. The technique enables direct fabrication of complex-shaped objects without tooling and machining, and it eliminates the need to join a number of single parts into a single complex one.

In traditional processes, complex parts are usually built by assembling separate simple parts, which can lead to premature structural failure at material joints.

Another advantage of this technology is that material composition can be changed at specified locations within a part at the processing stage, enabling various functions and graded properties to be incorporated directly during manufacturing.

The process also shortens lead time and makes small-lot-size customization—even a run of just a single part—economical.

Finally, in additive manufacturing, the material is placed just where it is needed, and the residual material can often be readily recycled or reused, reducing material waste.

"All of these features make additive manufacturing an attractive option for composite materials development," Chou says.

The paper reviews the state of the art within the scope of composites development and discusses challenges facing the broad adoption of additive manufacturing for directionally reinforced composites processing.

Those challenges include the need for new CAD tools and engineering standards, difficulties in process monitoring, and limitations in part size, printing accuracy, layer thickness, and surface smoothness.

Despite these limitations, Chou sees great potential in additive manufacturing of fiber-reinforced preforms, which, he says, are especially desirable for composite parts in aerospace and biomedical applications.

More information: "Additive manufacturing of multi-directional preforms for composites: opportunities and challenges," *Materials Today*, Available online 23 May 2015, ISSN 1369-7021, dx.doi.org/10.1016/j.mattod.2015.05.001

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