Fraunhofer ICT

Additive manufacturing

Rapid microwave-assisted additive manufacturing of lattice composites

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The additive manufacturing of continuous-fiber-reinforced plastics is attracting increasing interest in the field of composites manufacturing. Some printers and filaments are already on the market, but due to the slow printing speed, the costs of the printed parts are high.

Researchers at the Karlsruhe Institute of Technology (KIT), together with the Fraunhofer Institute for Chemical Technology ICT and Trumpf Hüttinger Microwaves, have developed a new method for printing continuous-fiber-reinforced composites with extremely high speed and the possibility to use different filament diameters, called SERPENS (Super-Efficient and Rapid Printing by Electromagnetic-Heating-Necessitated System).

Innovation

The first prototype of a SERPENS microwave printer can manufacture CFRP parts with up to 10 times higher printing speeds than traditional continuous-fiber additive manufacturing technologies by taking advantage of the rapid, selective and volumetric heating of microwaves.

Current additive manufacturing methods have a limited and slow printing speed because the traditional resistive heating approach is intrinsically slow and requires contact. As a result, current additive manufacturing methods with continuous fiber reinforced filaments manufacture composite products with a low printing speed and little potential for optimization.

The key innovations of this system include the small microwave-resonant heating cavity, the prediction-model-based printing temperature control and the load-dependent planning of the printing path. Using these innovations, SERPENS is able to produce new bionic and free-standing lattice truss CFRP structures in three-dimensional space at outstanding speed.

In cooperation with

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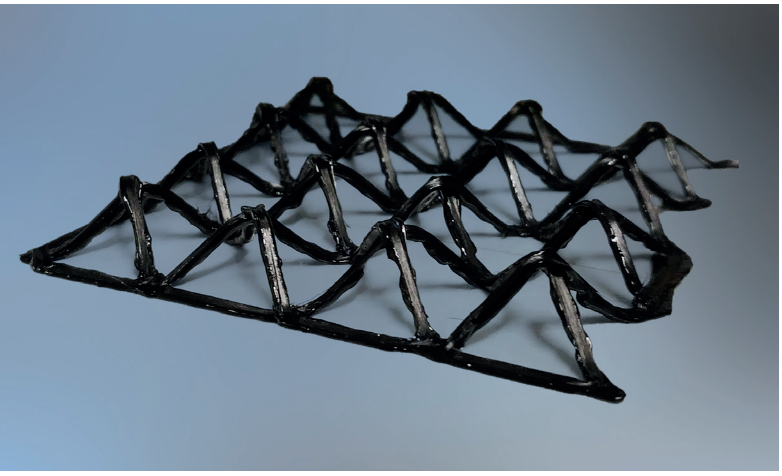

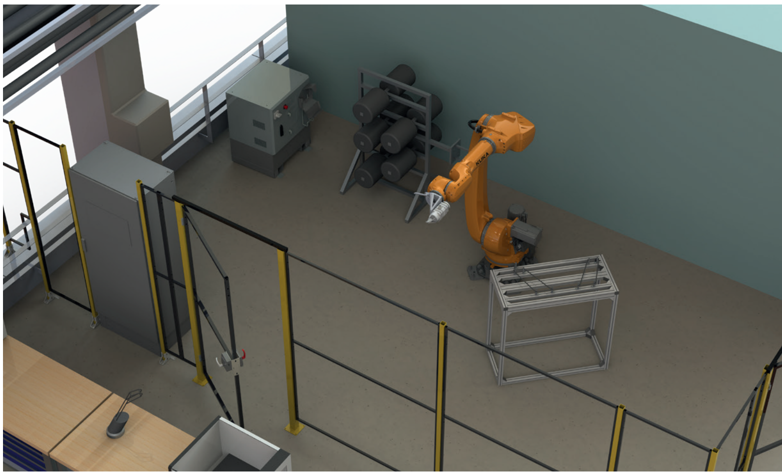

3D printed pyramidal lattice truss structure with endless carbon fiber reinforcement (left) and large-scale manufacturing cell (right).
Photos: KIT (left), Fraunhofer ICT (right)

Key benefits

- Printing speed of up to 100 mm/s
- Possibility to print different filament diameters
- Production of free-standing lattice truss structures
- Load-dependent printing path generation

Value

Besides the ultra-high speed, the microwave heating enables a volumetric and homogeneous heating of bigger filament diameters. The diameter of conventional industrially-used continuous-fiber-reinforced filaments is mainly about 0.35 mm. SERPENS, in comparison, allows the use of filaments with a thickness up to 5 mm. This leads to an outoput rate that is significantly increased compared to commercially available printers.

The continuous carbon fibers have excellent microwave absorbing properties that result in an extremely high heating efficiency. This technology has the ability to heat the CFRP filaments to 250 °C with 18 W power in less than one second. More importantly, the microwave penetrates the CFRP filament and provides non-contact and volumetric heating that ensures instantaneous uniform temperature distribution. By this means, the quality of printed parts can be optimized and fiber breakage minimized.

The additive manufacturing of CFRP is still at an emerging stage in the composites industry. One of the challenges is to manufacture the composite components with a short production cycle to reduce part costs. SERPENS will fill this gap to fabricate industrially required CFRP with ultra-high speed compared to conventional technologies. In addition, by utilizing the mechanical strength of the continuous carbon fiber in the printing direction, the bionic and free-standing lattice truss CFRP structures can be efficiently used to carry the structural loads in the composite part.

Partners and applications

SERPENS, developed by the KIT, was funded by an Alexander von Humboldt research was grant. The development is supported by the partners Fraunhofer ICT and Trumpf Hüttinger Microwaves. The high-speed microwave additive manufacturing technology is further refined by upscaling it to print larger parts at a higher material throughput. One possible promising application of such spatial lattice structures is the reinforcement of concrete building parts.

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