Integrated Functional and Structural Mesh Reflector Design and Floating 3D Printing Using Continuous Fiber

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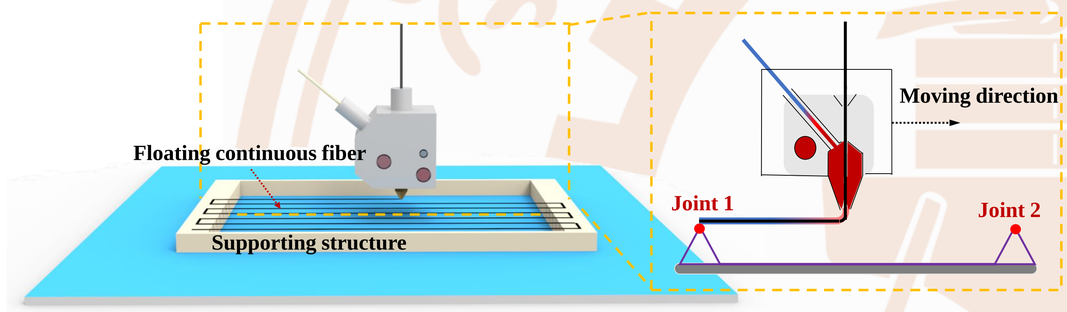
Abstract

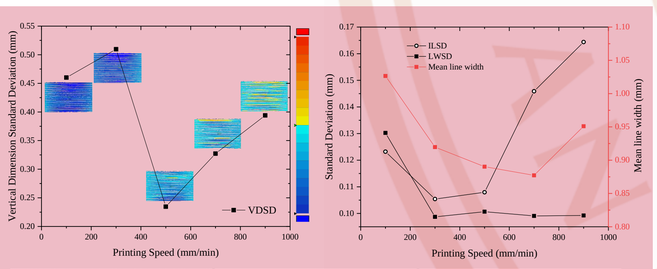
Continuous carbon fiber composites have been extensively used in current aerospace and become an essential optional material for antenna reflector due to their combined excellent mechanical properties and good electrical conductivity. To meet the requirements of space exploration and the large-scale development of antennas, this study designed the structure of the mesh reflector in a function-oriented manner and fabricated it using a novel floating 3D printing technique with continuous carbon fiber reinforced polyamide (PA) composites. In this research, the 3D scanning, SEM, CT scan and other methods were utilized to systematically characterize and analyze the influence of process parameters including floating distance, printing speed, printing temperature and layer count on the forming quality of the reflector from a multi-scale perspective. The results showed that the floating distance should be taken as small as possible, the printing speed is 300~500 mm/min, the printing temperature is 255~265℃, and the layer count is at least 3 to achieve high surface quality. The electromagnetic reflectivity of the mesh reflector at S band with the frequency of 2.9~3.6 GHz was conducted in a free-space test system, and the influence law of structural parameters such as mesh size and shape on the function was also studied. The measured reflectivity can exceed 95% to meet the application requirements. A set of process-structure-function integrated design and manufacturing strategy based on floating 3D printing technique can help the development of reflector antenna.

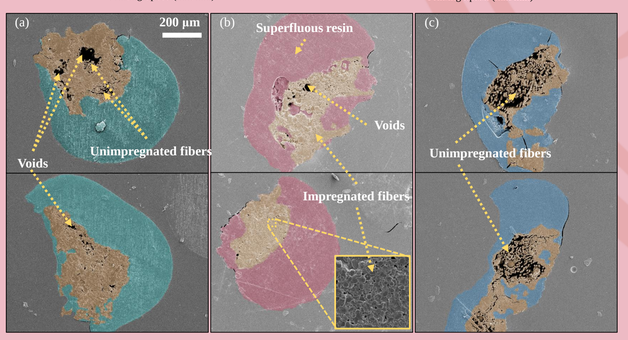
Process

Principle of floating 3D printing

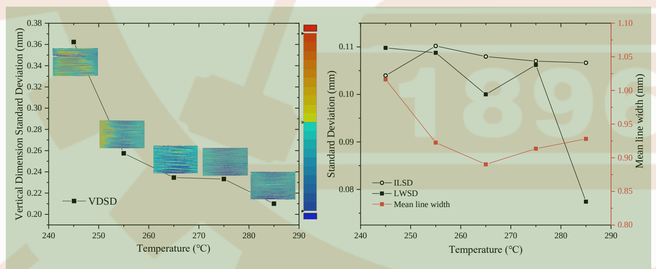


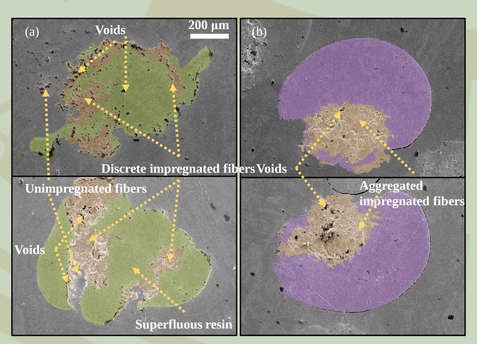
Research on printing process parameters



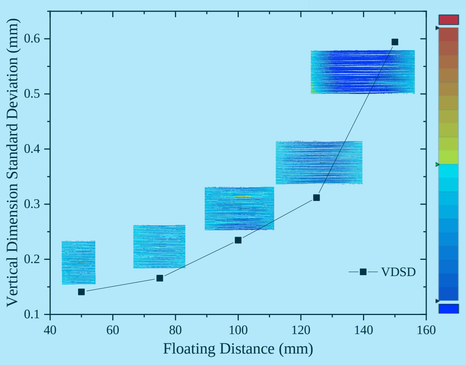


Printing speed

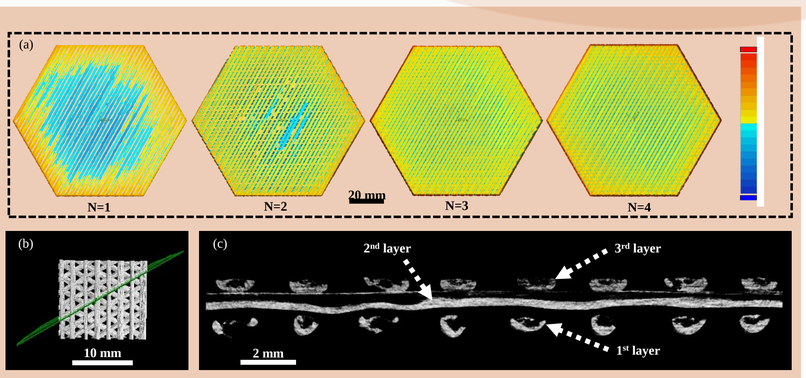




Printing temperature



Floating distance

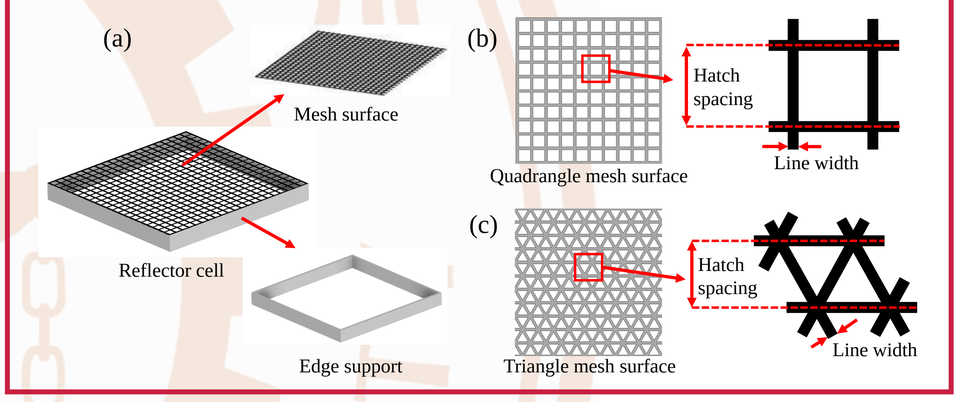


Layer count

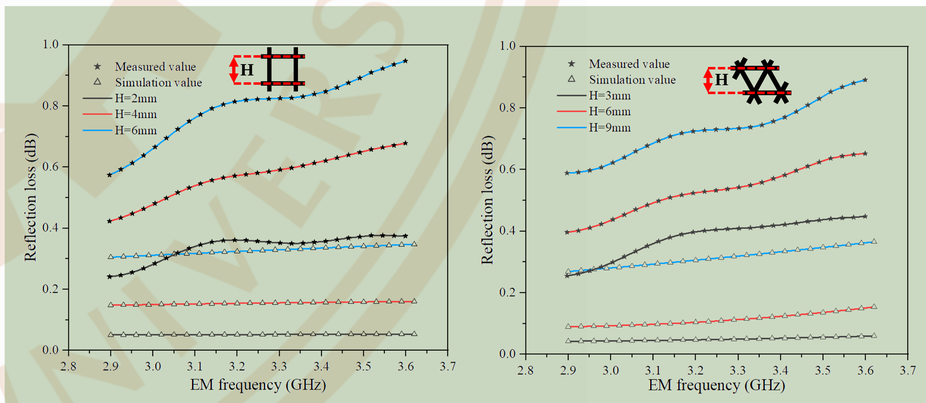
The influence of the process parameters on the forming quality can be used to guide the structure design of the mesh reflector.

Structure

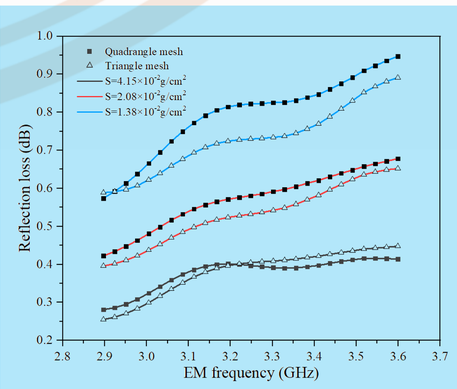
Mesh reflector structure design



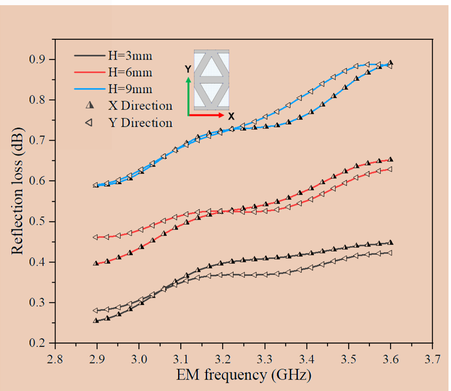
Research on structure parameters



Mesh size



Mesh shape



Electric field direction

The structural parameters are designed for functional applications to obtain high performance mesh reflectors.

Make the mesh reflector manufacturable

Make the mesh reflector usable