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Microwave Hybrid System in Carbonization and Graphitization

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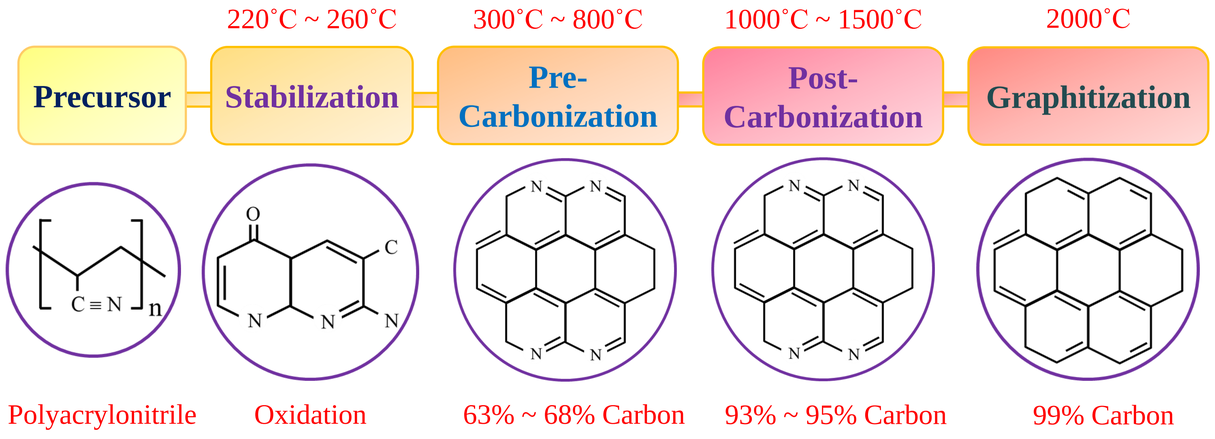
Abstract The manufacturing process of carbon fiber can be divided into four parts including stabilization, pre-carbonization, post-carbonization and graphitization. Among four parts, post-carbonization and graphitization must be carried out in higher temperature. According to some research, using microwave heating can get better efficiency in comparison with conventional heating. However, plasma is generated when microwaves are in higher temperature, and plasma damages carbon fiber. As a result, the goal of this experiment is to design a continuous microwave hybrid system to finish the carbonization and graphitization. To construct the microwave cavity, we use HFSS to simulate some parameters in order to meet the desired specification. And we will do some measurements to test whether the properties of products are up to the standard.

Manufacturing Process of Carbon fiber

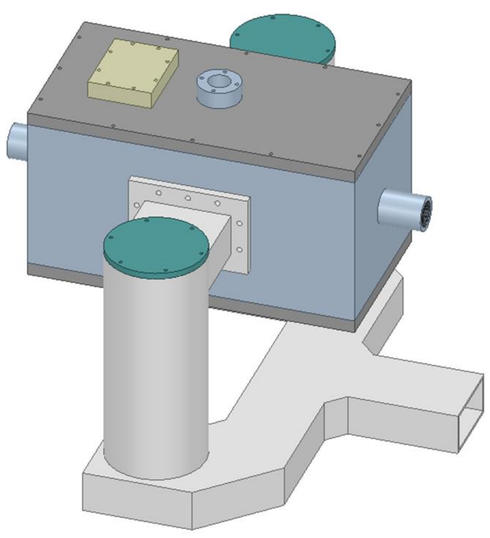
The heating procedure of carbon fiber includes stabilization, pre-carbonization, post-carbonization and graphitization. Among these steps, post-carbonization and graphitization must be carried out in higher temperature. According to Non-thermal microwave effect, we can get better results than conventional manufacturing. However, plasma is generated when microwaves are in higher temperature, and plasma damages carbon fiber. Consequently, we want to design a continuous microwave hybrid system to finish the carbonization and graphitization.



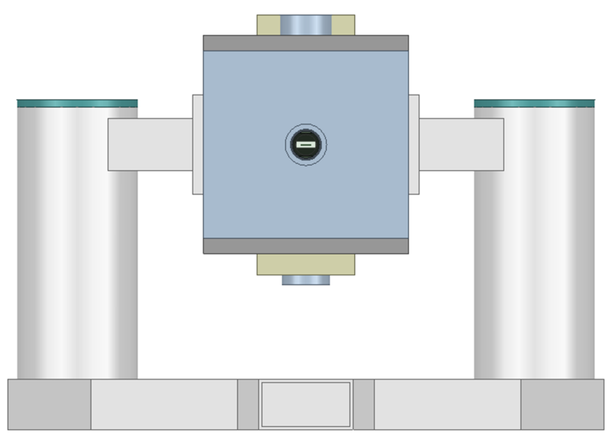
Cavity Design

In order to prevent plasma to damage the surface of carbon fiber, we use tungsten heating and combine it with microwave heating. Besides, we design antenna to make the microwave go into the main cavity to react.

Although the microwave absorption of carbon fiber in the stabilization is better than precursor, we introduce silicon carbide tube to enhance the efficiency of heating procedure.

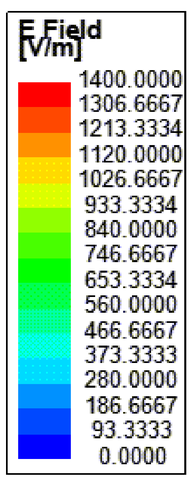


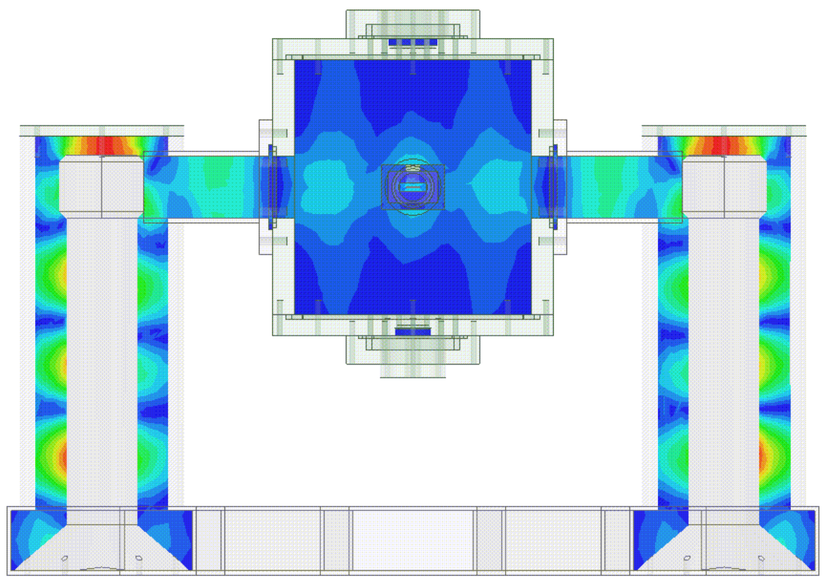
Side View



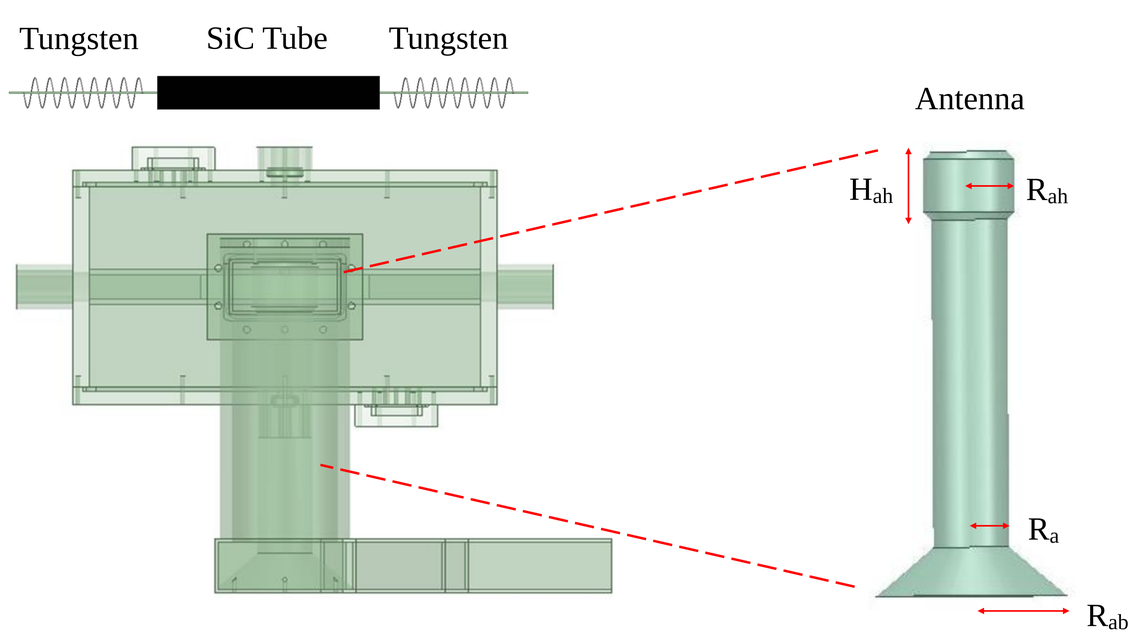
Front View

Electromagnetic Simulation

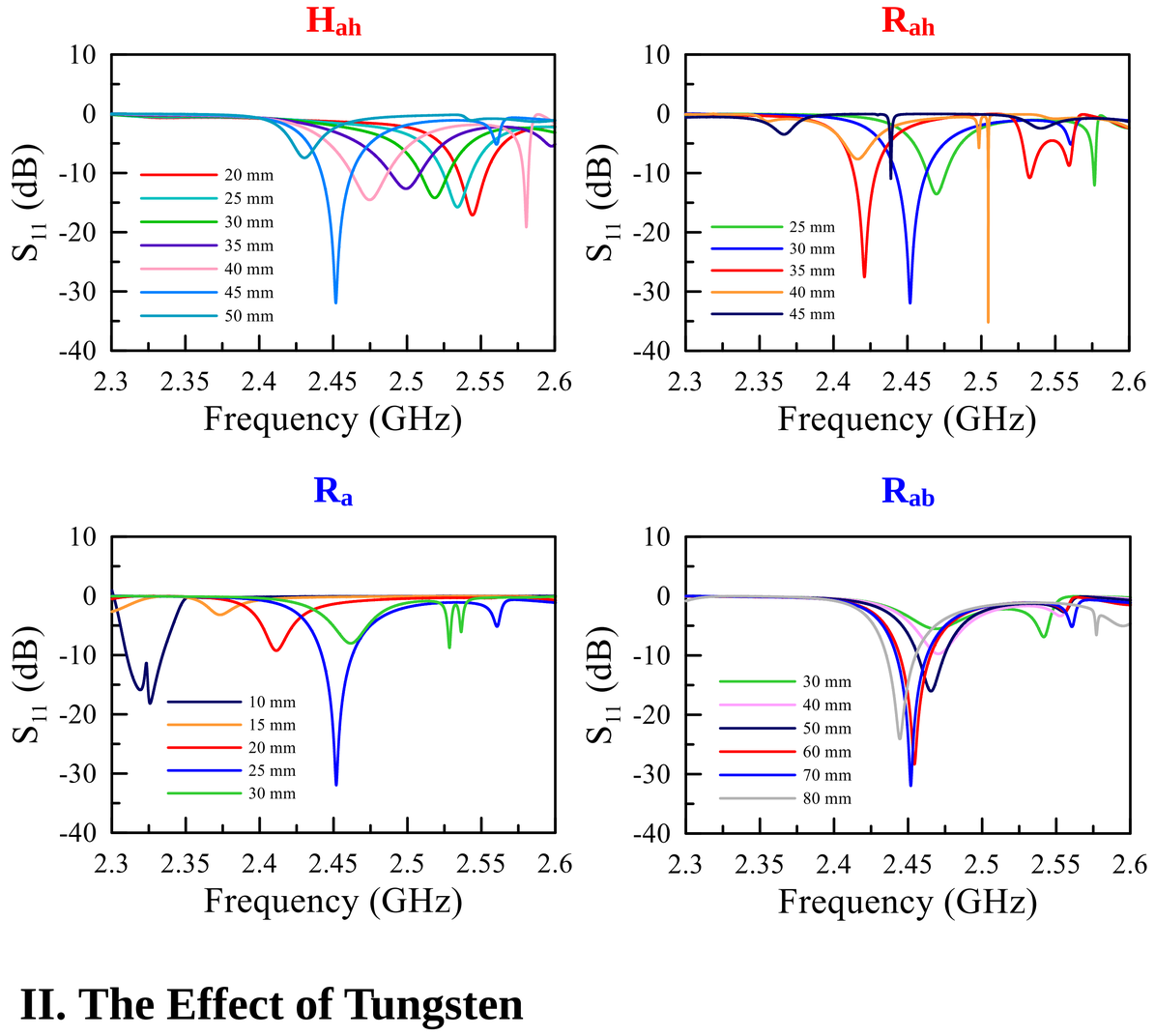




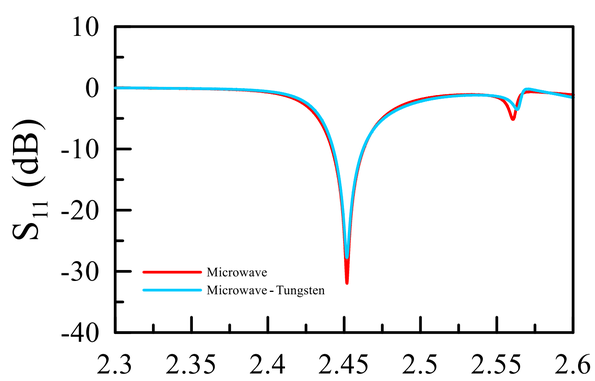
Simulation Setup

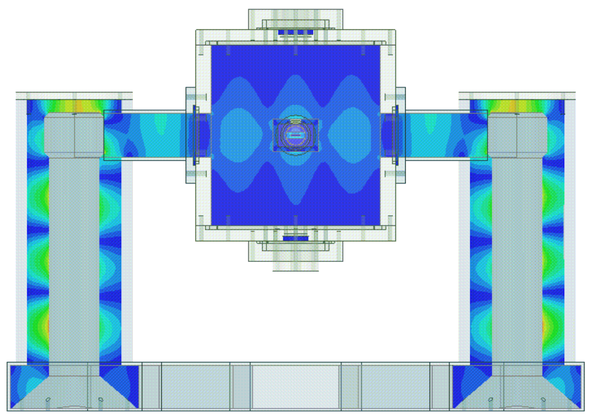


I. The Effect of Antenna



II. The Effect of Tungsten





Although tungsten is a kind of metal which may make the electric field unstable, we find that the influence of tungsten is less in this cavity. As a result, we can use thermoelectric effect to provide heating energy in the manufacturing process.

Reference

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2. G. Zhao, C. Zhang, L. Lv, J. Liu, S. Guo, *Diamond and Related Materials*, vol. 125, p. 108989, Mar 2022, doi: https://doi.org/10.1016/j.diamond.2022.108989.