4th Global Congress on Microwave Energy Applications
17-20 August 2022, Chengdu, Sichuan, China

Uniform Microwave Heating Based on Switchable Frequency Selective Surface

Chengrong Wang, Huacheng Zhu, Yang Yang, Liping Yan

College of Electronics and Information Engineering, Sichuan University, Chengdu, Sichuan, 610065, China

Abstract

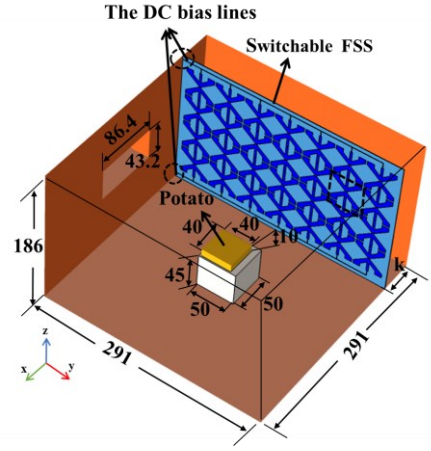
In order to improve the uniformity of microwave heating, a novel enclosure loaded with switchable frequency selective surface (FSS) is proposed. A switchable FSS is placed inside a microwave enclosure to enhance the heating uniformity. By turning ON or OFF the diodes in the unit cells with different bias voltage, the FSS structure can reflect or transmit the incident electromagnetic wave. As a result, the dimension size of the cavity can be changed in x-direction, so is the electromagnetic field distribution. The FSS was switched at a certain frequency during the microwave heating, leading to a more uniform electromagnetic field distribution in the enclosure. The results indicate that the switchable FSS can improve the microwave heating uniformity.

Key Words

Heating uniformity; Microwave heating; Switchable frequency selective surface (FSS)

Methodology

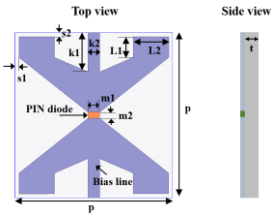
In order to investigate the microwave heating uniformity, the heating process of a piece of potato at 2450 MHz in the cavity is simulated using COMSOL Multiphysics.



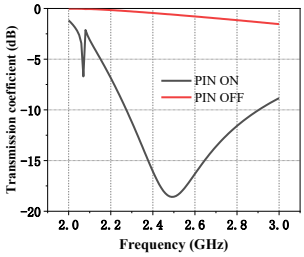
Geometry of the 3-D simulation model (unit: mm)

- A switchable FSS is placed inside a microwave enclosure to enhance the heating uniformity, as shown in above.
- The microwave power of 200 W is fed into the cavity for 20 s.

- By turning ON or OFF the diodes in the unit cells with different bias voltage, the FSS structure can reflect or transmit the incident electromagnetic wave[1].



Geometry of the proposed FSS structure



Simulated transmission coefficients of the switched FSS structure for ON and OFF states

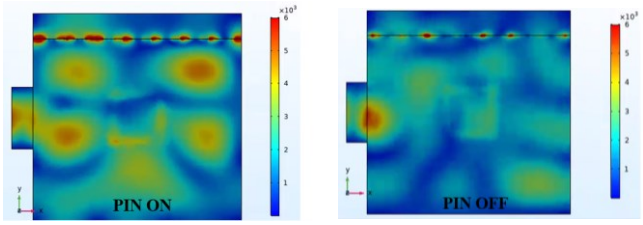
- In order to quantitatively discuss the uniformity of heating, the coefficient of variation (COV) which refers to the typical deviation between the temperature of each point and the average temperature is defined[2]. the smaller the COV, the uniform the heating.

$$\mathrm{COV}=\sqrt{\sum_{i=1}^{n}(T_i-\bar{T})^2}\Big/\sqrt{n}\,(\bar{T}-T_0)$$

where n is the total number of sample points (meshes) inside the potato, T_i is the temperature at these points and is the average temperature of all the points, T_0 is the initial temperature.

Results

- The electric field distribution inside the cavity varies because the size of the cavity is changed by the ON and OFF of the switchable FSS, as shown in below.



Simulated field distribution inside the cavity ($z = 0$) for ON and OFF status

- By controlling the diodes ON/OFF every two seconds, the COV can decrease to 0.34 when the distance of the switchable FSS to the metal wall of cavity is 40 mm, resulting in 35.8% improvement of uniformity compared to COV = 0.53 with no FSS.

Conclusion

- The novel enclosure loaded with switchable FSS could enhance the heating uniformity.
- The uniformity can be further improved through optimizing the FSS design and placement in the microwave heating enclosure.

References

[1] Zeng X , Meng G , Zhang L , et al. Design of a tuneable and broadband absorber using a switchable transmissive/reflective FSS, *IET Microw Antenna P*, 2018, 12(7): 1211-1215.

[2] Zhu H, He J, Hong T, et al. A rotary radiation structure for microwave heating uniformity improvement. *Appl Therm Eng*. 2018;141: 648-658.