

The influence of low temperature treatment on the focus of microwave heating of sphere materials

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Introduction: To solve the microwave's inhomogeneous heating when microwave applied in heating sphere materials, an ice shell is added on the materials, which can greatly improve microwave heating uniformity.

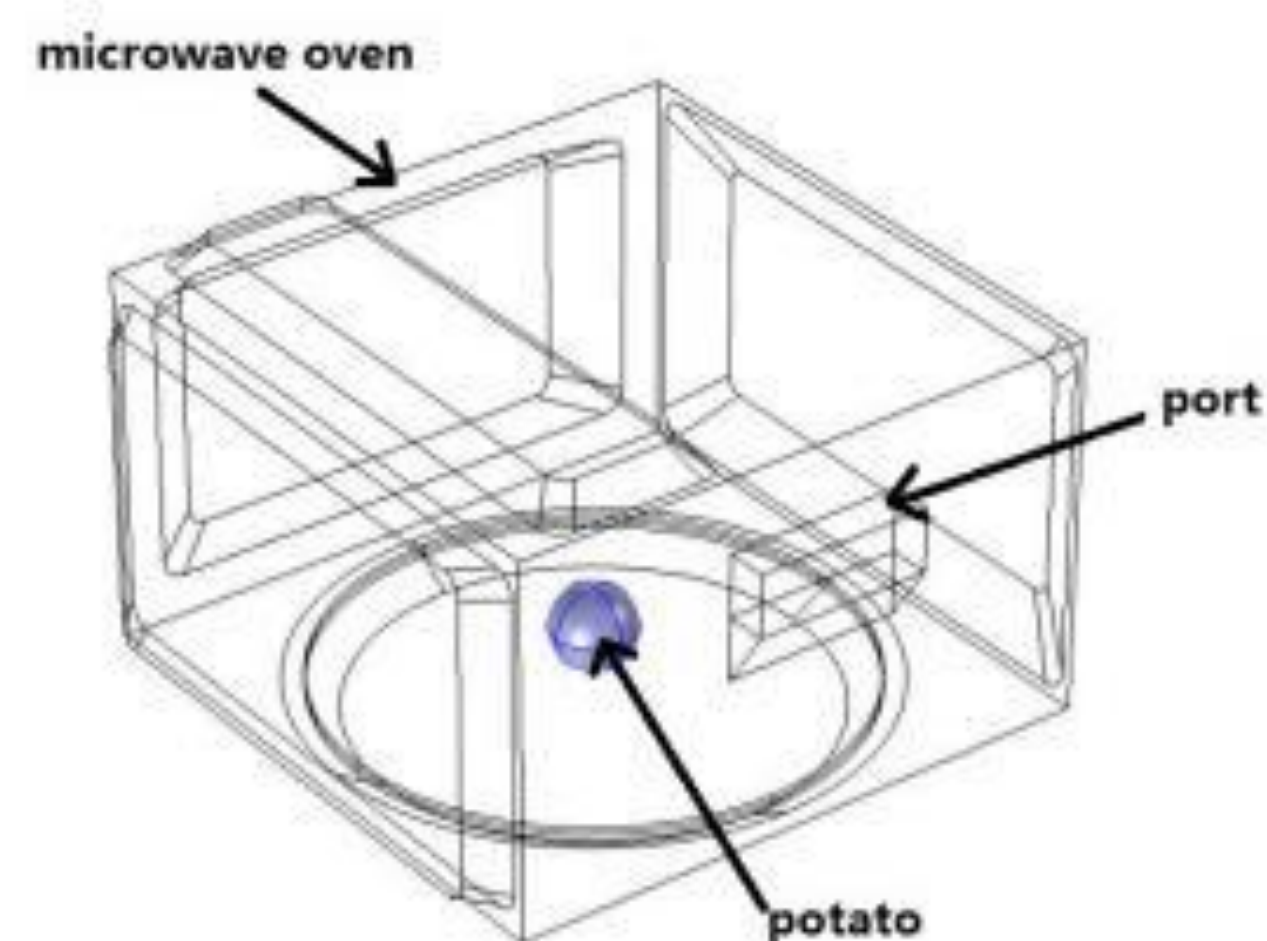


Figure 1. Schematic diagram of microwave oven model

Method: We use the multiphysics field analysis software COMSOL Multiphysics® based on finite element method to simulate the different states of spherical potatoes. RF module and Heat Transfer module calculate temperature distribution in the different states of spherical potatoes. Then the simulation results are verified by experiments through thermal infrared imaging system and optical fiber thermometer that measure the experimental results. The comparison of the simulation results prove the rationality and accuracy of the model.

Governing equation

Maxwell equations:

$$\begin{cases} \nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J} \\ \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \\ \vec{D} = \varepsilon \cdot \vec{E} \end{cases}$$

Heat transfer boundary condition:

$$k_n \left(\frac{\partial T}{\partial n} \right) \Big|_{MeS_3} + h(T_{S_3} - T_e) = 0$$

Results: The calculation results of the potatoes with different degree of freezing with and without ice shell.

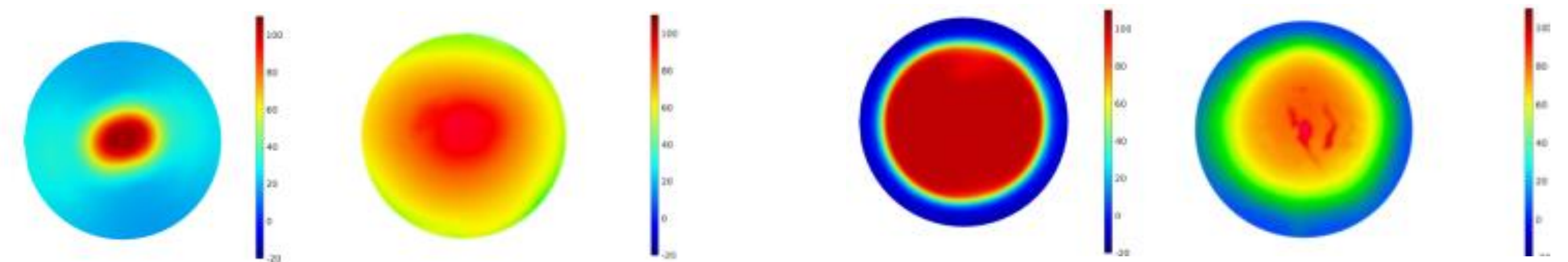


Fig 3. Comparison of temperature simulation and measured section (heating time: 10s, degree of freezing: non frozen, 1/4 frozen)

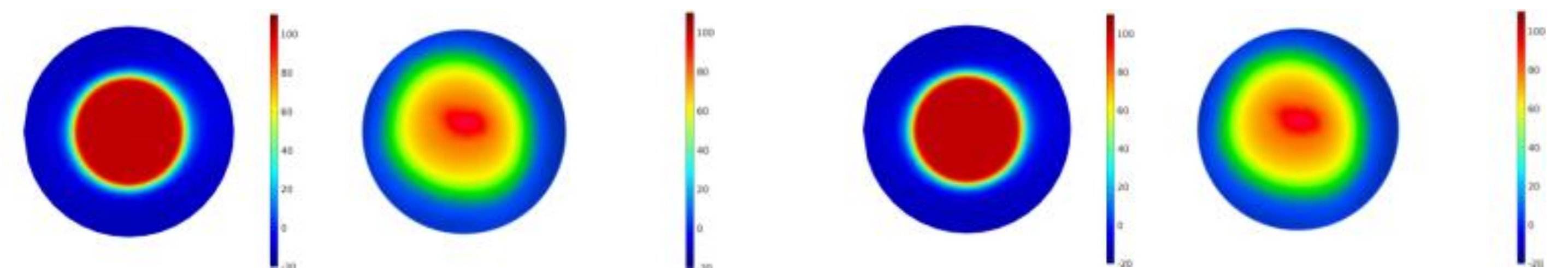


Fig 4. Comparison of temperature simulation and measured section (heating time: 10s, degree of freezing: 1/2 frozen, 3/4 frozen)

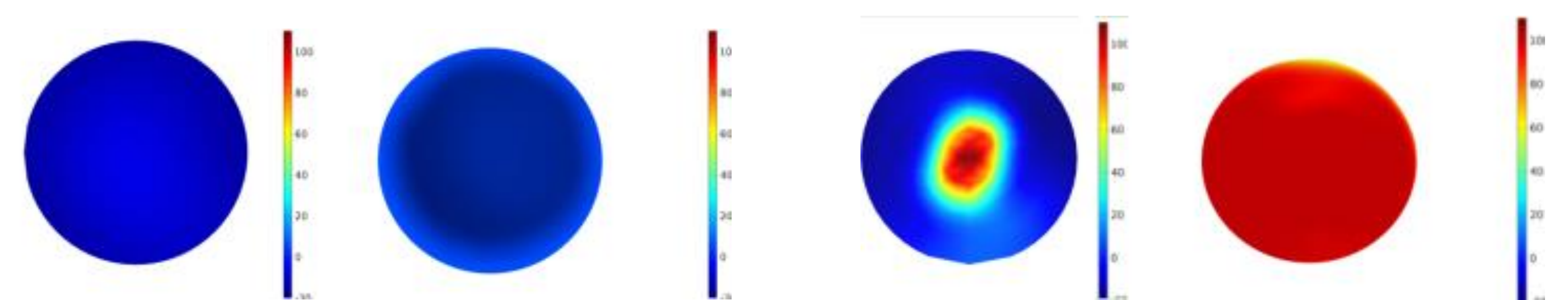


Fig 5. Comparison of temperature simulation and measured section (heating time: 10s, degree of freezing: total frozen, without ice shell, with ice shell)

Conclusion: We can see that low temperature treatment can effectively change the microwave energy distribution in the spherical material, which has a certain antifocusing effect. The improvement of sphere material heating uniformity will be helpful to low temperature treatment.