ABSTRACTS (MASTER THESIS)

Development of microwave heating devices using electromagnetic coupling

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Introduction

Microwave enables directly and selective heating that is different from conventional heating by heat transfer. Therefore microwave heating has been used in various fields recently. Cavity resonators are generally used as microwave heating devices. However, they are difficult to uniformly heat multiple samples at the same time. Moreover, the resonator requires the metal shield, which expands the size of cavity. Thus, conditions of the heated object in the cavity are hardly observed. A new heating device using electromagnetic coupling is developed in order to solve the above problem. Electromagnetic coupling techniques are often used in fields of wireless power transfer. It is possible to transmit energy without radiating electromagnetic wave using resonators coupling each other. Using this technique, a proposed heating device enables to heat samples in the open space with less microwave leakage.

The results of simulations and experiments

In this paper, heating devices using 2.45 GHz half-wavelength resonators are designed with a band pass filters design theory. We designed two types of devices to heat a heating sample and compared with each other from the perspective of heat efficiency and microwave leakage. One is a device using narrow side coupling and the other one is a device using broad side coupling. The simulation model of the device using broad side coupling is shown in Figure 1. HFSS (High Frequency Structural Simulator) using finite element method was used for simulation. As the results of simulation, although heat efficiency of the latter one is lower than former one, the microwave leakage is lower than former one. Therefore, broadside coupling type device was selected to experiment heating samples. In order to meet the radio wave protection guideline, the input power is limited below 30W and in this case absorption power is 6.31 W. This power is enough to heat 4.3mL pure water to 100 ◦C. We also designed the device to uniformly heat two samples. Modifying the resonator position, heating efficiency became higher and microwave leakage became lower. As the results, this device enables to heat two pure water to 80 ◦C in order to meet the JIS standard of microwave oven. The real device that can heat two pure water uniformly at the same time is shown in Figure 2. Moreover, the experimental results of heating two pure water samples showed that changing microwave frequency is valid for improvement of heating efficiency.

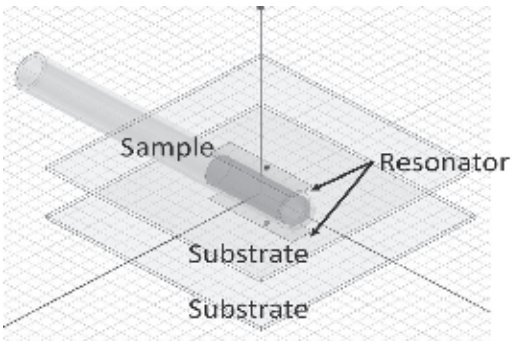

Figure 1. Simulation model of a heating device using broad side coupling

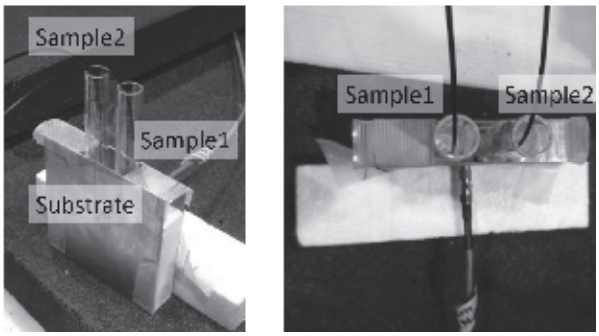

Figure 2. The experimental device