§31. Studies on Microwave/Millimeter-wave Absorption Measurement of Powder Materials

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We have been measured dielectric and absorption behaviors of ceramics at microwave and millimeter-wave region as a basis of developing microwave and millimeter-wave heating technology. R. Roy et al. reported that metal powders can be sintered by microwave heating[1], and many attentions have been attracted on the microwave heating of metal powders. Enlightened from their work, we started to measure microwave and millimeter wave adsorption behaviors of metal powders[2]. In this report, we will report microwave absorption measurement results for Co and Cu powders at elevated temperature by using an experimental microwave absorption measurement system.

As object materials, chemical grade pure metal powders (Wako Pure Chemical Industries LTD.; Co and Cu powders) were used. Microwave absorption behaviors were measured by using the experimental microwave absorption measurement system[2]. Sizes of the circular wave-guide fixtures made of stainless steel were 660mm long and 16mm internal diameter, and the matching frequencies was adjusted around 13GHz. A vector network analyzer (Wiltron 37269A) was used for the measurement. Sample powder was packed in the bottom end in the wave-guide fixture and reflection signal was measured at another side with the microwave network analyzer. One end of the fixture, in which sample powder was packed, was heated in a vacuum furnace. Measurements were done with a heating rate of 5°C/min until the sample temperature excess 900°C. Change of signal power from the sample during heating was measured using time domain mode of the microwave network analyzer.

Figs. 1 and 2 show a microwave absorption measurement results during vacuum heating of Co and Cu powder. Blank data, a measuring result of empty wave-guide fixture, is also plotted in the figures for comparison. Microwave reflection power form cobalt powder at room temperature is decreased about 2dB in comparison with the blank data. It means that roughly packed Co powder absorbs electromagnetic wave power. During the vacuum heating, reflection power start to increase around 600°C and it reaches almost same value with the value of empty fixture at 800°C, indicating that Co particles are electrically isolated up to 600°C and start to make electrical connects each other at the temperature. During the heating above 700°C and the cooling, the plot of reflection power form bottom traces the result of blank measurement. From these results, at 700°C, it is considered that almost all particles of cobalt

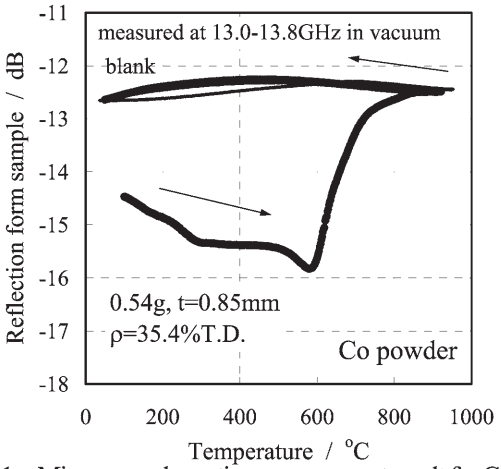

Fig. 1 Microwave absorption measurement result for Co powder.

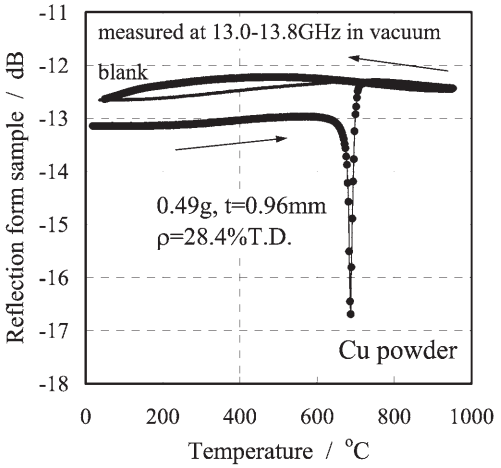

Fig. 2 Microwave absorption measurement result for Cu powder.

are electrically connected each other and the compacted body shows a behavior similar to a bulky metal surface, i.e. it behaves as a reflector for microwave. Fig. 2 shows a microwave measurement result for Cu powder. Reflection power start to decrease around 650°C, then make a peak and increase to reach same value of the empty fixture at 700°C. This result means that Cu powders make electric connections at a narrow temperature range than Co powder.

This result suggests that when metal powders were subjected to measure microwave absorption at elevated temperature, roughly packed metal powders absorb microwave at room temperature, and they become reflectors for microwave after metal particles make electrical connections each other during heating.

1) Roy, R. et al., Nature **399**, (1999), 668
2) Sano, S. et al., ISIJ International **47**, (2007), 588