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

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We have been measured dielectric and absorption behaviors of metal powders at microwave and millimeter-wave region under heating as a basis of developing microwave and millimeter-wave heating technology. We reported that metal powders absorb microwave power at room temperature. During vacuum heating, the microwave absorbency begins to decrease at certain temperature and became a microwave reflector. We supposed that almost all particles in a metal powder compact body are electrically isolated each other and it absorbs microwave power, and it changes to a microwave reflector with the progress of sintering, i.e. with the progress of formation of electrical connections between metal particles. The objective of this study is to reveal this assumption. Microwave absorbency changes in temperature and RF impedances of gold powder, which is expected makes electrical connections even at room temperature, copper powder and iron powder were measured..

As object materials, chemical grade pure metal powders (Wako Pure Chemical Industries LTD.; iron and copper powders) and gold powder (ISHIFUKU Metal Industry Co., Ltd.; TYPE S) are used. Microwave absorption behavior at elevated temperature is measured by using a measurement system consists of a circular wave-guide fixture, a vacuum furnace and a microwave network analyzer. Sizes of the circular wave-guide fixtures made of stainless steel are 660mm long and 16mm internal diameter, and the matching frequencies is adjusted around 13GHz. Change of signal power from the sample during heating is measured using time domain mode of the microwave network analyzer (Wiltron 37269A) up to 900°C. RF impedance is measured by using a LCR meter (HIOKI Type 3532) and a handmaid sample holder. The sample holder is consists of two brass electrodes, 25mm diameter, and an acryl sleeve. Connection cable between LCR meter and sample holder is calibrated prior to measurements. Measurement frequency range is from 42Hz to 5MHz.

Fig. 1 shows microwave absorption measurement results during vacuum heating of Cu and Au powders. Blank data, a measuring result of empty wave-guide fixture, is also plotted in the figures for comparison. The difference in reflection between gold powder and blank measurements goes within 0.05dB in measured temperature range as seen in the lower figure. Even at room temperature, roughly packed gold powder does not absorb microwave power different from copper powders.

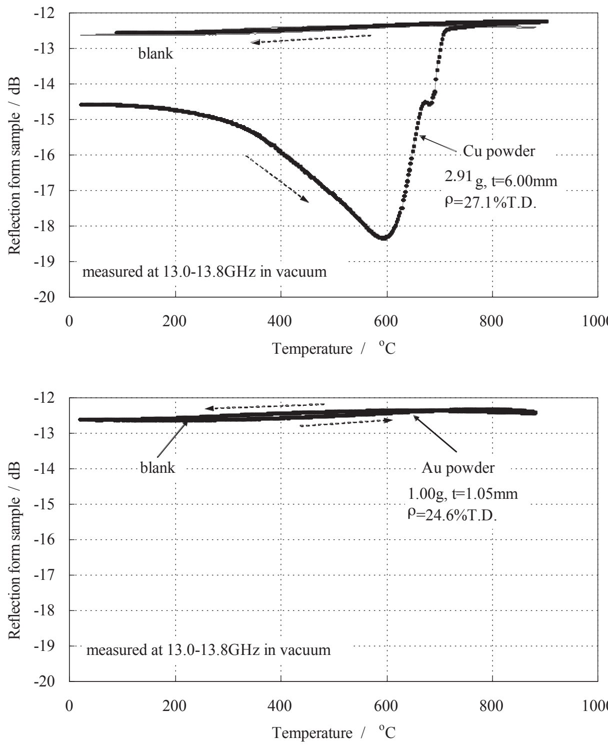

Fig.1 Microwave absorption measurement results for metal powders.

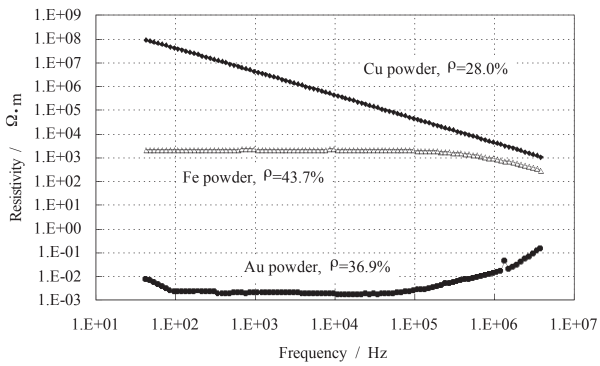

Fig.2 RF impedance measurement results for metal powders.

This result suggests that gold powder makes electrical connections between particles even when the powder was roughly packed.

Fig. 2 shows RF impedance measurement results of metal powders, iron, copper and gold. As expected, gold powder shows very low impedance, i.e. very low resistivity, over the measurement frequency range. In contrast with gold powder, iron and copper powders show high impedance, and impedances decreased with the increase of frequency, i.e. dielectric like responses.

From these results, it was thought that electrical isolation of metal particles in a powder compact body is an important factor to absorb microwave power by metal powders.

1) Sano, S et al., Proc. AMPERE 2009, (2009) 432-435