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Fundamentals and Applications of Microwave Heating of Metals

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ABSTRACT

As the fundamentals of microwave (MW) interaction with metals, boundary conditions of electromagnetic (EM) field on metal surface are discussed, which consider the EM field in the metal surface layer in terms of surface impedance. Experimental report on heating behavior of separated electric (E-) and magnetic (H-) fields of metal particles and films are shown. Temperature peak formation at the first heating curves was observed in both cases, which are discussed considering the microstructural alteration by MW heating.

In the last half section, various reports on MW heating of metal are reviewed. They were classified into the major application for sintering and materials fabrication. And also, its usage as a heating aid of glasses and soils, topics on metal hydride and catalytic metal particles are included.

KEYWORDS: Microwave, heating, metals

INTRODUCTION

In history of microwave application for heating, metal heating had been a minor application area, because the bulk metals are not possibly heated well, different from the other materials, such as food, organics, and some kinds of ceramics. In 1988, one of an interesting experimental result is reported by Walkievics [Walkievicz, G. et al., 1988], who tested heating of various metal powders, and demonstrated there are differences in their heating rates. In 1991-92, some reports related with heating of metals (cermets, composites) were presented in MRS symposium [Lorenson et al., 1991; Bescher et al., 1992]. In '95, Mingos attempted synthesis of metal sulfide by MW heating of metals [Whittaker and D.P.Mingos, 1995]. In '99, Roy [Roy et al., 1999] reported microwave sintering of metals in Nature magazine. And later, they attempted series of studies on heating of metals in the separated Electric (E-) and magnetic (H-) MW fields [Cheng et al., 2002; Roy et al., 2002]. In Europe, metal heating studies also have been performed [Rodiger et al., 1998; Leonelli et al., 2008]. Series of these researches further motivated the MW researchers to be directed to the metal heating studies.

In Japan, the authors held a special symposium in annual meeting of Japan Institute of Metals in 2005 on this topic. The author also published a review article [Yoshikawa, 2009] where the application fields are classified and authors' recent results were introduced. Some content will be also presented in this article.

In this study, fundamentals of microwave interaction with metals will be discussed, first and then heating phenomena of metal particles and films in the separated E- and Hfield heating