Metal-to-ceramic bonding in \((\text{Al}_2\text{O}_3 + \text{Fe})\) cermet studied by Mössbauer spectroscopy

C BANSAL
School of Physics, University of Hyderabad, Hyderabad 500 134, India

Abstract. Although a strong thermo-compression bond is formed between some metals and ceramics, the bonding mechanism is not clearly understood. In the present work \(^{57}\text{Fe}\) Mössbauer spectroscopic study of \((\text{Al}_2\text{O}_3 + \text{Fe})\) cermet is carried out to investigate the reason of adherence at the metal-ceramic interface. The isomer shift, quadrupole splitting and linewidths of Mössbauer spectra indicate that a compound of the spinel type \(\text{FeO} \cdot \text{Al}_2\text{O}_3\) is formed but the site symmetry around \(\text{Fe}\) may be locally distorted by a small amount as compared to that for stoichiometric \(\text{FeAl}_2\text{O}_4\).

Keywords. Cermet; thermo-compression bonds; Mössbauer spectroscopy; spinel.

1. Introduction

A strong bonding between metals and ceramics is produced by thermal compression. It is of interest to find out why adherence is produced between a non-reactive metal (such as \(\text{Fe}\)) and a refractory oxide \((\text{Al}_2\text{O}_3)\) although from a thermodynamic point of view the free energy decrease for metal oxide formation \((- 58 \text{ kcal for } \text{FeO})\) is less than the energy required to reduce the refractory oxide \((- 125 \text{ kcal per oxygen atom for } \text{Al}_2\text{O}_3)\). The methods used to produce these composites and the earlier investigations have been discussed by Klomp (1970). It was earlier hypothesised that there is first an evaporation of \(\text{Fe}\) on alumina surface and subsequently a contact between the metal-metal interface which results in bonding. However, Klomp and Lindenhovius (1978) prepared sintered compacts of alumina and iron powders to increase surface area and found no evidence for such a mechanism. The resistivity measured for the composite was same as that for pure alumina indicating no increase in metal-metal contacts. Mössbauer spectroscopy is ideally suited to study the bonding mechanism and an investigation of \((\text{Al}_2\text{O}_3 + \text{Fe})\) system is presented in this work.

2. Experimental procedure

The samples were prepared by sandwiching an alpha iron foil of 10 \(\mu\text{m}\) thickness between two sintered alumina discs (1 cm diameter \(\times\) 0.2 cm thickness). These were then placed under a tightened screw-cap under a pressure of about 0.2 kg/cm\(^2\) and heated in argon atmosphere at 1250 \(\text{C}\) for 30 minutes (figure 1). This temperature corresponds to 0.9 \(T_m\) (where \(T_m\) is the melting point of \(\text{Fe}\)) as recommended by Klomps (1970). Mössbauer spectra were recorded for the sample in transmission geometry with a \(^{57}\text{Co}\) in rhodium source.
3. Results

The Mössbauer spectrum at room temperature, shown in figure 2, consists of a broadened doublet near the centre together with a small absorption in the higher velocity regions. The absorption in the higher velocity regions was identified as that due