

High-Pressure Phase Transition and Demagnetization in Shock Compressed Fe-Mn Alloys*

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Shock deformation of Fe-Mn alloys up to 14 wt% Mn results in a shock-induced phase transformation. It has been shown that bcc martensite with manganese in the range 4–16 wt% transforms to a stable close-packed phase under pressure without the occurrence of reversion. The addition of manganese to iron also decreases the transition pressure from 133 kbar for pure Fe to less than 70 kbar for Fe-14Mn. X-ray diffraction, electron-probe microanalysis, electron microscopy, and density results indicate that for the Fe-4Mn and Fe-7Mn alloys, the fcc phase has been stabilized after shock deformation, while the ϵ phase has been stabilized for the Fe-14Mn alloy. Saturation magnetization studies have detected a residual reduction in magnetization due to the retainment of the high-pressure phase.

I. INTRODUCTION

A magnetic phase transition in iron in the vicinity of 130 kbar has been confirmed in both dynamic and static experiments.^{1–3} Recent experiments indicate that a partial phase transition to the nonmagnetic ϵ phase (hcp) can occur at shock pressures as low as 50 kbar.⁴ However, since iron reverts to its initial structure on relief, residual phase changes have not been observed.

The temperature-pressure diagram for iron, shown in Fig. 1, can be modified by the addition of alloying elements to iron. Specifically, the stability of the close-packed phase of iron can be increased by the addition of manganese.⁵ The phase diagram is shown in Fig. 2. Magnetic susceptibility measurements⁶ of Fe-Mn alloys that had been shocked at pressures up to 300 kbar indicated that the high-pressure phase could be retained at zero pressure. Since the duration of a shock-wave pressure pulse is about 10^{-6}

sec, any phase transformation which occurred must be martensitic.

The present work is an investigation of the residual magnetic and crystallographic phase changes in shock-deformed iron-manganese alloys. Our experimental results are related to shock-induced martensitic and magnetic transformations. We will show that in Fe-Mn density, x-ray microstructural, and magnetization changes are due to the partial retention of the high-pressure phase.

II. EXPERIMENTAL DETAILS

A. Sample Preparation

The composition of the alloys included in this study is given in Table I. All alloys were prepared using an electrolytic grade of iron and high-purity manganese (99.9%); 0.007 wt% carbon was the main im-

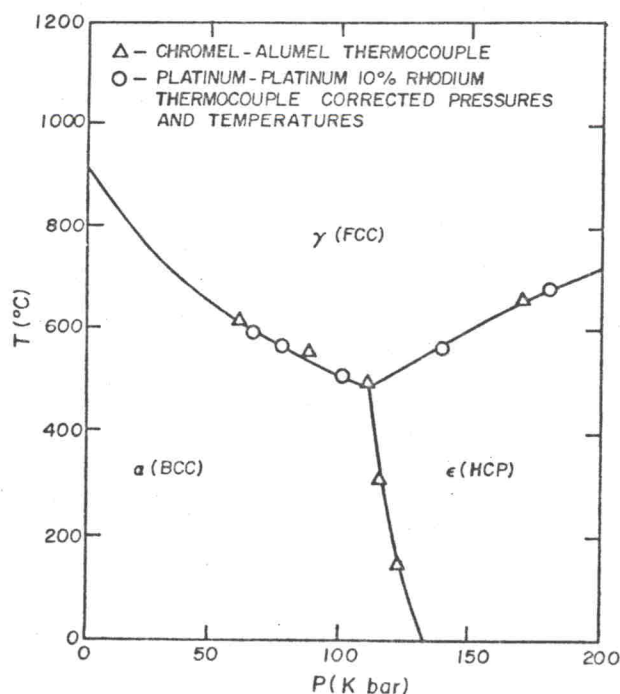


FIG. 1. Temperature-pressure diagram for iron (see Ref. 2).

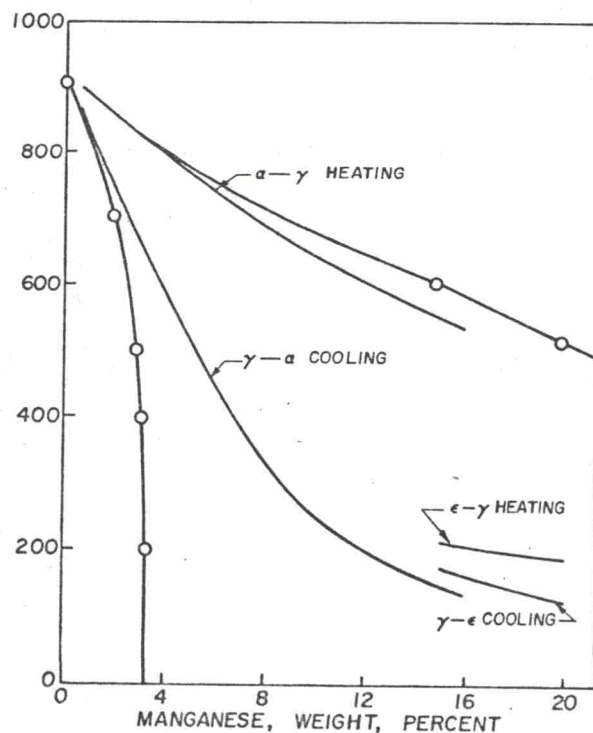


FIG. 2. Transformation and equilibrium diagram for the Fe-Mn system.