sure diagram by increasing the field of stability of the fcc and hcp phase. Therefore, the shock loading of a bcc-martensite structure with an appropriate solute content results in an $\alpha' \rightarrow \gamma$ or $\alpha' \rightarrow \epsilon$ transformation. Figure 12 shows that the triple point has been lowered to about 90 kbar for Fe-7Mn and 70 kbar for Fe-14Mn, and hence the fcc and hcp fields have been greatly stabilized with respect to the bcc phase. The $T_0$-$P$ lines for the Fe-7Mn and Fe-14Mn alloys as a first approximation were drawn parallel to the phase lines for pure iron, and were also made to pass through the two experimentally known states $(T_0, P=0)$ and $(T_c, P_c)$. The presure $P_c$ is the transformation pressure obtained from the Fe-Mn Hugoniot, and $T_c$ is the temperature of the compressed solid at $P_c$ calculated using the equations of McQueen *et al.*[21] From the present observations the phase line between the fcc and hcp phase must deviate as shown in Fig. 12 so as to explain the room-temperature stability of fcc for Fe-7Mn and hcp for Fe-14Mn.

The calculation of the initial $P$-$T_0$ slope ($P=0$, $T=T_0$) for Fe-7Mn and Fe-14Mn is based on the Calusius-Clapyron equation. The initial $PT$ slope for the bcc$\rightarrow$ fcc transformation has the following values:

$$\left(\frac{dT}{dP}\right)^{\alpha\rightarrow\gamma} = -10.5\ ^\circ\mathrm{K/kbar}.$$

The enthalpy change $\Delta H_{\alpha-\gamma}$ and the entropy change $\Delta S_{\alpha-\gamma}$ are functions of temperature and solute concentration.[22] Therefore the slope of the $P$-$T_0$ curve will deviate from the initial $dT/dP$ slope and from the slope of the pure-iron phase lines.

In addition to the thermodynamic considerations, dislocations generated by (a) the quench and (b) shock deformation and their interactions may stabilize the high-pressure phases. The first set of dislocations produced during quenching will have an internal stress field which is related to the shear mechanism during the martensitic transformation via quenching; an entirely different set of dislocations is produced by the martensitic transformation under shock, these two sets of dislocations interacting to form an extremely high dislocation density. When the shock pressure is removed, an entirely new set of dislocations must be produced in order for the high-pressure phase to revert to bcc. The shear process necessary for this reversion is prevented by the interaction of the existing dislocations. It is surprising that reversion of the high-pressure phase does not even occur when the specimens are cooled to liquid-nitrogen temperatures. Experiments will be performed to see if reversion occurs when specimens are cooled to 4.2 °K.

## V. CONCLUSIONS

Based on the experimental findings of this work, shock deformation of quenched Fe-4Mn, Fe-7Mn, and Fe-14Mn results in a shock-induced phase transformation with the high-pressure phase retained upon relief. Furnace-cooled alloys up to 14 wt% Mn do not show retained close-packed phases after shocking. These results are explained by the conclusion that bcc iron with at least 4% Mn in solid solution will retain the close-packed phase produced by shock loading. The addition of manganese to iron also decreases the transition pressure from 133 kbar to less than 90 kbar for Fe-14Mn.

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