CHAPTER 7

SUMMARY AND CONCLUSIONS

Little is known about atomic mechanisms which cause ultrafast phase transitions. This void in knowledge is partly due to lack of experimental data. Need for data and understanding of the transformation process is the reason for this study. Iron was chosen as the material to study primarily because of the wealth of existing thermodynamic and equation of state data.

Experimental intent of this study was to measure evolution of the plastic I shock in polycrystalline Armco iron when final driving stress is near 200 kbar. The most significant experimental result is that little or no variation of plastic I wave amplitude occurs for propagation distances between 0.9 and 6.35 mm. This implies a relaxation time of about 0.05 μsec or less for initial stages of the alpha to epsilon transformation. When the single measurement at 25.4-mm propagation distance is included with close-in data, one infers a slow variation of transformation stress with distance superimposed on the rapid decay for propagation distance of less than 1 mm. Inference of initial decay rate depends on the assumption that initial compression at the impact surface is entirely in the alpha phase.

Further results, which are essentially corrobative, are that:

1. Elastic precursor amplitude increases as sample thickness is decreased.

2. Transformation stress measured in a 25.4-mm-thick sample is 131.4 ± 3.3 kbar.

3. Relative volume behind the plastic II wave is $V_3/V_0 = 0.871 \pm .008$ for a stress of 201 ± 8.4 kbar.

4. Rise time in the plastic II shock front is 0.18 ± .02 μsec.

These results are in essential agreement with those of earlier experiments reported in References 36, 2, 2, and 23, respectively.

In addition to this study other data exist which relate to kinetics of transformation. They are:

1. Rise times of 0.2-0.3 μsec for the plastic II shock measured by Novikov, et al.[23] and more recently by Barker[15] and this author.

2. Metallurgical measurements of a hardness transformation zone thickness in shocked iron by Smith[24] and more recently by Smith and Fowler.[25]

3. Slow decay of the plastic I shock in iron first observed by Minshall[22] and confirmed by this work.

Considering all but the slow decay of plastic I stress, the inferred relaxation time from the data was approximately equal to 0.1 ± .05 μsec. This gives a lower bound for the initial transformation rate of 10^7/sec for the second phase.

The slow decay in the plastic I shock amplitude may be due to decay in the elastic precursor amplitude for iron samples thicker than 1 mm. This is suggested by the apparently constant stress jump in the plastic I shock. Because of effects of wave interactions, this conclusion is not firm; experiments with samples treated to modify precursor structure may improve understanding of this phenomenon.