CHAPTER 1

INTRODUCTION

Under the influence of shock waves certain materials undergo polymorphic transformations. The time available in a shock experiment for such a transformation to occur does not exceed a few microseconds, yet the same transformation may require minutes or hours for completion in a static experiment. This large transformation rate is an important distinctive feature of transformations in shock waves. Little is known about atomic mechanisms which cause these ultrafast transformations. This void in knowledge is partly due to lack of experimental data. The need for data and understanding of the transformation process is the reason for this work.

1.1. General Background of Polymorphism

The ability of a compound to crystallize in different structures is well-established. Bridgman[1] showed that many materials undergo a transformation to a new structure under the influence of pressure. In more recent times it has been shown that many transformations observed statically are also observed dynamically; i.e., under shock compression. Examples of this are found in materials such as iron,[2,3] carbon,[4,5] bismuth,[6,7] silicon,[8,9] boron nitride,[10,11] and many others.

To understand the varied aspects of polymorphism it is necessary to relate static results to dynamic measurements. Caution must be exercised in making this relation because of the distinct differences in compression methods. A plane shock wave results in uniaxial compression at very large strain rates accompanied with large shear forces. These properties can result in defect formation, plastic flow, and other irreversible effects.

Some progress in relating static and dynamic results has been made by identifying shear deformation as a likely mechanism that accelerates transformations. The addition of shear to a sample under static compression has been shown to accelerate the transformation process.[12] The accelerating effect of adding shear to static experiments has led Leiserowitz, et al.[13] to draw a controversial analogy between experiments on shock wave compression and experiments of hydrostatic pressure with shear stresses added. The role shear deformation plays in accelerating transformation rates in dynamic experiments is difficult to ascertain since an elevation of hydrostatic pressure above that normally required to produce the transformation can greatly increase the transformation rate.[14] To date no explanation for differences between static and dynamic rates is satisfactory.

In dynamic experiments the transformation rate affects the shape and amplitude of shock waves, which evolve towards the steady state. Studying evolution of a wave in time provides some understanding of dynamic polymorphism. Experimental shock studies of the kinetics of solid-solid phase transformations have been limited primarily to four materials: iron,[2,15]