Modified for the Web

Shock Compression Studies of Phase Changing Materials with PVDF and Manganin Gauges

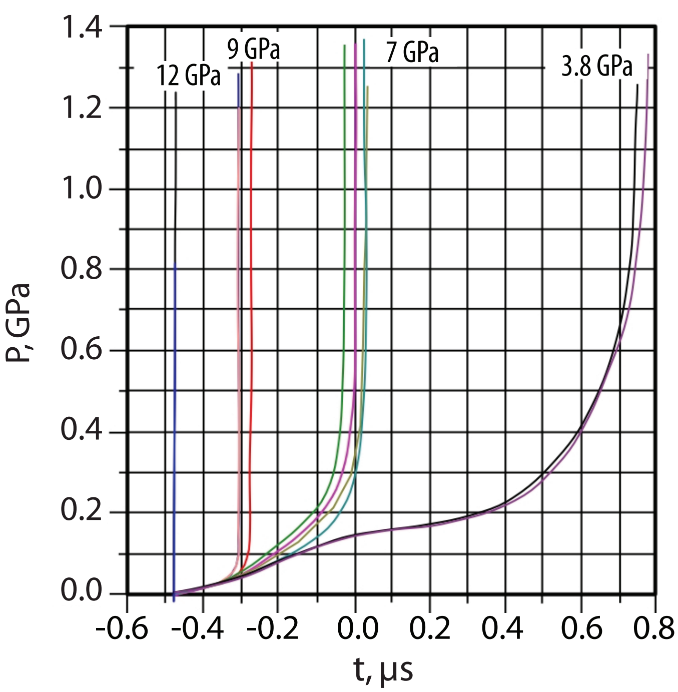
Principal Investigators: Frank J. Cherne III, Brian J. Jensen (LANL), and Mikhail V. Zhernokletov (VNIIEF)

Project Description

The development of an understanding of shock-induced phase transitions and models that describe these transitions is an area of active research. Included in this research is an evaluation of existing experimental techniques applied to materials that undergo large volume collapse as a result of phase transition. PVDF sensors will be employed to obtain sound velocities at shock conditions below which traditional photon emitting liquid sensors are applicable.

Under this project, experimental studies of the profiles of pressures, sound velocities, and temperatures for metals, organic and nonorganic compositions, which undergo phase transitions under shock compression and release, will be performed. This project is multi-faceted, including investigations of the shock-induced phase transition properties for three metals, namely, titanium, tin, and cerium. Contrary to expectation, preliminary results have shown that at the pressures under investigation, there is no indication of cerium metal reverting back to its low-pressure phase upon unloading. These preliminary studies included measurements of the sound speed of cerium under high pressure.

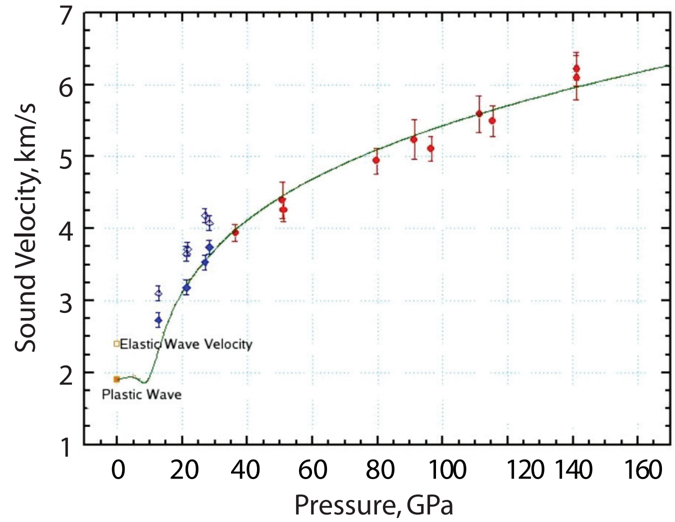
This project will include an investigation of the (γ–α) isomorphic solid-solid phase transition in cerium and the (α–ω) polymorphic solid-solid phase transition in titanium. Also to be investigated are the sound velocities in tin around the solid-liquid transition using the rarefaction overtake technique. The wave structure for these transitions will be thoroughly investigated, examining both the shock wave and its release wave structure. The gauges used for this work will be of the PVDF and Manganin variety. An additional necessary component of this research will be to examine the effect of temperature upon a variety of organic and inorganic compounds used during the study of phase transitions. With the data, we will be able to better understand the thermal effects produced during studies of shock-induced phase transitions.



Pressure versus time in cerium.

Technical Purpose and Benefits

The development of experimental techniques that foster the acquisition of data that can then be used to develop predictive models is essential if LANL is to meet its obligations to the NNSA and the country. Models that accurately describe the behavior of a material undergoing phase transition are of paramount importance in understanding the thermodynamic and kinetic states of the material. Useful measurements of the sound speed in cerium have already been obtained. In the conduct of these experiments, the overtake method was used with indicator liquids for higher pressures and with PVDF gauges for lower pressures. The lower pressure measurement technique utilized by VNIIEF was first applied to iron. The interest in the sound speed of cerium stems from the fact that sound speed is a more sensitive parameter for understanding the shocked state of the material. Aside from being able to extract the sound speed velocities using PVDF gauges, the gauges provide a time history of the shock wave, which can be used in the development of kinetic models for the various materials of interest.



Sound velocity as a function of pressure in cerium.

Collaboration between Los Alamos National Laboratory (LANL), Los Alamos, NM, USA, and the Russian Federal Nuclear Center – All Russian Research Institute of Experimental Physics (RFNC-VNIIEF), Sarov, Russia

A Publication of the Office of Advanced Simulation & Computing, NNSA Defense Programs. SAND 2007-4400P
Issued by Sandia National Laboratories for NNSA's Office of Advanced Simulation & Computing, NA-114. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.