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Title: Solid-Solid Phase Transition Measurements in Iron

Author(s): Schwartz, C.L.

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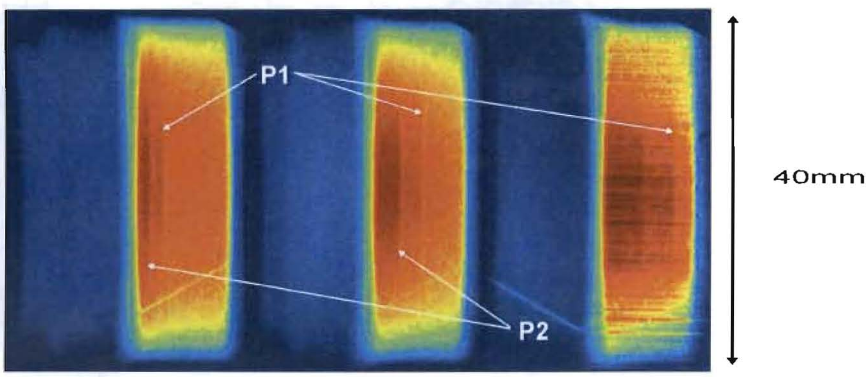
Solid-Solid Phase Transition Measurements in Iron

C. Schwartz, Los Alamos National Laboratory

Previously, dynamic experiments on iron have observed a non-zero transition time and width in the solid-solid α-ε phase transition.[1,2] Using Proton Radiography at the Los Alamos Neutron Science Center, we have performed plate impact experiments on iron to further study the α-ε phase transition which occurs at 13GPa. A 40mm bore powder gun was coupled to a proton radiography beam line and imaging system and synchronized to the impact of the projectile on the target sample with the proton beam pattern. A typical experimental configuration for the iron study, as shown below in 3 color-enhanced radiographs, is a 40mm diameter aluminum sabot impacting a 40mm diameter of polycrystalline ARMCO iron. The iron is backed by a sapphire optical window for velocimetry measurements. The aluminum flyer on the left of the iron is barely visible for visual display purposes.



Direct density jumps were measured[3] which corresponded to calculations to within 1% using a Wondy multi-phase equation of state model. In addition, shock velocities were measured using an edge fitting technique and followed that edge movement from radiograph to radiograph, where radiographs are separated in time by 500 ns. Preliminary measurements give a shock velocity (P1 wave) of 5.251 km/s. The projectile velocity was 0.725 km/s which translate to a peak stress of 17.5 GPa.

Assuming the P1 wave is instantaneous, we are able to calibrate the chromatic, motion, object and camera blur by measuring the width of the P1 wave. This approximation works in this case since each of the two density jumps are small compared to the density of the object. Subtracting the measured width of the P1 wave in quadrature from the width of the P2 wave gives a preliminary measurement of the transition length of 265 μm. Therefore, a preliminary measured phase transition relaxation time τ = transition length/u_s = 265 μm/5.251 km/s = 50 ns.

Both Boettger[1] & Jensen[2] conclude that the transition rate and likely the transition mechanisms depend on the impact stress and the sample thickness. Since Proton Radiography can measure directly the transition length as well as the shock velocity, a transition time can be directly calculated. With higher

higher energy protons we have better resolution of the measured width and edge locations. This will allow a more precise measurement of phase transition relaxation time. We propose to perform a series of experiments to measure the phase transition relaxation time, τ, as a function of drive and sample size.

1. J.C. Boettger and D. Wallace, "Metastability and dynamics of the shock-induced phase transition in iron", Phys. Rev. B **55**, 2840 (1997).

2. B.J. Jensen, G.T. Gray III and R.S. Hixson, "Direct measurements for the α-ε transition stress and kinetics for shocked iron", Journ. Appl. Physics **105**, 103502 (2009).

3. P.A. Rigg, C. L. Schwartz, et al., "Proton radiography and accurate density measurements: A window into shock wave processes", Phys. Rev. B **77**, 220101 (2001).