EXAFS Measurement of Iron **bcc-*to*-hcp** ***Phase Transformation in Nanosecond-Laser Shocks:*** The dynamics of material response to shock loading has been extensively studied in the past. The goal of those studies has been to understand the shock-induced deformation and structural changes at the microscopic level. Laser-generated shocks have been recently employed to broaden these studies to higher pressures (~1 Mbar or 100 GPa) and strain rates (~10^7 s^{-1} to 10^8 s^{-1}). The use of *in-situ* time-resolved EXAFS (extended x-ray absorption fine structure) on OMEGA for characterizing nanosecond-laser–shocked vanadium and titanium has been demonstrated.[1] The observed fast decay of the EXAFS modulations in titanium (shocked to ~35 GPa) was shown to be due to the α-Ti to ω-Ti phase transformation.[1]

We report here on new experiments where EXAFS has been used to demonstrate the phase transformation from body centered cubic (*bcc*) to hexagonal closely packed (*hcp*) in iron due to nanosecond-laser–generated shocks. This transformation is of great interest in geology and seismic studies because the core of the earth is believed to consist of the *hcp* iron phase.

Figure 1 shows a comparison between the experimental results for unshocked and shocked iron and the calculations by the EXAFS code FEFF8[2] for *bcc* and *hcp* iron. The comparison clearly shows a phase transformation through the disappearance of the “w” line. FEFF8 fitting to the measured EXAFS (Fig. 2) yields the volume compression (~20%) and temperature (~640 K) in the shocked iron, consistent with hydrodynamic simulations, and indicates a pressure of ~35 GPa, well above the known critical pressure for the transformation. These results indicate that the characteristic time for the transformation is ≲1 ns, much shorter than estimated in experiments using microsecond, gas-gun shock waves.

OMEGA Operations Summary: OMEGA conducted 131 target shots during January 2005 for LLNL, LANL, and LLE experiments as follows: 34 for LLNL, 26 for LANL, and 71 for LLE including RTI and various ISE campaigns.

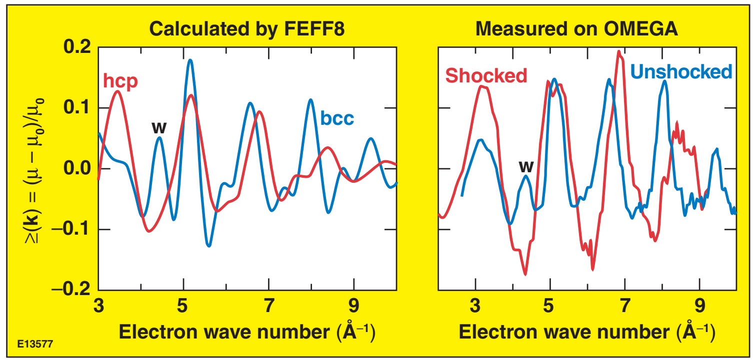

Figure 1. (a) FEFF8 calculation of the EXAFS spectrum for unshocked α-Fe (*bcc*) and ω-Fe (*hcp*). For the latter, a volume compression of 1.2 (with respect to the original density of α-Fe) and a temperature of 700 K were assumed. The disappearance of the peak marked “w” is a signature of the *bcc*-to-*hcp* transformation. (b) Experimental results: in the shocked case (at a pressure of ~35 GPa) the peak marked “w” is seen to disappear, indicating a *bcc*-to-*hcp* phase transformation. Also, the period of oscillation is seen to increase, indicating compression. Finally, the damping rate increases, indicating heating.

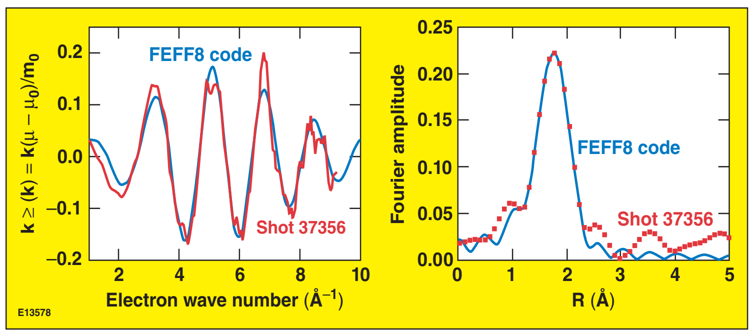

Figure 2. FEFF8 code fitting to the experimental results: (a) in the *k* space, (b) in the *R* space. The simulations assume the *hcp* phase. The best fit corresponds to a bond length of $R = (2.39 \pm 0.013)$ Å and $\sigma^2 = (0.0079 \pm 0.0019)$ Å^2. The values correspond to a 20% volume compression and a temperature of 670 K.


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The OMEGA EP Target Chamber is shown on the welding fixture at the manufacturer Ranor, Inc., Westminster, MA. The two spun aluminum hemispheres of the 3.3-m-diam, 7.9-cm-thick vacuum chamber are being welded at the equator. Ninety laser and diagnostic access ports will be machined into the surface of the target chamber. The OMEGA EP Target Chamber will be installed in May 2005. Greg Pien (Group Leader, OMEGA Experimental Operations) is shown next to the chamber.

1. B. Yaakobi *et al*., Phys. Rev. Lett. **92** 095504 (2004).
2. J. J. Rehr, R. C. Albers, and S. I. Zabinsky, Phys. Rev. Lett. **69**, 3397 (1992).

Contact: Wolf Seka (585) 275-3815; fax: (585) 275-5960; e-mail: seka@lle.rochester.edu
John M. Soures (585) 275-3866; fax: (585) 256-2586; e-mail: jsou@lle.rochester.edu