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Ultrafast studies of shock-induced melting and phase transitions at LCLS[1]

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The study of shock-induced phase transitions, which is vital to the understanding of material response to rapid pressure changes, dates back to the 1950s, when Bankcroft *et al* reported a transition in iron [1]. Since then, many transitions have been reported in a wide range of materials, but, due to the lack of sufficiently bright x-ray sources, the structural details of these new phases has been notably lacking [2]. While the development of nanosecond *in situ* x-ray diffraction has meant that lattice-level studies of such phenomena have become possible [3-5], including studies of the phase transition reported 60 years ago in iron [6], the quality of the diffraction data from such studies is noticeably poorer than that obtained from statically-compressed samples on synchrotrons. The advent of x-ray free electron lasers (XFELs), such as the LCLS, has resulted in an unprecedented improvement in the quality of diffraction data that can be obtained from shock-compressed matter. Here I describe the results from three recent experiment at the LCLS that looked at the solid-solid and solid-liquid phase transitions in Sb, Bi and Sc using single 50 fs x-ray exposures [7,8]. The results provide new insight into the structural changes and melting induced by shock compression. [1] D. Bancroft *et al*, J. Appl. Phys. **27**, 291 (1956). [2] G.E. Duvall and R.A. Graham Rev. Mod. Phys. **49**, 523 (1977). [3] Q. Johnson and A. Mitchell, Phys. Rev. Lett. **29**, 1369 (1972). [4] T. dAlmeida and Y.M. Gupta, Phys. Rev. Lett. **85**, 330 (2000). [5] J. R. Rygg *et al*, Rev. Sci. Instrum. **83**, 113904 (2012). [6] D.H. Kalantar *et al*, Phys. Rev. Lett. **95**, 075502 (2005). [7] M.G. Gorman *et al*, Phys. Rev. Lett. **115**, 095701 (2015). [8] R. Briggs*et al*, Phys. Rev. Lett. In Press (2016).

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