INTERNAL STRAIN MEASUREMENTS IN ULTRAHIGH-CARBON STEELS

M.L. Young¹, J.D. Almer², U. Lienert², D.R. Haeffner², D.C. Dunand¹
¹ Northwestern University, Evanston, IL, 60208
² Argonne National Laboratory, Argonne, IL, 60439

Although ultrahigh-carbon steels (UHCS) have existed for many centuries (e.g. the legendary Damascus blades), only recently have their composition and processing become understood metallurgically [1]. UHCS have remarkable properties, such as high hardness, high strength, wear resistance, and superplasticity.

In this study, a UHCS sample was heat-treated to form a composite consisting of a fine-grained ferritic matrix with 27 vol % submicron spheroidized cementite particles. Volume-averaged lattice strains in the ferrite and cementite phases were measured by synchrotron X-ray diffraction at various uniaxial tensile stresses up to 1 GPa. In the elastic region, load transfer was not observed because the ferritic matrix and cementite particles have nearly equivalent Young’s moduli. Luders band propagation was observed immediately after yielding. In the plastic region, dramatic load shedding was observed to occur from the matrix to the cementite particles up to fracture, similar to prior results obtained by neutron diffraction [2, 3]. The effect of texture was explored by measuring strain in two orthogonal directions. Finally, experimentally-observed load transfer was compared with Eshelby models.

References

Acknowledgements
The authors would like to thank Dr. Oleg D. Sherby at Stanford University for providing the ultrahigh-carbon steels and students (M. Benson, D. B. Drazkowski, A. Hagman, B. Li, C. Li, Y. Qian, K. H. See, S. Shmalo, E. Todd, and G. Zhou) from the 2004 National School on Neutron and X-ray Scattering for experimental assistance. Use of the Advanced Photon Source (APS) was supported by the U.S. Department of Energy (DOE), Office of Science, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.