PERFORMANCE AND APPLICATIONS OF THE ORNL LOCAL ELECTRODE ATOM PROBE

M. K. Miller and K.F. Russell
Metals and Ceramics Division, Oak Ridge National Laboratory,
Oak Ridge, TN 37831-6136, USA

The commercial introduction in 2003 of the local electrode atom probe (LEAP®) developed by Imago Scientific Instruments has made dramatic, orders of magnitude improvements in the data acquisition rate and the size of the analyzed volume compared to previous types of three-dimensional atom probes and other scanning atom probes. This state-of-the-art instrument may be used for the analysis of traditional needle-shaped specimens and specimens fabricated from "flat" specimens with focused ion beam (FIB) techniques. The advantage of this local electrode configuration is that significantly lower (~50%) standing and pulse voltages are required to produce the field strength required to field evaporate ions from the specimen. New high speed (200 kHz) pulse generators coupled with crossed delay line detectors and faster timing systems also enable significantly faster (up to 300 times) data acquisition rates to be achieved. This new design also permits a significantly larger field of view to be analyzed and results in data sets containing up to 10^8 atoms.

In the local electrode atom probe, a ~10-50 μm diameter aperture is typically positioned approximately one aperture diameter in front of the specimen. In order to accurately align the specimen to the aperture in the funnel-shaped electrode, the specimen is mounted on a three axis nanopositioning stage. An approximate alignment is performed while viewing the relative positions of the specimen and the local electrode with a pair of low magnification video cameras and then a pair of higher magnification video cameras attached to long range microscopes. The final alignment is performed with the use of the field evaporated ions from the specimen. A discussion on the alignment of the specimen with the local electrode, the effects of the fields on the specimen, and the effects of aperture size on aperture lifetime will be presented.

The performance of the ORNL local electrode atom probe will be described. The effects of this two orders of magnitude increase in the pulse repetition rate on the quantification of composition estimates and specimen lifetimes will be discussed. Some examples will be presented of the types of microstructural features that may be characterized with the local electrode atom probe including the analysis of low volume fraction features such as dislocations. Some of the issues associated with the analysis of datasets containing more than 20 million atoms will also be addressed.

Research at the SHaRE User Center was sponsored by the Division of Materials Sciences and Engineering, U. S. Department of Energy, under Contract DE-AC05-00OR22725 with UT-Battelle, LLC. LEAP® is a registered trademark of Imago Scientific Instruments, Inc.