DYNAMIC TRANSMISSION ELECTRON MICROSCOPE

Directly Imaging Fast Reaction Fronts.

FEBRUARY 2007

SCIENTIFIC IMPACT AREA

Nanoscale Materials Engineering, Diffusion-Controlled Phase Transformations

ACCOMPLISHMENT

Direct observation of fast intermetallic phase formation in Reactive Multilayer Foils (RMLFs) has been achieved. Snap-shots of the reaction appear to show development of mass-thickness contrast of the unmixed Al and Ni layers and an intermetallic phase.

SIGNIFICANCE

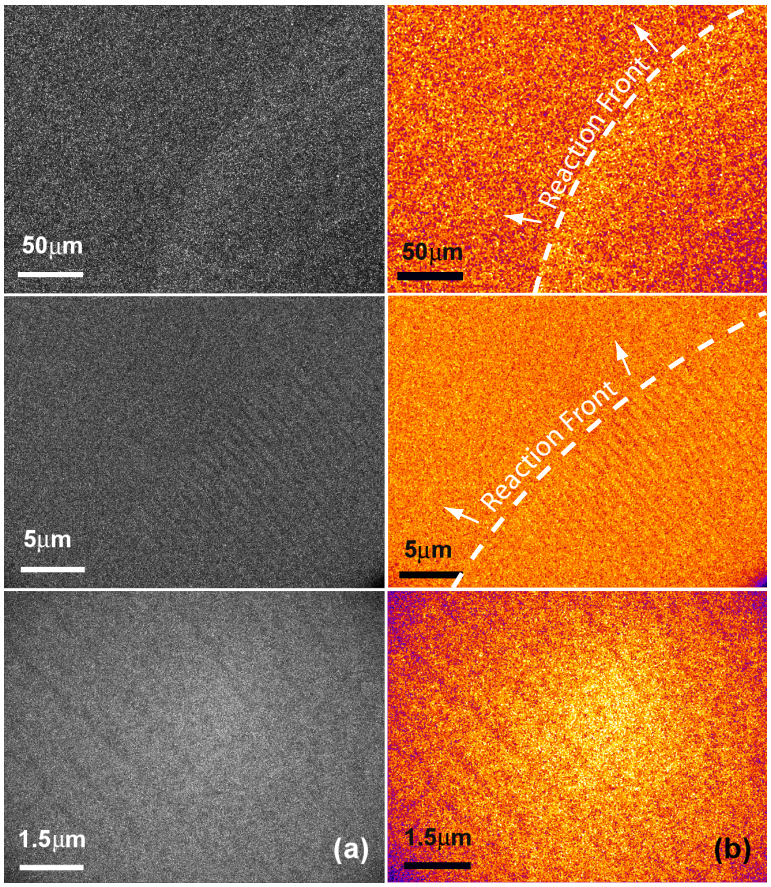
Electron imaging of these RMLF reaction fronts have never been attained in the past. The reaction front travels at ~10 meters per second as the nanoscale layers mix in an exothermic chain reaction, thus making traditional in situ electron microscopy ~10^5 times too slow to produce such an image.

ENABLING TECHNOLOGY

The DTEM capability to produce several million electrons within nanoseconds for single-pulse imaging made this experiment possible. Additionally, the sample drive laser ensures reliable experiment initiation and repeatability. In no other way could such a high velocity event be captured at this magnification.

FUTURE DIRECTIONS

RMLF reaction fronts continue to be analyzed via diffraction for complete phase evolution with respect to time. High quality diffraction patterns enable quantitative phase information to be obtained for future comparison to simulation.



The exothermic phase formation zone is imaged from a plan-view Al/Ni multilayer sample with a single 30 nanosecond electron pulse. These electron micrographs reveal the reaction front detail for the first time showing lines of contrast behind and perpendicular to the reaction front. Arrows indicate the motion of the reaction front. (a) Raw data. (b) 3x3 median filter, false coloring.

INVESTIGATORS

J. S. Kim, T. LaGrange, B. W. Reed, G. H. Campbell, N. D. Browning

PUBLISHED

In progress

cmls Directorate

UCRL-TR-228301

AUSPICES STATEMENT
Work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory, and supported by the Office of Science, Office of Basic Energy Sciences, Division of Materials Sciences and Engineering, of the U.S. Department of Energy under contract W-7405-Eng-48.