Microsymposium

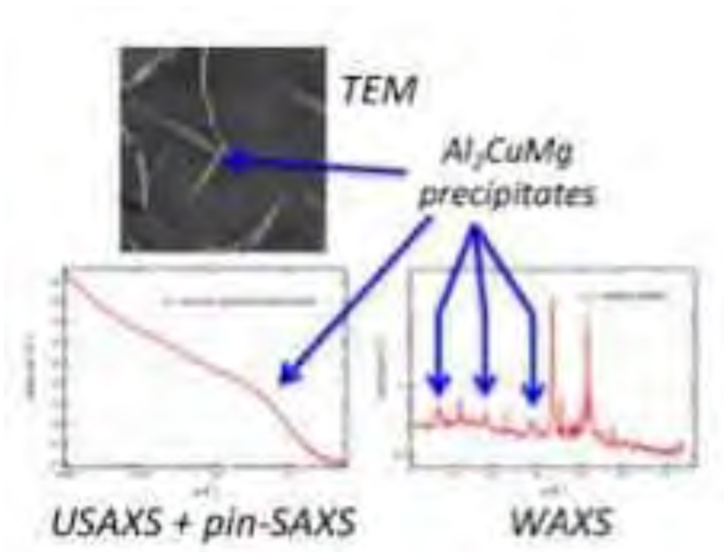
MS79.O01

Towards in operando material process characterization over many length scales

A. Allen[1], F. Zhang[1], L. Levine[1], J. Ilavsky[2]
[1]NIST, Material Measurement Laboratory, Gaithersburg, USA, [2]Argonne National Laboratory, X-ray Science Division, Argonne, USA

The properties and performance of complex material systems are frequently controlled by phenomena that operate over many length-scales from sub-nanometers to millimeters. Understanding the behavior of such materials requires statistically-representative measurement of these effects on the structure and microstructure evolution across this entire length-scale range, over timescales that match those of the phenomena of interest. Small-angle X-ray and neutron scattering (SAXS and SANS) can address much of this need and reveal cause-and-effect phenomena acting across many length scales. This is especially true if SAXS or SANS are combined with wide-angle X-ray and neutron scattering (WAXS and WANS) diffraction measurements to follow the corresponding phase evolution. These concepts are demonstrated in several high-impact studies pursued with our collaborators, including in operando studies to measure: the effects of gas sorption on the structures and microstructures of new carbon sorbent materials [1]; precipitate formation and growth, together with associated phase transformations in advanced light-weight alloys during annealing or plastic deformation; real-time dissolution, clustering and agglomeration of silver nanoparticles in an acidic environment (relevant to environmental health and safety concerns) [2]; and even cement hydration phenomena related to concrete shrinkage. Many of these measurements were made at the ultra-small-angle X-ray scattering (USAXS) facility at the Advanced Photon Source where rapid combined USAXS/SAXS/WAXS studies are now possible under in operando conditions. Planned further development of the instrument capabilities will significantly enhance such in operando measurements, as can be demonstrated by the impact on these same studies [3].

[1] *K.L. Kauffman, J.T. Culp, A.J. Allen, et al., Angew. Chem. Int. Ed., 2011, 50, 10888-10892.,* ***[2]*** *M.N. Martin, A.J. Allen, R.I. MacCuspie, et al., ACS Nano, 2014, submitted.,* ***[3]*** *J. Ilavsky, F. Zhang, A.J. Allen, et al., Metall. Mater. Trans. A, 2013, 44, 68-76.*



Keywords: small-angle scattering, SAXS, wide-angle scattering