

Combined in-situ neutron diffraction and imaging for strain investigations

Monday 16 April 2012 15:27 (3 minutes)

Wavelength dependent neutron transmission imaging has recently gained attention for the potential to spatially resolve texture, crystallographic phase and lattice strain. Especially promising is the time-of-flight (TOF) approach that takes maximum advantage of the new generation of pulsed spallation neutron sources, such as the SNS, JSNS and ESS. Compared to traditional (neutron) residual stress diffractometers, imaging approaches can obtain strain information over large areas simultaneously in one direction, while only one (gauge) volume at a time can be probed using traditional diffraction techniques.

In practice, the majority of neutron diffraction experiments utilize gauge volumes on the order of millimeters and this limitation gets exacerbated with the use of radial collimators at TOF sources. Because of the need to use larger gauge volumes due to geometric complexities associated with slits and alignment, one cannot capture large strain gradients occurring over stress concentration areas effectively. Experiments with sub millimeter gauge volumes have been performed at residual stress instruments occasionally, but are extremely time intensive due to the small volume of diffraction and are prone to problems associated with partial scattering volume being occupied by air. Furthermore, the instrument alignment and sample positioning required for sub millimeter experiments are extremely important and can only be achieved if specialized equipment, such as laser alignment tracking systems with specialized software (for example SScanSS), is available.

Neutron transmission imaging can overcome some of these limitations. The authors have undertaken measurements using the TOF engineering diffractometer (SMARTS) at Los Alamos Neutron Scattering Center (LANSCE), where two detector banks were used at 2θ of $\pm 90^\circ$ and a MCP (Multichannel Plate) detector in transmission geometry ($2\theta=180^\circ$). A tensile test was performed while acquiring data with all three detector systems, providing measurement of three separate strain components simultaneously. A torsion test was carried out, where imaging and diffraction was carried out separately, due to the non-uniform strain field in a torsion sample. Example data, experimental details and associated challenges will be discussed, which will be of relevance for current and future coupled imaging/diffraction beamlines and experiments.

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Session Classification: Short presentations (Poster session)