Determination of the strains in a polycrystalline material using 4-D XRD reveals sub-grain and grain-to-grain behavior as a function of stress. Here 4-D XRD involves an experimental procedure using polychromatic micro-beam X-radiation (micro-Laue) to characterize polycrystalline materials in spatial location as well as with increasing stress. The in-situ tensile loading experiment measured strain in a model aluminum-sapphire metal matrix composite using the Advanced Light Source, Beam-line 7.3.3. Micro-Laue resolves individual grains in the polycrystalline matrix. Results obtained from a list of grains sorted by crystallographic orientation depict the strain states within and among individual grains.

Locating the grain positions in the plane perpendicular to the incident beam is trivial. However, determining the exact location of grains within a 3-D space is challenging. Determining the depth of the grains within the matrix (along the beam direction) involved a triangulation method tracing individual rays that produce spots on the CCD back to the point of origin (see Figure). Triangulation was experimentally implemented by simulating a 3-D detector capturing multiple diffraction images while increasing the camera to sample distance. Hence by observing the intersection of rays from multiple spots belonging to the corresponding grain, depth is calculated. Depth resolution is a function of the number of images collected and the pixel resolution of the CCD. The 4-D XRD method provides grain morphologies, strain behavior of each grain, and interactions of the matrix grains with each other and the centrally located single crystal fiber.