Fatigue crack initiation in a polycrystal metal is one of the most poorly understood processes in all of materials science. In copper, where hard particles or corrosion pits cannot serve as initiation sites, microcrack initiation is entirely driven by cyclic plasticity processes. The difficulty in unraveling a problem like fatigue is the myriad of size and time scales involved. It is extremely challenging to objectively “watch” fatigue processes at work. The attributes of high energy synchrotron x-rays: small wavelength, adjustable energy and beam size, high flux and ability to penetrate bulk polycrystalline samples up to centimeters in thickness, make them ideal for studying the micromechanical processes associated with fatigue for validating sophisticated crystal-based material models. In this talk we describe High Energy Diffraction Microscopy (HEDM) experiments with cyclic in situ loading conducted at APS Beamline 1-IDC on a Cu-Zr-Cr alloy, OMC Copper, along with crystal-based finite element simulations of the experiments. The diffracted intensities from each individual grain show distinct changes with number of cycles and cyclic strain amplitude, which can be related directly to the evolving intragrain strain and orientation distributions. Using a projection of x-rays through the deforming finite element mesh, we produce synthetic diffraction distributions on a virtual detector, which we can compare directly to the experimental data. Once validated the model can be used to explore hypotheses related to the cyclic plasticity and the eventual initiation of fatigue damage.