Dislocation Loop Structure in Individual Grains of Proton Irradiated Polycrystalline Zr Aggregates

M. Topping[a,b], Gy. Zilahi[c], S. Irukuvarghula[a], G. Ribárik[c], A. Garner[a], A. Smith[a], R. Thomas[a], P. Kenesei[d], P. Frankel[a], M. Preuss[a], T. Ungár[a,c]

[a]School of Materials, The University of Manchester, Manchester, M13 9PL, UK
[b]Department of Mechanical and Materials Engineering, Queen's University, Kingston, Ontario, Canada
[c]Department of Materials Physics, Eötvös University Budapest, PO Box 32, H-1518, Budapest, Hungary
[d]Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439, USA

Integrity of fuel cladding Zr structures is a key issue in power generating nuclear reactors. Long term radioactivity makes it difficult to determine irradiation induced damage in neutron irradiated Zr. Short-lived activation and similar damage structure make fast proton irradiated Zr excellent surrogates for neutron irradiated Zr. Irradiation in Zr alloys produces dislocation loops, characterized by electron microscopy or X-ray diffraction. X-ray powder diffraction proves to be a powerful method to characterize average properties of dislocation loops. However, proton irradiation, unlike neutron irradiation, is unidirectional due to the beam line and reveals a very specific depth profile. It shows a plateau region up to about 25 micron from the specimen surface with a high Bragg peak of damage around about 30 micron. Cold rolled and partially recrystallized Zr alloys are strongly textured with inherently anisotropic grain structures. This raises the question to what extent grain orientation and depth influences the grain-to-grain dislocation structure in proton irradiated Zr and its alloys. We carried out three dimensional high angular resolution single grain diffraction experiments on bulk polycrystalline aggregates of Zr alloys at the 1-ID high energy beamline of the APS synchrotron at the Argonne National Laboratory. Based on these experiments we can assess the specific damage structures of individual grains at different depths and with different orientations with respect to the proton beam. Further details will be presented at the conference.