Neutron Diffraction Analysis of High Burnup LEU Fuel from NRU

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Al-U_3Si dispersion fuel has been used in the NRU reactor for almost two decades, and it has performed well, with stable swelling behaviour and no defects linked to the LEU fuel material. However, little is known about the phase composition and crystal structure of extruded Al-U_3Si fuel pins after irradiation to high burnup in the NRU reactor. AECL and NRC have developed the capability to perform neutron diffraction measurements on highly radioactive fuel samples using shielded apparatus on the C2 neutron diffractometer at NRU. This paper discusses diffraction measurements that were recently performed to assess the crystal structure of irradiated Al-U_3Si fuel from an NRU fuel rod. Samples were taken from different regions of the fuel rod that operate under different linear power, temperature and burnup conditions, to help assess the effect of these key operating parameters on fuel structure stability. Irradiated fuel samples with operating fuel temperatures ranging from 92 to 188 °C and burnups ranging from 63 to 90 atom% ^{235}U were tested. Measurements using a monochromatic neutron beam with $\lambda \sim 1.33$ Å show the only diffraction evidence of a crystalline phase is from the Al matrix, indicating that the U_3Si fuel particles and U-Si-Al reaction products that form during irradiation have become amorphous. The results provide a better understanding of the U_3Si fuel behaviour under neutron irradiation and help to characterize the spent LEU fuel that has accumulated in Canada from almost two decades of NRU operation.

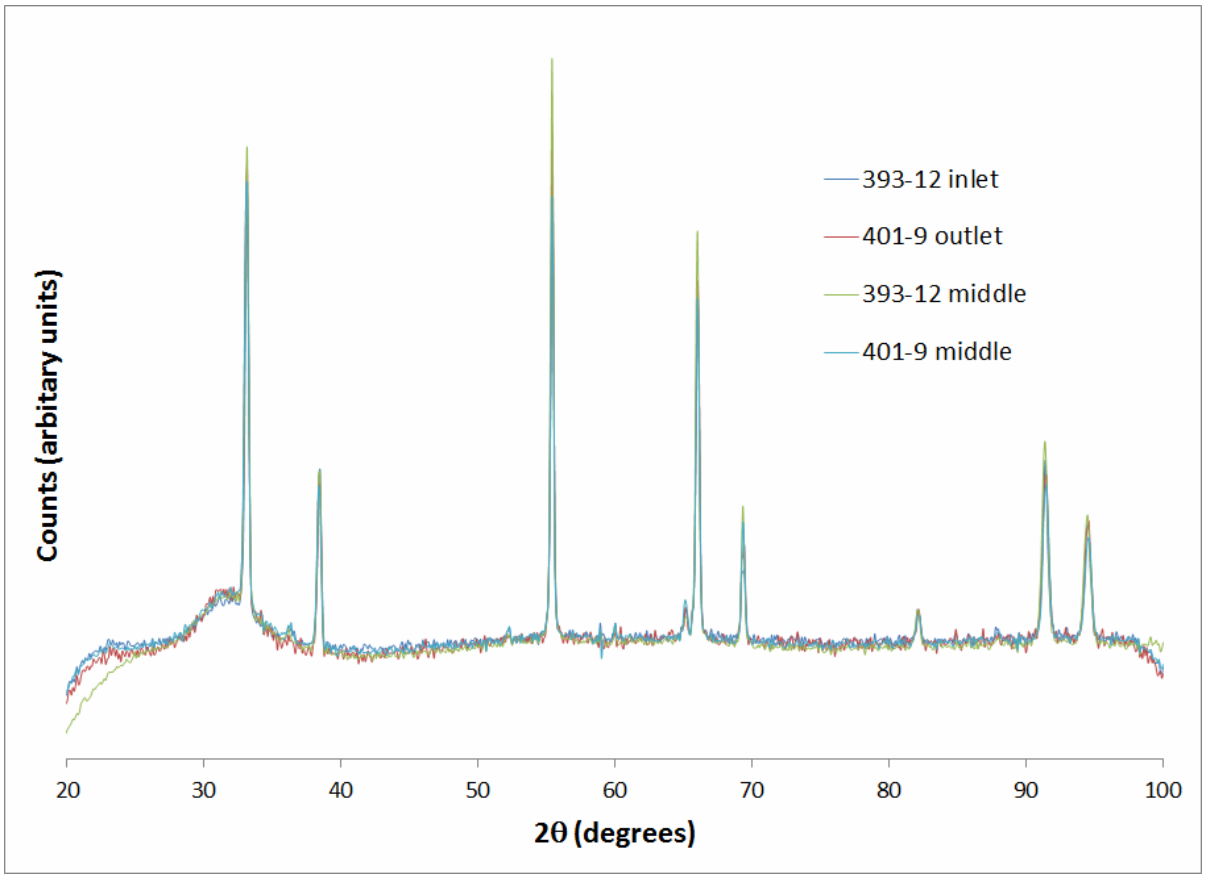

Fig. 1 Rescaled data of four different fuel samples from the bottom, middle and top sections of NRU fuel irradiated to high burnup (63-90 at%).