

Strain Rate Sensitivity in Actinide Materials Using Nano-Indentation Measurements

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In recent years, nanoindentation has emerged as a powerful technique for investigating the mechanical response of materials at the micro- and nanoscale. Its advantages include minimal sample preparation, small testing volumes, high spatial resolution, and relatively non-destructive operation. Traditionally, nanoindentation has been used to measure local mechanical properties such as hardness and elastic modulus. However, the deformation behavior of many materials is inherently time dependent.

This work is part of a comprehensive nanoindentation study of α -phase plutonium alloys conducted using a newly customized, glovebox-integrated FemtoTools FT-I04 nanoindenter. The enhanced system stability and precise displacement control enable systematic strain-rate-dependent indentation experiments, including constant strain-rate, strain-rate jump, and load-hold protocols. Such capabilities are particularly important for actinide materials, which exhibit complex thermally activated deformation behavior arising from strong electron correlations, multiple allotropes, and defect-sensitive plasticity.

The strain-rate dependence of deformation in α -phase plutonium alloys was evaluated at constant strain rates of 0.0001 s^{-1} , 0.001 s^{-1} , 0.01 s^{-1} and 0.1 s^{-1} , as well as through strain-rate jump experiments. These measurements provide insight into strain-rate sensitivity, activation volume, and activation energy. We further examine the relationship between indentation loading profiles and the corresponding measured hardness values. Such analysis aids in identifying the governing deformation mechanisms, defect interactions, and potential diffusion-assisted processes.

Overall, this work demonstrates the utility of advanced nanoindentation techniques within a glovebox environment and contributes to the development of a comprehensive micromechanical characterization framework for actinide materials.