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Probing the δ to α' phase transformation with X-ray Photoemission Spectroscopy

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Low-Gallium δ -stabilized Pu alloys exhibit low phase stability and are subject to reversion to the α' phase when subjected to thermal cycling or mechanical pressure. The α and α' phases have the same monoclinic structure but have diminutive difference in lattice parameter and included Gallium. Given the identical crystal structures it is expected that α and α' phases should have nearly identical electronic structure and should produce similar XPS spectra. The α and δ 4f XPS lineshape have clear differences, owing to changes in local bonding and electronic structure. The α' to δ phase transformation should be observable via X-ray photoemission spectroscopy (XPS) which can directly probe the transition as a function of temperature near-surface (first few nm). This work presents XPS on δ -Pu metal prepared such that the α' phase is mechanically induced. The sample was polished and was not annealed to retain polishing induced α' . The sample was measured in-situ while heating to monitor the reversion to the δ phase. Experiments inducing α' phase by cooling to cryogenic temperatures and subsequent reversion by heating will also be discussed. These experiments shed light on the mechanisms of α' formation and reversion related to temperature.