



The Stored Energy Fingerprints of Radiation Damage for Nuclear Forensics

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Abstract:

Every country that has made nuclear weapons has used uranium enrichment. Despite the centrality of this technology to international security, there is still no reliable physical marker of past enrichment that can be used to perform forensic verification of historically produced weapons. We show that the extremely low radioactivity from uranium alpha emissions during enrichment leaves detectable and irreversible calorimetric signatures in common enrichment materials, allowing for historical reconstruction of past enrichment activities at a sensitivity better than one weapon's quantity of highly enriched uranium. Fast scanning calorimetry also enables the measurement of sequentially microtomed slices, confirming the magnitude and the type of radiation exposure while also providing a detection of tampering and a method for analyzing field samples useful for treaty verification. This work opens the door for common items to be turned into precise dosimeters to detect the past presence of radioactivity, nuclear materials, and related activities with high confidence.

In this talk, we will review our group's recent work confirming the ability to distinguish less than 10kg of UF₆ throughput for a known enrichment, or to deduce the enrichment from irradiation resulting from the same quantity of UF₆ if its throughput is known. The work centers on measurements of PTFE (Teflon) gaskets following alpha irradiation. We are also expanding our work to include chlorinated Teflon (PCTFE), fluorinated epoxy, high-strength aluminum alloys, and stainless steels for a more multi-modal characterization of historical enrichment activity which will be more difficult to spoof or subvert. Because each material exhibits a very unique signature resulting from different, enrichment-relevant irradiation doses, the combined signature becomes more complete and self-consistent, providing a tool for weapons facility inspectors to better gauge the historical enrichment activity from physical specimens without relying on records kept by the entity under investigation.