CONNECT

CONsortium of Nuclear sECurity Technologies

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Oak Ridge National Laboratory

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2:00 - 3:30 pm
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Fabrication, Characterization and Testing of Nuclear Fuels to Support Nonproliferation

Worldwide interest in deployment of new nuclear reactors is at its highest point in nearly six decades. As with many modern technologies, material performance is a limiting factor. Design, development, qualification and eventual disposition of nuclear fuel combines many aspects of nuclear engineering and material science. The principles governing: (1) selection of compounds and composite architectures for the design of nuclear fuel forms, (2) how critical neutronic and material properties of that fuel form dictate reactor operation and safety, and (3) economic and policy considerations driven by these choices requires compromises at many junctures.

This presentation will provide an overview of the design methodologies used in development of nuclear fuels. Emphasis will be placed on the introductory aspects of material science, nuclear fuel cycle analysis, reactor design, and factors governing proliferation resistance of candidate nuclear fuels and fuel cycles. While these topics will be covered at an introductory level to orient newcomers, a recent case study in nuclear fuel development will provide a framework for technical discussion. The multiple stages of emerging nuclear fuel cycles make them one of the most important vectors for potential proliferation of nuclear material, motivating efforts to increase its resilience.

Intentional nuclear forensics involves deliberately incorporating persistent elements ('taggants') into nuclear fuels to create unique identifiers within the parent material. Taggants of interest must not impact fuel performance. The impact of a taggant on the microstructure and other material properties must be evaluated. A successful nuclear fuel taggant must: (1) survive the processing conditions used for producing nuclear fuel forms, (2) maintain acceptable fuel performance throughout steady state and transient reactor conditions, and (3) be measurable at required fidelity throughout the fuel cycle to support nonproliferation goals.

Strategies and approaches used to screen, incorporate, and retrieve taggants in uranium dioxide nuclear fuel will be presented. The impact of taggant chemistry and concentration on the resulting microstructure and baseline unirradiated properties will be discussed with an emphasis placed on quantification of taggant level throughout processing and high temperature sintering. Test irradiations designed to support fuel qualification will be introduced, and an overview given of post irradiation examination methods used to evaluate fuel performance. Finally, the computational tools and methods used to predict and evaluate nuclear fuel performance will highlight the anticipated impacts of tagged fuels on reactor operation to complete the survey of nuclear fuel development.

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