

**DOE-ID NEPA CX DETERMINATION  
Idaho National Laboratory**

**SECTION A. Project Title:** Oxidation of Cerium Nitride under Irradiation

**SECTION B. Project Description and Purpose:**

Nitride nuclear fuels have been developed since 1960s, being advanced fuels for light water reactors, fast reactors, and space reactors. However, in contradiction to oxide fuels, investigations of nitride fuels on the evolution of phases and defects in radiation environments are rare. Nitride fuels are susceptible to oxidation and hydrolysis due to high oxygen affinity of actinides. How radiation may affect the oxidation/hydrolysis of nitride fuels is rather unknown. Here, we propose to study the influence of radiation on the oxidation of cerium nitride (CeN), a non-radioactive surrogate for actinide nitrides by combining high-throughput synthesis, in situ electron microscopy characterization, and advanced modeling. The goal of this project is to obtain a fundamental understanding of oxidation behavior of CeN in radiation environment. Specifically, the project has following objectives:

- 1) Synthesis of CeN ceramics with controlled stoichiometry and microstructure using ultrafast sintering technique,
- 2) In-situ transmission electron microscopy (TEM) observation of irradiation-assisted oxidation in CeN,
- 3) Gamma irradiation and TEM characterization of irradiated CeN; and
- 4) Modeling of mass transport in CeN under oxidation and/or irradiation.

To test the hypotheses outlined above, CeN will be used as the non-radioactive surrogate for actinide nitrides. At Purdue University, CeN ceramics with controlled stoichiometry and microstructure will be fabricated by ultrafast sintering technique. In situ high-temperature oxidation of both as-fabricated and irradiated CeN ceramics will be studied at INL. To understand the mass transport in CeN under irradiation and oxidation, multimodal modeling will be pursued at INL.

The CeN powders will be processed with ball milling and compacted by the uniaxial pressing and cold isostatic pressing into green bodies. The composition and microstructural characterization, including X-ray diffraction and scanning electron microscopy of green bodies and sintered samples, will be conducted to achieve comprehensive understanding of the relationship between processing parameters and composition/microstructure.

We will conduct in situ electron irradiation using TEMs at INL utilizing fast-speed camera (320 frames/sec) to capture the oxidation of CeN ceramics under radiation.

To investigate the effects of extended defects on oxidation resistance of CeN, the as-fabricated CeN ceramics will be irradiated with proton beam at Texas A&M University through external collaboration.

To further study the radiolysis effects on oxidation, gamma irradiation will be also performed on CeN ceramics through internal collaborations with Gregory P. Horne at the Center for Radiation Chemistry Research at INL. The gamma irradiated samples will also be characterized using TEM techniques.

Samples will remain at the INL for future research. If they are not wanted, they can be disposed of as general (non-rad) waste.

**SECTION C. Environmental Aspects or Potential Sources of Impact:**

**Air Emissions**

N/A

**Discharging to Surface-, Storm-, or Ground Water**

N/A

**Disturbing Cultural or Biological Resources**

N/A

**Generating and Managing Waste**

N/A

**Releasing Contaminants**

N/A

**Using, Reusing, and Conserving Natural Resources**

All materials would be reused and recycled where economically practicable. All applicable waste would be diverted from disposal in the landfill where conditions allow. The project would practice sustainable acquisition.

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**SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification:** Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not "connected" to other action actions (40 CFR 1508.25(a)(1)) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

**References:** 10 CFR 1021, Appendix B to subpart D, items B3.6, "Small-scale research and development, laboratory operations, and pilot projects"

**Justification:** The proposed R&D activity is consistent with CX B3.6 "Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed area (where active utilities and currently used roads are readily accessible). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment."

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act)       Yes     No

Approved by Jason L. Anderson, DOE-ID NEPA Compliance Officer on: 07/15/2021