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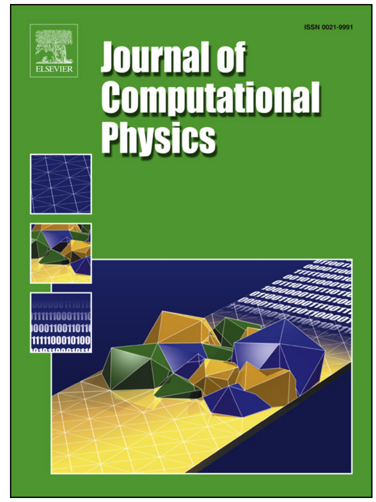


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PII: S0021-9991(16)30472-7
DOI: http://dx.doi.org/10.1016/j.jcp.2016.09.051
Reference: YJCPH 6862

To appear in: *Journal of Computational Physics*

Received date: 29 May 2015
Revised date: 17 August 2016
Accepted date: 21 September 2016

Please cite this article in press as: R. Montgomery et al., Use of multiscale zirconium alloy deformation models in nuclear fuel behavior analysis, *J. Comput. Phys.* (2016), http://dx.doi.org/10.1016/j.jcp.2016.09.051

# Use of Multiscale Zirconium Alloy Deformation Models in Nuclear Fuel Behavior Analysis

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**Abstract**

Accurate prediction of cladding mechanical behavior is a key aspect of modeling nuclear fuel behavior, especially for conditions of pellet-cladding interaction (PCI), reactivity-initiated accidents (RIA), and loss of coolant accidents (LOCA). Current approaches to fuel performance modeling rely on empirical constitutive models for cladding creep, growth and plastic deformation, which are limited to the materials and conditions for which the models were developed. To improve upon this approach, a microstructurally-based zirconium alloy mechanical deformation analysis capability is being developed within the United States Department of Energy Consortium for Advanced Simulation of Light Water Reactors (CASL). Specifically, the viscoplastic self-consistent (VPSC) polycrystal plasticity modeling approach, developed by Lebensohn and Tomé [1], has been coupled with the BISON engineering scale fuel performance code to represent the mechanistic material processes controlling the deformation behavior of light water reactor (LWR) cladding. A critical component of VPSC is the representation of the crystallographic nature (defect and dislocation movement) and orientation of the grains within the matrix material and the ability to account for the role of texture on deformation. A future goal is for VPSC to obtain information on reaction rate kinetics from atomistic calculations to inform the defect and dislocation behavior models described in VPSC. The multiscale modeling of cladding deformation mechanisms allowed by VPSC far exceed the functionality of typical semi-empirical constitutive models employed in nuclear fuel behavior codes to model irradiation growth and creep, thermal creep, or plasticity. This paper describes the implementation of an interface between VPSC and BISON and provides initial results utilizing the coupled functionality.

## 1. Introduction

The US DOE's Consortium for Advanced Simulation of Light Water Reactors (CASL) program is developing multiphysics, multi-dimensional modeling and analysis capabilities to assess safety margins and the impact of plant operation on nuclear fuel rod behavior. These activities include an enhanced version of the engineering scale fuel behavior code, BISON, that is being developed to model the thermal, mechanical, and chemical behavior of LWR fuel rods during normal operation, operational transients, and hypothetical accidents [2]. Integral to this endeavor is the research and development activities to expand mechanistic material behavior modeling that builds on the recent advances in computational material science, such as

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