The Summer Undergraduate Research Fellowship (SURF) Symposium
4th August, 2016
Purdue University, West Lafayette, Indiana, USA

Modeling of Ion/Target Interactions in Plasma Facing Components of Fusion Reactor

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Abstract

Nuclear fusion is a promising source of clean energy that can be one of the key future suppliers of the world's increasing power demand. One of today's main challenges faced by scientists and engineers regarding nuclear reactors is to design plasma-facing components (PFCs) that can withstand extreme conditions of temperature, pressure, and ions/particles irradiation. Material evolution and damage of PFCs are strongly related to the bombardment and diffusion processes of ions resulting from fusion fuel, i.e., deuterium and tritium and reaction products, i.e., helium. However, work is still needed in order to understand fuel diffusion in the presence of helium effects and damage produced in heterogeneous media of potential PFCs. This study simulates the diffusion of atoms in an alloy of changing solute concentration in an environment similar to that of a nuclear fusion reactor. The diffusion equation was solved numerically while taking into account the "potential diffusion" present in heterogeneous materials, as it was described analytically in recent studies. The solution was implemented in Fortran 90 code using SRIM software as an input generator and taking parameters found in literature. Our results show that heterogeneous membranes can greatly shift the deuterium concentration profile towards the vanadium back surface, increasing the material's permeability. These outcomes suggest that vanadium alloys with heterogeneous solute concentration distribution should be empirically analyzed in order to understand how these concentration shifts affect material properties and fuel retention.

Keywords:

Nuclear fusion, plasma-facing components, diffusion