2.6. Application of the ion bombardment technique to study the behavior of rare gases in UO_2; comparison with reactor irradiation and the influence of irradiation on fission gas bubbles.*

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Abstract

The ion bombardment technique is applied to study the behavior of the fission gases Xe and Kr in UO_2, a question of considerable importance in technology due to the contribution of the gases to the swelling of the fuel. The system of Stages in gas release is used to discuss the experimental results. In the order of increasing temperatures, Stages IA, IIA, IIB and III are observed, whereas Stage IB is missing. Stage IA release occurs at low temperatures, starting at about 600°C, and is probably due to gas located very near to the surface: it can explain the so called "burst" — effect observed in many studies, i. e. a fast initial release in isothermal experiments. Stage IB release is absent since no gross structural damage is formed in UO_2 during bombardment, the ratio of the crystallization temperature, T_c, and the melting point, T_m, being low (<0.30).

Normal volume diffusion of single gas atoms (Stage IIA) proceeds with an activation enthalpy, ΔH, of 3.9 ± 0.2 eV. Doping and channeling experiments together with results obtained following bombardment at different temperatures up to 1000°C suggest that the rare gas atoms migrate in small equilibrium vacancy clusters, e. g. in Schottky trios. At higher gas and damage concentrations, the gas mobility is retarded due to gas—gas or gas—damage interactions (Stage IIB), the most effective trapping centers probably being bigger vacancy clusters and loops.

At high gas concentrations and high temperatures, gas atoms interact with other gas atoms to form bubbles. The nucleation and mobility of these bubbles is discussed as well as their stability under irradiation. Recently, it was demonstrrated that gas atoms can be redissolved by fission events. The implications on swelling, i. e. on the dimensional stability of the fuel, are discussed. The present knowledge of the mobility of fission gases in UO_2 is shown to be adequate to qualitatively explain and predict the behavior of the fuel element in the reactor though important aspects have still to be investigated in more detail.

2.7. Ion irradiation induced damage in pure gold thin films

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1. Introduction

The irradiation of solids with electrons and light particles such as protons, neutrons and deuterons, has been successfully employed for about twenty years, to study the generation and behaviour of effects in solids since, when such particles, accelerated to high energy collide with the atoms of a solid lattice, sufficient energy can be transferred to cause displacement of these atoms and thus the production of defects. Specification of the incident particle energy can give direct information about the energies required for atomic displacenent and post irradiation thermal annealing studies can reveal the nature of the defects produced. The nature of these observations range from direct microsopic scale

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