Book Review

Irradiation Effects in Fissile Materials. By J. Leteurtre and Y. Quéré. North-Holland Publishing Company, Amsterdam and London, American Elsevier Publishing Company, New York (1972). 128 + x pp. $15.50.

The effects of neutron irradiation on fissile materials are complicated by the large amount of energy released in the fission process and by the rather unusual crystallography of the heavy elements concerned. A considerable body of information on the practical aspects of such effects has been collected because of their obvious technological importance, but a detailed physical understanding of the experiments is often lacking. The intent of the authors of this book was to review what fundamental knowledge there is, with the hope of inspiring further experimentation in this important area. *Irradiation Effects in Fissile Materials* is Volume 6 in the series *Defects in Crystalline Solids*, edited by S. Amelinckx, R. Gevers, and J. Nihoul. Its authors, J. Leteurtre and Y. Quéré, are from the Centre d'Etudes Nucléaires, Fontenay-aux-Roses, France. Their book discusses some aspects of radiation damage in fissile materials in terms of the physics of defects. The greatest attention is paid to fission induced growth in α-uranium, to self-irradiation effects in plutonium, and to fission product gas swelling in fuel materials. These are all areas in which the authors have extensive experience. Since the scope and viewpoint of this book are limited, it is not a substitute for the comprehensive review of Robertson,[1] nor does it include the detailed discussion of fission fragment tracks given by Chadderton and Torrens[2]. It is rather interesting to find three books with such different and even complementary contents concealed under such similar titles.

Leteurtre and Quéré begin their book with an introductory chapter intended to give summary descriptions of the fission process and the partition of the fission fragment energy between electron excitation and atomic displacements, as well as to introduce the concepts of displacement cascade and thermal spike. The treatment is, unfortunately, rather unsatisfactory. It is not adequate to instruct the novice and no guide to the considerable literature on these topics is given. They seem to confuse displacement *cascades* with the quite different concept of displacement *spikes*. Their treatment of the fission fragment energy dissipation problem could have made good use of the famous paper of Bohr.[3] Surely the discussion of interatomic potentials is out-of-place in this book. It would have been very helpful to the reader if this chapter could have included brief summaries of the physical and isotopic properties of the main fissile materials. Some discussion of plutonium is included in a later chapter, but corresponding information on uranium would have been useful.

The book then turns to a study of fission damage in α-uranium, which means primarily fission induced growth. One chapter is devoted to effects at high burnups, where the growth is controlled by the condensation of point defects into dislocation loops under the influence of anisotropic thermal stresses. Another chapter discusses the initial stage of damage, particularly changes in length and electrical resistivity. A very clear picture is built up concerning the nature of the defects introduced, the temperatures at which aggregation of point defects occur, and the temperature and dose dependences of the changes in dimension of α-uranium samples. The fourth chapter turns to a very brief discussion of amorphization and disordering of uranium alloys and a longer discussion of radiation damage in the ceramic fuels UC and UO_2. The difference between these materials is attributable to the metallic character of UC, a point which is not made too clearly.

The fifth chapter presents a discussion of the interesting phenomena associated with self-irradiation, that is, with damage introduced into α-emitting materials by the α particles and associated recoiling nuclei. Most of the material concerns α- and β-plutonium. This chapter is marred by confusing typographical errors in Table 5.3 and in the title of Fig. 5.2. The authors have made a probably unfortunate decision to interpret the plutonium data on the assumption that α-plutonium becomes antiferromagnetic below about 65°K. The most recent information[4] indicates, however, that low temperature magnetic ordering does not occur in α-plutonium. Thus, Leteurtre and Quéré's interpretation of much of the plutonium data is open to question. There seems to be some inconsistency in the Frenkel pair production rates cited in this chapter, values from 2000 to >5000 pairs per α disintegration being deduced at 4.2°K from various observations on α-, β-, and δ-plutonium. This may only reflect uncertainties in the interpretation of the experiments, however.

The final chapter deals with fission product effects in a variety of fuel materials, especially the swelling associated with the fission product rare gases, krypton and xenon. A good account is given of bubble statics and mobility. The phenomenon of breakaway swelling is discussed on the basis of immobile bubbles.

On the whole, except for the first chapter, *Irradiation Effects in Fissile Materials* can be recommended as a good survey of the topics covered. The book would have benefited in a few spots from the service of a native English-speaking editor or proofreader.

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About the Reviewer: Mark Robinson has been a member of the Solid State Division of the Oak Ridge National Laboratory following completion of graduate studies at Oklahoma State in 1951. Dr. Robinson's principal research interests are in atomic collisions and radiation effects in solids.

[1] J. A. L. ROBERTSON, *Irradiation Effects in Nuclear Fuels*, Gordon and Breach, New York (1969).

[2] L. T. CHADDERTON and I. M. TORRENS, *Fission Damage in Crystals*, Methuen and Co. Ltd., London (1969).

[3] N. BOHR, *Kgl. Danske Videnskab. Selskab, Mat.-Fys. Medd.*, **18**, *8* (1948).

[4] M. B. BRODSKY, in *Rare Earths and Actinides*, p. 75, Institute of Physics, London and Bristol (1971).