

論文 / 著書情報
Article / Book Information

題目(和文)	高速炉用炭化ホウ素中性子吸収材の中性子照射効果
Title(English)	Effect of Fast Neutron Irradiation on B4C Absorber for Fast Reactors
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

専攻：	原子核工学	専攻
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申請学位(専攻分野)：	博士	(学術)
Academic Degree Requested	Doctor of	
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要旨 (英文 800 語程度)
Thesis Summary (approx.800 English Words)

Chapter 1 “Introduction”

The research background of the B₄C neutron absorber material was overviewed in this chapter. First, the advantages of B₄C which made it the leading candidate as the neutron absorber for the next-generation fast reactors was briefly introduced. Then, the key issue of the B₄C applied in fast reactors was explained based on the practical experiences on the experimental fast reactor “JOYO”. Finally, the previous studies on the neutron-irradiated B₄C were briefly reviewed, and the motivation of this study was described.

Chapter 2 “Neutron Irradiated B₄C samples for experiments”

The basic information of the B₄C materials was described in this chapter, including the appearance of the as-received samples, estimated burnups, irradiation conditions in JOYO.

Chapter 3 “XRD analysis of the neutron-irradiated B₄C”

With combinations of post-irradiation annealing, the XRD analysis results were explained in this chapter. The neutron-irradiated B₄C samples with different burnups were analyzed by XRD with a comparison to the non-irradiated B₄C samples. Anisotropic changes in lattice parameters and the diffraction peak breadth were found in the neutron-irradiated samples. Then the samples were annealed up to 1000°C by steps. The samples showed recovery behaviors in lattice parameters and peak breadth were confirmed after annealing. The results suggested that the specific types of irradiation-induced defects in B₄C were thermally activated at the temperature of up to 1000°C.

Chapter 4 “TEM observation of the neutron-irradiated B₄C samples”

The helium bubbles and the grain boundaries of the B₄C samples were observed by TEM, and the results were explained in this chapter. The intragranular helium bubbles were all appeared in spherical or ellipsoidal shapes with similar sizes in the B₄C samples from an actual control rod of JOYO. However, in the sample capsuled irradiated in a rig, the intragranular helium bubbles are in flat plate shapes. The results suggested that the unstable irradiation condition in the control rods make the helium bubbles have no sufficient time to migrate and accumulate into large bubbles. In addition, a trace of the neutron-induced lithium migrating to the surface of the specimen was confirmed by in-situ TEM.

Chapter 5 “Density functional theory”

The theoretical basis of the calculations based on the density functional theory was introduced in this chapter.

Chapter 6 “First-principles investigation of neutron-irradiation-induced point defects in B₄C”

First-principles calculations based on DFT were carried out to investigate the nobilities of the

neutron-induced point defects in B_4C . The results indicated the vacancy-type defects tend to migrate to the C-B-C chains of B_4C to obtain a lower total energy, which indicates that the icosahedral cage structures of B_4C have strong resistance to neutron irradiation. The lithium and helium atoms had significantly lower migration barriers along the rhombohedral (111) plane of B_4C than along the vertical direction to this plane. This implies that the helium and lithium interstitials tended to follow a two-dimensional diffusion regime in B_4C at low temperatures; which could explain the formation of flat plate-shaped helium bubbles experimentally observed in B_4C pellets after neutron irradiation.

Chapter 7 “First-principles study on the helium migration energies in $B_{12}X_2$ (X=O, Si, P, As) crystals”

This part of work is being submitted to Journal.

Chapter 8 “Conclusions”

The important results and findings obtained in this study were summarized.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note：Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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