

論文 / 著書情報
Article / Book Information

題目(和文)	無配向および高配向窒化アルミニウムの欠陥生成に及ぼす中性子照射の影響および熱アニールによる回復挙動
Title(English)	Neutron Irradiation Effects on Defect Formation in Random and Highly Oriented Aluminum Nitride and Their Recovery Behavior by Thermal Annealing
著者(和文)	ポンパットデットウドムタナタオン
Author(English)	Thanataon Pornphatdetaudom
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11642号, 授与年月日:2020年9月25日, 学位の種類:課程博士, 審査員:吉田 克己,加藤 之貴,小林 能直,片淵 竜也,近藤 正聡
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11642号, Conferred date:2020/9/25, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

系・コース : Department of, Graduate major in	Materials Science and Engineering Nuclear Engineering	系 コース	申請学位 (専攻分野) : Academic Degree Requested	博士 Doctor of (Engineering)
学生氏名 : Student's Name	PORNPATDETAUDOM THANATAON		指導教員 (主) : Academic Supervisor(main)	Katsumi Yoshida
			指導教員 (副) : Academic Supervisor(sub)	

要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

Aluminum nitride (AlN) is a semiconductor ceramic material with high thermal conductivity, low thermal expansion and low dielectric constant and a promising candidate for fusion molten salt-cooled (FLiBe) or liquid metal (Li-Pb or Li)-cooled reactor. It is an anisotropic material with a hexagonal wurtzite structure where each axis may respond to the irradiation differently.

The commercially available specimens with randomly oriented grains, Shapal, was manufactured by Tokuyama Soda Co. Japan. The prepared samples were irradiated in the Japan Materials Testing Reactor (JMTR) in various conditions and step-wise thermal annealed up to 1673 K for six hours at each step, to provide useful experimental data and defect recovery analyses. Both unirradiated and irradiated specimens were characterized by x-ray diffractometry, and observed recovery behavior by dilatometry. The effect on lattice swelling was found differently regarding neutron fluence and irradiation temperature.

Irradiated specimens at lower neutron fluence and irradiation temperature responded isotropic unit-cell expansion. A higher dose also caused greater swelling in this low condition irradiation. This result indicated a uniform distribution of point defects, which increases when the number of neutrons in the system is increasing and/or very small defect clusters. On the other hand, irradiated specimens at above $2 \times 10^{24} \text{ n/m}^2$ ($E > 0.1 \text{ MeV}$), expanded anisotropically as lower in the a-axis and significantly larger in the c-axis. This result indicated the (0001)-basal plane dislocation, which has a high density of the defects along the c-axis.

The recovery of the first specimens group started at as same as irradiated temperature, at 523 K and gradually reached the maximum at 1573 K. Results of Arrhenius' plot applied for 2nd order kinetics can divide the recovery to three temperature regions, a low region from room temperature up to 573K, an intermediate region at 573 to 1023 K, and a high region at 1073 to 1423 K. For the low and intermediate, the result explained to be involved with the migration of V_N and V_{Al} , respectively. Before the saturation of length recovery, the high region with high activation energy represents final constant recovery. It is supposed that the more complex clustering has occurred in the system, such as dissociation of the vacancy-antisite or interstitial nitrogen clustering.

On the other hand, up to 723 K thermal annealing, the anisotropic expanded specimen did not recover. It is indicated almost no dependent interstitials that can be mobile. The similar energy required at the high region of the first group was found at 773 to 1123 K in this specimen, which the same mechanism could be explained. At 1173 to 1423 K, rapidly quick and large shrinkage was observed with very high activation

energy. The combination of small interstitial loops that enlarged the size of the line defects might be attributed to forming larger dislocation loops. However, for more understanding, the mechanisms at this annealing stage should be further experimental and theoretical observed.

Point defects and dislocation loops lying on the (001) plane induced by neutron irradiation are focused on bringing a dramatic change and swelling in the material. The AlN ceramics with highly oriented grains is expected as one of the routes to obtaining improved properties. The highly oriented specimens were successfully fabricated under a strong magnetic field for 12 T in the National Institute of Materials Science, Japan. Then, the specimens were neutron-irradiated in the BR2 reactor, and similar thermal annealing and characterization with randomly oriented grain specimens were performed. At low neutron fluence, both random and highly oriented specimen showed small anisotropic expansion, which also similar to the report on commercial AlN. The unit-cell volume expansion of the randomly oriented specimen was almost the same as that of the highly oriented one. Still, at higher neutron fluence, the unit-cell volume expansion of randomly oriented specimen was found significantly larger.

In case of length recovery after thermal annealing, both specimens were found similarly started near to the irradiation temperature at around 573 K. The recovery profiles of the specimen with randomly oriented grains and the aligned grains measured along a-axis dominant direction resembled each other. However, the profile result measured along the c-axis direction was different. The larger expansion was found the tended to continue up to the maximum observation temperature.

The different types of defects also affected the hardening of the specimen. All specimen was hardened after irradiation, where the specimen without dislocation loops has a higher hardening value. The existence of dislocation caused a reduction in hardening and the weakness of the surface that the indentation quickly generated cracks during the test. The color appearance of specimens also affected and changed from the original translucent yellowish to non-translucent black of non-dislocation, and brown of those with dislocation. Thermal annealing caused the recovery in color. This incident is related to the color center mechanism and can be advantaged to sensor applications.

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).

注意：論文要旨は、東工大リサーチリポジトリ (T2R2) にてインターネット公表されますので、公表可能な範囲の内容で作成してください。

Attention: Thesis Summary will be published on Tokyo Tech Research Repository Website (T2R2).