Differences in the Irradiation Effects of IG-110 and IG-430 Nuclear Graphites
- Effects of Coke Difference-

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1.Introduction

In the high temperature gas cooled reactors (HTGRs), graphite acts as a moderator and reflector as well as a major structural component that may provide channels for the fuel and coolant gas, channels for control and shut down, and thermal and neutron shielding. During a reactor operation, many of the physical, chemical and mechanical properties of these graphite components are significantly modified as a function of the temperature, environment, and an irradiation. On the other hand, currently, all the nuclear graphites are being manufactured from two types of cokes, i.e., petroleum and coal-tar pitch coke, and it has been understood that the type of coke plays the most critical role determining the properties of a specific graphite grade [1].
To investigate the effects of coke types on the irradiation response of a graphite, two graphites of different cokes were irradiated by 3 MeV C+ ions and the differences in the response of ion-irradiation were investigated.

2. Experimental

Specimens (10x10x2 mm^3) made of IG-110 and IG-430 fine-grained isotropic nuclear graphite, were irradiated to the peak fluence of 0.26 ~ 6.15 dpa by 3 MeV carbon ions of 1 μA beam current using a Tandem Vande-Graff accelerator at room temperature. Table 1 compares some of physical and mechanical properties of IG-110 and IG-430. The IG-110 is made of petroleum cokes, and IG-430 is made of coal-tar pitch cokes. All the ion-irradiation specimen surfaces were prepared by mechanical polishing up to 0.05 ㎛ Al_2O_3. The range of ions calculated by TRIM98 was 3.2 μm (E_d =25 eV). Ultra-microhardness tester (DUH-200) was used for the mesurement of hardness (H) by loading-unloading method. Calculation of Young's modulus (E) followed the unloading compliance – E relationship [2]. In the Raman spectroscopy, an Ar-Kr ion laser beam of 488 nm wavelength (beam power: ~ 200 mW)(Model: Coherent Innova 70 Spectrum) and a double grating monochromator (Model: Jobin-Yvon Ramanor U-1000) were used at room temperature. Installed grating of the monochromator was 1800 grooves.mm, and the spectrum intensity was measured by using a phpotomultiplier tube (Model: Haramatsu 943-02 GaAs photomultiplier). The resolution of the present equiment was 0.2cm^{-1}. Details of the experiment are reported elsewhere [3][4].

Table 1 Typical properties of IG-110 and IG-430.

Grade	IG-110	IG-430
Coke	petroleum	coal-tar pitch
Grain Size (mm)	0.02	0.01
Apparent density	1.77	1.82
Anisotropy ratio	1.10	1.09
Ash content(ppm)	Less than 10	Less than 10
Impurity (ppm)	0.001 – 0.1	0.001 – 0.1
E, GPa	9.7	10.6
Tensile Str. (Mpa)	27.2	37.8
Comp. Str. (MPa)	79	96
Thermal Con. (W/mK)	129-140	138-147

3. Results and Discussion

3.1 Differences in the mechanical properties: Hardness and Young's modulus

Fig. 1.a and **1.b** show the change of hardness and Young's modulus due to irradiation, respectively. It is seen that both the increase in the hardness and Young's modulus is larger in the IG-430 than IG-110. **Fig. 1.a** shows that both grades show a two step increase in hardness. While the IG-110 shows an apparent two step increase with a peak around 1 dpa, the IG-430 shows a rather linear increase after about 1 dpa resulting in a large difference to IG-110. The difference in the change of Young's modulus between the two grades, however, appears negligible in **Fig. 1.b.** Both grades show a rather saturation in the early stage of irradiation, i.e., 1 dpa.

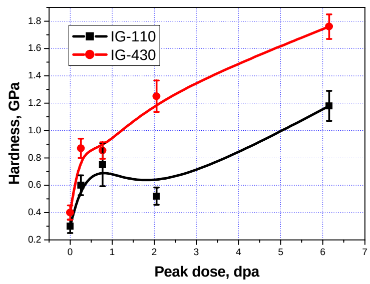

Fig.1.a. Change of hardness due to irradiation.

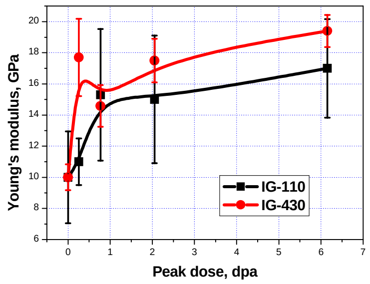

Fig.1.b. Change of Young's modulus due to irradiation.

3.2 Differences in the Raman spectroscopy

Previous experiences in the application of Raman spectroscopy for the evaluation of radiation effects in nuclear graphite have shown that, while the intensity parameter saturates rather in the early stage of irradiation, the FWHM parameter changes rather gradually for a wide dose range [**5**]. **Fig. 2** shows the changes in the $(FWHM)_D/(FWHM)_G$ with dose, where $(FWHM)_D$ and $(FWHM)_G$ correspond to the FWHM of D-peak and G-peak, respectively. It is seen that the increase in the $(FWHM)_D$ of IG-430 is larger than that of IG-110. Thus, from this observation, it is understood that the irradiation sensitivity of IG-430 may be higher than the IG-110 for the present dose range investigated. The observation agrees well with the results on the mechanical property changes, i.e., where IG-430 shows a higher irradiation sensitivity than IG-110, **Fig. 1.a and 1.b.** Further investigation as to the cause of present observation may be required.

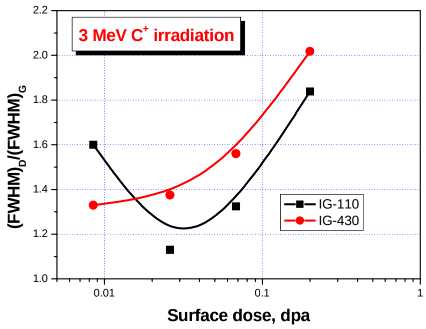

Fig. 2. The change of $(FWHM)_D/(FWHM)_G$ with dose.

4. Conclusions

Differences in the irradiation effects of IG-110 (petroleum coke)and IG-430 (coal-tar pitch coke) nuclear graphites were investigated based on the results of hardness test and Raman spectroscopy of 3 MeV carbon-ion irradiated specimens. Results show that the irradiation sensitivity of IG-430 is a little higher than that of IG-110. Further studies are required as to the cause of present observation.

REFERENCE

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