EFFECT OF ARGON ION IRRADIATION ON THE MECHANICAL PROPERTIES OF CARBON MATERIALS

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Introduction

Carbon/Carbon (C/C) composite materials have been extensively used for many fusion plasma devices such as JT-60 (JAERI) and may be used for plasma facing components of fusion reactors in the future. The degree of property deterioration, such as decrease in thermal conductivity and changes in mechanical properties due to neutron irradiation damage, should be known in advance of the structural design for carbon components. On the other hand, it is important to develop C/C composite materials that have smaller effects of radiation damage on the various properties[1]. In this connection it is necessary to evaluate radiation damage effects on various properties of C/C composite materials. The purpose of this paper is to evaluate effect of argon ion irradiation on mechanical properties of some C/C composite materials and nuclear grade graphites by using the indentation test in which we can measure indented load and displacement continuously. An evaluation of radiation damage was performed using the TRIM code.

Experimental

Materials tested here were two kinds of C/C composite materials and four grades of isotropic graphite materials. Table 1 shows the typical properties of tested materials. The specimens were a block type which has the size of 5-10 mm placed in the area of 60 mmx35 mm. Ion used here was $^{40}Ar^{8+}$ which has an energy of 175 MeV-1 μ A which was obtained from the AVF cyclotron. Ion was irradiated so as to scan the above area with 50 Hz in the X-direction and 0.5 Hz in the Y-direction for 200 min. In the TRIM code it was assumed that the density was 1.8 g/cm3, the displacement threshold energy 37 eV, the binding energy 0.21 eV as required parameters. As a result, the range of argon ion in the carbon was estimated as about 50 μ m, the fluence was about 0.15 dpa near the range and about 0.7×10^{-3} dpa by the surface from the range. Indentation tests were performed using DUH-201 (made by Shimadzu Corp.). The load levels used were 19.6 mN, 147 mN, 490 mN and 980 mN.

Results and Discussion

Mechanical property parameters, B and D were defined as in Figure 1. The value B is known to be proportional to the strength and the value D to the Young's modulus. Argon ion was irradiated in the axial direction of carbon fiber and indentation tests were made in the same direction. The results of PCC-2S (C/C composite) have been indicated in Figure 2. The parameter B increased slightly due to ion irradiation and the parameter D gave large increase.

When the loads were more than 50 g, little changes were seen The reason for this may be due to that the depth indented approached to near the range (50 μ m).

After the ion was irradiated in the axial direction, the values of B and D in the perpendicular direction to the fiber axis have been shown in Figure 3. The parameter values decreased sharply in the region of more than 50 μ m that is the range. of the argon ion.

The changes in the parameters of the carbon materials ion-irradiated in the axial direction were larger than those irradiated in the perpendicular direction. It suggests that radiation damage effects are dependent on the direction of ion irradiation.

Conclusions

The mechanical property parameters, B and D of the C/C composites and the isotropic graphites increased due to argon ion irradiation. Radiation damage effects depend upon the direction of ion irradiation., The distribution of the parameters in the depth direction corresponds to the range of argon ion in the carbon calculated by the TRIM code.

References

[1]Oku T., Suzuki S., Inagaki M., Kurumada K. and Kawamata K., Extended Abstracts, Eurocarbon, Science and Technology of Carbon Strasbourg, France, P2E50, X.15(1998-7)

Acknowledgments

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Table 1 Materials tested.

Material	Brand	Apparent Density (kg/m^3)	Young's Modulus (GPa)	
			Axial	Radial
C/C Composite	PCC-2S	1830	20	5.9
	CX-2002U	1670	11.0	3.4
Graphite	IG-430U	1820	10.0	-
	IG-430UHP	1820	7.7	-
	ISO-88	1915	12.7	-
	PD-330S	1820	11	-

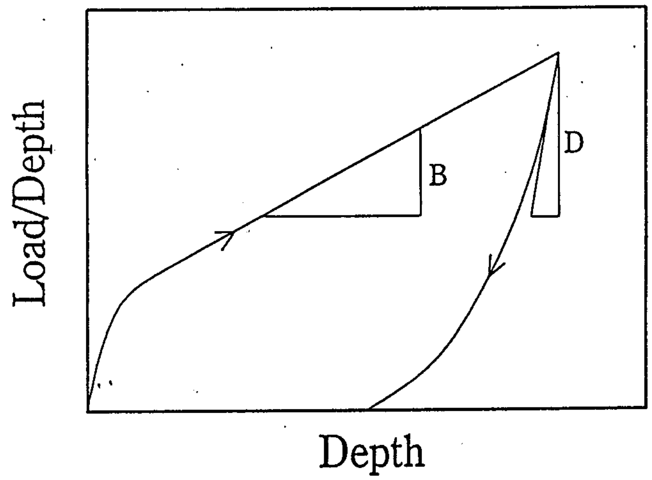

Figure 1 Typical load/depth versus depth curve in loading and unloading conditions. (Definition of parameters B and D.)

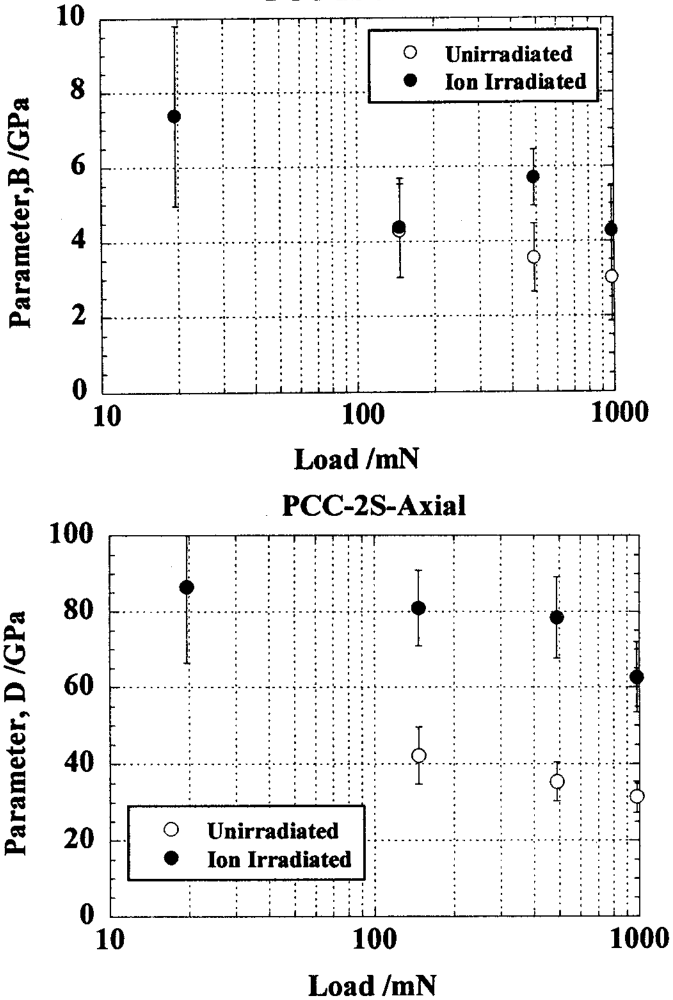

Figure 2 Parameters B and D for PCC-2S-Axial before and after ion irradiation as a function of load.

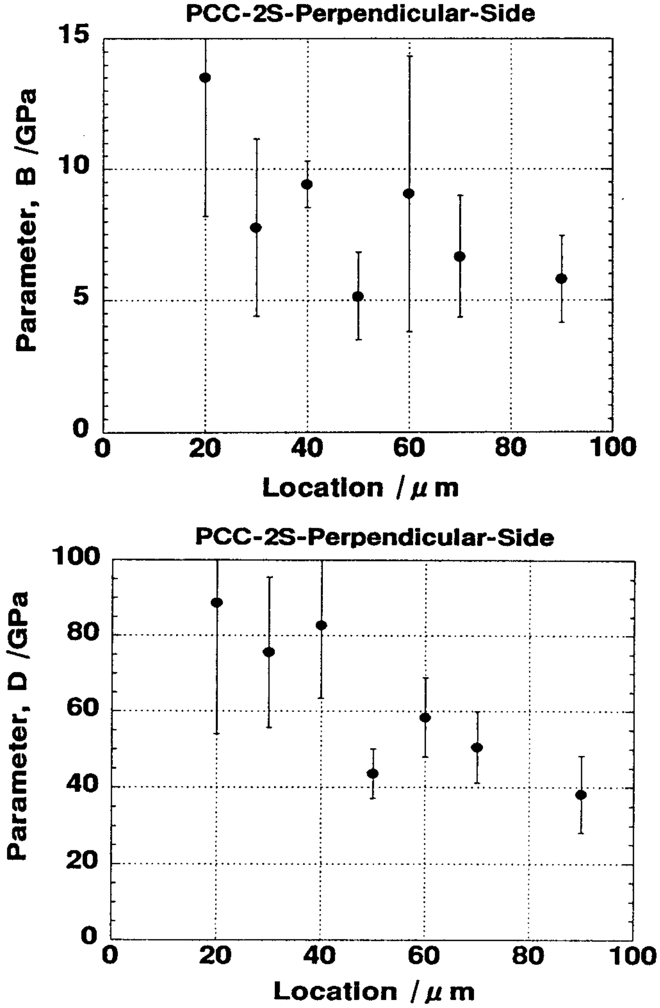

Figure 3 Parameters B and D for PCC-2S-Perp. after ion irradiation as a function of location..