ION IRRADIATION EFFECTS ON MECHANICAL PROPERTIES AND MICROSTRUCTURES OF DIFFERENT CARBON FIBERS

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Introduction

Carbon/Carbon composites have been used for plasma facing materials of fusion reactor devices, and it is thought that they will be taken as one of candidate materials of the next fusion experimental reactor. In order to apply them to the reactor, changes in microstructures and properties due to radiation damage must be measured, and furthermore development of new C/C composites with radiation-resistant properties will be needed. Thermal and mechanical properties of C/C composites are well known to depend on those of carbon fibers since carbon fibers in C/C composites are generally less crystalline than the carbon matrix part.

In this study, nine kinds of carbon fibers, which have different microstructures in the cross section and different mechanical properties, were irradiated by high energy carbon and argon ions. The effects of radiation damage on the microstructures and the tensile properties of the carbon fibers are described.

Experimental

For carbon and argon ions irradiation tests, three grades with nine kinds of carbon fibers were selected, which were PAN based fibers (M55JB, M40JB, T700SC by Toray Corp.), mesophase pitch based fibers (YS-70-60S, XN-70-60S, YS-15-60S by Nippon Graphite Fiber Corp.) and pitch based fibers (K13C2U, K1392U, K1352U by Mitsubishi Chemical Co.).

Carbon ions ($^{12}C^{+6}$) of 100 MeV with 0.5 micro-A were irradiated to $6x10^{-6}$ dpa using the TANDEM accelerator in Tokai, Japan Atomic Energy Research Institute (JAERI), and argon ions ($^{40}Ar^{+8}$) of 175 MeV with 1 micro-A were irradiated to $1.1x10^{-3}$ dpa using the AVF cyclotron in JAERI Takasaki on four kinds of carbon fibers in those described above. The ranges of carbon and argon ions calculated by TRIM code were 221 and 52.8 micron, respectively. On the other hand, as the ion irradiated carbon fibers have less than 20 micron in diameter, irradiation damages were thought to be uniform across the cross section.

Tensile tests and scanning electron microscope observations were conducted separately before and after ion irradiation.

Results and Discussion

Figure 1 shows changes in cross sectional areas of carbon fibers after ion irradiation. The cross sectional areas increased due to ion irradiation except for the XN-70-60S and tended to increase with increasing radiation damage. One of the causes was considered to be the swelling of carbon basal planes due to lattice defects in the graphite interlayer.

Figures 2 and 3 show changes in tensile strengths and Young's moduli of carbon fibers after ion irradiation, respectively. The tensile strengths tended to decrease due to ion irradiation, and the effects on Young's moduli were similar to those of the tensile strengths. The mechanism of radiation damage effects on the carbon fibers has not been completely illustrated. Axial defects of carbon fibers need to be considered in addition to defects in the cross section.

Within the limits of this study, the tensile strength and Young's modulus of the YS-15-60S mesophase pitch based fiber were stable to radiation damage. Also it seemed that the tensile strengths and Young's moduli of the carbon fibers with random structure were comparatively more stable to radiation damage than those with radial structure.

Acknowledgments

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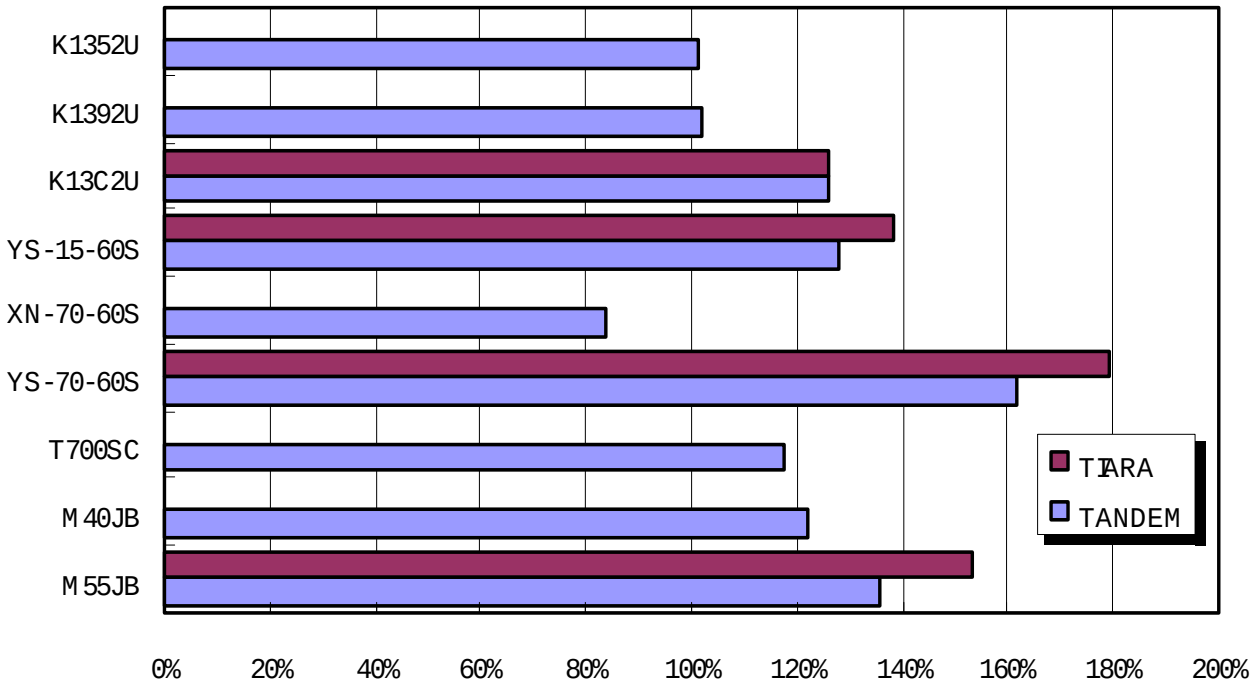

Figure 1. Changes in cross sectional areas of carbon fibers after ion irradiation.

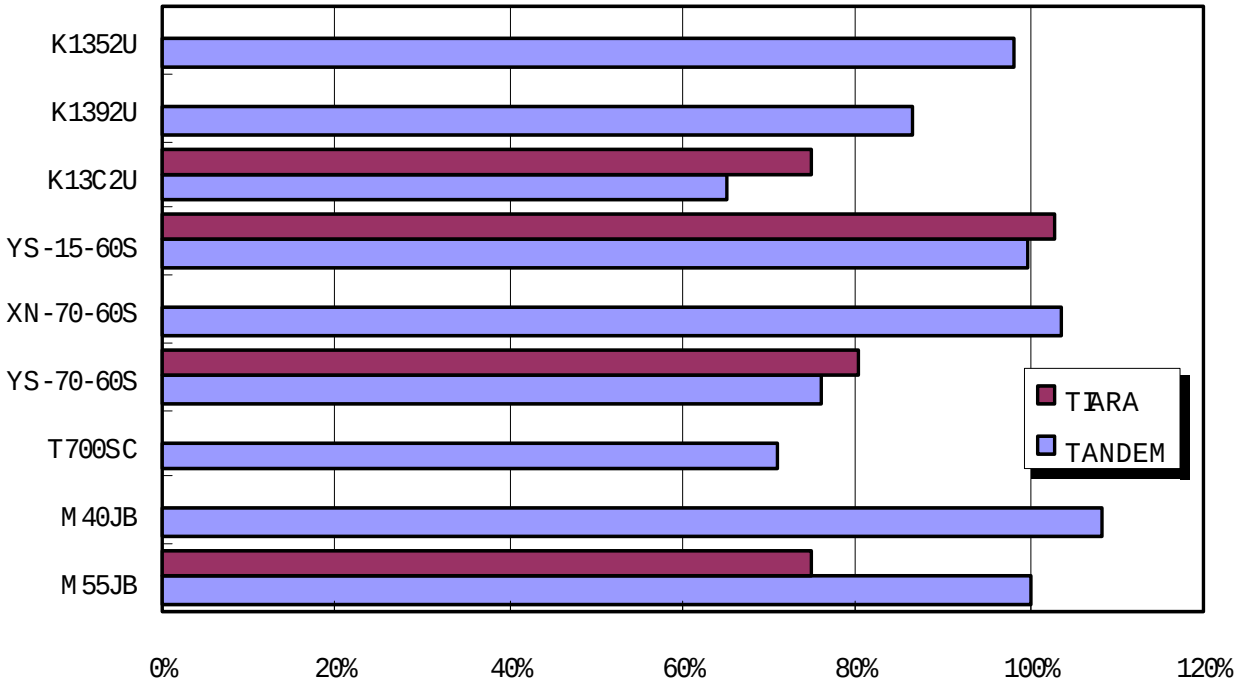

Fig. 2 Changes in tensile strengths of carbon fibers after ion irradiation.

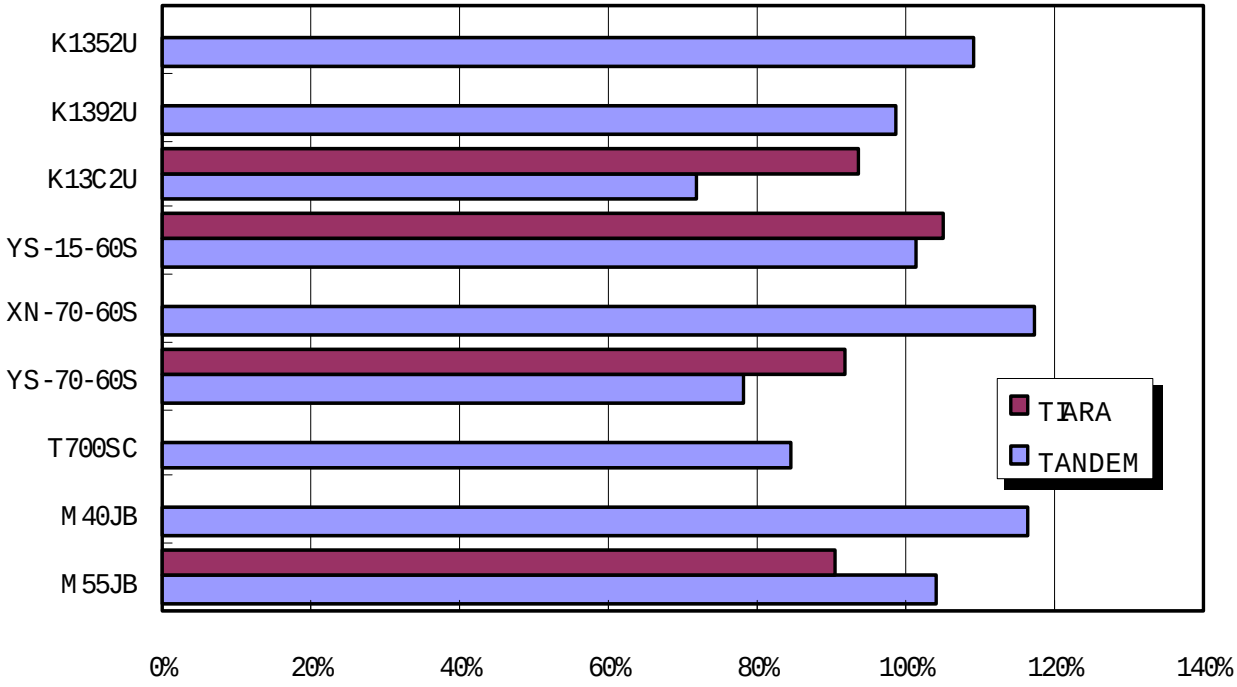

Fig. 3 Changes in Young's moduli of carbon fibers after ion irradiation.