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High temperature irradiation damage of carbon materials studies by Laser Raman spectroscopy

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Extensive studies have been done on erosion and hydrogen retention in plasma facing carbon materials concerning tritium safety and maintenances of fusion devices. Until now, however, little studies have been devoted to high temperature and high flux irradiation relevant to ITER divertor condition. In present work, we have studied high temperature irradiation of carbon materials with high flux of hydrogen and helium ions applying Laser Raman spectroscopy.
Graphite samples (IG-430U) analyzed here were irradiated with low energy and high flux hydrogen and helium ions in a linear plasma device, NAGDIS-II in Nagoya University at a temperature ranging from 800 to 1200K. Samples irradiated with 3-5 keV ions were also analyzed. The irradiated samples were analyzed by Laser Raman spectroscopy, scanning electron microscopy and transmission electron microscopy.
The obtained Raman spectra were composed of two main peaks centered at 1580 cm^{-1} and 1355 cm^{-1}, and deconvoluted into two Lorenzian peaks to determine peak intensities (I_{1580} and I_{1355}) and the full width at half maximum ($FWHM_{1580}$ and $FWHM_{1355}$), respectively. The intensity rations (I_{1355}/I_{1580}) and $FWHM_{1580}$ were compared with those of the ion irradiated samples in terms of their microstructures determined by TEM diffraction patterns [1]. The Raman spectra for the irradiated samples in NAGDIS-II with very high flux hydrogen ions ($7.7 \times 10^{26} m^{-2}$) at 1200K show very sharp two peaks like that of the original graphite but their peak intensity ratio is quite different, i.e. for the un-irradiated graphite I_{1580} is more intense than I_{1355}, while the opposite for the irradiated samples. Moreover the relation between $FWHM_{1580}$ and I_{1355}/I_{1580} is similar to that for the ion irradiated graphite at lower temperature, indicating grain sizes became very fine. From such relation, we can conclude that micro structure of the graphite sample irradiated with very high flux at elevated temperatures is modified such that grain size becomes very fine but each grain is well graphitized than those of the original grain of the un-irradiated sample. Most probably because high flux irradiation makes the grain size small but simultaneous high temperature annealing makes the grain well graphitized.
[1] K.Niwase, et al. J.Nucl.Mater 179-181 (1991)

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