CHARACTERIZATION OF KAPTON-DERIVED CARBON FILM OBTAINED BY PULSE YAG LASER IRRADIATION

Y. A. Kim, C. Kim, Y. J. Kim, T. Hayashi, T. Matushita, T. Kasai and M. Endo

Faculty of Engineering, Shinshu University, 500 Wakasato, Nagano 380-8553, Japan

Introduction

Aromatic polyimde-derived carbon films are extensively studied due to its high crystallinity amounting to that of pyrolytic graphite, and its particular carbonization behavior without cracks and pores [1-4]. In this study, this kinds of carbon film have been tried to obtain by YAG laser (λ=1064nm) irradiation to the Kapton-type polyimide film under nitrogen atmosphere, and characterized the structural properties of the film, as compared that of carbon film by simple heat-treatment under argon atmosphere, by using polarized Raman spectroscopy.

Experimental

A Kapton film of 125μm (Toray-Du Pont Ltd.) thickness was irradiated by 10Hz pulse YAG laser radiation with different time from 30 to 180min under nitrogen. The laser power of one pulse at the decided sample position was maintained at 243mJ, the pulse width 8ns, and spot size diameter 7mm. On the other hand, by using simple heat treatment in graphite furnace, carbon film was obtained at various temperature from 600 to 2800°C. As a analytical technique, Raman spectroscopy is used, especially with two different geometry, such as parallel and vertical directions.

Results and Discussion

Raman scattering for Kapton film obtained by simple heat treatment shows distinctly different behavior. For the range from 600 to 1000°C, the second order Raman scattering show very broad band , indicating that very small number and size of crystallite would only weakly coupled to the incident laser beam, and thus contribute to little to the Raman scattering. And the higher Relative intensity (I_D/I_G) (Fig. 1) and lower value of D_p of G peak (Fig. 2) for the sample at 800°C as compared that of sample at 600°C means abrupt disturbance of structural ordering due to degassing process. Furthermore, the downshifted of G peak probably relate to bond angle disorder in carbon film. Therefore, physical meaning of Kapton film for this range would be transformation from polymer to amorphous carbon film. Separation of the second order Raman scattering and Raman frequency of G peak at around 1588cm^{-1} for sample at 1200°C means enough development of graphene size to couple to incident laser beam. For the range from 1200 to 2000°C, abrupt increase of Raman intensity of second order Raman scattering, and consecutive increase of D_p of G peak relate to the development of crystallite. Finally for the range from 2400 to 2800 °C , the downshifted of Raman frequency of G peak approaching to that of graphite, higher value of D_p of G peak, and very low value of Relative intensity means the graphitization process for this region. Furthermore, the shape of 2D peak at around 2725cm^{-1} for sample at 2800°C is asymmetric, strongly implying the development of three-dimensional stacking ordering.

Carbon film obtained by YAG irradiation shows irregular surface morphology consisting of Top and Valley part (swelling phenomena) due to degassing caused by abrupt carbonization. Microprobe Raman technique makes selective characterization for both parts. In the case of Top part, the relative intensities (I_D/I_G) show minimum value for sample at 90 minute (Fig. 4), and consecutively increase with increasing irradiation time. And also, reverse trends for D_p of G peak are observed (Fig. 3). The most interesting thing is that the swelling height increased with 90minute-irradiation time, and collapsed with increasing irradiation time. On the other hand, the Valley part show gradual carbonization behavior. Therefore, For Top part, gradual carbonization occurred up to the sample with 90minute-irradiation time accompanying the swelling phenomena, and with increasing irradiation time, microstructure would transform to disordered carbon accompanying the collapsed phenomena.

Conclusions

We prepared and characterized the carbon films obtained with different methods (simple heat-treatment and YAG laser irradiation) by using polarized Raman

spectroscopy. As compared that of carbon film by HTT, the carbon film by irradiation showing generally very high D_p of G peaks and lower relative intensity (I_D/I_G) indicate that even though the level of carbonization is relatively high, structural ordering is relatively lower due to the abrupt carbonization.

References

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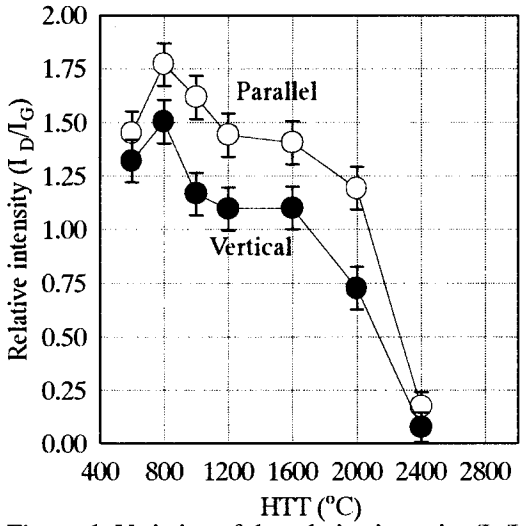

Figure 1. Variation of the relative intensity (I_D/I_G) as a function of temperatures

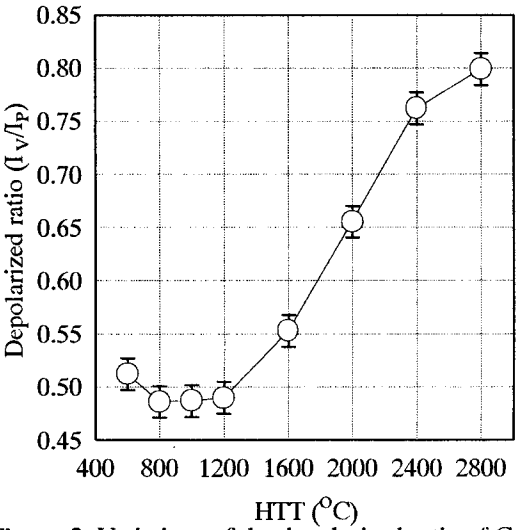

Figure 2. Variations of the depolarized ratio of G peak as a function of temperature.

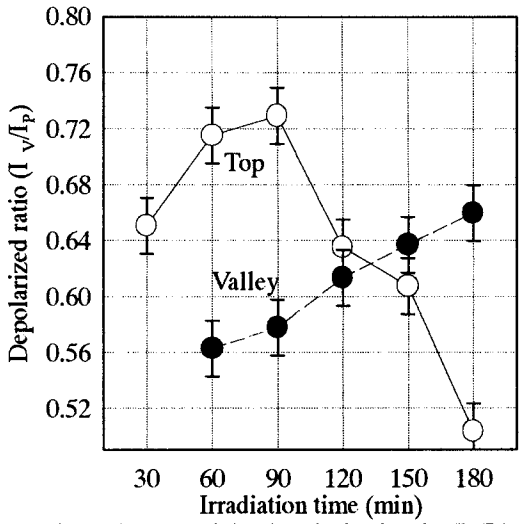

Figure 3. Variations of the depolarized ratio (I_V/I_P) as a function of irradiation time.

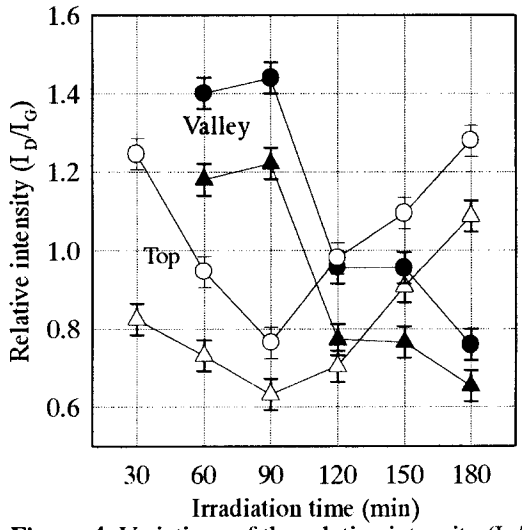

Figure 4. Variations of the relative intensity (I_D/I_P) as a function of irradiation time.