Characterization of carbon films prepared from polyimide films at different heat-treatment temperatures and their intercalation behavior

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Five carbon films were prepared by pyrolysis of polyimide films at heat-treatment temperatures of 1600, 2000, 2400, 2600, and 2800 °C and characterized in terms of their structural, electrical, and thermal properties. Furthermore, intercalations of potassium and molybdenum chloride ($MoCl_5$) into carbon films were performed.

A distinct structural change was observed in the carbon films heat treated at approximately 2000 °C, where their Raman spectra exhibited a D band larger than that of the G band without a sharp XRD peak. Corresponding to this distinct structural change, the electrical and thermal conductivities of carbon films significantly decreased. On the other hand, the Seebeck coefficient showed more complex behavior, where the carbon films heat treated at 2800 and 1600 °C showed a negative coefficient, whereas those heat treated at 2600, 2400, and 2000 °C had a positive coefficient. It is well known that higher graphitization carbons such as highly oriented pyrolysis graphite (HOPG) exhibit a negative Seebeck coefficient because of their semi-metal characteristics.

K and $MoCl_5$ showed different intercalation behaviors with a critical temperature of 2400 °C. The intercalation of $MoCl_5$ did not occur in the carbon films heat treated at below 2400 °C, whereas slight intercalation of K was observed. The carbon films heat treated at lower temperatures were insufficiently graphitized, which prevented intercalation and destabilized any resulting intercalated compounds. The change in the Seebeck coefficient after intercalation is also discussed herein.