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Program Title (English) :Structure control and solid state properties of nano carbon materials
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1. 概要（Summary ）

Due to many open edges, high height/thickness ratio, large surface areas and chemical stability, vertically-aligned carbon nanosheets (CNSs) which consist of few-layer graphene have been extensively investigated in many fields of biosensors, field electron emissions, supercapacitors, lithium ion batteries, fuel cells et al. Among the various synthesis methods for CNSs, plasma-enhanced chemical vapor deposition (PECVD) has been considered as a promising method for the formation of vertically-aligned CNSs because of mass production, large area, and low cost as well as low-temperature growth. Previously, carbonaceous gases and liquid precursors have been employed as carbon sources to synthesize the CNSs by PECVD technique. In this work, we report the growth of vertically-aligned CNSs obtained on the Cu substrate from Kapton polyimide film which is a solid carbonaceous polymers as carbon source under Ar/H_2 plasma irradiation.

2. 実験（Experimental）

The vertically-oriented CNSs were fabricated by 2.45 G MPECVD equipment. The cleaned Kapton polyimide film was putted on Cu substrate and irradiated by the plasma of Ar and H_2. The as-synthesized CNSs were characterized by field emission scanning electron microscope (FE-SEM, SU8000, Hitachi), transmission electron microscope (TEM, JEM-2100F, JEOL), X-ray photon spectroscopy (XPS, Phi 5600), energy-dispersive X-ray spectroscopy (EDX) and Raman spectroscopy (ReinshawinVia Raman).

3. 結果と考察（Results and Discussion）

Fig. 1a shows a typical high-magnification SEM image of as-synthesized carbon films. It can be found that the films were composed of petal-like nanosheets with many sharp open edges, which are similar to the CNSs obtained from CH_4 gas under plasma irradiation. The low-magnification SEM image exhibits a uniform distribution of these nanosheets on the Cu substrate. The cross-sectional SEM image (inset of Fig. 1b) displays that the resulting nanosheets are oriented perpendicularly to the substrate. The average length and height of the nanosheets were calculated to be 1 and 4.5 μm, respectively. The thickness of the edges was about 2 nm, as was confirmed by transmission electron microscope (TEM) images (see in Fig. 1c-d). Fig. 1e shows Raman spectrum of vertically-aligned CNSs, which includes four main features of D, G, D' and 2D peaks. The D (1349 cm^{-1}) and D' (1619 cm^{-1}) peaks are disorder-induced bands that are often observed in defective graphite structures. The G peak (1586 cm^{-1})is associated with the doubly degenerate phonon mode at the Brillouin zone center. The half-maximum full width of the G band (ω_G) and the ratio of the D band to G band (I_D/I_G) are utilized to estimate graphitization and the average size of graphite crystallinity. It suggests that the as-synthesized CNSs consisted of few-layer graphene with high crystallinity. XPS result in Fig. 1f suggests that the resulting CNSs have high purity.

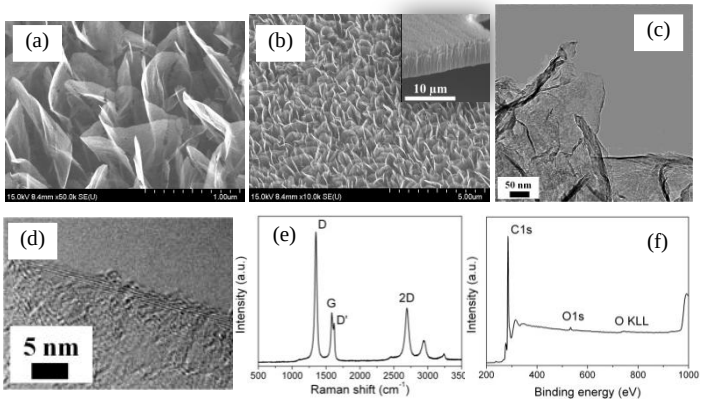

Fig. 1 (a-b) SEM images of vertically-aligned CNSs on the Cu substrate from Kapton PI film as carbon source under Ar/H_2 plasma irradiation. Inset in (b): cross-sectional SEM image of vertically-aligned CNSs. (c-d) Typical TEM images. (e) Raman spectrum. (f) Survey scan XPS spectrum.

4. その他・特記事項（Others）

なし

5. 論文・学会発表（Publication/Presentation）

(1) Z. Wang, H, Ogata, S. Morimoto, M. Fujishige, K. Takeuchi, Y. Hashimoto and M. Endo. Structure changes of MPECVD-grown carbon nanosheets under high-temperature treatment. Carbon, 68 (2014) 360-368.
(2) Z. Wang, H, Ogata, S. Morimoto, M. Fujishige, K. Takeuchi, Y. Hashimoto and M. Endo. Structure changes of MPECVD-grown carbon nanosheets under high-temperature treatment. ChinaNano 2013 in Beijing, Sept 6, 2-13.
(3) Z. Wang, H, Ogata, S. Morimoto, M. Fujishige, K. Takeuchi, Y. Hashimoto and M. Endo. Synthesis of carbon nanosheets from Kapton polyimide by microwave plasma treatment. Carbon, 72 (2014) 421-424.
(4) Z. Wang, H, Ogata, S. Morimoto, M. Fujishige, K. Takeuchi, Y. Hashimoto and M. Endo. マイクロ波プラズマ法によるポリイミドからのカーボンナノシート。応用物理学会第61回春季学術講演会，平成26年3月19日.

6. 関連特許（Patent）　なし