Screen-printed patterning of diamond-carbon nanofilaments composite

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New carbons, such as carbon nanotubes (CNTs) and carbon nanofilaments (CNFs), have been attracted much attention as a material for an electron emitter, a bio-sensor, and an catalyst support due to their unique, nanosized structures and large surface areas. We have investigated to synthesize the diamond-carbon nanofilaments composite (Dia.-CNFs) by the decomposition of lower hydrocarbon over oxidized diamond-supported group Ⅷ metal catalysts [1]. The Dia.-CNFs are considered to be a carbon conposite nanomaterial, i.e. a composit of a diamond (sp^3 bonding) and CNFs (sp^2 bonding). A wide variety of physical and/or chemical properties are expected to be yielded by the material as the unique sp^3-sp^2 composite structure of Dia.-CNFs. For the purpose of elucidating the property of the Dia.-CNFs, it is important to make the Dia-CNFs in the form of a fine powder into a patterned form having a desired dimension. In this study, we have tried to prepare a Dia.-CNFs paste to make desired patterns on silicon substrate by screen-printing method. The printed patterns were observed by scanning electron microscopy (SEM) to evaluate the printing conditions for obtaining a desired pattern.

For the Dia.-CNFs growth, the oxidized diamond-supported Ni (Ni/O-dia) catalysts were used. They were prepared by impregnating a $Ni(NO_3)_2 \cdot 6H_2O$ solution onto the oxidized diamond supports. The Ni/O-dia. catalysts were put in the thermal chemical vaper deposition (CVD) reactor. The mixture of CH_4 and Ar gas was introduced and decomposed catalytically on the catalysts surface, then the Dia.-CNFs were obtaind. For the screen-printed patterning, the paste consisted of the Dia.-CNFs, ethyl cellulose and 2-(2-Butoxyethoxy) ethanol were prepared. Ethyl cellulose and 2-(2-Butoxyethoxy) ethanol were mixed as a binder. The Dia.-CNFs were fully dispered into the mixed binder.The Dia.-CNFs paste was printed on substrate by screen-printing. The printed patterns were heat treated at 693 K in air in order to remove the binder. The morphology were observed by SEM.

Fig. 1 shows SEM image of the grown carbon materials. As shown in Fig.1(a), the Dia.-CNFs showed a spherical shape. The higher imagnification image (Fig.1(b)) revealed that the Dia.-CNFs consisted with the fibous nanocarbon, called as CNFs. Fig. 2 shows SEM image of the Dia.-CNFs patterns that were printed on the Si substrate. As shown in Fig. 2(a), the line patterns having 140 μm width were obtained with using the paste which weight composition as following ; the Dia.-CNFs : ethylcelluose : 2-(2-butoxyethoxy)ethanol = 20 :40: 260.The higher imagnification image (Fig. 2(b)) revealed that the patterns consisted the Dia.-CNFs.

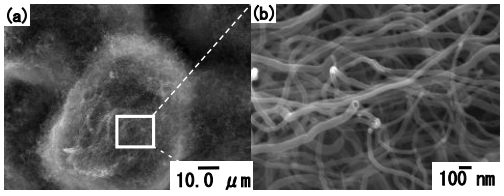

Fig. 1 SEM images of grown Dia.-CNFs from Ni (5 wt%)/O-dia catalyst. Dia.-CNFs were grown at 550 ℃ by CVD using metane as a carbon source.

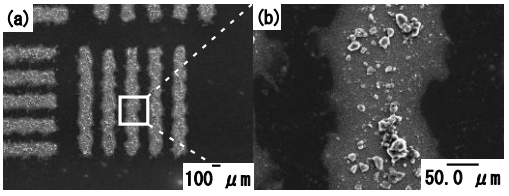

Fig. 2 Pattern images of Dia.-CNFs pastes
Dia.-CNFs : ethyl cellulose : 2-(2-butoxyethoxy)etanol = 20: 40: 260.
The patterns were calcined at 673 K for 30 minutes.

[Reference]

[1] K. Nakagawa, M. Yamagishi, H. Nishimoto, N. Ikeda, T. Suzuki, T. Kobayashi, M. N.-Gamo, T. Ando, *Chem. Mater.* **15**, 4571. (2003).