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Research Letter

Preparation of Powdery Carbon Nanotwist and Application to Printed Field Emitter

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In the present study, an automatic production system with sequencer control for the synthesis of carbon nanofibriform based on catalytic CVD using a substrate was developed. The carbon nanotwist (CNTw), which is one of the helical carbon nanofibers, was then synthesized in powdery form with an Ni–SnO_2-composed catalyst. The production rate was 5 400 times that of the conventional CVD system and Ni–Cu–In_2O_3 catalyst. The powdery CNTw was easily scraped off the substrate, then pasted with organic binder, and printed by a squeegee method on ITO glass substrate for an electron field emitter. The field emission performance was found to be better than that of the directly grown CNTw film in conventional CVD with Ni–Cu catalyst.

1. INTRODUCTION

Some carbon nanomaterials are considered to be attractive and potential materials for an electron field emitter in next-generation flat panel displays [1]. Fibriform carbon nanomaterials, such as carbon nanotube (CNT) and carbon nanofiber (CNF), are synthesized by an arc discharge method and various types of catalytic chemical vapor deposition (catalytic CVD). There are two approaches to prepare the field emission cathode using carbon nanomaterials for a field emission display (FED) or device: one is direct film-growth deposition on a substrate by CVD, and the other is application of the presynthesized carbon nanomaterials on a substrate by various methods such as spin coating, dip coating, spray deposition, and print. The most cost-effective method is considered to be a printing method, which is currently used in the industrial manufacturing process of vacuum fluorescent display (VFD).

Helical carbon nanofiber (HCNF), which is a carbon nanofiber with helix shape and is 50 to 500 nm in fiber diameter, is one of the candidates for field emitter material, and its potential has been demonstrated [2]. HCNFs are categorized into carbon nanocoil (CNC), carbon nanotwist (CNTw), and carbon nanorope (CNR) [3]. The CNC has a spring-like shape with a hollow along its outward form, whereas CNTw has a twisted string-shape without such a hollow. The CNR has a shape with multistrings twisted together. The HCNF has been synthesized and studied since the 1970s [4–15]. The CNC and CNTw relatively have good reproducibility, but CNR has been seldom seen. So far, various catalysts have been tried. For example, for CNC, Ni [4], Fe–ITO [8], Cu–(Ni, Cr, Ti or Zn) [9], Au [10], Fe–SnO_2 [11, 12], and Fe-based alloys (Fe–Cr–Mn–Mo, Fe–Cr–Ni–Mo (SUS513)) [13] have been tried, while for CNTw, Ni [4], Ni–Cu [3], Cu [14], and Fe-based alloys (Fe–Ni–Cr–Mo–Mn–Sn) [15] have been used. Compared with CNC, the CNTw has been able to be prepared in almost 100% purity with high uniformity of fiber diameter and shape [3]. However, only the thin-film form of CNTw has been obtained on the substrate [3] and not in sufficient amounts to apply to the printing method to prepare FED. A large amount of CNF in powdery form can be synthesized by the catalyst injection CVD method, but not for