UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte HIROSHI OHKI, TSUNAKI TSUNESADA,
MASAO URAYAMA, TAKASHI KYOTANI,
KEITAROU MATSUI, and AKIRA TOMITA

Appeal 2007-2045
Application 10/204,670
Technology Center 1700

Decided: July 20, 2007

Before and CHUNG K. PAK, PETER F. KRATZ, and
LINDA M. GAUDETTE, *Administrative Patent Judges*.

GAUDETTE, *Administrative Patent Judge*.

DECISION ON APPEAL

This is an appeal from the Examiner's final rejection of claims 1-5, 40-48, and 54. Claims 49-53 are also pending in the application, but have been withdrawn from consideration. We have jurisdiction over the appeal pursuant to 35 U.S.C. § 6(b).

Appellants' invention relates to carbon nanotubes for use in field emission displays. Independent claims 1 and 5 are reproduced below:

1. A carbon nanotube comprising at least one layer of a cylindrical carbon network film,

wherein the carbon network film has a polycrystal structure which is divided into a plurality of crystallites in a tube axis direction., and

wherein an end face of the carbon network film is modified such that field emission efficiency is increased.

5. A display comprising:

an electron source which includes a plurality of carbon nanotubes as a field emission part; and

electric field applying means for applying an electric field to each carbon nanotube so as to cause each carbon nanotube to emit electrons,

wherein:

each carbon nanotubes is at least one layer of a cylindrical carbon network film, and

the carbon network film has a polycrystal structure which is divided into a plurality of cystallities in a tube axis direction, and

wherein an end face of the carbon network, film is modified such that field emission efficiency is increased.

The Examiner relies on the following prior art references to show unpatentability:

Hiura	US 5,698,175	Dec. 16, 1997
Shih	US 6,346,303 B1	Feb. 12, 2002

A. G. Rinzler, *Unraveling Nanotubes: Field Emission from an Atomic Wire,* 269 Science 1550-155 (1995)

The Examiner made the following rejection:

Claims 1-5, 40-48, and 54 under 35 U.S.C. § 103(a) as unpatentable over Shih in view of Rinzler with or without Hiura.

ISSUE

The Examiner contends that nanotubes produced by Shih's process would inherently possess the features recited in Appellants' independent claims with the exception of modified end faces. The Examiner further contends that it would have been obvious to have modified the end faces of Shih's nanotubes in view of Rinzler, with or without Hiura to achieve the claimed features. Appellants contend that the Examiner has not provided a sufficient factual basis to support a prima facie showing of obviousness. The issue for us to decide is: Are the Examiner's findings sufficient to establish that one of ordinary skill in the art would have been motivated to combine the applied prior art in the manner claimed within the meaning of 35 U.S.C. § 103?

For the reasons discussed below, we answer this question in the affirmative as to claims 1-4 and 40-45 and in the negative as to claims 5, 46-48, and 54.

RELEVANT FINDINGS OF FACT

1) Shih discloses a process for synthesizing one-dimensional nanosubstances in which a membrane having a plurality of parallel aligned through channels serves as a host material. (Col. 3, ll. 30-33).

2) In Shih's process, an electron cyclotron resonance chemical vapor deposition (ECR-CVD) system is used to contact the membrane with a microwave excited plasma of a precursor gas. One-dimensional nanosubstances are formed in the channels of the membrane by chemical vapor deposition of the precursor gas. (Col. 3, ll. 33-39).

3) According to Shih, a high percentage of dissociation of the precursor gas occurring under the ECR system provides a higher plasma density at lower temperatures than other more conventional processes such as rf, dc or microwave plasma enhanced chemical vapor deposition (CVD) systems. Shih states that the advantage of the ECR system is that a large amount of ion flux can pass through the channels of the membrane, and nanosubstances can be synthesized in the channels over a large area. (Col. 4, ll. 3-10).

4) Shih discloses that the carbon nitride nanosubstances can be in the form of hollow nanotubes or solid nanofibers. (Col. 5, ll. 15-23).

5) Rinzler teaches that field emission of electrons from carbon nanotubes may be dramatically enhanced by opening the nanotube tips using laser evaporation or oxidative etching. (Abstract).

6) Rinzler discloses experiments which included monitoring the tips of nanotubes to determine "precisely when the tip had opened." (P. 1550, col. 3).

7) According to the present inventors, "the reason the end surface of carbon nanotubes processed by CHF_3 plasma appears to be closed is that the carbon that makes up the tips of the carbon nanotubes reacts with fluorine radicals, and fluorides (fluorocarbon) are deposited on the tips (end surface) of the carbon nanotubes." (Specification 106-107).

8) Hiura states that "[i]t is known that crude carbon nanotubes after synthesis have been capped at the tips by carbon fragments which comprise pentagons (five-membered carbon rings) as well as carbon impurities such as carbon nanoparticles, amorphous carbons or the like . . . are adhered to around them." (Col. 1, ll.15-20).

9) Hiura teaches that purification of the crude carbon nanotubes may be effected by an oxidation reaction. (Col. 2, ll. 15-19).

10) According to Hiura, "at the initial stage of a reaction, the tips of the carbon nanotubes first start reacting, then carbon nanoparticles reacts [sic] prior to the side walls of carbon

nanotubes which show the highest resistivity against the reaction." (Col. 2, ll. 37-44).

11) Hiura further teaches that the disclosed process makes it "possible to react only with the tips of carbon nanotubes and uncap it from there." (Col. 5, ll. 7-8).

12) The Specification discloses that in one embodiment, "the cathode electrode wires 2, the gate electrode wires 11, the anode electrode 27, and a power supply which applies a voltage to these elements make up electric field applying means that applies an electric field to the carbon nanotubes 8." (Specification 116:3-8).

ANALYSIS AND CONCLUSIONS

The Examiner found that Shih discloses a film of carbon nanotubes made by CVD in the pores of an anodic alumina membrane without a metal catalyst. (Answer 3). The Examiner notes that Shih's alumina membrane has the same pore size and density as the membrane used by Appellants. (Answer 3). The Examiner further points out that Shih uses a plasma assisted CVD process with process parameters and hydrocarbon feed materials in line with those of Appellants' CVD process. (Answer 3). The Examiner concluded that "[a]lthough Shih does not test the tubes for crystallite size & thickness and total resistivity, Shih does make it clear that a goal of the reference is to create nanotubes with improved current densities (Column 1), and it is expected that the carbon nanotube product properties would be patentably indistinct from those of the current disclosure." (Answer 3).

In our view, the facts and reasons presented in the Examiner's Answer provide a reasonable basis to conclude that the features of the claimed carbon nanotube are inherent in Shih's carbon nanotube. Thus, the burden was properly shifted to Appellants to prove that the claimed subject matter is patentably distinct. *See In re Schreiber*, 128 F.3d 1473, 1478, 44 USPQ2d 1429, 1432 (Fed. Cir. 1997). Contrary to Appellants' contention, merely pointing out that the claimed nanotubes are formed using a thermal CVD process and an anodic oxidation stopping layer while Shih employs ECR CVD (Reply 2) is not sufficient to satisfy this burden. *See In re Spada*, 911 F.2d 705, 708-09, 15 USPQ2d 1655, 1657-58 (Fed. Cir. 1990) ("The Board held that the compositions claimed by Spada 'appear to be identical' to those described by Smith. While Spada criticizes the usage of the word 'appear', we think that it was reasonable for the PTO to infer that the polymerization by both Smith and Spada of identical monomers, employing the same or similar polymerization techniques, would produce polymers having the identical composition."). In particular, Appellants have not provided a convincing explanation as to why Shih's ECR CVD process would not produce the claimed carbon nanotube given the Examiner's undisputed finding that Shih uses process parameters and feed materials which are similar to those of Appellants.[1]

In rejecting the claims, the Examiner further relies on Rinzler for a teaching that oxidative etching of nanotube tips improves their current

[1]Shih suggests that an ECR CVD process is an improvement over a conventional CVD process in that "a large amount of ion flux can pass through the channels of the membrane, and nanosubstances can be synthesized in the channels over a large area" (*see* Finding of Fact 3).

emission properties. (Answer 4). The Examiner concedes that Shih does not teach modifying the tips of the nanotubes, but contends that it would have been obvious for one of ordinary skill in the art at the time the invention was made to etch the tips of the nanotube array taught by Shih in order to improve electron emissions of those tubes as taught by Rinzler. (Answer 4).

Appellants contend that one of ordinary skill in the art would not have been motivated to modify Shih in view of Rinzler because Shih's nanotubes are already open at the ends. (Reply Br. 3). Appellants thus dispute the Examiner's finding that Shih discloses nanotubes with closed ends, arguing that Shih discloses only solid nanofibers or hollow, open-ended nanotubes. (Reply Br. 3). As noted above, unsupported attorney argument alone (e.g., the explanation provided on page 3 of the Reply Brief) is insufficient to overcome the Examiner's prima facie showing that this feature is inherent in Shih's nanotubes given the similarity in Shih's and Appellants' processes. *See In re Best*, 562 F.2d 1252, 1255-56, 195 USPQ 430, 433-34 (CCPA 1977) ("Where, as here, the claimed and prior art products are identical or substantially identical, or are produced by identical or substantially identical processes, the PTO can require an applicant to prove that the prior art products do not necessarily or inherently possess the characteristics of his claimed product."). *See also*, Findings of Fact 7 & 8.

The Examiner relies on Rinzler and Hiura to establish that the claimed oxygen to carbon ratio of the etched nanotubes in the tip area would have been obvious because it is a result effective variable. (Answer 4). Appellants argue that the Examiner has not established that oxygen to

carbon ratio of the end face of a carbon nanotube is a result-effective variable that can be optimized by routine experimentation. (Br. 10). We disagree. Both Hiura and Rinzler indicate that processes for opening the tips are readily controllable (*see* Findings of Fact 6 & 11). Moreover, we are in agreement with the Examiner's unrefuted finding that one of ordinary skill in the art would have been motivated to optimize oxygen atom content of the nanotubes to obtain optimum electrical properties (Answer 4).

Claims 5, 46-48, and 54 differ from claims 1-4 and 40-45 in that they include means-plus-function language. In particular, claim 5 recites "electric field applying means for applying an electric field." Therefore, the strictures of 35 U.S.C. § 112, sixth paragraph, apply, *see Texas Digital Sys., Inc. v. Telegenx, Inc.*, 308 F.3d 1193, 1208, 64 USPQ2d 1812, 1822-23 (Fed. Cir 2002), and the "electric field applying means" must be limited to the "corresponding structure" disclosed in the written description in the Specification and "equivalents" thereof. *In re Donaldson Co.*, 16 F.3d 1189, 1192-95, 29 USPQ2d 1845, 1848-50 (Fed. Cir. 1994) ("[T]he 'broadest reasonable interpretation' that an examiner may give means-plus-function language is that statutorily mandated in [35 U.S.C. § 112,] paragraph six."). In this case, a proper means-plus-function analysis required a comparison of the structure described on page 116, lines 3-8 and Figure 15 of the Specification (*see* Br. 8-9) to the structure described in Shih, to determine if Shih discloses identical or equivalent structure.

The Answer does not identify any particular structure from the Specification corresponding to the "electric field applying means" limitation (*see* Answer 5). Therefore, the Examiner did not interpret the "means for"

language in claim 5 with respect to the "corresponding structure" in the Specification and "equivalents" thereof in a manner consistent with the statutory requirements necessary to establish a prima facie case of obviousness of claim 5 and claims 46-48 and 54, dependent thereon.

Accordingly, we affirm the rejection under 35 U.S.C. § 103(a) as to claims 1-4 and 40-45 and reverse the rejection as to claims 5, 46-48, and 54.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(i)(iv).

AFFIRMED-IN-PART

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