

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NISSAN NORTH AMERICA, INC. and
HITACHI AUTOMOTIVE SYSTEMS, LTD.,
Petitioner,

v.

DIAMOND COATING TECHNOLOGIES, LLC,
Patent Owner.

Case IPR2014-01546
Patent No. 6,066,399

Before CHRISTOPHER L. CRUMBLEY, JO-ANNE M. KOKOSKI, and
BRIAN P. MURPHY, *Administrative Patent Judges*.

CRUMBLEY, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
35 U.S.C. § 318 and 37 C.F.R. § 42.73

I. INTRODUCTION

In this *inter partes* review trial, instituted pursuant to 35 U.S.C. § 314, Petitioner Nissan North America, Inc. and Hitachi Automotive Systems, Ltd. (collectively, “Petitioner”) challenge the patentability of claim 1 of U.S. Patent No. 6,066,399 (Ex. 1001, “the ’399 patent”), owned by Diamond Coating Technologies, LLC (“Patent Owner”).

We have jurisdiction under 35 U.S.C. § 6(c). This Final Written Decision, issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73, addresses issues and arguments raised during trial. For the reasons discussed below, we determine that Petitioner has met its burden to prove, by a preponderance of the evidence, that claim 1 of the ’399 patent is *unpatentable*.

A. Procedural History

On September 26, 2014, Petitioner requested an *inter partes* review of claim 1 of the ’399 patent. Paper 1, “Pet.” Patent Owner filed a Patent Owner Preliminary Response. Paper 13.¹ We authorized Petitioner to file additional briefing regarding real party in interest issues raised in the Preliminary Response, pursuant to which Petitioner filed a Reply to the

¹ The Preliminary Response was filed as “Parties and Board Only,” accompanied by a Motion to Seal. Paper 14. A redacted version of the Preliminary Response was included as Exhibit A to the Motion to Seal. *Id.* In an Decision issued today, we grant Patent Owner’s Motion to Seal, unseal the Motion, and direct Patent Owner to file a copy of the redacted Preliminary Response (Exhibit A) as a separate Paper in the record.

Preliminary Response. Paper 17.² In a Decision on Institution of *Inter Partes* Review (Paper 22³, “Dec.”), we determined that the Petition named all real parties in interest, and instituted trial of claim 1 based on the following grounds:

1. Whether claim 1 is unpatentable under 35 U.S.C. § 102 as anticipated by Menu;⁴ and
2. Whether claim 1 is unpatentable under 35 U.S.C. § 102 as anticipated by Hirochi.⁵

Dec. 19.

Following institution of trial, Patent Owner filed a Patent Owner Response (Paper 33, “PO Resp.”), and Petitioner filed a Reply (Paper 38, “Reply”).

Petitioner supported its Petition with the Declaration of Dr. Mark C. Hersam (Ex. 1007), and Patent Owner took the cross-examination of Dr. Hersam via deposition. Ex. 2022. With its Response, Patent Owner submitted the Declaration of Dr. Richard B. Kaner (Ex. 2028), and Petitioner took the cross-examination of Dr. Kaner via deposition. Ex. 1017.

² Petitioners filed a sealed version of the Reply, accompanied by a Motion to Seal with a redacted version of the Reply as Exhibit A. Paper 16. As with the Preliminary Response, we grant the Motion and direct Petitioners to file a copy of Exhibit A as a separate Paper in the record.

³ Paper 22 is a redacted version of the Decision; an unredacted version was issued under seal as Paper 18.

⁴ Ex. 1002, US 5,837,331 to Menu et al., (Nov. 17, 1998).

⁵ Ex. 1005, US 4,877,677 to Hirochi et al., (Oct. 31, 1989).

No Motions to Exclude or Motions for Observation were filed by either party. Oral hearing was requested by both parties, and a hearing was held January 6, 2016. A transcript of the oral hearing is included in the record. Paper 48, “Tr.”

B. The '399 Patent

The '399 patent relates to a hard carbon thin film formed on a substrate, wherein the film has a graded structure. Ex. 1001, Abstract. Specifically, the '399 patent discloses varying the type of carbon-carbon bonding in the film to achieve improved properties. *Id.* at 2:10–14. According to the '399 patent, it is generally known that the carbon-carbon bonds in graphite are predominantly sp^2 type, whereas diamond contains predominantly sp^3 bonds. *Id.* at 2:42–46. In the films of the '399 patent, the ratio of sp^2 to sp^3 bonding is varied through the thickness of the film, such that the interior of the film has a lower sp^2/sp^3 ratio than the outer edges. *Id.* at 2:33–41. This graded structure is illustrated in Figure 5 of the patent, shown below:

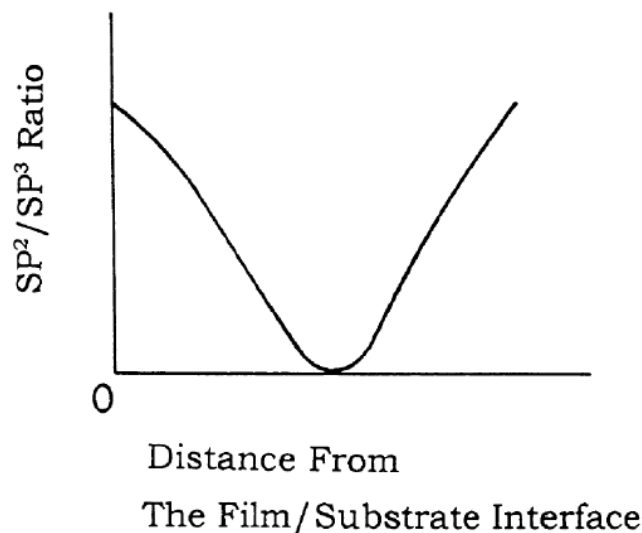


Figure 5 of the '399 patent depicts the relationship between sp^2/sp^3 ratio and the distance from the film/substrate interface.

The '399 patent discloses that an increased proportion of sp^2 bonding (higher sp^2/sp^3 ratio) results in a decrease in internal stress in the film and provides better adhesion to a substrate, while an increased proportion of sp^3 bonding (lower sp^2/sp^3 ratio) leads to increased hardness and internal stress. *Id.* at 2:58–64.

C. Challenged Claim

Claim 1 is the only challenged claim of the '399 patent, and recites:

1. A hard carbon thin film arrangement comprising a hard carbon thin film having a surface and an interface opposite said surface with a thickness direction extending through said thin film from said interface to said surface, and having a graded carbon composition in which a ratio of sp^2 to sp^3 carbon-carbon bonding in said thin film decreases in said thickness direction from said interface to a minimum at an internal location of said thin film between said interface and said surface, and increases from said minimum at said internal location toward said surface of said thin film.

Ex. 1001, 23:1–11.

II. DISCUSSION

A. Claim Construction

For purposes of our Decision to Institute, we analyzed each claim term in light of its broadest reasonable interpretation, as understood by one of ordinary skill in the art and as consistent with the specification of the '399 patent. 37 C.F.R. § 42.100(b); *see In re Cuozzo Speed Techs., LLC*, 793 F.3d 1268, 1278–79 (Fed. Cir. 2015), *cert. granted*, *Cuozzo Speed Techs.*

LLC v. Lee, 84 U.S.L.W. 3218 (U.S. 2016). In the Decision, we determined that no claim term required an explicit construction at that stage of the proceeding. See Dec. 10–11 (citing *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

During the course of the trial, the parties’ dispute focused on the claim term *hard carbon thin film*, and the parties proffered competing constructions of that term. Petitioner maintains that an explicit construction of the term is unnecessary, but that, if the Board construes the term, it should be interpreted to mean “a carbon film having a significant amount of sp^3 -hybridized carbon, including a crystalline diamond carbon thin film, an amorphous diamond-like carbon thin film, and a diamond-like carbon thin film having a partial crystalline structure.” Pet. 10–11; Reply 7–8. Patent Owner, by contrast, proposes the construction “a film that contains significant amounts of sp^3 -hybridized carbon and that excludes graphitic carbon.” PO Resp. 12.

Petitioner also informs us that, in a copending District Court patent infringement action between the parties, the court construed *hard carbon thin film* under the standards set forth by the Federal Circuit in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc), and arrived at the construction “a film containing a significant fraction of sp^3 -hybridized carbon. Hard carbon film excludes graphitic or polymer-like carbon film.” Pet. 10; Ex. 1015, 8. The court also noted that “[b]oth parties now agree that the term excludes graphitic or polymer-like carbon film.” Ex. 1015, 8. While the court acknowledged that the construction would require the trier of fact to determine what constitutes a “significant fraction of sp^3 -hybridized

carbon,” Judge Pfaelzer found that the “Koidl reference,” cited during prosecution of a related patent issued to the same inventors, “may serve as a guide.” *Id.* at 8–10 (“Significant variation from the ratios expressed in the Koidl reference may be evidence that a film is not hard carbon and does not reflect the properties of hard carbon: hardness, resistivity, and chemical stability.”). While neither party has introduced the Koidl reference—or the prosecution history of the ’399 patent—into the record of this proceeding, we understand from the District Court’s opinion that the Koidl reference disclosed an $sp^3:sp^2:sp^1$ ratio of 68:30:2 in hard carbon, as opposed to a 53:45:2 ratio in polymer-like carbon. *Id.* at 9.

We have taken into consideration Judge Pfaelzer’s construction of *hard carbon thin film*, recognizing that the District Court claim construction standard differs from that applied during *inter partes* review of an unexpired patent. In an *inter partes* review, “[a] claim in an unexpired patent shall be given its broadest reasonable construction in light of the specification of the patent in which it appears.” 37 C.F.R. § 42.100(b). Under this standard, we construe claim terms using “the broadest reasonable meaning of the words in their ordinary usage as they would be understood by one of ordinary skill in the art, taking into account whatever enlightenment by way of definitions or otherwise that may be afforded by the written description contained in the applicant’s specification.” *In re Morris*, 127 F.3d 1048, 1054 (Fed. Cir. 1997). We presume that claim terms have their ordinary and customary meaning. See *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007) (“The ordinary and customary meaning is the meaning that the term would have to a person of ordinary skill in the art in question.”) (internal

quotation marks omitted). A patentee may rebut this presumption, however, by acting as his own lexicographer and providing a definition of the term in the specification with “reasonable clarity, deliberateness, and precision.” *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

Before turning to the contentions of the parties, a background on the chemistry of carbon films is helpful. As the '399 patent acknowledges, it was generally known that carbon made up exclusively, or predominantly, of sp^2 -bonded carbon is graphite, whereas exclusively or predominantly sp^3 -bonded carbon is diamond. Ex. 1001, 2:42–46. In between these extremes lie a number of intermediate forms of carbon which are amorphous⁶ or polycrystalline in nature. Ex. 1007, 54–55. The forms may be characterized as “graphitic,” which are soft, or “diamond-like,” which are hard. Tr. 31 (Patent Owner’s counsel agreeing it is nonsensical to describe a hard graphitic film, or a soft diamond-like film). Dr. Hersam testified that this continuum can be depicted on a “ternary phase diagram” (Ex. 2022, 13), a

⁶ An amorphous structure is one that lacks long-range order. See Ex. 2022 (Hersam cross-examination), 62; Ex. 1002 (Menu) 3:60–63.

version of which appears in the Robertson⁷ reference submitted by Patent Owner:

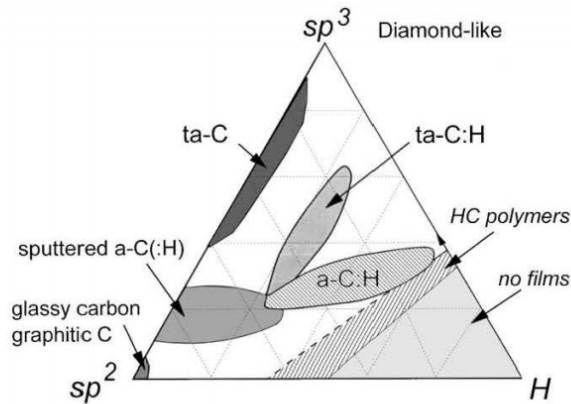


Fig. 2. Ternary phase diagram of bonding in amorphous carbon hydrogen alloys.

Figure 2 of Robertson depicts a ternary phase diagram having vertices of sp^2 , sp^3 , and H , as well as regions of graphitic carbon, amorphous carbon (a-C), tetrahedral amorphous carbon (ta-C), and hydrogenated amorphous carbon (a-C:H and ta-C:H). Ex. 2021, 130–131.

The continuum of pure carbon films ranging from graphite to diamond lies along the left-hand side of the ternary phase diagram, and has a small region of graphitic carbon followed by larger regions of amorphous carbon and tetrahedral amorphous carbon. *Id.* The ternary phase diagram also depicts carbon films that contain varying amounts of hydrogen, called hydrogenated carbon films. *Id.* Dr. Kaner testified that the hard carbon

⁷ J. Robertson, *Diamond-Like Amorphous Carbons*, 37 MATERIAL SCI. AND ENGINEERING REP. 129 (2002) (Ex. 2021).

films of the '399 patent may include both pure carbon films as well as films containing hydrogen. Ex. 1017, 151.

The parties' experts disagree on the exact transition point between hard (diamond-like) carbon films and soft (graphitic) carbon films. According to Dr. Hersam, a "few percent" of sp^3 bonding is sufficient to move the film beyond the graphitic range. Ex. 2022, 10–11. Dr. Kaner disagreed slightly, testifying that a film would need to have up to about 15% sp^3 bonding before it became non-graphitic. Ex. 1017, 69–70. Both experts agreed, however, that a carbon film can contain a large amount of sp^2 carbon and still be diamond-like in character. This is in accordance with the disclosure of the '399 patent itself; claim 3 of the patent, which depends from claim 1, recites that the hard carbon film may have an sp^2/sp^3 ratio ranging from 0–3, meaning that carbon films may be up to 75% sp^2 and still considered hard within the usage of the patent.

Resolution of this *inter partes* review trial does not require us to determine exactly where the transition between soft carbon films and hard carbon films occurs on the continuum of sp^2/sp^3 ratios, or define what constitutes a "significant" fraction of sp^3 -hybridized carbon as used in the District Court's construction of the term. The ternary phase diagram from Robertson, depicted above, shows that a wide range of compositions—including compositions having very high percentages of sp^2 bonding—are within the scope of amorphous hard carbon films. Ex. 2021, Fig. 2. Indeed, only a comparably small range of films in the lower left corner of the

diagram are classified as graphitic carbon films, which the parties agree is outside the scope of the claims.

Returning to the disclosure of the '399 patent itself, the specification sets forth three exemplary forms of carbon that fall within the scope of the claim term *hard carbon thin film*: “crystalline diamond carbon thin film,” “amorphous diamond-like carbon thin film,” and “diamond-like carbon thin film having a partial crystalline structure.” Ex. 1001, 3:1–5; *see also* claim 4 (dependent claim specifying types of films within claim 1). This disclosure confirms that *hard carbon thin film* covers a wide range of the ternary phase diagram, including the top vertex (diamond film) as well as much of the left border and interior (amorphous and polycrystalline films).

As noted above, Patent Owner asks that we adopt a construction that specifically excludes “graphitic carbon.”⁸ PO Resp. 12. We decline to do so. To the extent that Patent Owner’s proposed “graphitic carbon” exclusion could be interpreted to exclude films which are diamond-like overall, but which have regions of sp^2 (graphitic) bonding, it is improper. As Petitioner correctly notes, diamond-like carbon films necessarily have regions of sp^2 bonding within the amorphous structure. Reply 5 (citing Ex. 1017 (Kaner cross-examination), 77); *see also* Ex. 2028 (Kaner direct testimony) ¶¶ 49–

⁸ We note that this differs from the District Court’s construction, which only excludes graphitic carbon *films* (i.e., films that are—as a whole—graphitic). Ex. 1015, 8.

51 (diamond-like carbon is a combination of diamond and graphite that has clusters of sp^2 -carbon bonding).

Nor do we consider it necessary to adopt, as Petitioner suggests, a construction that includes examples of films within the scope of the term, namely “a crystalline diamond carbon thin film, an amorphous diamond-like carbon thin film, and a diamond-like carbon thin film having a partial crystalline structure.” Reply 8. As noted above, these examples are set forth in the ’399 patent itself, including in dependent claim 4, meaning that claim 1’s *hard carbon thin film* must encompass them. We decline to adopt a construction that expressly recites these examples, to the extent it might imply that all other types of carbon films are excluded.

For these reasons, we determine that the broadest reasonable interpretation of *hard carbon thin film* in light of the specification is “film containing a significant fraction of sp^3 -hybridized carbon.” This construction is not inconsistent with that adopted by the District Court,⁹ and we agree with the court that it excludes graphitic carbon films. While it is unnecessary to determine the exact boundary of the hard carbon film domain, we note that “a significant fraction of sp^3 ” encompasses a wide range of sp^3/sp^2 ratios that may even be a majority sp^2 -bonding, extending to at least 75% sp^2 .

⁹ We decline to adopt the District Court’s reliance on a 68:30 ratio of sp^3/sp^2 bonding as indicative of “a significant fraction,” as the Koidl reference upon which that ratio is based is not in the record of this proceeding, nor does it appear to have been cited during the prosecution history of the ’399 patent. Ex. 1001, References Cited.

B. Anticipation by Menu

Petitioner contends that claim 1 is unpatentable under 35 U.S.C. § 102 as anticipated by Menu. Pet. 11–24. To establish anticipation, Petitioner must prove that each and every element in a claim may be found in Menu, arranged as recited in the claim. *Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008); *Karsten Mfg. Corp. v. Cleveland Golf Co.*, 242 F.3d 1376, 1383 (Fed. Cir. 2001). For the following reasons, Petitioner has established by a preponderance of the evidence that Menu anticipates claim 1.

Menu discloses amorphous carbon multi-layered structures, also called amorphous superlattice structures, and an improved method for making such structures. Ex. 1002, 1:5–10. The properties of the structures' layers are predetermined, and may have varying degrees of resistivity, electronic emission, band gap, density, hardness, and stress. *Id.* at 4:6–7. To form the layers, a precursor such as graphite is vaporized to form carbon ions, which are then impinged upon a substrate to form a solid carbon layer. *Id.* at 3:63–4:3. By varying the total ion impinging energy during deposition, Menu discloses that the proportion of sp^2 - and sp^3 -bonded carbon in the resulting layers can be controlled. *Id.* at 4:30–50. This relationship between the amount of sp^3 bonding in a layer and the total ion impinging energy is depicted in Figure 2 of Menu:

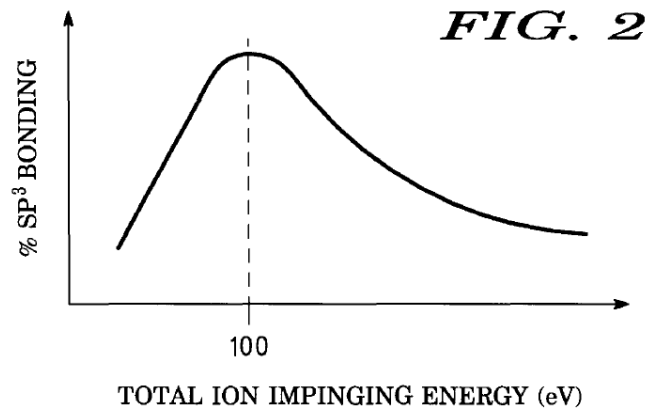


Figure 2 of Menu shows “a graphical depiction of per cent sp^3 -bonding in a deposited carbon layer as a function of total ion impinging energy.” *Id.* at 30–32.

Figure 3 of Menu shows the variation of applied voltage over time during the deposition process, and indicates a period of high voltage $|U_s|_{max}$, followed by low voltage $|U_s|_{min}$, followed by high voltage $|U_s|_{max}$ again. *Id.* at Fig. 3. Menu discloses that $|U_s|_{max}$ has a value corresponding to the low % sp^3 range in the graph of Figure 2. *Id.* at 5:25–27.

Drawing on these disclosures, Petitioner reasons that the voltage pattern of Figure 3 would result in a graded carbon film having a region of lower sp^3 bonding (higher sp^2/sp^3 ratio), followed by an interior region of higher sp^3 bonding (lower sp^2/sp^3 ratio), followed by a surface region of lower sp^3 bonding again. Pet. 14. According to Petitioner, this satisfies claim 1’s requirement of a graded carbon composition in which the sp^2/sp^3 ratio decreases from the substrate “interface to a minimum at an internal location of said thin film between said interface and said surface, and increases from said minimum at said internal location toward said surface of said thin film.” *Id.*

Patent Owner raises two substantive arguments¹⁰ in response. First, Patent Owner contends that the structures of Menu are not *hard carbon thin film*, as required by the claims. Second, Patent Owner argues that the structures of Menu are not *graded carbon compositions*. We discuss each argument in turn below.

1. *hard carbon thin film*

Patent Owner argues that Menu’s disclosure that the structure is “amorphous” carbon does not necessarily mean that it is diamond-like, or hard. PO Resp. 19; *see also* Ex. 1017, 53 (Q: “Are amorphous carbon films diamond-like carbon films?” KANER: “Not necessarily.”). Rather, Patent Owner directs us to Menu’s disclosure that its first-phase (outer) layers are “rich in sp^2 bonds,” as compared to the second-phase (inner) layer that is “rich in sp^3 bonds.” PO Resp. 20 (citing Ex. 1002, 7:53–57). In addition, Menu discloses that its layers have distinct physical, chemical, and electrical properties, and that the outer layers have a low resistivity. Ex. 1002, 3:4–25. From these disclosures, Patent Owner contends that a person of ordinary

¹⁰ Patent Owner also raises two arguments directed to the sufficiency of the analysis set forth in the Petition, claiming that it fails to establish a “clear and unambiguous disclosure” of the elements of claim 1 (“Petitioner’s anticipation ‘analysis’ with regard to Menu must fail as it is the epitome of ambiguity”), or fails to set forth the elements “arranged as in the claim” (“the Petition reads more like an obviousness analysis picking and choosing multiple distinct teachings”). PO Resp. 14–19. We consider these objections to be without merit, as the Petition identifies the grounds with sufficient particularity to comply with the statute and our Rules. *See* 35 U.S.C. § 312(a)(3); 37 C.F.R. § 42.104(b)(4).

skill in the art would have understood that the outer layers of Menu are graphitic, while the inner layer is diamond-like, taking the structure of Menu outside the scope of claim 1's *hard carbon thin film*. PO Resp. 21.

Petitioner disagrees, arguing that Menu equates the term “amorphous carbon” with “diamond-like carbon,” and thus the disclosed “amorphous carbon multi-layered structures” are diamond-like in character overall. Reply 11. Menu also discloses that its structures may be used in “hard coatings.” *Id.* (citing Ex. 1002, 12:58). Petitioner contends that a person of ordinary skill in the art would not have understood Menu's description of the outer layers as “rich in sp^2 bonds” to imply that the layers were graphitic, noting that the '399 patent itself uses the phrase “ sp^2 -rich” in the context of a hard carbon film. *Id.* at 13–14 (citing Ex. 1001, 18:55–61). Rather, Petitioner argues, the description of layers as “rich” in sp^2 or sp^3 bonding merely describes the composition of the layers in relative terms. *Id.* at 14.

Upon review of the reference, the expert testimony, and the parties' arguments, we find that the amorphous carbon structures of Menu are *hard carbon thin films*. While we agree with Dr. Kaner's testimony that the general usage of “amorphous carbon films” may encompass both diamond-like and graphitic carbon, we also agree with Dr. Hersam that Menu is using the term in a more limited way, as synonymous with “diamond-like carbon.” *See* Ex. 2022, 62. Menu discusses “the need for an improved method for fabricating DLC [diamond-like carbon] superlattice structures” (Ex. 1002, 1:38–40), and it is reasonable to conclude that the method disclosed is directed to addressing this need. In addition, as Petitioner points out, Menu

refers initially to “amorphous carbon, or ‘diamond-like carbon’ (DLC)” (*id.* at 1:25–28), implying that the terms are being used synonymously.

The reference to Menu’s first-phase outer layers as “rich in sp^2 bonds” (*id.* at 53–56) does not persuade us otherwise. As Petitioner notes, the ’399 patent uses the same terminology when referring to hard carbon films, suggesting that “rich in sp^2 ” does not imply graphitic. Furthermore, as discussed above, there is a wide range of carbon films within the scope of *hard carbon thin films*, including films having at least 75% sp^2 bonding. Such films can reasonably be termed “rich in sp^2 ” bonds, yet still fall within the domain of diamond-like carbon.

Finally, the disclosure that Menu’s layers have distinct properties does not convince us that the first phase must be graphitic while the second is diamond-like. At the oral hearing, Patent Owner’s counsel agreed that two compositions within the diamond-like carbon domain could have distinct chemical, physical, or electrical properties. Tr. 43. This is consistent with the ternary phase diagram of Robertson, which shows various types of diamond-like carbon having distinct properties. Ex. 2021, Figure 2. For example, Table 1 of Robertson shows tetrahedral amorphous carbon (ta-C) having a hardness of 80 GPa and a band gap of 2.5 eV, whereas hard hydrogenated amorphous carbon (a-C:H hard) has a hardness of 10–20 GPa and a band gap of 1.1–1.7 eV. *Id.* at 130. We conclude that Menu’s layers could have distinct properties, while still remaining within the domain of hard carbon thin films.

2. *graded carbon composition*

Patent Owner also contends that Menu's structure cannot be a *graded carbon composition*, as required by claim 1, for two reasons. PO Resp. 23–25. First, Figure 3 of Menu is said to disclose a second application of $|U_s|_{min}$, which would result in a fourth layer similar in composition to the sp^3 -rich, second-phase inner layer. *Id.* at 24 (citing Ex. 1002, Fig 3). Second, Patent Owner points to the “transition layers” of Menu, labeled as 104 in Figure 1 below:

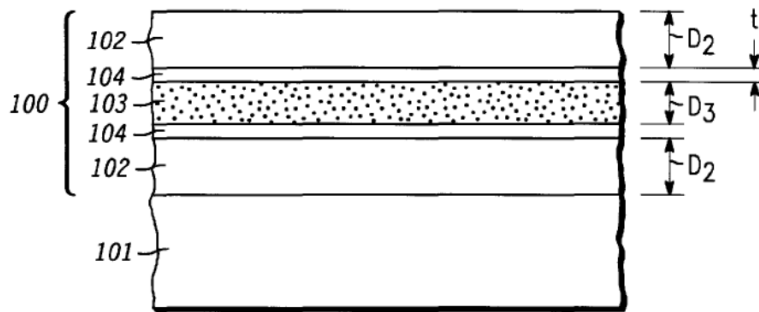


Figure 1 of Menu depicts “a cross-sectional view of a structure which is realized by performing various steps of a method in accordance with the [Menu] invention.” Ex. 1002, 2:37–39.

Figure 1 of Menu depicts a multi-layered structure, comprising “first-phase layers 102 includ[ing] layers of amorphous carbon which are rich in sp^2 bonds, and second-phase layer 103 includ[ing] a layer of amorphous carbon which is rich in sp^3 bonds.” Ex. 1002, 7:54–57. As Patent Owner emphasizes, however, Figure 1 also discloses transition layers 104, which have “chemical compositions” that “are not the same due to the different deposition conditions at the time the voltage step changes are made.” *Id.* at 7:67–8:2. The voltage changes are fast, however, “so that transition layers

104 have thicknesses, t , which are less than one atomic layer.” *Id.* at 7:65–67.

According to Patent Owner, “any alleged gradation in sp^2/sp^3 ratio from first-phase layer 102 to second-phase layer 103 back to first-phase layer 102 is interrupted by two additional layers of an unknown and uncertain composition.” PO Resp. 25. Characterizing the composition of the transition layers as “unknown,” Patent Owner posits that the layers 104 could have more sp^3 bonding than the interior second-phase layers 103, resulting in an increase in sp^3 bonding towards the exterior of the composition at the 103/104 transition. *Id.* at 25. Patent Owner argues that this would mean that the structure of Menu cannot be a *graded carbon composition* as used in the ’399 patent claims.

We find that a preponderance of the evidence supports a finding that Menu discloses a *graded carbon composition*, and do not find either of Patent Owner’s arguments to the contrary to be persuasive. First, contrary to Patent Owner’s interpretation of Figure 3 of Menu, the embodiment of Figure 1 clearly depicts only three layers, with two extremely thin transition layers in between. In any event, we do not consider a four-layer embodiment, with alternating sp^2 and sp^3 content, to fall outside the scope of *graded carbon composition*. The claim language only requires that the sp^2/sp^3 ratio decreases toward an internal location of the thin film, and then increases from a minimum toward the surface of the film. Nothing in the claim, or elsewhere in the ’399 patent, requires that the sp^2/sp^3 ratio *only* increase once past the minimum, or that the increase continue all the way to the surface; it merely requires that it increase *toward* the surface for some

distance. Importantly, the '399 patent discloses that a stepwise change in sp^2/sp^3 ratio is a *graded carbon composition*, irrespective of the fact that the ratio is constant in between the stepwise changes. Ex. 1001, 25–30. Nor does the claim language exclude the presence of multiple minima or more than three layers; claim 1 uses the transition phrase “comprising,” and therefore permits the inclusion of additional elements.

Similarly, we do not conclude that the existence of transition layers 104 in the Menu structure prevents it from being a *graded carbon composition*. As just noted, nothing in the claim restricts the number of layers present in the film. Nor does Patent Owner’s speculation that transition layers 104 *could* have a higher sp^3 content than second-phase layer 103 convince us otherwise. Because the ion impinging energy is transitioning between $|U_s|_{max}$ and $|U_s|_{min}$ —or vice versa—at the time transition layers 104 are formed, it is more reasonable to conclude that transition layers 104 have sp^2/sp^3 ratios somewhere between that of first-phase layers 102 and second-phase layer 103. Even if Patent Owner were correct that transition layers 104 have high sp^3 content, this would merely mean the sp^2/sp^3 ratio reaches its minimum at the transition layer before increase again toward the surface into the first-phase layer. Such an arrangement would also fall within the scope of claim 1, which does not require the sp^2/sp^3 to be located in any particular layer.

For the foregoing reasons, we find that Menu discloses a *hard carbon thin film* having a *graded carbon composition* as set forth in claim 1 of the '399 patent. We, therefore, conclude that Menu anticipates claim 1.

C. Anticipation by Hirochi

Petitioner also asserts that claim 1 is unpatentable under 35 U.S.C. § 102 as anticipated by Hirochi. Pet. 39–51. Upon review of the Petition, the experts' testimony, and the reference, we find that Hirochi discloses all of the elements of claim 1.

Hirochi discloses hard carbon films formed by ion-beam sputtering on the surface of a substrate. Ex. 1005, Abstract. In its third embodiment, Hirochi discloses that a buffer film is first formed adjacent to the substrate, followed by a hard carbon film, and then a lubricative film. *Id.* at 3:55–4:7. This embodiment is depicted in Figure 4 of Hirochi:

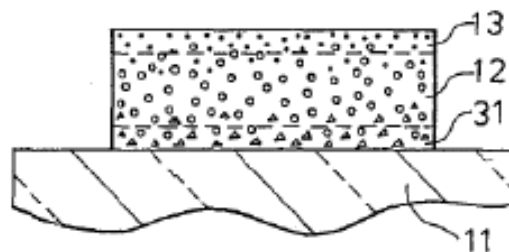


Figure 4 of Hirochi depicts an embodiment comprising substrate 11, buffer film 31, hard carbon film 12, and lubricative film 13.

The film of Hirochi is formed by sputtering a carbon target using an ion-beam of argon gas, in which the hydrogen component of the argon gas can be varied. *Id.* at 4:21–28. Buffer layer 31 containing both carbon and hydrogen is first formed on a substrate, and the hydrogen content gradually increases as the layer is deposited, reaching a maximum at hard carbon film 12. *Id.* at 3:58–61. The hydrogen content is held steady within hard carbon film 12, and then decreases gradually to the surface of lubricative layer 13.

Id. at 3:61–66. This gradual increase and decrease of hydrogen concentration is depicted in Figure 4A, below:

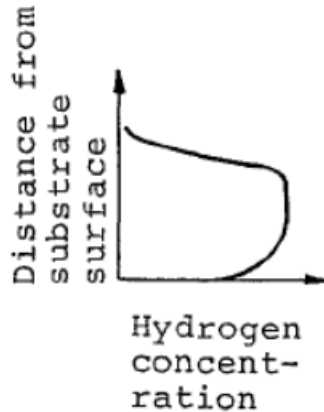


Figure 4A of Hirochi depicts the gradual change in hydrogen content over the distance from the substrate surface.

According to Hirochi, Raman spectroscopic analysis of the embodiment of Figure 4 “confirmed that the structures of the lubricative film 13 and the buffer film 31 are of graphite-like carbon and that of the hard carbon film 12 is of diamond-like carbon.” Ex. 1005, 4:61–66. Dr. Hersam concludes from this disclosure that the lubricative film and buffer film have relatively high sp^2/sp^3 ratios, while the hard carbon film has a low sp^2/sp^3 ratio. Ex. 1007 ¶ 102. Petitioner, therefore, contends that Hirochi discloses all elements of claim 1.

As with Menu, Patent Owner makes two substantive arguments regarding the disclosure of Hirochi. First, Hirochi allegedly does not disclose a *hard carbon thin film*. Second, Patent Owner argues that Hirochi does not vary the sp^2/sp^3 ratio of its layers, but rather adjusts the hydrogen content. We discuss each argument below.

1. *hard carbon thin film*

As it did with Menu, Patent Owner first argues that Hirochi does not disclose a *hard carbon thin film*. In particular, Patent Owner directs us to Hirochi's disclosure that the outer layers (buffer and lubricative films) are graphitic carbon. PO Resp. 29–31 (citing Ex. 1005, 4:61–66). As such, these layers cannot be part of the *hard carbon thin film* as claimed. Patent Owner, therefore, argues that the only layer of Hirochi that may be considered for anticipation purposes is the hard carbon film inner layer. *Id.* at 32. As depicted in Figure 4A, however, this layer has a constant composition across its thickness and therefore is not “graded” as required for claim 1. *Id.*

Petitioner responds by arguing that the outer layers of Hirochi are hard carbon, noting that the reference states that the lubricative film may be, “for instance, a hard carbon film.” Ex. 1005, 4:13–14. Arguing that the term “graphite-like” is used only in a sense relative to the harder, diamond-like inner layer, Petitioner contends that the films overall have characteristics sufficient to make them hard carbon films. Reply 21–23.

Upon review of the reference and the experts' testimony, we agree that Hirochi uses conflicting terminology in describing the composition of its buffer and lubricative layers. Patent Owner correctly notes that Hirochi characterizes the layers, at least as formed in the process described in column 4 of the specification, as “graphite-like carbon.” Claim 18 of Hirochi, cited in the Petition, also requires the buffer layer to have a “graphitic structure.” Ex. 1005, 7:37–8:3. At the same time, Petitioner is also correct that the lubricative layer is said to be “hard carbon film.” We

also note that the lubricative film is described as a carbon film having “hydrogen concentration . . . equal to or smaller than that of the hard carbon film,” but that in addition to such carbon films the lubricative layer can also be graphite. *Id.* at 2:37–50. Claim 18 is similarly broad, indicating that the lubricative film consists essentially of at least one constituent selected from a group that includes “graphitic-structure carbon” and “carbon with up to 50 percent hydrogen,” implying that the lubricative film can be either graphitic or non-graphitic.

Regardless of this ambiguity, however, we find that Hirochi discloses the claimed *hard carbon thin film*. As Petitioner notes, even if the outer portions of the lubricative and buffer layers are graphitic, Figure 4A shows that the structure changes gradually over the thickness of the layers. Reply 22 (citing Ex. 1005, 3:55–66). The inner portions of the lubricative and buffer layers of Hirochi have compositions with only slightly less hydrogen—and, therefore, that are only slightly less hard—than the hard carbon film layer, which the parties agree is diamond-like. As argued by Petitioner, “[a]t a minimum, the claim limitations would be met by considering hard carbon film 12, and at least the initial portions of films 31 and 13 where the transition begins and entails a rise in the sp^2/sp^3 ratio, as required by claim 1.” Reply 23. We agree with Petitioner that these inner portions of Hirochi’s film meet the *hard carbon thin film* requirement of claim 1. As discussed above with respect to Menu, claim 1 is an open-ended “comprising” claim, and, therefore, the inclusion of additional, graphitic layers on the outer portions of the film does not remove Hirochi from the scope of claim 1.

2. *ratio of sp^2 to sp^3 carbon-carbon bonding*

As Patent Owner correctly notes, Hirochi does not discuss the amount of sp^2 or sp^3 bonding in the layers of its film, or indeed mention the type of carbon-carbon bonds at all. PO Resp. 33. Petitioner instead relies on Hirochi's description of the physical characteristics of the layers to infer the degree of sp^2 and sp^3 bonding. Pet. 40–41; Ex. 1007 ¶ 102. Patent Owner disagrees with this conclusion, arguing that the characteristics of the layers are varied by changing the hydrogen content of the film, not by varying the sp^2/sp^3 ratio in the layer. PO Resp. 33–34. Dr. Kaner testified that a person of ordinary skill in the art “would have found it difficult to understand how or why the variation in hydrogen content varies the sp^2/sp^3 carbon-carbon bonding ratio in the films.” Ex. 2028 ¶ 116.

On cross-examination, however, Dr. Kaner contradicted this testimony, testifying that:

[O]ne of the things that hydrogen does is it actually eats sp^2 graphitic-type carbon. It also actually eats sp^3 diamond-like carbon. However, it eats the graphitic carbon at a much faster rate. Often on the order of three orders of magnitude faster. So by controlling the amount of hydrogen in the deposition, you can control the sp^2/sp^3 ratio.

Ex. 1017, 94. In fact, Dr. Kaner specifically stated that in the context of the '399 patent, “hydrogen is used to scavenge the sp^3 . And so to control the ratio of sp^2/sp^3 .” *Id.* at 108; *see also* Ex. 1001, 14:14–19 (varying sp^2/sp^3 ratio by varying the supply of hydrogen into the reaction chamber).

Later in his testimony, Dr. Kaner attempted to distinguish the '399 patent's use of hydrogen to control the sp^2/sp^3 ratio from Hirochi's use of

hydrogen, which he said was used to make hydrogenated films (in other words, to incorporate hydrogen into the film itself). Ex. 1017, 155. We do not find this distinction to be credible. Both the '399 patent and Hirochi use hydrogen in the same manner, by introducing it as a gas into the reaction chamber during formation of the carbon film. *Compare* Ex. 1001, 13:14–17, 25–29 (hydrogen introduced into chamber containing argon and methane gas) *with* Ex. 1005, 4:30–32 (hydrogen component of argon gas in chamber is varied). Patent Owner does not explain, nor does the record reflect, any reason why Hirochi's methods would result in incorporation of hydrogen into the film while the '399 patent methods do not. Furthermore, as Dr. Kaner acknowledges, the hard carbon thin films of the '399 patent include hydrogenated films. Ex. 1017, 151.

From this record, we conclude that the use of hydrogen in Hirochi achieves the same result as disclosed in the '399 patent; namely, variation of the ratio of sp^2/sp^3 bonding. By increasing the hydrogen content of the chamber during formation of the film, Hirochi also increases the amount of sp^3 bonding relative to sp^2 bonding, causing the sp^2/sp^3 ratio to decrease to a minimum in the inner hard carbon film layer. Similarly, gradually decreasing the amount of hydrogen causes the sp^2/sp^3 ratio to increase from the minimum toward the surface of the Hirochi film. We find that Hirochi discloses a graded carbon composition in which the sp^2/sp^3 ratio is varied, as required by claim 1.

For the foregoing reasons, we find that Hirochi discloses a *hard carbon thin film* having a *graded carbon composition* as set forth in claim 1 of the '399 patent. We, therefore, conclude that Hirochi anticipates claim 1.

III. CONCLUSION

We conclude that Petitioner has demonstrated, by a preponderance of the evidence, that claim 1 of the '339 patent is unpatentable under 35 U.S.C. § 102 as anticipated separately by Menu and Hirochi.

IV. ORDER

Accordingly, it is

ORDERED that claim 1 of U.S. Patent No. 6,066,399 is *unpatentable*;

FURTHER ORDERED that, pursuant to 35 U.S.C. § 318(b), upon expiration of the time for appeal of this decision, or the termination of any such appeal, a certificate shall issue canceling claim 1 in U.S. Patent No. 6,066,399; and

FURTHER ORDERED that, because this is a final decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

Case IPR2014-01546
Patent No. 6,066,399

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