APPENDIX

APPENDIX A

UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

CONTINENTAL CIRCUITS LLC,

Plaintiff-Appellant

v.

INTEL CORPORATION, IBIDEN U.S.A. CORPORATION, IBIDEN COMPANY LIMITED,

Defendants-Appellees

2018-1076

Appeal from the United States District Court for the District of Arizona in No. 2:16-cv-02026-DGC, Judge David G. Campbell.

Decided: February 8, 2019

JEFFREY A. LAMKEN, MoloLamken LLP, Washington, DC, argued for plaintiff-appellant. Also represented by MICHAEL GREGORY PATTILLO, JR., BENJAMIN THOMAS SIROLLY; BRADLEY WAYNE CALDWELL, JASON DODD CASSADY, JOHN AUSTIN CURRY, WARREN JOSEPH MCCARTY, III, Caldwell Cassady & Curry, Dallas, TX.

JOSEPH J. MUELLER, Wilmer Cutler Pickering Hale and Dorr LLP, Boston, MA, argued for defendants-appellees. Also represented by KEVIN GOLDMAN, RICHARD WELLS O'NEILL, SARAH B. PETTY, KEVIN SCOTT PRUSSIA; NINA S.

TALLON, Washington, DC. Defendant-appellee Intel Corporation also represented by MATTHEW JOHN HULT, Intel Corporation, Santa Clara, CA.

Before LOURIE, LINN, and TARANTO, *Circuit Judges*.

LOURIE, *Circuit Judge*.

Continental Circuits LLC appeals from the judgment of the United States District Court for the District of Arizona of noninfringement of the asserted claims of U.S. Patents 7,501,582 ("the '582 patent"); 8,278,560 ("the '560 patent"); 8,581,105 ("the '105 patent"); and 9,374,912 ("the '912 patent"). *See* Final Judgment, *Cont'l Circuits LLC v. Intel Corp.*, No. 16-2026 (D. Ariz. Sept. 12, 2017), ECF No. 273. The parties stipulated to a judgment of noninfringement, *see* Stipulation & Joint Motion, *Cont'l Circuits LLC v. Intel Corp.*, No. 16-2026 (D. Ariz. Sept. 7, 2017), ECF No. 266, based on the district court's claim construction of certain claim terms, *see Cont'l Circuits LLC v. Intel Corp.*, No. 16-2026, 2017 WL 3478659 (D. Ariz. Aug. 9, 2017) ("*Claim Construction Order*"). Because we conclude that the district court erred in its claim construction, we vacate the judgment of noninfringement and remand for further proceedings.

BACKGROUND

Continental owns the '582, '560, '105, and '912 patents, which are directed to a "multilayer electrical device . . . having a tooth structure" and methods for making the same. *See, e.g.*, '582 patent Abstract. The four patents at issue, which have since expired, are continuations of one another and thus share

substantially the same specification.[1] According to the patents, multilayer electric devices "suffer from delamination, blistering, and other reliability problems," especially when "subjected to thermal stress." *Id.* col. 1 ll. 30–32. The inventions of the patents purport to solve this problem by "forming a unique surface structure . . . comprised of teeth that are preferably angled or hooked like fangs or canine teeth to enable one layer to mechanically grip a second layer." *Id.* col. 1 ll. 52–57. The specification further explains that the increased surface area of the teeth improves the adhesion of the layers to one another. *See id.* col 1 l. 58–col. 2 l. 6.

The patents additionally "theorize[] . . . that the best methods for producing the teeth [are] to use non-homogenous materials and/or techniques . . . such that slowed and/or repeated etching will form teeth instead of a uniform etch." *Id.* col. 2 ll. 24–29. The specification then explains that "[o]ne technique for forming the teeth is . . . the swell and etch or desmear process, except that contrary to all known teachings in the prior art . . . a 'double desmear process' is utilized." *Id.* col. 5 ll. 40–44. It continues by explaining that "the peel strength produced in accordance with the present invention is greater than the peal [sic] strength produced by the desmear process of the prior art, i.e., a single pass desmear process." *Id.* col. 7 ll. 3–6. The specification then discloses that "[i]n stark contrast with the etch and swell process of the known prior art . . . a second pass through the process . . . is used" because it "make[s] use of [the] non-homogenaities

[1] In this opinion, citations are only to the '582 patent specification because the specifications of the four patents are substantially identical.

[sic] in bringing about a formation of the teeth." *Id.* col. 9 ll. 1–5.

Continental sued Intel Corp.; its supplier, Ibiden U.S.A. Corp.; and Ibiden U.S.A. Corp.'s parent company, Ibiden Co. Ltd. (collectively, "Intel"), for patent infringement in the District of Arizona. Continental asserted claims 85, 87, 89, 92, 94, 95, 100, 109, 114, and 122 of the '582 patent; claims 14 and 19 of the '560 patent; claims 13, 53, 71, 80, 82, 86, 88, 91, 95, 97, 101, and 103 of the '105 patent; and claims 2, 3, 18–20, and 26–28 of the '912 patent. All of the asserted claims include claim limitations regarding the "surface," "removal," or "etching" of "a dielectric material" or "epoxy," which the district court construed together as the "Category 1 Terms," and their construction depends on resolving whether they should be limited to a repeated desmear process. *See Claim Construction Order*, 2017 WL 3478659, at *2; *see also* J.A. 1879–89.[2]

Claim 100 of the '582 patent is illustrative of a claim that includes a "surface" claim term and reads as follows:

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[2] The Category 1 Terms include "surface," "removal," and "etching" related claim terms:

- The "surface" claim terms are "surface of a dielectric material," "surface of a layer of a dielectric material," and "a dielectric material comprising a surface."
- The "removal" claim terms are "removal of a portion of the dielectric material," and "removal of some of the dielectric material."
- The "etching" claim terms are "etching [of] the epoxy" and "etching [of] the dielectric material."

The district court construed all of these claim terms together.

> 100. An electrical device including:
>
> a conductive layer built up so as to fill undercuttings with respect to a *surface of a dielectric material* so as to form teeth in cavities, a plurality of the undercuttings being obtuse to the surface, wherein the conductive layer is a portion of circuitry of an electrical device, and a plurality of the teeth are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and
>
> wherein at least one of the cavities includes an upgrade slope with respect to the *surface of the dielectric material*, and one of the teeth engages a portion of the dielectric material at the slope.

'582 patent col. 18 ll. 48–59 (emphases added).

Claim 114 of the '582 patent is representative of a claim that includes a "removal" claim term and reads as follows:

> 114. An electrical device including:
>
> a dielectric material having a surface remaining from *removal of a portion of the dielectric material*; and
>
> means for mechanically gripping a conductive layer to the surface of the dielectric material so that the conductive layer is burrowed in and under the top surface of the dielectric material, wherein the conductive layer forms a portion of circuitry of an electrical device, wherein the

> means for mechanically gripping is comprised of teeth, and a plurality of the teeth are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and
>
> wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

Id. col. 20 ll. 30–44 (emphasis added).

Claim 14 of the '560 patent is representative of a claim that includes an "etching" claim term and reads as follows:

> 14. An article of manufacture, the article comprising:
>
> an epoxy dielectric material delivered with solid content sufficient that *etching the epoxy* forms a non-uniformly roughened surface comprising cavities located in and underneath a surface of the dielectric material, and sufficient that the *etching of the epoxy* uses non-homogeneity with the solid content to bring about formation of the non-uniformly roughened surface with at least some of the cavities having a first cross-sectional distance proximate the initial surface and a substantially greater cross-sectional distance distant from the initial surface, and
>
> a conductive material, whereby the *etching of the epoxy* forms the cavities, and a portion

> of the conductive material in the cavities thereby forming teeth in the cavities, wherein the etching of the non-homogeneous composition forms the cavities, and wherein the conductive material forms a portion of circuitry of an electrical device.

'560 patent col. 10 ll. 7–25 (emphases added).

Aside from the "device" and "article of manufacture" claims recited above, the asserted claims also include process and product-by-process claims. Claims 2 and 18 of the '912 patent are illustrative and read as follows:

> 2. A process of making an article of manufacture, the process comprising:
>
> implementing a circuit design for an electrical device by coupling a dielectric material delivered with solid content, the dielectric material and the solid content being non-homogeneous materials, sufficient that etching the dielectric material forms a non-uniformly roughened surface comprising cavities located in, and underneath a surface of, the dielectric material, and sufficient that the etching of the dielectric material uses non-homogeneity with
>
> the solid content in bringing about formation of the non-uniformly roughened surface with at least some of the cavities having a first cross-sectional distance proximate the surface and a greater cross-

> sectional distance distant from the surface, with a conductive material, whereby the etching of the dielectric material forms the cavities, and a portion of the conductive material in the cavities thereby forming teeth in the cavities, wherein the etching of the non-homogeneous composition forms the cavities, in circuitry of the electrical device.
>
> . . . .
>
> 18. A product produced by the process of claim 2.

'912 patent col. 9 l. 58–col. 10 l. 11, col. 11 l. 14.

The district court construed the Category 1 Terms to require that the "surface," "removal," or "etching" of the dielectric material be "*produced by a repeated desmear process*." *See Claim Construction Order*, 2017 WL 3478659, at *2–3 (emphasis added). The district court concluded that Intel had "met the exacting standard required" to read a limitation into the claims. *Id.* at *3. Specifically, the district court found that the specification not only "repeatedly distinguishe[d] the process covered by the patent from the prior art and its use of a 'single desmear process,'" *id.* at *4, but also characterized "the present invention" as using a repeated desmear process, *see id.* at *5.

Additionally, the district court found that the prosecution history corroborated its construction. The examiner made indefiniteness and written description rejections during the prosecution of the '560 patent of the claim limitation "etching of the epoxy uses non-homogeneity with the solid content," which is used to bring about formation of the non-uniformly roughened

surface of the angular toothshaped cavities. *See* J.A. 2122–23. In response to the office action, Continental submitted an expert declaration explaining that the "etching" process disclosed in the specification uses "this known Probelec XB[ ]7081 resin" and "two separate swell and etch steps" as "a technique which forms the teeth." J.A. 2074; *see also* J.A. 2068–69. The district court found that the expert declaration "clearly describe[d] the patented method as involving two etching processes." *Claim Construction Order*, 2017 WL 3478659, at *6. Moreover, the district court observed that extrinsic documents produced by the inventors state the use of a "two pass desmear cycle" and that "we use a double pass desmear to achieve the tooth structure." *Id.* (quoting J.A. 3321, 3324). The court acknowledged that those statements were "not reliable enough to be dispositive," but found they "provide[d] helpful corroboration." *Id.*

Based on the court's claim construction and the fact that all of the asserted claims involve the question whether they should be limited to a repeated desmear process, the parties stipulated to noninfringement and the court entered judgment accordingly. On appeal, Continental challenges only the district court's claim construction. We have jurisdiction under 28 U.S.C. § 1295(a)(1).

DISCUSSION

Claim construction is ultimately a question of law that we review *de novo*. *Teva Pharm. USA, Inc. v. Sandoz, Inc.*, 135 S. Ct. 831, 841 (2015). Any subsidiary factual findings based on extrinsic evidence "must be reviewed for clear error on appeal." *Id.* But "when the district court reviews only evidence intrinsic

to the patent (the patent claims and specifications, along with the patent's prosecution history), the judge's determination will amount solely to a determination of law," which we review *de novo*. *Id.*

Continental argues that the district court erred in construing the Category 1 Terms to require that the dielectric material be "produced by a repeated desmear process."[3] *See Claim Construction Order*, 2017 WL 3478659, at *2–3. Continental contends that the plain language of the claims does not include a repeated desmear process. Also, according to Continental, the specification does not clearly and unmistakably limit the claims to require a repeated desmear process. Although Continental acknowledges that the preferred embodiment discusses using a repeated desmear process, Continental argues that it is not proper to limit the claims to the preferred embodiment. Continental next contends that the expert declaration cited by the district court, which applicants invoked to respond to indefiniteness and written description rejections by the examiner, does not include a clear and unmistakable disavowal for prosecution disclaimer to attach. Finally, Continental argues that the inventor documents cited by the district court merely reflect the inventors practicing

[3] We note that the specification discusses use of a "*double* desmear process" while the district court construed the claims to require a "*repeated* desmear process." *Compare generally* '582 patent, *with Claim Construction Order*, 2017 WL 3478659, at *2–3 (emphasis added). The parties do not argue this difference is material, and because we ultimately do not agree with the district court that the claim limitation should have been read into the claims, the difference in wording does not impact the outcome. Thus, for purposes of this opinion, we assume the terms are interchangeable.

the preferred embodiment and thus lend no support for the district court's construction.

Intel responds that it was proper for the district court to limit the claims to a repeated desmear process because the patentees repeatedly disparaged and disavowed the single-pass desmear process and expressly defined "the present invention" as requiring a repeated desmear process. Intel also argues that the prosecution history further supports reading in this limitation because the expert declaration submitted during prosecution reiterated that "the claimed invention is directed to surface roughening performed by 'two separate' passes of a desmear process." Appellee's Br. 29. Furthermore, Intel contends that documents authored by the inventors demonstrate an inability to obtain the desired levels of roughening using a single-pass desmear process, which confirms that their alleged invention was limited to a repeated desmear process.

We agree with Continental that the district court erred in limiting the claims to require a repeated desmear process. In construing claims, district courts give claims their ordinary and customary meaning, which is "the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention." *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc). "[B]ecause patentees frequently use terms idiosyncratically, the court looks to" sources including "the words of the claims themselves, the remainder of the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art." *Id.* at 1314 (quoting *Innova/Pure Water, Inc. v. Safari Water*

Filtration Sys., Inc., 381 F.3d 1111, 1116 (Fed. Cir. 2004)).

From this list of sources, "the claims themselves provide substantial guidance as to the meaning of particular claim terms." *Id.* However, the claims "do not stand alone." *Id.* at 1315. They are part of "'a fully integrated written instrument,' consisting principally of a specification that concludes with the claims," and must therefore "be read in view of the specification." *Id.* (quoting *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 978–79 (Fed. Cir. 1995)). Accordingly, the specification "is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term." *Id.* (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)).

"In addition to consulting the specification, we have held that a court 'should also consider the patent's prosecution history, if it is in evidence.'" *Id.* at 1317 (quoting *Markman*, 52 F.3d at 980). "Like the specification, the prosecution history provides evidence of how the [United States Patent and Trademark Office ("PTO")] and the inventor understood the patent." *Id.* We have cautioned, however, that "because the prosecution history represents an ongoing negotiation between the PTO and the applicant, rather than the final product of that negotiation, it often lacks the clarity of the specification and thus is less useful for claim construction purposes." *Id.*

With these principles in mind, we turn to the construction of the Category 1 Terms. Beginning with the claim language, we first note that none of the

asserted claims actually recite a "repeated desmear process." *Accord Claim Construction Order*, 2017 WL 3478659, at *2. Thus, at least based on the plain language, the claims are not limited to a repeated desmear process.

We continue our analysis by reading the claims "in view of the specification, of which they are a part." *Phillips*, 415 F.3d at 1315 (quoting *Markman*, 52 F.3d at 979). Our case law has recognized that "the specification may reveal a special definition given to a claim term by the patentee that differs from the meaning it would otherwise possess." *Id.* at 1316. When the patentee acts as its own lexicographer, that definition governs. *See id.* "To act as its own lexicographer, a patentee must 'clearly set forth a definition of the disputed claim term' other than its plain and ordinary meaning." *Thorner v. Sony Comput. Entm't Am. LLC*, 669 F.3d 1362, 1365 (Fed. Cir. 2012) (quoting *CCS Fitness, Inc. v. Brunswick Corp.*, 288 F.3d 1359, 1366 (Fed. Cir. 2002)). We have also found instances where "the specification may reveal an intentional disclaimer, or disavowal, of claim scope." *Phillips*, 415 F.3d at 1316. In those situations, it is again the inventor's disavowal that is dispositive of the claim construction. *See id.* "To disavow claim scope, the specification must contain 'expressions of manifest exclusion or restriction, representing a clear disavowal of claim scope.'" *Retractable Techs., Inc. v. Becton, Dickinson & Co.*, 653 F.3d 1296, 1306 (Fed. Cir. 2011) (quoting *Epistar Corp. v. Int'l Trade Comm'n*, 566 F.3d 1321, 1335 (Fed. Cir. 2009)).

We acknowledge the difficulty in drawing the "fine line between construing the claims in light of the specification and improperly importing a limitation

from the specification into the claims." *Id.* at 1305. To avoid improperly importing limitations into the claims, "it is important to keep in mind that the purposes of the specification are to teach and enable those of skill in the art to make and use the invention and to provide a best mode for doing so." *Phillips*, 415 F.3d at 1323.

Based on our review of the specification, none of the statements relied upon by the district court rises to the level of "a clear and unmistakable disclaimer." *Thorner*, 669 F.3d at 1367. The specification begins by explaining that the invention is an "electrical device" with teeth. *See* '582 patent col. 1 ll. 13–15, col. 1 l. 50–col. 2 l. 6. The specification then explains that "*[o]ne technique* for forming the teeth," which is "contrary to all known teachings in the prior art" is the double desmear process. *See id.* col. 5 ll. 40–44 (emphasis added). Additionally, the disclosures provide that "the present invention *can be carried out* by a new use" of a dielectric material called Probelec XB 7081. *See id.* col. 6 ll. 41–48 (emphasis added). And within this context, "*[f]or example*, the present invention differs from the common desmear process in that sub-steps in the desmear process are repeated as *a way* of forming the teeth." *Id.* col. 8 ll. 49–52 (emphases added). This, the patent explains, is "[i]n stark contrast with the etch and swell process of the known prior art." *Id.* col. 9 ll. 1–2. The specification also notes that the peel strength produced by the new use of Probelec XB 7081 is greater than that of "the prior art, i.e., a single pass desmear process." *See id.* col. 7 ll. 3–9.

Overall, those statements simply describe how to make the claimed invention using the preferred Probelec XB 7081 in a "new" way that is different from

the prior art process and are not statements clearly limiting the claimed "electrical device" to require a repeated desmear process. Heeding the warning in *Phillips* to keep in mind that a goal of the specification is to provide a best mode to make and use an invention, phrases such as "one technique," "can be carried out," and "a way" indicate that using Probelec XB 7081 is only one method for making the invention and does not automatically lead to finding a clear disavowal of claim scope. *See Phillips*, 415 F.3d at 1323. We have also "expressly rejected the contention that if a patent describes only a single embodiment, the claims of the patent must be construed as being limited to that embodiment." *Id.*; *see also Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 906 (Fed. Cir. 2004) ("Even when the specification describes only a single embodiment, the claims of the patent will not be read restrictively unless the patentee has demonstrated a clear intention to limit the claim scope using 'words or expressions of manifest exclusion or restriction.'" (quoting *Teleflex, Inc. v. Ficosa N. Am. Corp.*, 299 F.3d 1313, 1327 (Fed. Cir. 2002))). Therefore, we conclude that disclosing only the Probelec XB 7081 embodiment, without more, does not result in a clear disavowal of claim scope.

Additionally, distinguishing the double desmear process as "contrary to" or "in stark contrast" with the single desmear process, which again appears within the context of disclosures of the preferred embodiment, are not clear and unmistakable limiting statements. We have held that "[m]ere criticism of a particular embodiment . . . is not sufficient to rise to the level of clear disavowal." *Thorner*, 669 F.3d at 1366. Thus, comparing and contrasting the present technique to

that of the prior art does not "rise to the level of [a] clear disavowal" of claim scope. *Id.*

Similarly, the descriptions of "the present invention," which also appear within the discussion of the preferred embodiment, are not limiting here. While descriptions "of the 'present invention' as a whole" could limit the scope of the invention, *see Verizon Servs. Corp. v. Vonage Holdings Corp.*, 503 F.3d 1295, 1308 (Fed. Cir. 2007), "use of the phrase 'present invention' or 'this invention' is not always so limiting, such as where the references . . . are not uniform, or where other portions of the intrinsic evidence do not support applying the limitation to the entire patent," *Absolute Software, Inc. v. Stealth Signal, Inc.*, 659 F.3d 1121, 1136–37 (Fed. Cir. 2011). In this case, the statements that "*the present invention* can be carried out by a new use" of a dielectric material called Probelec XB 7081, *see* '582 patent col. 6 ll. 41–48 (emphasis added), and "*the present invention* differs from the common desmear process in that sub-steps in the desmear process are repeated as *a way* of forming the teeth," *id.* col. 8 ll. 49–52 (emphases added), do not characterize the present invention "as a whole," *Verizon*, 503 F.3d at 1308. Instead, they disclose one way to carry out the present invention using Probelec XB 7081, and references to "the present invention" occur within this context.

Moreover, the use of "the present invention" throughout the specification does not uniformly require use of a repeated desmear process. *See Absolute Software*, 659 F.3d at 1136–37. In certain portions of the specification, such as the summary, the invention is described with respect to its "unique surface structure," '582 patent col. 1 l. 52, without any

requirement that the invention must encompass the repeated desmear process. In fact, "desmear" does not appear in the summary of the invention section at all. *See id.* col. 1 l. 48–col. 2 l. 29. In light of this, it is difficult to say that the present invention "as a whole," *Verizon*, 503 F.3d at 1308, necessarily includes the repeated desmear process. Thus, absent "clear and unmistakable" language suggesting otherwise, we conclude that the aforementioned statements do not meet the "exacting" standard required to limit the scope of the claims to a repeated desmear process. *See Thorner*, 669 F.3d at 1366–67.

The district court also found that the prosecution history further supported its claim construction. Similar to disclaimers in the specification, "[t]o operate as a disclaimer, the statement in the prosecution history must be clear and unambiguous, and constitute a clear disavowal of scope." *Verizon*, 503 F.3d at 1306. We do not agree that such a clear disavowal exists in this prosecution history. The expert declaration cited by the district court, which the applicants relied on to respond to both the indefiniteness and the written description rejections, explained that the written description disclosed "*a technique* which forms the teeth" by "performing two separate swell and etch steps." J.A. 2074 ¶ 7 (citing '582 patent col. 9 ll. 1–9) (emphasis added). The district court found this statement "clearly describe[d] the patented method as involving two etching processes." *See Claim Construction Order*, 2017 WL 3478659, at *6. But clearly describing a particular claim term to overcome an indefiniteness or written description rejection is not the same as clearly disavowing claim scope. Moreover, the statements in the expert declaration merely explain one technique

for forming teeth and do not amount to clear statements of disavowal. We therefore conclude that the cited statements in the prosecution history do not clearly and unmistakably disavow any claim scope.

Before we conclude our analysis of the intrinsic evidence, we note that in order to read a process limitation into a product claim, it must meet one more criterion. Generally, "[a] novel product that meets the criteria of patentability is not limited to the process by which it was made." *Vanguard Prods. Corp. v. Parker Hannifin Corp.*, 234 F.3d 1370, 1372–73 (Fed. Cir. 2000). "However, process steps can be treated as part of a product claim if the patentee has made clear that the process steps are an essential part of the claimed invention." *Andersen Corp. v. Fiber Composites, LLC*, 474 F.3d 1361, 1375 (Fed. Cir. 2007). For the same reasons that the statements relied upon by the district court do not show that the patentee clearly and unmistakably disavowed claim scope, they also do not make clear that the repeated desmear process is "an essential part" of the claimed electrical device having a tooth structure. *Id.* Far from being essential, the statements from the intrinsic evidence merely indicate a preference for using Probelec XB 7081 and include comparisons with the prior art techniques. Because the patentee has not "made clear" that the repeated desmear process is "an essential part of the claimed invention," *id.*, it was improper for the district court to read this process limitation into the product claims for this additional reason.

Finally, secondary to the intrinsic evidence, "we have also authorized district courts to rely on extrinsic evidence, which 'consists of all evidence external to the patent and prosecution history, including expert and

inventor testimony, dictionaries, and learned treatises.'" *Phillips*, 415 F.3d at 1317 (quoting *Markman*, 52 F.3d at 980). But "while extrinsic evidence 'can shed useful light on the relevant art,'" *id.* (quoting *C.R. Bard, Inc. v. U.S. Surgical Corp.*, 388 F.3d 858, 862 (Fed. Cir. 2004)), it is "less significant than the intrinsic record in determining the 'legally operative meaning of disputed claim language,'" *C.R. Bard*, 388 F.3d at 862 (quoting *Vanderlande Indus. Nederland BV v. Int'l Trade Comm'n*, 366 F.3d 1311, 1318 (Fed. Cir. 2004)); *see also Phillips*, 415 F.3d at 1317. Generally, we have viewed extrinsic evidence as "less reliable" than intrinsic evidence. *Phillips*, 415 F.3d at 1318.

Here, the district court acknowledged that the extrinsic evidence, which consisted of documents authored by the inventors, was "not reliable enough to be dispositive," but "provide[d] helpful corroboration." *See Claim Construction Order*, 2017 WL 3478659, at * 6. The inventor documents state that the inventors used "two passes through desmear," J.A. 3321, and a "double pass desmear" J.A. 3324, to achieve the tooth structure. However, similar to the intrinsic evidence, those statements reflect use of the preferred embodiment but give the public no indication that they have any limiting effect. Because we have already determined that the intrinsic evidence does not support reading a repeated desmear process into the claims, the "less reliable" extrinsic evidence, *Phillips*, 415 F.3d at 1318, which even the district court acknowledged was "not reliable enough to be dispositive," *see Claim Construction Order*, 2017 WL 3478659, at * 6, does not counsel otherwise. Accordingly, we conclude that the Category 1 Terms should not be limited to requiring a repeated desmear

process and should be given their plain and ordinary meaning.

CONCLUSION

For the foregoing reasons, we conclude that the district court erred in reading a "repeated desmear process" limitation into the Category 1 Terms. Because the parties stipulated to noninfringement based on the court's erroneous construction, we vacate the judgment of noninfringement and remand for further proceedings.

VACATED AND REMANDED

APPENDIX B

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF ARIZONA

[Filed 9/13/2017]

No. CV16-2026 PHX DGC

CONTINENTAL CIRCUITS LLC,
Plaintiff,

v.

INTEL CORPORATION, ET AL.,
Defendants.

FINAL JUDGMENT

Pursuant to and for the reasons set forth in Continental Circuits LLC's ("Continental Circuits") and Defendants Intel Corporation, Ibiden U.S.A. Corporation, and Ibiden Co., Ltd.'s ("Defendants") September 7, 2017 Stipulation And Joint Motion For Entry Of Final Judgment Of Non-Infringement And Non-Indefiniteness ("Stipulation") (Doc. 266).

THE COURT ENTERS FINAL JUDGMENT of:

1. non-infringement of all asserted claims of U.S. Patent No. 7,501,582 ("the '582 patent"), U.S. Patent No. 8,278,560 ("the '560 patent"), U.S. Patent No. 8,581,105 ("the '105 patent"), and U.S. Patent No. 9,374,912 ("the '912 patent") (collectively the "Patents-in-Suit") in view of the Court's construction of the Category 1 terms in the Claim Construction Order (ECF No. 243); and

2. non-indefiniteness under 35 U.S.C. §112, ¶ 2 with respect to the terms "a sample of the circuitry" (claims 94, 95, and 122 of the '582 patent); "upgrade slope" (claims 85, 87, 89, 92, 94, 95, 100, 109, 114, and 122 of the '582 patent); "peel strength greater than a peel strength that would be produced by a single desmear process" (claims 87 and 92 of the '582 patent); and "substantially greater cross-sectional distance distant from the [initial] surface" (claims 14 and 19 of the '560 patent; and claims 13, 53, 71, 80, 82, 86, 88, 91, 95, 97, 101, and 103 of the '105 patent).

The Court also **dismisses without prejudice** Defendants' defenses and counterclaims, except for those concerning indefiniteness under §112, ¶ 2 with respect to the terms listed in the preceding paragraph. Defendants may revive any defenses and counterclaims dismissed without prejudice in the event of a remand.

This is a final, appealable judgment.

Dated this 12th day of September, 2017.

/s/ David G. Campbell
David G. Campbell
United States District Judge

APPENDIX C

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF ARIZONA

[Filed 8/9/2017]

No. CV16-2026 PHX DGC

CONTINENTAL CIRCUITS LLC,
Plaintiff,

v.

INTEL CORPORATION, ET AL.,
Defendants.

ORDER

Plaintiff Continental Circuits LLC asserts claims for patent infringement against Defendants Ibiden U.S.A. Corp., Ibiden Co. Ltd., and Intel Corp. The Court held a *Markman* hearing on August 4, 2017. This order will set forth the Court's ruling on the issues addressed during the hearing and in the parties' briefs.

I. Background.

Defendant Ibiden produces layered electronic devices at its facilities overseas. *See* Doc. 133, ¶¶ 51, 110.[1] These layered devices are used in computer

[1] Page citations are to numbers placed at the top of each page by the Court's CM/ECF system rather than the document's original page numbers.

electronics, including computer processors manufactured by Defendant Intel. *See id.*, ¶¶ 49-51.

The devices are made of alternating layers of conductive and non-conductive materials. *See id.*, ¶ 29. When adhesion between the layers is poor, the layers can separate, creating problems for or failure of the electronic product in which they are incorporated. *See id.* In the 1990s, four employees of Continental Circuits, Inc., a now-defunct circuit-board manufacturer, invented a "novel surface roughening technique" using etching to create a "non-uniformly roughened surface" that allows for stronger adhesion between layers. *Id.*, ¶¶ 28-29, 120. The four co-inventors applied to patent the surface-roughening technology in 1997, and two patents were issued in 2000 and 2004. *Id.*, ¶¶ 12-13. Those patents are not at issue in this case. A continuation application was filed by early 2005, and eventually resulted in the issuance of the four patents that are at issue here: U.S. Patent Nos. 7,501,582 (2009), 8,278,560 (2012), 8,581,105 (2013), and 9,374,912 (2016) (collectively, the "patents-in-suit"). *See id.*, ¶¶ 14-17, 35-36. Copies of these patents can be found at Doc. 188-3, Exs. 1-4.

Plaintiff Continental Circuits LLC is a non-operating entity that was formed in 2016 and owns the patents-in-suit. Doc. 49, at 11 n.8; Doc. 133, ¶ 19. The day after the last of the patents-in-suit was issued, Plaintiff filed this action. *See* Doc. 1. Plaintiff alleges that Defendants have infringed the patents-in-suit.

The parties have filed a joint claim construction statement that identifies the patent terms to be addressed in this order. Doc. 177. The statement identifies three categories of claims to be construed,

each of which includes a number of closely related claims found in the patents. *Id.* It also identifies four terms that Defendants claim are indefinite and therefore invalid. *Id.* The parties have filed briefs on claim construction. Docs. 188, 189, 199, 200. At the Court's request, the parties filed additional memoranda regarding the ramifications of their claim construction positions. Docs. 225, 230.[2]

II. Legal Standard.

A patent includes two basic components: (1) a written description of the invention, referred to as the "specification" of the patent, and (2) the patent claims. The claims define the scope of the invention covered by the patent. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc). Claim construction is a matter of law to be decided by the Court. *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 372 (1996).

Words of a claim are generally given the ordinary and customary meaning the words would have for a person of ordinary skill in the art at the time of the invention. *Phillips*, 415 F.3d at 1313. "[T]he person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification." *Id*. The specification is also highly relevant. The Federal Circuit has characterized it as "the single best guide to the meaning of a disputed term." *Id.* at 1315 (quotation marks and citation omitted). A court may also consider the patent's prosecution history. *Id*. at 1317. "Like the

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[2] Some of the parties' filings are redacted to remove trade secrets. Unredacted versions have been filed under seal at Docs. 234-238.

specification, the prosecution history provides evidence of how the PTO and the inventor understood the patent." *Id.* The claims, specification, and prosecution history are commonly referred to as "intrinsic evidence."

Extrinsic evidence may also be used in claim construction. Extrinsic evidence consists of all evidence external to the patent and prosecution history, including expert and inventor testimony, dictionaries, learned treatises, and other patents. *Id.* Extrinsic evidence is viewed as less reliable than the patent and its prosecution history in determining how to read claim terms. *Id.* at 1318.

III. Category 1 Terms.

Category 1 in the parties' joint claim construction statement concerns a number of claims in the patents-in-suit that address the etching of the dielectric or epoxy layer of an electronic circuit board or comparable device. Doc. 177 at 4-9. Some of the claims simply refer to "etching the epoxy," while others refer to "etching the dielectric material," "removal of a portion of the dielectric material," "removal of some of the dielectric material," "a surface of a layer of a dielectric material," "a surface of a dielectric material," and "a dielectric material comprising a surface." *Id.* Plaintiff contends that these phrases require no construction. Defendants contend that each phrase should be construed to include a requirement that the etching, removal, or modification of the dielectric material be "produced by a repeated desmear process." *Id.*

As Plaintiff correctly notes, Defendants do not contend that the actual words of the claims provide this additional meaning. Rather, Defendants seek to add a limitation to the claims – namely, that the etching or alteration of the dielectric material occur through a repeated desmear process. Because the plain and ordinary meaning of the phrases at issue does not include Defendants' proposed limitation, Defendants carry a heavy burden. The Federal Circuit has explained that there are only two exceptions to the rule that claims are given their plain and ordinary meaning: "1) when a patentee sets out a definition and acts as his own lexicographer, or 2) when the patentee disavows the full scope of a claim term either in the specification or during prosecution." *Thorner v. Sony Computer Entm't Am. LLC*, 669 F.3d 1362, 1365 (Fed. Cir. 2012). The standard Defendants must meet for either of these exceptions is "exacting." *Id.* at 1366.

"To act as its own lexicographer, a patentee must 'clearly set forth a definition of the disputed claim term' other than its plain and ordinary meaning." *Id.* at 1365 (quoting *CCS Fitness, Inc. v. Brunswick Corp.*, 288 F.3d 1359, 1366 (Fed. Cir. 2002)). "It is not enough for a patentee to simply disclose a single embodiment or use a word in the same manner in all embodiments, the patentee must 'clearly express an intent' to redefine the term." *Id.* (quoting *Helmsderfer v. Bobrick Washroom Equip., Inc.*, 527 F.3d 1379, 1381 (Fed. Cir. 2008)).

A disavowal also must be "clear and unmistakable." *Id.* at 1367. "'Where the specification makes clear that the invention does not include a particular feature, that feature is deemed to be outside the reach of the claims of the patent, even though the language of the

claims, read without reference to the specification, might be considered broad enough to encompass the feature in question.'" *Id.* at 1366 (quoting *SciMed Life Sys., Inc. v. Advanced Cardiovascular Sys., Inc.*, 242 F.3d 1337, 1341 (Fed. Cir. 2001)). "'The patentee may demonstrate intent to deviate from the ordinary and accustomed meaning of a claim term by including in the specification expressions of manifest exclusion or restriction, representing a clear disavowal of claim scope.'" *Id.* (quoting *Teleflex, Inc. v. Ficosa N. Am. Corp.*, 299 F.3d 1313, 1325 (Fed. Cir. 2002)).

After careful review of the patents-in-suit, the Court concludes that Defendants have met the exacting standard required to adopt their proposed limitation.

A. The Patents' Disavowal of Prior Art.

The Federal Circuit has found disavowal when a patent "repeatedly disparaged an embodiment as 'antiquated,' having 'inherent inadequacies,' and then detailed the 'deficiencies [that] make it difficult' to use." *See GE Lighting Solutions, LLC v. AgiLight, Inc.*, 750 F.3d 1304, 1309 (Fed. Cir. 2014) (quoting *Chi. Bd. Options Exch., Inc. v. Int'l Sec. Exch., LLC*, 677 F.3d 1361, 1372 (Fed. Cir. 2012)). For example, in *Inpro II Licensing, S.A.R.L. v. T-Mobile USA, Inc.*, 450 F.3d 1350, 1354-55 (Fed. Cir. 2006), the Federal Circuit affirmed the construction of "host interface" as a "direct parallel bus interface." The court noted that the only embodiment disclosed was a direct parallel bus interface and that "the specification emphasizes the importance of a parallel connection in solving the problems of the previously used serial connection." *Id.* This discussion demonstrated "what the inventor has

described as the invention." *Id.* at 1355; *see also OpenWave Sys., Inc. v. Apple Inc.*, 808 F.3d 509, 513-17 (Fed. Cir. 2015) (narrowly construing claim term "mobile device" to exclude communication devices containing a "computer module" based on limiting statements in specification that disparaged prior art communication devices containing such "computer modules"); *Fed. Retractable Techs., Inc. v. Becton, Dickinson & Co.*, 653 F.3d 1296, 1305 (Fed. Cir. 2011) (limiting scope of syringe "body" to a one-piece body based in part on distinction of prior art syringes composed of multiple pieces); *SciMed*, 242 F.3d at 1341 (finding disavowal based on disparagement of a particular embodiment and statements that the "present invention" does not include the embodiment).

The specification, which is common to all the patents-in-suit, provides this introduction: "The present invention is directed to methods for making or manufacturing an electrical device, and the process, composition, and product thereof. More particularly, the present invention involves such multi-layer electrical devices as circuit boards constructed by joining a dielectric material to a subsequently applied conductive material." '582 Patent at 1:13-18.[3] The purpose of the invention is to improve on multi-layer electrical devices that "suffer from delamination, blistering, and other reliability problems. This is particularly true when the laminates are subject to thermal stress." *Id.* at 1:30-32.

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[3] The parties' Category 1 arguments all focus on the '582 Patent. The Court will focus on that patent as well. The Court's citations to portions of a patent throughout this order will include a column number and line numbers, separated by a colon.

The specification explains that the patented invention produces a stronger bond between the dielectric layer and the conductive layer by forming teeth in each layer that interlock with each other. "The surface structure is comprised of teeth that are preferably angled or hooked like fangs or canine teeth to enable one layer to mechanically grip a second layer." *Id*. at 1:54-57.

The specification then proceeds to explain the process by which these teeth are formed in the manufacturing of a multi-layer electrical device. Step 6 is the relevant step for purposes of Category 1 claims. Step 6 "involves the etching [of] cavities, veins, openings, or gaps in the applied dielectric material, or more particularly an outermost surface thereof, to accommodate the teeth." *Id.* at 5:37-40. The process by which layers of dielectric material are prepared for boding to a conductive layer is known as a "desmear" process. The '582 Patent repeatedly distinguishes the process covered by the patent from the prior art and its use of a "single desmear process." Five portions of the specification are particularly relevant.

First, the specification explains that "[o]ne technique for forming the teeth is somewhat similar to what has been known as the swell and etch or desmear process, except that ***contrary to all known teachings in the prior art, in effect, a 'double desmear process' is utilized.***" *Id.* at 5:41-44.[4] The description then becomes even more specific: "That is, not merely increasing the times and temperatures and other parameters for the desmear process***, but***

[4] All bolded and italicized emphases in this order have been added by the Court.

instead completing the process a first time, and then completing the process a second time." Id. at 5:44-48.[5]

Second, the patent explains that "the desmear process ***as disclosed herein*** is contrary to the manufacturer's specification, ***i.e., a 'double desmear process,' rather than the single desmear process of the known prior art***." *Id.* at 5:60-63. This statement not only equates the prior art with a "single desmear process," but specifically states that "the desmear process as disclosed herein" is "contrary" to that prior art.

Third, the specification explains:

> the peel strength produced in accordance with ***the present invention*** is greater than the [peel] strength produced by ***the desmear process of the prior art, i.e., a single pass desmear process***. For example, if a ***prior art desmear process*** is used to produce a 6 lb/in average peel strength, ***the present invention*** may produce an average peel strength on the order of 10 lb/in or more.

Id. at 7:3-9. This statement again equates the prior art with "a single pass desmear process," and states that "the present invention" produces a greater strength than that prior art.

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[5] Plaintiff emphasizes that this description applies to "[o]ne technique for forming the teeth," arguing that this is only an illustration. The Court will address this argument below.

Fourth, the patent recommends the use of Probelec XB 7081 for creation of the dielectric layer. The specification contains this explanation:

> Although Probelec XB 7081 apparently was intended for use in the common desmear (swell and etch) process as used in conventional plated through hole plating lines, Probelec XB 7081 ***can alternatively be used in carrying out the present invention***. For example, ***the present invention differs from the common desmear process in that sub-steps in the desmear process are repeated as a way of forming the teeth***.

Id. at 8:45-52. This language explains that although Probelec XB 7081 was intended for the prior art process of single desmear, it "can alternatively be used in carrying out the present invention." In other words, the prior art single desmear process is not "the present invention." It also explains precisely how "the present invention" differs from the prior art: "sub-steps in the desmear process are repeated as a way of forming the teeth."

Fifth, the specification contains this strong statement: "In ***stark contrast*** with the etch and swell process of the ***known prior art***, however, a second pass through the process (sub-steps A through F) is used. The second pass seems to make use of non-homogeneities in bringing about a formation of the teeth." *Id.* at 9:1-9. This language draws a "stark contrast" between the "known prior art" and the current invention's "second pass through the process."

In summary, these statements identify the "swell and etch" or "single desmear" process as the "prior art," the "known prior art," the "common desmear process," and "the desmear process of the prior art," and expressly distinguish that prior art from the patented invention. The specification states that the invention is "contrary to all known teachings in the prior art" (*id.* at 5:43-48), is "contrary" to "the single desmear process of the known prior art" (*id.* at 5:61-63), "differs from the common desmear process" (*id.* at 8:50-52), and stands in "stark contrast" with the "known prior art" (*id.* at 9:1-3). These statements are clear and strong. They do not merely point out deficiencies in the prior art, they state with emphasis that this invention is different from the prior art. They make clear that the invention does not include the prior art's single desmear process.

B. "The Present Invention."

When an inventor describes "the present invention" as including particular elements, it can be viewed as a disavowal of a broader scope that might otherwise apply. *See Hill-Rom Servs., Inc. v. Stryker Corp.*, 755 F.3d 1367, 1372 (Fed. Cir. 2014) ("[W]e have held that disclaimer applies when the patentee makes statements such as 'the present invention requires . . .' or 'the present invention is . . .' or 'all embodiments of the present invention are . . .'"); *see also Pacing Technologies, LLC v. Garmin Intern., Inc.*, 778 F.3d 1021, 1025 (Fed. Cir. 2015).

In *Honeywell Int'l, Inc. v. ITT Indus., Inc.*, 452 F.3d 1312, 1318 (Fed. Cir. 2006), the court addressed a "fuel injection system component." Although the ordinary meaning of a "fuel injection system component" is not

limited to a fuel filter, the Federal Circuit found that the proper construction was narrower than the customary meaning and was limited to a filter. The court noted that the specification repeatedly described the fuel filter as "this invention" and "the present invention," and held that "[t]he public is entitled to take the patentee at his word and the word was that the invention is a fuel filter." *Id.*; *see also Edwards Lifesciences LLC v. Cook Inc.*, 582 F.3d 1322, 1327 (Fed. Cir. 2009) (limiting the claim term "graft" to mean "intraluminal graft" when "the specification frequently describes an 'intraluminal graft' as 'the present invention' or 'this invention'").

As shown in the quotations above, the specification states that "the peel strength produced in accordance with ***the present invention*** is greater than the [peel] strength produced by the desmear process of the prior art, i.e., a single desmear process." '582 Patent at 7:3-6. This statement suggests "the present invention" produces results different from the single desmear process. The specification also states that "***the present invention*** differs from the common desmear process in that sub-steps in the desmear process are repeated as a way of forming the teeth." *Id.* at 8:50-52. This statement clearly asserts that "the present invention" – not just the embodiment discussed in the specification as an example – differs from the prior art because it involves a repeat of the desmear process. The specification further states that "***the desmear process as disclosed herein*** is contrary to the manufacturer's specifications, i.e., a 'double desmear process,' rather than the single desmear process of the known prior art." *Id.* at 5:59-63. Although this statement is addressing the specifications of the XB 7081, it also states that "the desmear process as

disclosed" in the patent is a "double desmear process." These statements unmistakably affirm that "the present invention" differs from the single desmear process of the prior art.

C. Prosecution History and Other Portions of the Patents.

As Defendants note, the examiner rejected all pending claims during prosecution of the '560 Patent. Doc. 188-3 at 155. In response, the applicants submitted a declaration from Professor C.P. Wong, Ph.D, which included this explanation:

> As described in this paragraph, performing two separate swell and etch steps is a technique which forms the teeth. Although how this occurs within the dielectric material is not recited with in-depth detail, I understand the specification as informing that the teeth formation results from the release of some solid content in the first etching pass, forming irregular recesses and volume displacement. By forming the irregular releases in the first etching pass, an opening within the dielectric material would then be enlarged in the second etch pass, making the structure shown in Figure 1 and recited in the claims[.]

Doc. 188-3 at 109.

This statement clearly describes the patented method as involving two etching processes. Although Plaintiff correctly notes that Dr. Wong refers only to "a technique" as opposed to "the technique," Dr. Wong explains that the patented teeth are created by the

second etching pass. This part of the prosecution history corroborates the conclusions reached above, even if not sufficient on its own to find disavowal.

Other portions of the patents also support the conclusions reach above. For example, the '582 Patent includes claims which assert that the products produced by the patented process are superior to products created by "a single roughening process," "a single pass roughening," or "a single desmear process." *See, e.g.,* '582 Patent at 10:25, 10:33-34, 11:4, 11:11, 11:48, 11:55, 12:2, 12:15, 12:42-43, 12:59, 14:7, 17:34, 17:38-39,18:1, 18:6, 18:36-37, 18:41-42, 19:10-11, 19:14-15, 19:26. 19:40, 19:66-67, 20:15-16. These claims are not at issue in this case, but both sides agreed during the *Markman* hearing that the Court can consider them in this order. Their wording confirms that the present invention is different from a single desmear process.

Defendants also point to extrinsic evidence that supports the Court's conclusion. Documents produced by the inventors state that "a two pass desmear cycle doubles the peel strength of a one pass desmear cycle, but varying the times in the cycle do not seem to have that great of an effect." Doc. 235-2, Ex. 26. The primary inventor of the patented product, Brian McDermott, wrote in a 1998 letter that "we use a double pass desmear to achieve the tooth structure." Doc. 235-3, Ex. 30. This extrinsic evidence, although not reliable enough to be dispositive, provides helpful corroboration of the Court's conclusion. *Phillips*, 415 F.3d at 1319 (explaining that extrinsic evidence "may be useful to the court").

D. Plaintiff's Arguments.

Plaintiff relies on the principle of claim differentiation and argues that references to a repeat desmear process are found in several independent claims, but not in dependent claims. Doc. 189 at 16. Plaintiff notes that "the presence of a dependent claim that adds a particular limitation gives rise to a presumption that the limitation in question is not present in the independent claim." *Phillips*, 415 F.3d at 1315.

The claim differentiation presumption can be overcome by clear indicia in the specification and prosecution history. As the Federal Circuit has explained, "claim differentiation is a rule of thumb that does not trump the clear import of the specification." *Edwards*, 582 F.3d at 1332; *see also Seechange Int'l, Inc. v. C-COR, Inc.*, 413 F.3d 1361, 1369 (Fed. Cir. 2005) (noting that claim differentiation is "not a hard and fast rule and will be overcome by a contrary construction dictated by the written description or prosecution history.").

The Court finds, for reasons explained above, that the specification clearly distinguishes between the current invention and the prior art of a single desmear process. The clear and unequivocal rejection of that prior art overcomes any presumption raised by claim differentiation.

Plaintiff also notes that the specification begins its discussion of the double desmear process by describing it as "[o]ne technique for forming the teeth[.]" '582 Patent at 5:40-41. Although this is true, the patent then proceeds to explain at length the difference

between the current invention and the prior art single desmear process. As already noted, in two places the specification distinguishes this prior art from "the present invention." Thus, although the specification does include a reference to "one technique," the subsequent, detailed explanation makes clear that the patented invention is different from the single desmear process.

Similarly, the words "for example" in one portion of the specification do not suggest that the double desmear process is only an illustration of one embodiment of the patented invention. *Id.* at 8:49-50. Rather, the language is used to explain why XB 7081, which is normally made for a single desmear process, "can alternatively be used in carrying out the present invention." *Id*. at 8:48-49. The specification states: "For example, the present invention differs from the common desmear process in that sub- steps in the desmear process are repeated as a way of forming the teeth." *Id*. at 8:49-52. Thus, the example is not one means by which the invention may be embodied, but an explanation of why XB 7081 can be used with the patented product – by repeating the desmear process for which XB 7081 was designed.

Plaintiff notes that an early statement in the specification refers to methods of production other than repeated desmearing: "For example, a dielectric material can have a non-homogeneous composition or thickness to bring about an uneven chemical resistance, such that ***slowed and/or repeated etching*** will form teeth instead of the uniform etch." *Id*. at 2:27-30. Plaintiff argues that this sentence identifies "slowed" etching as an additional method for making the patented invention, in contrast to repeated

etching. The word "slowed" does appear once in the specification, but the Court cannot conclude that this single word justifies a finding that the patents include the single desmear process.

As explained above, the balance of the specification makes clear that the single desmear process of the prior art is not part of the invention. In fact, it is part of the problem the invention was designed to overcome. Defendants' expert, Dr. Srini Raghavan, also credibly explains in his declaration that a person of ordinary skill in the art would not read the word "slowed" in the context of the patents to mean that the patents embrace single-pass desmearing. Doc. 199-3, ¶¶ 15-17. Finally, language in the specification and in the extrinsic evidence suggests that varying the times of a single desmear process does not produce the teeth that are key to the invention. *See* '582 Patent at 5:43-47; Doc. 235-2, Ex. 26. For these reasons, the Court cannot accept Plaintiff's argument that the single word "slowed" constitutes an alternative embodiment of the patented invention. *See Trustees of Columbia University in City of New York v. Symantec Corp.*, 811 F.3d 1359, 1366 (Fed. Cir. 2016) (explaining that "[t]his single sentence in the specification cannot overcome the overwhelming evidence in other parts of the specification").

Finally, the Court notes that the boilerplate disclaimer of lexicography and disavowal at the end of the specification does not alter its conclusion. '582 Patent at 9:18-25. The Court finds the detailed and repeated explanation of the specification, not this disclaimer, to be controlling.

IV. Category 2 Terms.

The parties' second category of disputed claims includes the following phrases from the '560, '105, and '912 Patents: "Epoxy dielectric material delivered with solid content," "epoxy dielectric material . . . the dielectric material delivered with solid content," "dielectric material delivered with solid content," "dielectric material that is delivered with solid content," and "dielectric material delivered with . . . solid content." Doc. 177 at 12-13. Defendants contend that each of these phrases should be construed to mean dielectric material "delivered with solid particles suspended in a liquid." *Id.* Plaintiff contends that no construction is necessary. Alternatively, Plaintiff contends that the phrases should be interpreted to include "dielectric material having solid particles suspended in the dielectric material." *Id.* The dispute is whether the patents require the use of liquid dielectric material in manufacturing the multi-layer electronic devices they cover. For several reasons, the Court concludes that Plaintiff is correct – the patents do not require use of a liquid dielectric material.

A. Plain and Ordinary Meaning.

As noted above, words of a claim are generally given the ordinary and customary meaning the words would have to a person of ordinary skill in the art at the time of the invention. *Phillips*, 415 F.3d at 1313. The Court concludes that the plain and ordinary meaning of the words in Category 2 does not require use of a liquid dielectric material.

The parties agree that dielectric material can be applied either in solid or liquid form. Neither side

argues that the simple phrase "dielectric material" necessarily specifies one or the other. Given this fact, the Court concludes that the plain and ordinary meaning of "epoxy dielectric material delivered with solid content" or "dielectric material delivered with solid content" is delivery of a dielectric material the content of which is solid. Were it not for other portions of the patents, the Court would be inclined to conclude that the form of dielectric material specified in the claims is solid. This is precisely opposite the argument made by Defendants – that the ***only form*** of dielectric material permitted under the claims is liquid. The plain meaning does not support Defendants' position.

B. Specification.

The specification provides clarification. Dielectric material is applied to the multi-layer electronic device in Step 3 of the process described in the patents. The specification gives this description of Step 3:

> Step 3 includes applying the dielectric material to the outermost surface of the conductive layer (and the base if appropriate for the circuitry or electrical device at issue) prepared in accordance with step 2. ***The dielectric material can be applied by as [sic] a (dry film), a (liquid) curtain coating, a (liquid) roller coating, or an analogous application or bonding technique.***

'582 Patent at 5:15-21.[6] This language explains that the patented invention can use either dry or liquid dielectric material. The explanation is unambiguous.

The specification goes on to provide a preferred embodiment for the invention. It includes this explanation:

> Turning now particularly to the process for forming the teeth and the cavities for the teeth, the present invention ***can be carried out*** by a new use of a CIBA-GEIGY product known as Probelec XB 7081 as a photoimagable dielectric material. Generally, and in accordance with its specifications sheet, Probelec XB 7081 is a single component, 100% epoxy photodielectric material especially developed for . . . multi-layer boards.

Id. at 6:41-48.

As is clear from this language, the use of XB 7081 is a preferred embodiment, an illustration. The specification says only that the patent "can be carried out" by using this product, which is a liquid, not that it must be carried out in this manner. Later portions of the specification continue discussion of this preferred embodiment. When the specification describes the method for applying the dielectric

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[6] Some sentences in the specification include numbers that refer to specific components of the figures shown at the beginning of the specification. Quotations throughout this order omit those numbers.

material, it again uses XB 7081 as an illustration. *Id.* at 7:15-37.

"[I]t is improper to read limitations from a preferred embodiment described in the specification – even if it is the only embodiment – into the claims absent a clear indication in the intrinsic record that the patentee intended the claims to be so limited." *Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 913 (Fed. Cir. 2004). Unlike the Category 1 phrases discussed above, where the specification clearly distinguishes the invention from the prior art single desmear process, the specification and other intrinsic evidence contain no clear indication that the dielectric material to be used in the patented process must be liquid. Nor does the specification describe "the present invention" as not including solid forms of dielectric material. For a court to find that a specification has disclaimed a particular possible interpretation of the claims, "there must be a clear and unmistakable disclaimer." *Thorner*, 669 F.3d at 1366-67; *see also Pacing Techs.*, 778 F.3d at 1024. The patents' preferred embodiment of XB 7081 does not constitute a clear and unmistakable disclaimer of a solid dielectric material.

C. Prosecution History.

Defendants look to the prosecution history to support their argument that the dielectric material must be applied in liquid form. Doc. 188 at 14-15. But the legal standard for finding a prosecution history disclaimer requires "a clear and unmistakable disavowal of scope during prosecution." *Purdue Pharma L.P. v. Endo Pharm. Inc.*, 438 F.3d 1123, 1136 (Fed. Cir. 2006). Ambiguous statements in the

prosecution history will not support a finding of disclaimer. *SanDisk Corp. v. Memorex Prods., Inc.*, 415 F.3d 1278, 1287 (Fed. Cir. 2005) ("There is no 'clear and unmistakable' disclaimer if a prosecution argument is subject to more than one reasonable interpretation, one of which is consistent with a proffered meaning of the disputed term."); *see also LG Elecs., Inc. v. Bizcom Elecs., Inc.*, 453 F.3d 1364, 1373-74 (Fed. Cir. 2006) (finding that prosecution history statements were not sufficiently clear to justify limiting claims), *reversed on other grounds by Quanta v. LG Elecs.*, 128 S. Ct. 2109 (2008).

Defendants note that the examiner for the '560 Patent rejected a number of claims because "[i]t is not clear as to what is meant by a dielectric material being delivered with solid content and it is also unclear as to how epoxy uses non-homogeneity with the solid content." Doc. 183 at 158. The applicants responded with a document submitted on June 25, 2012. Doc. 188-3 at 96-109. The document attached a declaration by Dr. Wong. *Id.* at 107-109. The relevant portions of the document provide this explanation:

> Dr. Wong testifies that, from the identified passages of the specification of the subject application, one of ordinary skill would understand that the specification disclosed the use of a generally liquid epoxy non-homogeneous dielectric, specifically as noted by the Examiner in the Action Sentence bridging [pages] 3 and 4. As noted by Dr. Wong, by describing the epoxy as having a solid content of 58%, one skilled in the art would understand that Probelec XB

> 7081 includes solid particles suspended in a generally liquid epoxy.
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> * * *
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> As discussed above, the specification describes the use of a "dielectric material" with "non-homogeneous composition . . . to bring out uneven chemical resistance, such that slowed and/or repeated etching will form teeth instead of a uniform etch." The operation of this aspect of the process of the present application is explained in the Declaration, Paragraph 7. In addition, the Specification describes the use of an epoxy, e.g., Probelec XB 7081, having "a solid content of 58%." By describing the epoxy as having a solid content of 58%, one skilled in the art would understand that Probelec XB 7081 includes solid particles in a percentage of 58% suspended in a generally liquid epoxy and that utilization of an epoxy "delivered with solid content" similar to Probelec as the applied dielectric material.

Id. at 103-104. Defendants also emphasize this paragraph from Dr. Wong's attached declaration:

> I have been asked to comment on the question of disclosure in the original specification for the claim language requiring an epoxy dielectric material delivered with solid content . . . . A particular example of this epoxy having solid content is disclosed as Probelec XB

> 7081 as described in paragraphs (0051-0065). Paragraphs (0051 to 0060) describe the various properties of this epoxy material. In paragraph (0056), McDermott discloses a "solid content of 58%." By describing this epoxy as having a solid content of 58%, I understand that Probelec XB 7081 includes solid particles suspended in a generally liquid epoxy.

Id. at 108.

Defendants contend that this language amounts to a disclaimer of solid dielectric material for the patented process. The Court does not agree.

Portions of the quoted language simply describe XB 7081, the product used in the specification's preferred embodiment. These portions state that XB 7081 includes solid particles suspended in a generally liquid epoxy. Such a description of a product used in a preferred embodiment does not constitute a disclaimer of all other possible forms of dielectric material.

Other portions of the quoted language refer to epoxy "having a solid content of 58%," and state that one skilled in the art would understand this to mean a liquid containing solid particles. But the reference to 58% does not appear in any of the Category 2 claims to be construed – they all refer to dielectric material "delivered with solid content." The fact that dielectric material "having a solid content of 58%" suggests a liquid with 58% solid particles, as the statements from the prosecution history say, does not mean that the phrase "delivered with solid content," standing alone,

also means a liquid. At most, the statements are ambiguous.

The prosecution history does not clearly and unmistakably disavow use of solid dielectric materials. *Purdue*, 438 F.3d at 1136. As a result, the Court cannot rely on the prosecution history as a basis for concluding that solid dielectric materials are excluded from the patent. To the contrary, the specification expressly states that a dry film dielectric material may be used.

V. Category 3.

The parties' third category of claim terms are "means-plus-function limitations." Doc. 177 at 2-3. The relevant statute provides that "[a]n element in a claim for a combination may be expressed as a means or a step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim ***shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.***" 35 U.S.C. § 112(f). When this statute applies to a claim, the claim is construed by identifying the "function" associated with the plain language, and then identifying the corresponding "structure" in the specification that is associated with that function.

The parties have identified three claim terms requiring construction, and agree that each of these terms constitutes a means-plus-function limitation. The parties also agree on the function for each term. The Court's task, therefore, is to find the corresponding "structure" in the specification for each function.

The first limitation, found in the '582 Patent, is "means for joining the conductive layer to the dielectric material." Doc. 177 at 15. The parties agree that this claim has the following function: "joining the conductive layer to the dielectric material." *Id*.

The second claim also comes from the '582 Patent and reads: "means for mechanically gripping a conductive layer to the surface of the dielectric material so that the conductive layer is burrowed in and under the top surface of the dielectric material." *Id*. The parties agree on the following function for this claim: "mechanically gripping a conductive layer to the surface of the dielectric material so that the conductive layer is burrowed in and under the top surface of the dielectric material." *Id.*

The third term comes from the '105 Patent and reads: "means for interlocking a conductor part of the circuitry configured for filling cavities with an epoxy dielectric material disposed in combination with the circuitry and coupled with the conductor part." *Id.* at 116. The parties agree on this function: "interlocking a conductor part of the circuitry configured for filling cavities with an epoxy dielectric material disposed in combination with the circuitry and coupled with the conductor part." *Id.*

The parties disagree on the structure that should correspond to each claim. With respect to the first claim, Plaintiff asserts that the structure should be Figure 1 of the '582 Patent, together with the following statement from the specification: "It could also be said that the layers joined in a saw-toothed manner, i.e., teeth made of both materials in an interlocking bite." Defendants, on the other hand, contend that the

structure should include seven paragraphs from the '582 Patent specification – paragraphs that discuss the connection between the dielectric material and the conductive layer in considerable detail. These paragraphs include a discussion of teeth, a saw-toothed description of the teeth, a triangular shape description of the teeth, canine or fang-shaped teeth, and preferable sizes and frequencies for the teeth. '582 Patent at 3:18 to 4:11.

With respect to the second claim term, Plaintiff contends that the corresponding structure consists of Figure 1 and the following statement:

> However, the preferred embodiment utilizes a surface of obtuse, canine, or fang-shaped teeth to help the conductive coating hook under the exterior surface of the applied dielectric material to mechanically grip the applied dielectric material. The obtuse, canine, or fang-shaped teeth are in contrast to the shallower, more rounded surface typically produced by known roughening techniques. Note in FIG. 2 that roughening techniques can produce some occasional gouging but nothing on the order of the present invention.

'582 Patent at 3:42-51. Defendants propose the same seven-paragraph structure that they advocate with respect to the first claim.

For the third claim, which is found in the '105 Patent, Plaintiff proposes that the structure include Figure 1 and the following language from the specification:

> The invention can be carried by forming cavities in the applied dielectric material for receiving the teeth, and then forming the teeth from the conductive coating and metal layer formed thereon. Generally, the teeth can be of any triangular shape (e.g., equilateral, isosceles, scalene, right, obtuse, or any combination thereof). Preferably, though, the teeth are obtuse so as to hook or angle under the exterior surface of the applied dielectric material.

'105 Patent at 3:40-47. Defendants propose the same seven-paragraph structure that they propose for the other claims. *Id.* at 3:26-4:29.

The Federal Circuit has instructed "that corresponding structure must include all structure that actually performs the recited function." *Cardiac Pacemakers, Inc. v. St. Jude Medical, Inc.*, 296 F.3d 1106, 1119 (Fed. Cir. 2002); *see also Callicrate v. Wadsworth Mfg., Inc.*, 427 F.3d 1361, 1369 (Fed. Cir. 2005) (holding that it was error for the district court to limit the corresponding structure to the preferred embodiment and not include "all structure in the specification corresponding to the claimed function"). In light of this guidance, the Court concludes that Plaintiff's proposed structures are too narrow. Although they include some discussion of the means by which the conductive and dielectric layers adhere to each other, those discussions do not include "all structure" described in the specification "that actually performs the recited function." *Cardiac Pacemakers*, 296 F.3d at 1119. The Court also disagrees with Plaintiff's suggestion that the words "joining," "mechanically gripping," and "interlocking" have

different meanings. These terms are not defined in the patents. Each is used to describe the means by which the layers adhere to each other. And, as Defendants note, these terms are used interchangeably in some parts of the specification. *See, e.g.,* '582 Patent at 1:50-57, 3:21- 23.

The seven paragraphs identified by Defendants describe the structure by which the dielectric material adheres to the conductive layer in more detail, but even they leave out some structure, and the Court has difficulty understanding how these technical and lengthy paragraphs could be used by a jury to determine whether the accused products infringe. Indeed, both sides acknowledged during the *Markman* hearing that it would be best to prepare for the jury a short and clear description of the structure that corresponds to the functions identified above.

The disagreement between the parties seems to be over which portions of the structure discussed in the specification must be present for a product to infringe. Plaintiff contends that the presence in the accused product of any part of the structure will be sufficient. Defendants argue that at least four different components of the structure must be present before infringement is found. Defendants identify these components by looking to parts of the specification that are not included in their seven paragraphs of proposed structure.

The Court concludes that the parties' *Markman* briefs do not provide a sufficient discussion of the law or the specification for the Court to resolve this disagreement. As a result, the Court will require the parties to do the following:

1. Develop an agreed-upon description of each element of structure found in the specification that relates to the adhering function of these claims. This can include separate paragraphs for each element (tooth shape, frequency, size, etc.) or a narrative description of the entire structure. It should be in language suitable for a jury instruction.

2. Brief two questions: (1) As a legal matter, how many elements of a structure must be present in an accused product for a finding of infringement? (2) How does that law apply to these patents – what elements of structure disclosed in the specification must be present for an accused product to infringe in this case?

3. The parties shall confer and, within 10 days of this order, propose a schedule for completing these tasks, including page limitations.

VI. Indefiniteness.

The relevant statute provides that "[t]he specification shall conclude with one or more claims ***particularly pointing out and distinctly claiming*** the subject matter which the applicant regards as his invention." 35 U.S.C. § 112(b). This requirement ensures that a patentee adequately notifies the public of the scope of his or her invention. "A patent is invalid for indefiniteness if its claims, read in light of the specification delineating the patent, and the prosecution history, fail to inform, with reasonable certainty, those skilled in the art about the scope of the invention." *Nautilus v. Biosig Instruments, Inc.*, 134 S. Ct. 2120, 2123 (2014). At the same time, however,

"absolute precision is unattainable." *Id.* Courts therefore "must take into account the inherent limitations of language" and allow a "modicom of uncertainty" so as to provide appropriate incentives for innovation. *Id.* at 2128. Because an indefinite claim is an invalid claim, an accused infringer must prove indefiniteness clearly and convincingly. *Bancorp Servs., LLC v. Hartford Life Ins. Co.*, 359 F.3d 1367, 1371 (Fed. Cir. 2004).

A. "A Sample of the Circuitry."

Claims in the '582 Patent require that "a sample of the circuitry" have a frequency of teeth sufficient to provide at least 5,000 teeth per linear inch. '582 Patent, Claims 94, 95, 122. Defendant contends that the phrase "a sample of the circuitry" is indefinite because it does not provide enough precision for a person skilled in the art to determine the scope of the invention with reasonable certainty. *See Nautilus*, 134 S. Ct. at 2129. The Court does not agree.

The specification begins by identifying the location of the teeth that are critical to the patent. Figure 1 is a magnified photograph of the interface between a conductive layer and a dielectric layer in a device made according to the patent, and clearly illustrates the teeth of the two layers that interlock with each other. Figure 2 is a magnified photograph of the same interface in a device made by the prior art. The boundary between the two layers is much smoother and lacks the cavities and teeth illustrated in Figure 1. The specification then provides this explanation:

> FIG. 1 is an illustration of a conductive coating and metal layer on the applied

> dielectric material with a desirable tooth structure. In contrast, FIG. 2 is an illustration of a prior art conductive coating and metal layer on the applied dielectric material with the surface produced by roughening processes. . . . Compare FIG. 1 and FIG. 2, and note particularly the size, shape, frequency, and depth of the teeth in FIG. 1 with the surface produced by roughening in FIG. 2.

'582 Patent at 3:8-17.

The specification proceeds to explain the nature of the teeth called for by the patents:

> As to frequency, the teeth should be quite frequent in number; at least about 5,000 teeth per linear inch, and preferably about 10,000 per linear inch; and even better is at least about 15,000 teeth per linear inch.
>
> As to surface area, there should be at least about 25,000 teeth per square inch, better still is essentially at least about 100,000 per square inch, and preferably at least about 200,000 per square inch, or even greater.

Id. at 3:62 to 4:2

> Having described this tooth frequency, the specification explains:
>
> It should be recognized that the teeth generally are not formed to a precise dimension. As shown in FIG. 1, some of the teeth are somewhat differently sized,

> angled, and proportioned. Thus, ***a representative sample*** of the electrical device should have teeth in about these ranges.
>
> Having at least about 20% of the teeth in one or more of these ranges, and preferably about 50% is a preferred balance of mechanical grip without a weakening [of] the integrity of the layer, particularly in combination.

Id. at 4:3-11.

Several points are apparent from this quoted language. First, the teeth are located at the interface between the dielectric material and the conductive layer. Second, the frequency of the teeth should be at least 5,000 per linear inch and 25,000 per square inch. Although Defendants protest that they don't know where these teeth are located, Figure 1 and this language makes clear that they are located in the interface between the two layers. Third, the specification states that "a representative sample of the electrical device should have teeth in about these ranges." *Id.* at 4:6-7.

In light of this specification, claims in the '582 Patent are not indefinite. Claim 94 states that the patented device includes "a conductive layer of material built up on a surface on a layer of dielectric materials, the layers joined in a saw-tooth manner made of both materials in an interlocking bite." *Id.* at 18:14-17. The claim then states: "[T]he conductive layer is a portion of circuitry of an electrical device, the conductive layer is comprised of teeth such that a

sample of the circuitry has a frequency of the teeth sufficient to provide at least 5,000 of the teeth per linear inch." *Id.* at 18:18-22. According to this language, the conductive layer is a portion of the circuitry, and a sample of the circuitry – the conductive layer – should show a frequency of teeth sufficient to provide at least 5,000 teeth per linear inch. In light of the specification's suggestion that the samples should be "representative," and its unambiguous explanation that the location of the teeth and the area to be sampled is the interface between the dielectric and conductive layers, the Court concludes that a person reasonably skilled in the art could determine how to obtain such a sample.

Defendants argue that the size and location of the sample are not specified in the claim. True, but the size clearly must be large enough to show "a frequency of the teeth sufficient to provide at least 5,000 of the teeth per linear inch," and, according to the specification, should be a "representative sample." The parties may disagree on how big that sample ought to be, but the Court cannot conclude that such disagreement makes this claim indefinite. Persons of ordinary skill in the art would understand a sample size large enough to be representative of the interface as a whole.

The Court disagrees with Defendants' argument that the location of the sample is unknown, or that the sample might even be taken from locations in the electronic device other than the interface between the dielectric material and the conductive layer. Reading the specification leaves no doubt as to the meaning of the claim: the interface is the location of the teeth to be sampled, and the teeth in the interface must be

shown by sampling to have a frequency of at least 5,000 per linear inch.

B. "Upgrade Slope."

Claims in the '582 Patent call for the formation of cavities in the dielectric material "wherein at least one of the cavities includes an upgrade slope with respect to the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope." '582 Patent at 17:58-61. Defendants claim that the phrase "upgrade slope" is indefinite because a person of ordinary skill could not distinguish when a slope is "upgrade" as opposed to "downgrade," or where the slope is located. Plaintiff responds that the slope, according to the language of each claim at issue, calls for "an upgrade slope ***with respect to the surface of the dielectric material***." *See, e.g.,* '582 Patent, Claims 89, 94. Plaintiff argues that this language shows that "upgrade slope" describes the orientation of cavity walls in relation to the surface of the dielectric material. Doc. 200 at 15.

The specification includes this explanation:

> A further way of articulating the "teeth" concept is to view each tooth as being substantially triangular in shape, with the base of the triangle being a plain of the dielectric material before it is etched, or more precisely by the exterior surface thereof. The invention can be carried out by forming cavities in the applied dielectric material for receiving the teeth, and then forming the teeth from the conductive coating and then a layer formed thereon.

> Generally, the teeth can be of any triangular shape, e.g., equilateral, isosceles, scalene, right, obtuse, or any combination thereof". Preferably, though, the teeth are obtuse so as to hook or angle under the exterior surface of the applied dielectric material.
>
> The use of any shape of teeth increases the surface area where the conductive coating is on the applied dielectric material. However, the preferred embodiment uses a surface of obtuse, canine, or fang-shaped teeth to help the conductive coating and metal layer hook under the exterior surface of the applied dielectric material.

'582 Patent at 3:28-46.

With this explanation from the specification, the Court concludes that a person of ordinary skill in the industry could understand with reasonable certainty the meaning of the claim at issue: A dielectric material comprising a surface with cavities "wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope." The cavities formed in the dielectric material must have sloped sides, relative to the flat surface of the dielectric material, and the teeth formed from the conductive layer must engage a portion of the dielectric material at the sloped side of the cavity.

As Plaintiff's counsel conceded at the *Markman* hearing, this terminology does not specify any specific slope or angle, and, as a result, every cavity, no matter how small or shallow, would have sides that are sloped

relative to the surface of the dielectric material and therefore satisfy this claim requirement. Indeed, even the undulating surface of the prior art as illustrated in Plaintiff's opening brief (Doc. 189 at 9, lines 13-15) would appear to satisfy this description. As a result, the Court cannot see how this claim language distinguishes the patented invention from the prior art, but that is not a question of definiteness.

C. "Peel Strength Greater Than."

Defendants challenge the '582 Patent claims that call for "peel strength greater than a peel strength that would be produced by a single desmear process." Doc. 177 at 18. Defendants agree that "peel strength" is a term of art that generally refers to the adhesive strength that exists between two layers. Doc. 188 at 25. Defendants argue, however, that this claim language specifies no method for measuring peel strength and no criteria for determining the peel strength of a product produced by a single desmear process, and therefore leaves a person of ordinary skill in the art with no basis to determine what measurement is intended.

Plaintiff asserts with some persuasive force that IPC-TM-650, method 2.4.8, is the standardized method for measuring peel strength by one skilled in the art. Doc. 200-3 at ¶ 30**.** But Plaintiff also argues that any scientifically reasonable method for measuring peel strength could be used, the only requirement being that it show a peel strength in the product made under the patent that is greater than the peel strength of a product made by a single desmear process.

The Court agrees with Plaintiff. Defendants do not contend that the word "greater" is indefinite. And the fact that a particular method of measuring peel strength is not identified does not make the language indefinite. Those skilled in the art know the accepted means for measuring peel strength. Nor is the claim indefinite because the baseline peel strength of a product made with a single desmear process is not specified. No particular peel strength is required; it just must be lower, upon measurement, than the peel strength of the patented product measured by the same method. Persons skilled in the art know how to conduct such measurements and how to locate a product made by a single desmear process.

D. "Substantially Greater."

Claims 14 and 19 of the '560 Patent and several claims in the '105 Patent call for cavities in the dielectric layer having "a first cross-sectional distance proximate the [initial] surface" and a "substantially greater cross-sectional distance distant from the [initial] surface." Doc. 177 at 19. Defendants contend that the intrinsic record is devoid of any objective criteria for determining how much greater is "substantially greater" within the meaning of the claims, and that these limitations therefore are indefinite. Defendants note that the '912 Patent does not include the word "substantially," calling simply for a "greater cross-sectional distance." As a result, Defendants argue, "substantially" must have some meaning beyond "greater," a meaning not apparent from the intrinsic evidence.

Plaintiff notes that the Federal Circuit has "repeatedly confirmed that relative terms such as

'substantially' do not render patent claims so unclear as to prevent a person of skill in the art from ascertaining the scope of the claim." *Deere & Co. v. Bush Hog, LLC*, 703 F.3d 1349, 1359 (Fed. Cir. 2012). Plaintiff agrees, however, on the relevant test: "Such a term is not indefinite if the intrinsic evidence provides 'a general guideline and examples sufficient to enable a person of ordinary skill in the art to determine [the scope of the claims].'" *Enzo Biochem, Inc. v. Applera Corp.*, 599 F.3d 1325, 1335 (Fed. Cir. 2010) (citation omitted).

Plaintiff points to the following language from the specification as providing guidance on the meaning of "substantially":

> In comparison with the above-mentioned roughening techniques of the prior art, it is believed that a surface of the teeth is an improvement in that there is an increase in surface area. However, it is still better to use teeth that are fang-shaped to enable a mechanical grip that functions in a different manner than adherence by means of increased surface area. By using the fanged, angled, canine, or otherwise hooked teeth (in addition to increased surface area), there is a multidirectional, three dimensional interlacing and overlapping of layers.

'582 Patent at 1:58-66. Plaintiff also points to language in the specification stating that "the . . . metal layer is actually burrowed under the dielectric material and vice versa." *Id.* at 1:66 to 2:3.

Plaintiff's expert, Dr. Hoffman, provides this explanation of why this description is sufficient for one skilled in the art to understand the meaning of "substantially":

> In light of the specification and the art, a person of ordinary skill would understand that the cross-sectional distance of the interior of a cavity must exceed a crosssectional distance nearer the opening of a cavity enough to create the "mechanical grip" described in the patents and allow the conductive material to burrow "in and under" the dielectric material. *See, e.g.,* '582 Patent at 1:58-2:3.
>
> A person of ordinary skill in the art would recognize that if the cross-sectional distance of the interior of the cavity only exceeds the cross- sectional distance of the opening by a very slight amount, the mechanical grip disclosed in the patents would not be achieved.
>
> A person of ordinary skill in the art would further understand that the specific difference between comparative cross-sectional distances may vary based on particular application and material properties. For example, a person having ordinary skill in the art would understand that materials having high tensile strength will more readily grip copper, meaning that the degree of undercutting and burrowing (that is to say the amount which the cross-sectional distance distant the surface is

> greater than the distance proximate the surface) can be lesser than a material with lower tensile strength.

Doc. 200-3 at ¶¶ 35-37.

As noted above, the Supreme Court recently held that "a patent's claims, viewed in light of the specification and prosecution history, [must] inform those skilled in the art about the scope of the invention with ***reasonable certainty***." *Nautilus, Inc.*, 134 S. Ct. at 2129. After *Nautilis*, the Federal Circuit explained that "[t]he claims, when read in light of the specification and the prosecution history, ***must provide objective boundaries*** for those of skill in the art." *Interval Licensing LLC v. AOL, Inc.*, 766 F.3d 1364, 1371 (Fed. Cir. 2014). The Federal Circuit also explained that "[w]hen a 'word of degree' is used, the court must determine whether the patent provides '***some standard for measuring that degree***.'" *Biosig inst., Inc. v. Nautilis, Inc.*, 783 F.3d 1374, 1378 (Fed. Cir. 2015) (quoting *Enzo Biochem*, 599 F.3d at 1332).

Although it is a close question, the Court concludes that the patents satisfy this standard. Language from the specification quoted above explains that the cavities should extend under the surface of the dielectric material ("actually burrowed under the dielectric material") so that the teeth that fill the cavities "mechanical[ly] grip" the dielectric material. '582 Patent at 1:58 to 2:3. This suggests that the base of the cavity should not be perfectly aligned with the surface of cavity, the sides of the cavity forming a perpendicular wall, but instead should be sufficiently offset from the surface opening to permit the tooth to

engage the dielectric material in a mechanical grip. The Court concludes that one skilled in the art could determine the extent to which the cavity must extend under the dielectric material to permit such a mechanical grip. The claims provide additional guidance by stating that the peel strength formed by these gripping teeth must exceed the peel strength of a layer created by a single-pass desmear process. And Figure 1 provides further explanation, illustrating the kinds of cavities and teeth intended by the patent.

Admittedly, this language requires some judgment by persons skilled in the art, but it is judgment informed by the intended function of the cavities (to create a mechanical grip), the result that should be realized (peel strength greater than single-pass desmearing creates), and the illustration in Figure 1. As the Federal Circuit explained after *Nautilis*, "absolute or mathematical precision is not required." *Interval Leasing*, 766 F.3d at 1370. The Federal Circuit also favorably cited its previous holding that the phrase "not interfering substantially" was not indefinite even though the construction "define[d] the term without reference to a precise numerical measurement." *Enzo Biochem*, 599 F.3d at 1335.

E. Indefiniteness Conclusion.

With respect to the claims in Category 4, the Court concludes that Defendants have not satisfied their "clear and convincing" burden of showing that the claims are indefinite.

Dated this 9th day of August, 2017.

/s/ David G. Campbell
David G. Campbell
United States District Judge

APPENDIX D

NOTE: This order is nonprecedential.

UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

[Filed 6/14/2019]

CONTINENTAL CIRCUITS LLC,

Plaintiff-Appellant

v.

INTEL CORPORATION, IBIDEN U.S.A. CORPORATION, IBIDEN COMPANY LIMITED,

Defendants-Appellees

2018-1076

Appeal from the United States District Court for the District of Arizona in No. 2:16-cv-02026-DGC, Judge David G. Campbell.

ON PETITION FOR PANEL REHEARING AND REHEARING EN BANC

Before PROST, *Chief Judge*, NEWMAN, LOURIE, LINN*, DYK, MOORE, O'MALLEY, REYNA, WALLACH, TARANTO, CHEN, HUGHES, and STOLL, *Circuit Judges*.

PER CURIAM.

* Circuit Judge Linn participated only in the decision on the petition for panel rehearing.

ORDER

Appellees Intel Corporation, Ibiden U.S.A. Corporation and Ibiden Company Limited filed a combined petition for panel rehearing and rehearing en banc. A response to the petition was invited by the court and filed by Appellant Continental Circuits LLC. The petition was referred to the panel that heard the appeal, and thereafter the petition for rehearing en banc was referred to the circuit judges who are in regular active service.

Upon consideration thereof,

IT IS ORDERED THAT:

The petition for panel rehearing is denied.

The petition for rehearing en banc is denied.

The mandate of the court will issue on June 21, 2019.

FOR THE COURT

June 14, 2019
Date

/s/ Peter R. Marksteiner
Peter R. Marksteiner
Clerk of Court

APPENDIX E

US0075O1582B2

(12) **United States Patent**
McDermott et al.

(10) **Patent No.: US 7,501,582 B2**
(45) **Date of Patent: Mar. 10, 2009**

(54) **ELECTRICAL DEVICE AND METHOD FOR MAKING SAME**

(75) Inventors: **Brian J. McDermott**, Winter Springs, FL (US); **Daniel McGowan**, Casselberry, FL (US); **Ralph Leo Spotts, Jr.**, Lake Mary, FL (US); **Sid Tryzbiak**, Winter Springs, FL (US)

(73) Assignee: **Peter K. Trzyna, Esq.**, Chicago, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 98 days.

(21) Appl. No.: **10/790,363**

(22) Filed: **Mar. 1, 2004**

(65) **Prior Publication Data**

US 2004/0163847 A1 Aug. 26, 2004

Related U.S. Application Data

(63) Continuation of application No. 09/694,099, filed on Oct. 20, 2000, now Pat. No. 6,700,069, and a continuation of application No. 08/905,619, filed on Aug. 4, 1997, now Pat. No. 6,141,870.

(51) **Int. Cl.**
H05K 1/03 (2006.01)

(52) **U.S. Cl.** **174/255**; 174/256; 174/257

(58) **Field of Classification Search** 174/255–262; 29/850–853; 216/15-16

See application file for complete search history.

(56) **References Cited**

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5,517,758. A * 5/1996 Nakamura 29/852

* cited by examiner

Primary Examiner—Tuan T. Dinh

(57) **ABSTRACT**

A multilayer electrical device, such as a printed circuit board, having a tooth structure including a metal layer set in a dielectric. The device includes a base; a conductive layer adjacent to the base; a dielectric material adjacent to conductive layer, a tooth structure including a metal layer set in the dielectric material to join the dielectric material to the metal layer; and wherein the metal layer forms a portion of

circuitry in a circuit board having multiple layers of circuitry.

162 Claims, 2 Drawing Sheets
(1 of 2 Drawing Sheet(s) Filed in Color)

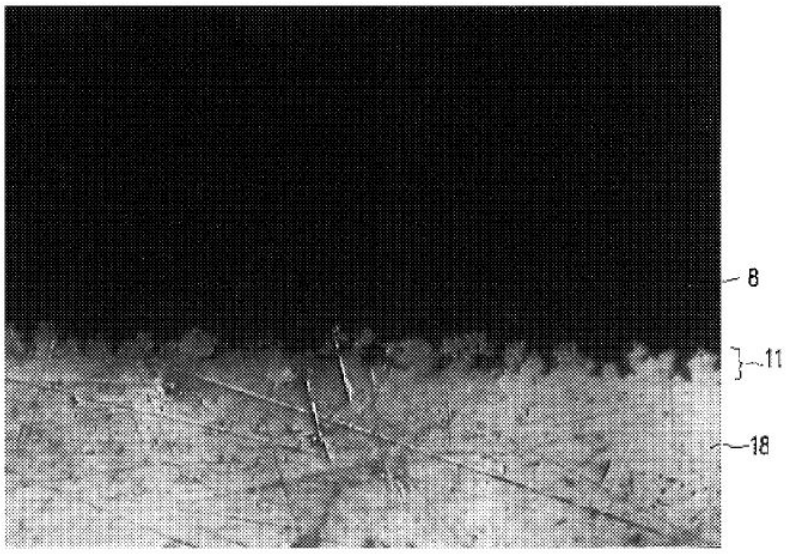


FIG. 1

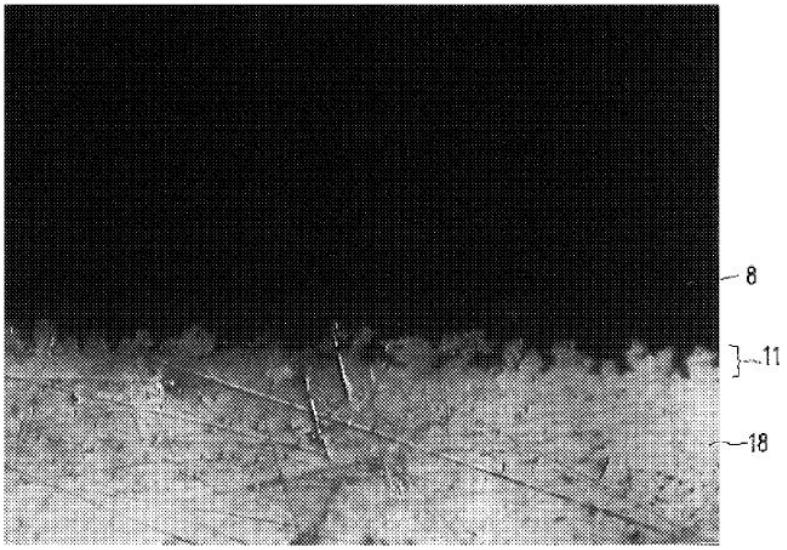


FIG. 2 PRIOR ART

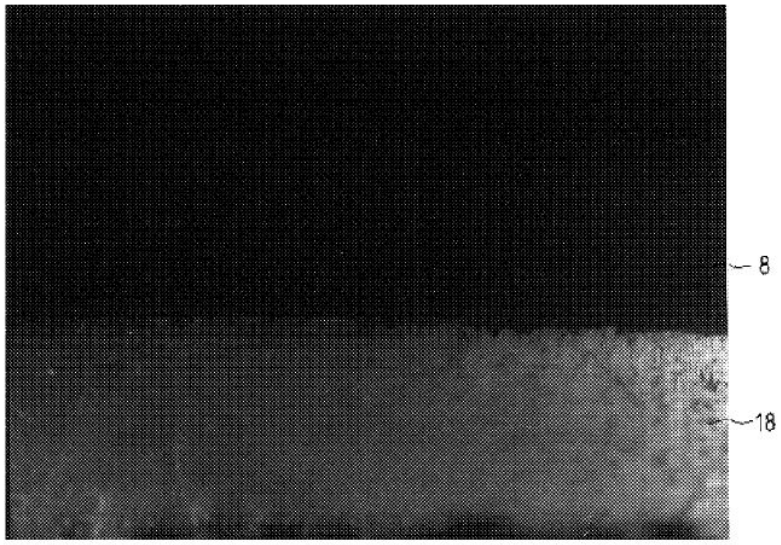


FIG. 3

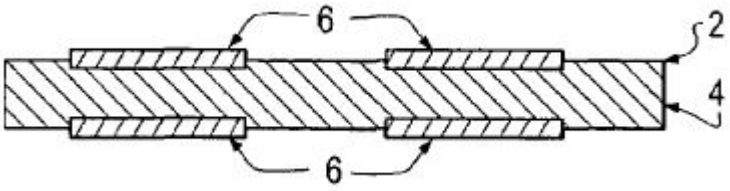


FIG. 4

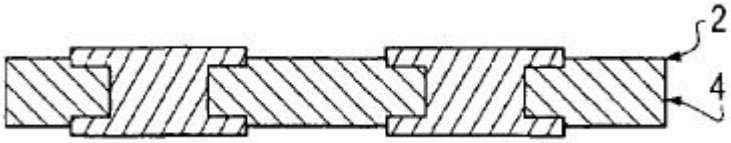


FIG. 5

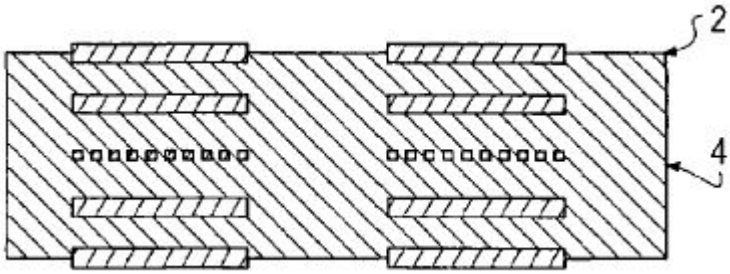


FIG. 6

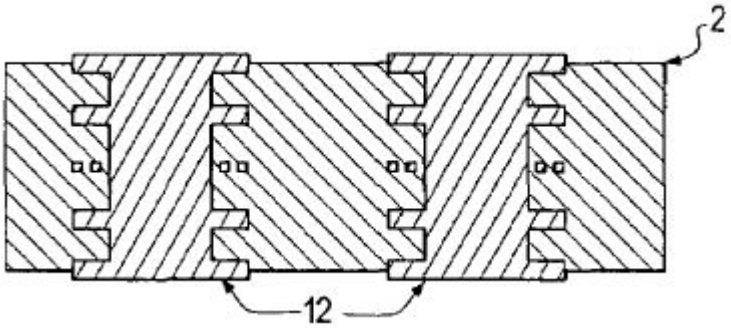


FIG. 7

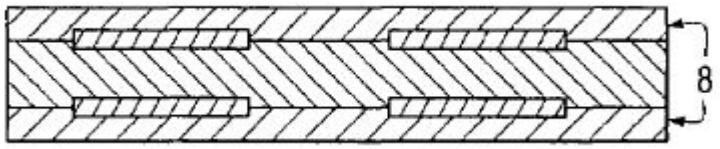


FIG. 8

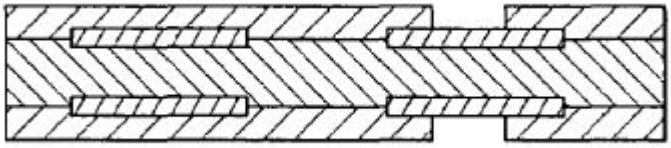


FIG. 9

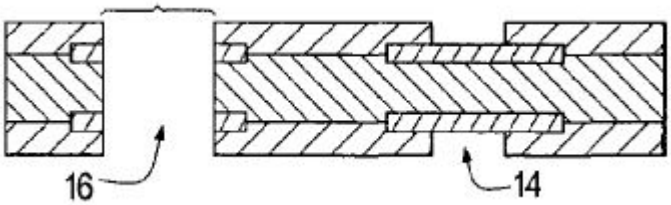


FIG. 10

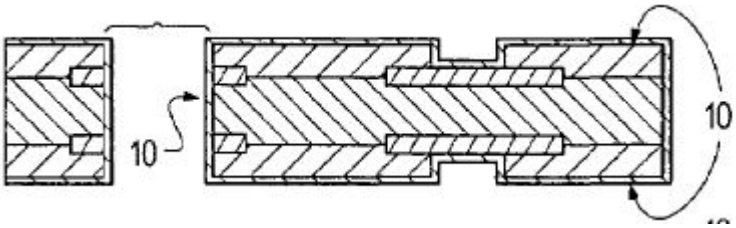
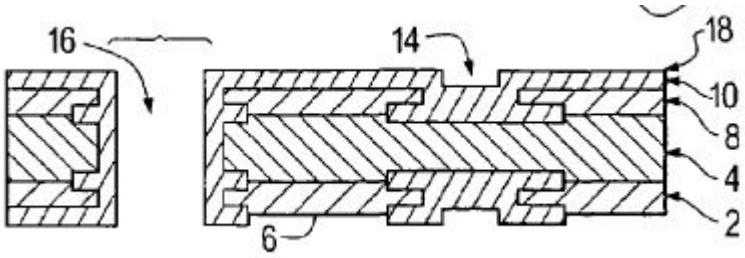


FIG. 11



ELECTRICAL DEVICE AND METHOD FOR MAKING SAME

This patent application is a continuation application that claims priority, and incorporates by reference, from U.S. patent application Ser. No. 08/905,619, now U.S. Pat. No. 6,141,870, filed Aug. 4, 1997, and U.S. patent application Ser. No. 09/604,099, filed Oct. 20, 2000, issuing Mar. 2, 2004, as U.S. Pat. No. 6,700,069.

I. FIELD OF THE INVENTION

The present invention is directed to methods for making or manufacturing an electrical device, and the process, composition, and product thereof. More particularly, the present invention involves such multilayer electrical devices as circuit boards constructed by joining a dielectric material to a subsequently applied conductive material. Still more particularly, the present invention involves an electrical device having a substrate or base, an applied dielectric material thereon, which in turn has a thin conductive coating thereon, and a conductive layer formed upon the conductive coating, the conductive layer being joined to the applied dielectric material in an improved manner.

II. BACKGROUND OF THE INVENTION

Multilayer electrical devices—those made from layering a dielectric material and a conductive material on a base—suffer from delamination, blistering, and other reliability problems. This is particularly true when the laminates are subjected to thermal stress.

Known attempts to solve these problems seem to have focused on physical or chemical roughening, particularly of the base or substrate. See for example, U.S. Pat. No. 4,948, 707. Although oxide-related chemical roughening processes have been used, an emphasis on physical roughening may reflect the use of materials that are relatively chemically resistant. Both physical and chemical roughening approaches have improved adherence to the base.

However, the extent to which this adherence can be increased by roughening has its limits. And despite a long standing recognition of delamination, blistering, and reliability problems, and the attempts to find a solution, these problems have been persistent in electrical devices made of layered materials.

III. SUMMARY OF THE INVENTION

The inventors herein have observed that the general problem of poor adherence between the laminates or layers can be addressed by forming a unique surface structure, which is particularly suitable for joining the dielectric material to the conductive coating and conductive layer. The surface structure is comprised of teeth that are preferably angled or hooked like fangs or canine teeth to enable one layer to mechanically grip a second layer.

In comparison with the above-mentioned roughening techniques of the prior art, it is believed that a surface of the teeth is an improvement in that there is an increase in surface area. However, it is still better to use teeth that are fang-shaped to enable a mechanical grip that functions in a different manner

than adherence by means of increased surface area. By using the fanged, angled, canine, or otherwise hooked teeth (in addition to increased surface area), there is a multidirectional, three dimensional interlacing or overlapping of layers. For example, in joining the dielectric material to the conductive coating and metal layer, the conductive coating and metal layer is actually burrowed in and under the dielectric material and vice versa. Thus, separating them not only involves breaking the surface area adherence, but also involves destroying the integrity of at least one of the layers by ripping the teeth, the layer pierced by them, or both.

Further, it has been found preferable to have numerous teeth sized and shaped so that they are not too large or too small. If the teeth are too small, wide, straight, and shallow, then the surface resembles the roughened surface of prior art techniques, vaguely analogous to a surface of molar teeth, and the adherence is not much better than that achieved by known prior art roughening techniques.

However, if the teeth are too large, deep, and fanged or hook-shaped, the teeth undercut the surface to such an extent that the strength of the dielectric material surface is weakened. As a result, adherence is decreased over the preferred embodiment.

Not too great and not too slight, the right sized and shaped teeth, set in a fanged orientation and with sufficient frequency, have been found to be the best structure. If the correct balance of these critically important factors is created, the result is a greatly improved circuit board or other such electrical device.

It is theorized by the inventors that the best methods for producing the teeth is to use non-homogeneous materials and/or techniques. For example, a dielectric material can have a non-homogeneous composition or thickness to bring about an uneven chemical resistance, such that slowed and/or repeated etching will form teeth instead of a uniform etch.

IV. BRIEF DESCRIPTION OF THE DRAWINGS

The file of this patent contains at least one drawing executed in color. Copies of this patent with the color drawing(s) will be provided by the Patent and Trademark Office upon request and payment of the necessary fee

FIG. 1 is an illustration of a conductive coating and metal layer applied dielectric material with a desirable tooth structure;

FIG. 2 is an illustration of a prior art conductive coating and metal layer on the applied dielectric material with the surface produced by roughening processes;

FIG. 3 is an illustration of a double sided printed circuit board without plated through holes:

FIG. 4 is an illustration of a multilayer printed circuit board with plated through holes, filled or unfilled with conductive or nonconductive material;

FIG. 5 is an illustration of a multilayer printed circuit board without plated through holes;

FIG. 6 is an illustration of a multilayer printed circuit board having more than two layers with plated through holes filled or unfilled with conductive or nonconductive material;

FIG. 7 is an illustration of any of the foregoing printed circuit boards after applying a dielectric material thereon;

FIG. 8 is an illustration of the multilayer printed circuit board of FIG. 7 after forming micro vias:

FIG. 9 is an illustration of the multilayer printed circuit board of FIG. 7 after opening the through holes and after etching the applied dielectric material to produce the teeth illustrated in FIG. 1;

FIG. 10 is an illustration of the multilayer printed circuit board of FIG. 9 after application of a conductive coating to fill in around the teeth and connect micro via holes and the through holes; and

FIG. 11 is an illustration of the multilayer printed circuit board of FIG. 10 after plating the conductive coating to form a metal layer and complete forming circuitry.

V. DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of a conductive coating and metal layer on the applied dielectric material with a desirable tooth structure. In contrast, FIG. 2 is an illustration of a prior art conductive coating and metal layer on the applied dielectric material with the surface produced by roughening processes. In both

FIGS. 1 and 2, show a dielectric material and a combination of a thin conductive coating and metal later.

Compare FIG. 1 and FIG. 2, and note particularly the size, shape, frequency, and depth of the teeth in FIG. 1 with the surface produced by roughening in FIG. 2.

A way of articulating this "teeth concept is to view each tooth as being made of one layer and set in a second layer. However, the perspective is arbitrary, and one could equally view each tooth as made of the second layer set in the first. It could also be said that the layers join in a saw-toothed manner, i.e., teeth made of both materials in an interlocking bite. In any case, however, there are teeth, and for the sake of consistency, this specification will adopt the convention of referring to the teeth as being made of the conductive coating and metal layer set in the dielectric material.

A further way of articulating the "teeth concept is to view each tooth as being substantially triangular in shape, with the base of the triangle being defined by a plane of the applied dielectric material before it is etched, or more precisely by the exterior surface thereof. The invention can be carried by forming cavities in the applied dielectric material 6 for receiving the teeth, and then forming the teeth from the conductive coating and metal layer formed thereon. Generally, the teeth can be of any triangular shape (e.g., equilateral, isosceles, scalene, right, obtuse, or any combination thereof). Prefer ably, though, the teeth are obtuse so as to hook or angle under the exterior surface of the applied dielectric material.

The use of any shape of teeth increases the surface area where the conductive coating is on the applied dielectric material. However, the preferred embodiment utilizes a sur face of obtuse, canine, or fang-shaped teeth to help the conductive coating and metal layer hook under the exterior surface of the applied dielectric material to mechanically grip the applied dielectric material. The obtuse, canine, or fang shaped teeth are in contrast to the shallower, more rounded surface typically produced by known roughening techniques. Note in FIG. 2 that roughing techniques can produce some occasional gouging, but nothing on the order of the present invention.

As to size of the teeth, as mentioned above, it is preferable that the teeth be within a certain size range. The optimal size range for obtuse, canine, or hook-shaped teeth involves a balance between maximizing surface area and mechanical grip, but not undercutting the surface of the applied dielectric material 8 to such an extent as to weaken it. Accordingly, the teeth should be sized at least 1 tenth of a mil deep. Better is at least 1.25 tenths of a mil deep, and even better is at least 1.5 tenths of a mil deep. However, 1.75 tenths of a mil is acceptable, and about 2 tenths of a mil is reaching the limit.

As to frequency, the teeth should be quite frequent in number; at least about 5,000 teeth per linear inch, and preferably at least about 10,000 teeth per linear inch; and even better is at least about 15,000 teeth per linear inch.

As to surface area, there should be at least about 25,000 teeth per square inch, better still is essentially

at least about 100,000 per square inch, and preferably at least about 200,000 per square inch, or even greater.

It should be recognized that the teeth generally are not formed to a precise dimension. As shown in FIG. 1, some of the teeth are somewhat differently sized, angled, and proportioned. Thus, a representative sample of the electrical device should have teeth in about these ranges. Having at least about 20% of the teeth in one or more of these ranges, and preferably at least 50%, is a preferred balance of mechanical grip without a weakening the integrity of the layering, particularly in combination.

As illustrated in FIGS. 3-11, there is an electrical device, such as a printed circuit board 2 having a base 4. The base 4 has a conductive layer 6 thereon. A dielectric material 8 is applied on the conductive layer 6, and a conductive coating 10 (such as a thin coating of palladium) is deposited on the dielectric material 8. Metal layer 12 is formed on the conductive coating 10.

FIG.3 illustrates one of the many ways to begin the process of forming the teeth in accordance with the present invention. A first step (step 1), includes providing a base 4 for constructing an electrical device, such as a printed circuit board 2. FIG. 3 illustrates one such construction, namely a base 4 for constructing a multilayer printed circuit board 2, the base 4 having any positive number of layers or laminates, for example the two layers shown in FIGS. 3 and 4, or more than two layers as illustrated in FIGS. 5 and 6, etc. One configuration or another is not significant, except that multiple layers provide a better medium for constructing circuitry of increased complexity or density. FIGS. 3-6 illustrate an embodiment in which

the conductive layer 6 is on at least an upper side, and preferably also on a lower side of the base 4.

As may be needed for a particular circuitry design, FIG. 4 illustrates that the electrical device can be further manipulated, for example, by forming through holes 12 by mechanical drilling, laser drilling, punching, or the like. The plated through holes 12 are shown in FIGS. 4 and 6 as filled or unfilled with a conductive or a nonconductive material.

FIG. 5 illustrates a configuration for the multilayer printed circuit board 2 with base 4 having more than two layers or laminates, the conductive layers 6 located there between.

FIG. 6 shows the multilayer printed circuit board 2 after forming, plating, and if needed, filling the through holes 12 in the manner of FIG. 4.

To summarize, step 1 of the process includes providing a base 4 for forming an electrical device such as a printed circuit board 2, wherein the base 4 can be formed to have one or more layers or laminates. At least one conductive layer 6 is on the base 4. The base 4 can be double sided with the conductive layer 6 being located outside the base 4 and between the layers or laminates.

The printed circuit board 2 can be further prepared, as may be desirable for a particular circuitry design, by forming open through holes 12 and plating and if needed, filling the through holes 12 to electrically connect to that portion of the conductive layer 6 appropriate for whatever circuitry design is being constructed, e.g., each side of a double sided circuit

board 2. In other words, step 1 involves providing one of the configurations described in FIGS. 3-6.

Step 2 includes preparing an outer-most surface of the conductive layer 6 for any of the above-mentioned configurations. The step of preparing is carried out to enable adherence, e.g., of the applied dielectric material 8 to the conductive layer 6, preferably in a manner that utilizes a respective tooth structure. The step of preparing can be carried out, for example, by using an oxide or an oxide replacement process to treat the conductive layer 6 to such an extent that the teeth (or cavities for teeth) are formed.

As to using an oxide process, a copper oxide can be chemically deposited on a copper surface to produce a tooth-like structure on the surface of the copper. This process is carried out to prepare the copper surface prior to applying another layer of material, thereby providing increased bond strength between the two materials.

As to using an oxide replacement process to form a tooth structure, a micro etch on the surface of the copper is followed by a coating of an adhesion promoter to enhance a bond between copper and the dielectric material 8. For example, Alpha Metals, Inc. offers a PC-7023 product which is suitable for an oxide replacement process.

Step 3 includes applying the dielectric material 8 to the outermost surface of the conductive layer 10 (and the base 4 if appropriate for the circuitry or electrical device at issue) prepared in accordance with the step 2. The dielectric material 8 can be applied by as a (dry) film, a (liquid) curtain coating, a (liquid) roller coating,

or an analogous application or bonding technique. FIG. 7, in comparison with FIGS. 3-6, illustrates the dielectric material 8 on the outermost surface(s) of the conductive layer 4 (and the base 2).

Step 4 includes preparing the applied dielectric material 8 for receipt of a conductive coating 10, which to exemplify, is detailed more particularly below. Generally, though, the preparing step 4 can include exposing, developing, and curing the applied dielectric material 8 to form patterns for further construction of the circuitry, including such features as constructing a via or photo via 14, for optionally filling by conductive or non-conductive materials, e.g., screened, roller coated, etc. Compare FIGS. 6 and 7.

Step 5 includes forming open through holes 16 as shown in FIG. 9. As indicated above with regard to filled through holes 12, the open through holes 16 can be formed by such methods as drilling, boring, punching, and the like.

Step 6, as discussed subsequently in greater detail, involves the etching cavities, veins, openings, or gaps in the applied dielectric material 8, or more particularly an outermost surface thereof, to accommodate the teeth. One technique for forming the teeth is somewhat similar to what has been known as the swell and etch or desmear process, except that contrary to all known teachings in the prior art, in effect, a “double desmear process" is utilized. That is, not merely increasing the times and temperatures and other parameters for the desmear process, but instead completing the process a first time, and then completing the process a second time. Consider using the following Shipley products for the double desmear

process: CIRCUPOSIT MLB conditioner 211, promoter 213B, and neutralizer 216. Non-homogeneous materials and/ or processes seem to be determinative.

Step 7 includes applying a conductive coating 10 to the cavities in the applied dielectric material 8. The conductive coating 10 is also applied to the photo-defined via holes 14 and the open through holes 16. Techniques for applying the conductive coating 10 include a direct plate process or an electroless copper process. To carry out the present invention, it is preferable to use a palladium-based direct plate process or other non-electroless process. In this regard, a Crimson product of Shipley is suitable, though the desmear process as disclosed herein is contrary to the manufacturer's specifications, i.e., a "double desmear process," rather than the single desmear process of the known prior art. Compare FIGS. 1, 2, and 9.

Step 8 includes forming a metal layer 18 on the conductive coating 10, by such metal deposition techniques as electrolytic or non-electrolytic plating, to form the tooth structure and teeth as discussed above. The metal layer 18 and conductive coating 10 collectively form circuitry on the outermost surface of the applied dielectric material 8, which can connect to whatever portion of conductive layer 6 as may be needed for a particular design, preferably by making at least one connection through a micro via. See FIG. 10. A direct plate process, followed as needed by say a semi-additive or fully additive pattern plating process, is recommended.

A direct plate process is a replacement for traditional electroless copper plating of non-

conductive surfaces. Direct plate processes apply a very thin conductive coating (e.g., using palladium or graphite) to the non-conductive surface, thus enabling electroplating of copper or other conductive material onto the previously non-conductive surface. Thus, "direct plate" is used to describe directly plating onto a non-conductive surface without first requiring a non electrolytic (electroless) plating process.

A semi-additive plating process involves first electroplating a thin conductive layer onto the total non-conductive surface, before applying a photoresist and subsequently pattern plating the required circuitry. For semi-additive plating, the thin conductive layer must be removed (etched) from the non-conductive surface. For fully additive plating, photoresist is applied directly on the non-conductive surface, followed by pattern plating the required circuitry (after applying the thin conductive coating in the direct plate process). That is, the fully additive plating forms only the required circuitry and requires no etching.

It should be recognized that the present invention can optionally be carried out by initially skipping step 5 (forming the open through holes 16) during initial "sets of the foregoing steps, i.e., completing steps 6 and 7; then repeating steps 2 through 8, again skipping step 5 each time until the last set of steps, as required to form the electrical device or circuitry of interest. This will produce an electrical device with a second tooth structure that is not set in the first layer of dielectric material 8, and indeed the idea of using a toothed structure is not limited to any one layer and is best employed in holding multiple layers together.

Step 5 can be carried out after the desired layers have been formed.

Turning now more particularly to the process for forming the teeth and the cavities for the teeth, the present invention can be carried out by a new use of a Ciba-Geigy product known as Probelec XB 7081 as a photoimagable dielectric material 8. Generally, and in accordance with its specification sheet, Probelec XB 7081 is a single component, 100% epoxy photodielectric material specially developed for Sequential Build Up (SBU) of multilayer boards.

Probelec XB 7081 is a negative working, high resolution liquid photo-imageable (LPI) material which allows mass-forming of micro vias for fabrication of high-density interconnects (HDI). Compatible with conventional plating and circuitization techniques, Probelec XB 7081 also provides outstanding electrical and physical properties for most circuit board applications, and is compatible with most circuit board substrate materials.

Probelec XB 7081 is specially developed to act as a dielectric between circuit layers in fabrication of blind and buried micro via MLBS. The high resolution photo dielectric allows mass forming of micro vias for the construction of high density interconnects. Probelec XB 7081 has wide process latitudes, excellent handling characteristics, and is known as self-leveling and having an adjustable dry thickness of 1-3 mils. Probelec XB 7081 has a high resolution capability of 1-2 mil micro vias, and is known for chemical resistance, even for additive plating; there are excellent electrical and physical properties and a UL 94V-0 rating.

Probelec is specified to demonstrate more than a 6 lb/in peel strength. By application of this invention this peel strength should be significantly increased due to the formation of the teeth. Accordingly the peel strength produced in accordance with the present invention is greater than the peal strength produced by the desmear process of the prior art, i.e., a single pass desmear process. For example, if a prior art desmear process is used to produce a 6 lb/in average peel strength, the present invention may produce an average peel strength on the order of 10 lb/in or more.

As to the general properties of Probelec XB 7081, there is a storage stability (1-component system) for more than 6 months at 25°C.; the pot life in a coater machine is more than 1 week; the hold time of the coating is more than 1 week (dark or exposed) and more than 1 day in yellow light.

When using Probelec XB 7081 to carry out the above-mentioned step 3 of applying a coating of the dielectric material, there is a pre-cleaning sub-step A. Pre-cleaning should be carried out in chemical, mechanical brushing, or pumice spray units. Extra precaution is needed to ensure that the pre-cleaning equipment and chemistry is not contaminated by materials from previous processing steps. Contrary to Ciba specifications, it is preferred to use an oxide or oxide replacement to prepare the surface prior to applying a coating of the dielectric. Hold times after pre-cleaning should be minimized to avoid oxidation of copper surfaces. In all coating applications, pre-cleaned substrates should be free of particles. Additional cleaning steps, e.g., with detergents, may be required to remove organic residues.

Next there is a coating sub-step B. Probelec XB7081 seems to have been primarily designed for curtain coating and is delivered with a solid content of 58%. Substrates should be heated to about 40° C. prior to coating to ensure all residual moisture is removed and to prepare substrate for curtain coating. For initial charging of a coater machine, Probelec XB 7081 needs to be premixed with about 15% of PMA (PMA is 1-methoxy-2-propyl acetate) to ensure proper viscosity. The additional PMA thins the coating down to about 50% solids.

The resin temperature should be 25±1°C., with a conveyor speed of 90 m/min. The viscosity is at 25°C. DIN AK4 cup at 60 sec. (400 cps), with a coater gap width of 500 mm. The wet weight is 7.5-10.0 gms/600 CM sq. and 11.6-15.5gms/ft sq. The dry thickness is 45-60 mm.

Next is a flash dry sub-step C. Coated panels must be held in a horizontal position under dust-free conditions to air dry. At this stage, minimal air flow is recommended. The drying time is 12-18 min. at a drying temperature of 30-40°C.

Next is a final dry sub-step D. After flash air drying, final drying at an elevated temperature is needed to achieve better than 95% removal of solvents for tack-free handling. This can be accomplished in batch or conveyorized tunnel ovens, as follows:

	Tunnel Oven	Batch Oven
Drying Temperature:	130-140° C.	90° C.
Drying Time:	2-3 minutes	30 minutes

After cooling, the panels can have a second side coating (Sub-steps A through D) if appropriate for the circuit design, and then for an exposure sub-step E.

In the exposure sub-step E, catalyst for cross linking of epoxy resin is generated. The main spectral sensitivity of Probelec XB 7081 is in the range of 350-420 nm. Conventional exposure units, collimated or non-collimated, with peak spectral emission of 365 nm are recommended. Both diazo and silver halide films are suitable as working photo-tools. Good artwork to coating contact is essential for consistent micro via reproduction. The exposure energy is 1200-1600 mJ/cm sq. and the exposure time (7 kW) is 30-40 seconds. The Stouffer Step (21 scale) is 5-7.

Next is a thermal bump step F. Thermal bump provides the energy for crosslinking the catalyzed epoxy resin. This process can be done in convection batch or conveyorized tunnel ovens. For a batch oven, 110° C. for 60 min. is appropriate, and for a conveyorized tunnel oven, 130°C. for 10-20 min. is appropriate.

Next is a developing sub-step G. The unexposed areas of Probelec XB7081 are developed away in continuous spray developing machines. Various models with different processing capacities are available for this purpose. A Ciba-Geigy product DY950 (Gamma-Butyrolactone (GBL)) developer is recommended for processing Probelec XB7081. This developer is a halogen-free, high-boiling organic solvent suitable for on-site distillation or recycling. Probimer 450/470 spray developing equipment is specially designed for use with this developer solution. The temperature is 20+2° C., and the spray pressure

is 2-4 bar. The speed for Probimer 450 is 2-3 m/min: for Probimer 470, 3-4 m/min.

Next is a final cure sub-step H. Final thermal curing is needed to impart good mechanical, chemical, and electrical properties to the dielectric film. The thermal curing can take place in batch or conveyorized tunnel ovens. The thermal curing temperature is 150° C., with a thermal curing time of 60 minutes.

Next can come the step 5 of further preparing, for example, by forming through holes 16. If plated through holes 16 (PTH's) are needed for interconnecting layers to the bottom or back side of the printed circuit board 2, drilling should of course be done before plating. This allows the plating of the surface together with the through holes 16. Plating and such post-processing of the photoimagable dielectric material 8 is dependent on particular process preferences. Probelec XB7081 is compatible with panel-plate, pattern-plate or additive plating.

The following process sub-steps of the above-mentioned step 6 describe a generic sequence for a desmear process to form cavities in the dielectric. Although Probelec XB7081 apparently was intended for use in the common desmear (swell and etch) process as used in conventional plated through hole plating lines, Probelec XB7081 can alternatively be used in carrying out the present invention. For example, the present invention differs from the common desmear process in that sub-steps in the desmear process are repeated as a way of forming the teeth. Sub-step A, swelling the dielectric material 8, can be carried out with butyl diglycol/sodium hydroxide/water 80°C. for 3-5 minutes. Sub-step B is

rinsing the dielectric material 8 in deionized water at room temperature for 4 minutes. Sub-step C is etching the dielectric material 8, which can be carried out using potassium permanganate/sodium hydroxide/water 80° C. 6-10 minutes. Sub-step D is rinsing the dielectric material 8 in deionized water at room temperature for 4 minutes. Sub-step D includes a further rinsing of the dielectric material 8 in deionized water at room temperature for 4 minutes. Sub-step E is neutralizing the dielectric material 8 in sulfuric peroxide (1.5%) for 3 to 5 minutes. Finally step F is rinsing the dielectric material 8 in deionized water at room temperature for 4 minutes.

In stark contrast with the etch and swell process of the known prior art, however, a second pass through the process (sub-steps A through F) is used. The second pass seems to make use of non-homogenaities in bringing about a formation of the teeth. Thus, unlike the prior swell and etch chemical roughening process, which produces a surface characterized by a surface gloss measurement at an angle of 60° which is between 15 and 45%, the present invention has less gloss (<10%).

Turn now in greater detail to the step 7 of applying the conductive coating 10 for subsequent deposition of the metal layer 18 by, say, plating. Good results can be achieved with a flash plate of 0.7-1.0 mm (30-40 micro inches). The flash plate is followed by baking at 130-150° C., for 2 hours.

For pattern plating, plating resist can be applied after baking. Depositing the metal layer 18 by electroplating can be carried out such that there is 10-25 mm (0.4-1.0 mil.).

While a particular embodiment of the present invention has been disclosed, it is to be understood that various different modifications are possible and are within the true spirit of the invention, the scope of which is to be determined with reference to the claims set forth below. There is no intention, therefore, to limit the invention to the exact disclosure presented herein as a teaching of one embodiment of the invention.

We claim:

1. A process of making an electrical device, the process including:

> removing a portion of a dielectric material in producing cavities in a surface of a remaining portion of the dielectric material; and
>
> building up a conductive layer in the cavities in forming teeth set in and under the surface and in forming a portion of circuitry of an electrical device, wherein a plurality of the cavities are obtuse with respect to the top surface, and a plurality of the cavities are at least 1 tenth of a mil deep and less than 1.75 tenths of a mil deep, and
>
> wherein at least one of the cavities includes an upgrade slope with respect to the surface of the remaining portion of the dielectric material, and one of the teeth engages the remaining portion of the dielectric material at the slope.

2. The process of claim 1, wherein the removing of the portion is sufficient to produce a surface gloss measurement at an angle of 60 degrees of less than 10%.

3. The process of claim 1, wherein the producing cavities does not include physical roughening, and the building up the conductive layer includes building up the conductive layer in producing a dielectric surface contact area greater than a dielectric surface contact area that would be produced by a single pass roughening.

4. The process of claim 1, wherein the producing cavities does not include physical roughening, and the building up the conductive layer includes building up the conductive layer in producing a peel strength greater than a peel strength that would be produced by a single desmear process, and the forming teeth includes forming a plurality of hooked teeth.

5. The process of claim 1, wherein the producing cavities does not include physical roughening, and the building up the conductive layer includes filling the cavities sufficiently that separation of the conductive layer from the remaining portion of the dielectric material requires destroying integrity of at least one of the conductive layer and the remaining portion of the dielectric material.

6. The process of claim 2, wherein the building up is sufficient to produce a peel strength greater than a peel strength of a single desmear process.

7. A process of making an electrical device, the process including:

> producing, from a dielectric material, a surface including cavities remaining from removing a portion of the dielectric material; and
>
> building up a conductive layer in the cavities in forming substantially angular teeth set in a remaining portion of the dielectric material and in forming a portion of circuitry of an electrical device, and wherein a sample of the circuitry has at least 20% of the teeth being at least 1 tenth of a mil deep and less than 1.75 tenths of a mil deep, and
>
> wherein at least one of the cavities includes an upgrade slope with respect to the surface and one of the teeth engages the remaining portion of the dielectric material at the slope.

8. The process of claim 7, wherein the removing of the portion is sufficient to produce a surface gloss measurement at an angle of 60 degrees of less than 10%.

9. The process of claim 7, wherein the removing is such that froming the cavities does not include physical roughening, and the building up the conductive layer includes building up the conductive layer in producing a dielectric surface contact area greater than a dielectric surface contact area that would be produced by a single pass roughening, and the forming substantially angular teeth includes forming a plurality of substantially angular teeth that

mechanically grip the remaining portion of the dielectric material, more than by adherence.

10. The process of claim 7, wherein the removing is such that forming the cavities does not include physical roughening, and the building up the conductive layer includes building up the conductive layer in producing a peel strength greater than a peel strength that would be produced by a single desmear process, and the forming substantially angular teeth includes forming a plurality of substantially angular hooked teeth.

11. The process of claim 7, wherein the removing is such that forming the cavities does not include physical roughening, and the forming substantially angular teeth is such that separation of the conductive layer from the remaining portion of the dielectric material would destroy integrity of at least one of the conductive layer and the remaining portion of the dielectric material.

12. A process of making an electrical device, the process including:

> building up a conductive layer of material on a surface of a layer of dielectric material, the layers joined in a saw-tooth manner made of both materials in an interlocking bite in forming a portion of circuitry of an electrical device, the conductive layer forming teeth such that a sample of the circuitry has a frequency of the teeth sufficient to provide at least 5,000 of the teeth per linear inch, the teeth set respectively in cavities of the bite, and the sample of the circuitry has at least

20% of the teeth being at least 1 tenth of a mil deep and less than 2 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface, and one of the teeth engages a portion of the dielectric material at the slope.

13. The process of claim 12, further including providing a micro via interconnect for the circuitry.

14. The process of claim 12, wherein, prior to the building up, the layer of the dielectric material has a surface gloss such that a surface gloss measurement at an angle of 60 degrees is less than 10%.

15. The process of claim 12, wherein the removing is such that forming the cavities does not include physical roughening, and the building up the conductive layer includes building up the conductive layer in producing a dielectric surface contact area greater than a dielectric surface contact area that would be produced by a single pass roughening. Such that a plurality of the teeth mechanically grip the layer of dielectric material, more than by adherence, at the surface contact area.

16. The process of claim 12, wherein the producing the interlocking bite does not include physical roughening, and the building up the conductive layer includes building up the conductive layer in producing a peel strength greater than a peel strength that would be produced by a single desmear process, such that the forming teeth includes forming a plurality of hooked teeth.

17. The process of claim 12, wherein the forming teeth is such that separation of the layers would destroy integrity of at least one of the conductive layer and the dielectric material.

18. A process of making an electrical device, the process including:

> building up a conductive layer in filling undercuttings with respect to a surface of a dielectric material so as to form a plurality of teeth in cavities, some of the teeth being obtuse to the surface and in the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, informing a portion of circuitry of an electrical device,
>
> wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

19. A process of making an electrical device, the process including:

> producing a surface with cavities remaining after removing portion of a dielectric material sufficient to produce a surface with a surface gloss measurement at an angle of 60 degrees of less than 10%; and
>
> building up a conductive layer in the cavities in forming electrical device circuitry, wherein the cavities are obtusoly angled and the building up the conductive layer includes

forming teeth in the cavities and in the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface, and one of the teeth engages a portion of the dielectric material at the slope.

20. The process of claim 19, wherein producing the cavities does not include physical roughening, and the building up the conductive layer includes building up the conductive layer in producing a dielectric surface contact area greater than a dielectric surface contact area that would be produced by a single pass roughening, and the forming teeth includes forming a plurality of teeth that mechanically grip, more than by adherence, the surface contact area.

21. The process of claim 19, wherein the producing cavities does not include physical roughening, and the building up the conductive layer fills the cavities sufficiently to produce a peel strength greater than a peel strength that would be produced by a single desmear process, and the forming teeth includes forming a plurality of hooked teeth.

22. The process of claim 19, wherein the producing cavities does not include physical roughening, and the building up the conductive layer includes building up the conductive layer sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of at least one of the conductive layer and the dielectric material.

23. A process of making an electrical device, the process including:

> forming electrical device circuitry with teeth produced by building up a conductive layer in cavities of a dielectric material that has an exterior surface and a dielectric surface area greater than a dielectric surface area that would be produced by a single pass roughening, wherein a sample of the circuitry has at least 20% of the teeth that are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and
>
> wherein at least one of the cavities includes an upgrade slope with respect to the exterior surface, and one of the teeth engages a portion of the dielectric material at the slope.

24. The process of claim 23, further including providing a micro via interconnect for the circuitry.

25. The process of claim 23, further including producing the cavities without physical roughening and sufficiently to produce a peel strength greater than a peel strength that would be produced by a single desmear process, and Such that a plurality of the teeth are hooked teeth.

26. The process of claim 23, wherein the conductive layer is built up sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of at least one of the conductive layer and the dielectric material.

27. A process of making an electrical device, the process including:

> combining a dielectric material with a conductive layer in forming a portion of circuitry of an electrical device, said combining being carried out with means for joining the conductive layer to the dielectric material,
>
> the means including teeth built up on the dielectric material and angled sufficiently to mechanically grip the dielectric material in three dimensions, wherein a plurality of the teeth are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and
>
> wherein at least one of the teeth is in one of a plurality of cavities that includes an upgrade slope with respect to an etched surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

28. A process of making an electrical device, the process including:

> combining a dielectric material with means for joining a conductive layer built up on the dielectric material sufficient to produce a peel strength greater than a peel strength that would be produced by a single desmear process, the conductive layer forming a portion of circuitry, wherein

the combining is carried out with the means for joining comprised of teeth, a plurality of the teeth being obtuse to a top surface of the dielectric material and within cavities in the range of at least 1 tenth of a mil deep to 1.75 of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

29. A process of making an electrical device, the process including:

forming electrical device circuitry by building up a conductive layer on a surface of dielectric material so as to produce a peel strength greater than a peel strength that would be produced by a single desmear process, wherein

a sample of the circuitry includes at least 20% of teeth that are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of a plurality of cavities, respectively adjacent to the teeth, includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

30. The process of claim 29, wherein the electrical device comprises a circuit board.

31. The process of claim 29, wherein the building up the conductive layer includes building up the conductive layer sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of at least one of the conductive layer and the dielectric material.

32. A process of making an electrical device, the process including:

> producing a surface remaining from removing a portion of a dielectric material; and
>
> applying means for mechanically gripping a conductive layer to the surface so that a conductive layer is burrowed in and under the surface, wherein
>
> the conductive layer forms a portion of circuitry of an electrical device, wherein the applying is carried out with the means for mechanically gripping comprising teeth, and a plurality of the teeth are within the range of 1 tenth of a mil deep to 2 tenths of a mil deep, and
>
> wherein at least one of a plurality of cavities, respectively adjacent to the teeth, includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

33. A process of making an electrical device, the process including:

forming electrical device circuitry by building up a conductive layer on a dielectric material sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of the conductive layer and of the dielectric material, wherein

the building up the conductive layer includes forming teeth that are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of a plurality of cavities, respectively adjacent to the teeth, includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

34. A process of making an electrical device, the process including:

building up a conductive layer on a dielectric material sufficient to produce a surface gloss measurement at an angle of 60 degrees of less than 10%, in forming circuitry of an electrical device, wherein

the building up the conductive layer includes producing teeth within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of a plurality of cavities, respectively adjacent to the teeth, includes an upgrade slope with respect to the surface of

the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

35. The process of claim 34, wherein building up the conductive layer includes building up the conductive layer sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of the conductive layer.

36. The process of claim 34, wherein the building up the conductive layer includes building up the conductive layer sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of the dielectric material.

37. The process of claim 34, wherein the building up the conductive layer includes building up the conductive layer sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of the conductive material and the dielectric material.

38. A process of making an electrical device, the process including:

combining a dielectric material with means for joining a conductive layer built up on a conductive coating on the dielectric material at a dielectric surface contact area greater than a dielectric surface contact area that would be produced by a single pass roughening,

the conductive layer forming a portion of circuitry, wherein the combining is carried

out with the means for joining comprised of teeth within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of a plurality of cavities, respectively adjacent to the teeth, includes an upgrade slope with respect to an etched surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

39. A process of making an electrical device, the process including:

combining a dielectric material with means for joining a conductive layer built up on the dielectric material sufficiently that separation of the dielectric material from the conductive layer requires destroying integrity of at least one of the conductive layer and the dielectric material,

said means for joining comprising filled cavities that form a portion of circuitry of an electrical device, wherein the filled cavities comprise teeth that are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to an etched surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

40. The process of any one of claims 1,7, 11, 18, 19, 23, 27, 28, 32, 33, 38, or 39 wherein:

a sample of the circuitry includes a frequency of the teeth sufficient to provide at least 5,000 said teeth per linear inch

41. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 29, 32, 33,38, or 39 wherein:

a sample of the circuitry includes a frequency of the teeth sufficient to provide at least 10,000 said teeth per linear inch.

42. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 29, 32, 33, 38, or 39 wherein:

a sample of the circuitry includes a frequency of the teeth sufficient to provide at least 15,000 said teeth per linear inch.

43. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 29, 32, 33, 38, or 39 wherein:

a sample of the circuitry includes a frequency of the teeth sufficient to provide at least 25,000 said teeth per square inch.

44. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 29, 32, 33, 38, or 39 wherein:

a sample of the circuitry includes a frequency of the teeth sufficient to provide at least 100,000 said teeth per square inch.

45. The process of any one of claims 1,7, 12, 18, 19, 23, 27, 28, 29, 32, 33, 38, or 39 wherein:

> a sample of the circuitry includes a frequency of the teeth sufficient to provide at least 200,000 said teeth per square inch.

46. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 29, 32, 33, 38, or 39 wherein: a sample of the circuitry includes at least 20% of the teeth are shaped to mechanically grip the dielectric material.

47. The process of any one of claims 1, 12, 18, 19, 27, 28, 32, 33, 38, or 39 wherein:

a sample of the circuitry includes at least 50% of the teeth that are obtuse shaped.

48. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 32, 33, 38, or 39 wherein:

> a sample of the circuitry includes at least 20% of the teeth that are within the range of at least 1 tenth of a mil deep to 1.75 tenths of a mil deep.

49. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 29, 32, 33, 38, or 39 wherein: a sample of the circuitry includes at least 50% of the teeth that are within the range of least 1 tenth of a mil deep to 1.75 tenths of a mil deep.

50. The process of any one of claims 1, 3, 7, 12, 18, 19, 27, 28, 32, 33, 38, or 39 wherein: a sample of the circuitry includes at least 20% of the teeth that are

within the range of tenth of a mil deep to 1.5 tenths of a mil deep.

51. The process of any one of claims 1, 2, 3, 7, 12, 18, 19, 27, 28, 29, 32, 33, 38, or 39 wherein: a sample of the circuitry includes at least 50% of the teeth that are within the range of tenth of a mil deep to 1.5 tenths of a mil deep.

52. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 29, 32, 33, 38, or 39 wherein: a sample of the circuitry includes at least 20% of the teeth that are in the range of 1.5 tenths of a mil deep to 1.75 tenths of a mil deep.

53. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 29, 32, 33, 38, or 39 wherein: a sample of the circuitry includes at least 50% of the teeth that are in the range of 1.5 tenths of a mil deep to 1.75 tenths of a mil deep.

54. The process of claim 40, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

55. The process of claim 41, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

56. The process of claim 42, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising

said teeth and another of said layers comprising correspondingly made teeth.

57. The process of claim 43, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

58. The process of claim 44, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

59. The process of claim 45, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

60. The process of claim 46, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

61. The process of claim 47, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

62. The process of claim 48, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising

said teeth and another of said layers comprising correspondingly made teeth.

63. The process of claim 49, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

64. The process of claim 50, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

65. The process claim 51, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

66. The process of claim 52, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

67. The process of claim 53, further including configuring the circuitry of the electrical device as multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising correspondingly made teeth.

68. The process of claim 40, further including configuring the circuitry as of double sided circuitry,

one side comprising said teeth and another side comprising correspondingly made teeth.

69. The process of claim 41, further including configuring the circuitry as double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

70. The process of claim 42, further including configuring the circuitry as double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

71. The process of claim 43, further including configuring the circuitry as of double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

72. The process of claim 44, further including configuring the circuitry as of double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

73. The process of claim 45, further including configuring the circuitry as of double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

74. The process of claim 46, further including configuring the circuitry as of double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

75. The process of claim 47, further including configuring the circuitry as double sided circuitry, one

side comprising said teeth and another side comprising correspondingly made teeth.

76. The process of claim 48, further including configuring the circuitry as double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

77. The process of claim 49, further including configuring the circuitry as double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

78. The process of claim 50, further including configuring the circuitry as double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

79. The process of claim 51, further including configuring the circuitry as double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

80. The process of claim 52, further including configuring the circuitry as double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

81. The process of claim 53, further including configuring the circuitry as double sided circuitry, one side comprising said teeth and another side comprising correspondingly made teeth.

82. A product produced by the process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 32, 29, 33, 38, or 39.

83. An electrical device including:

a dielectric material comprising a surface with cavities remaining from removal of a portion of the dielectric material;

a conductive layer built up on the dielectric material So as to fill the cavities and form teeth set in and under the surface of the dielectric material; and wherein:

the conductive layer is a portion of circuitry of an electrical device, and a plurality of the cavities are obtuse with respect to the top surface and are at least 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

84. The device of claim 83, wherein, prior to the conductive layer of material being built up thereon, the surface with the cavities has a gloss sufficient to produce a surface gloss measurement at an angle of 60 degrees of less than 10%.

85. The device of claim 83, wherein the electrical device comprises a micro via interconnect.

86. The device of claim 83, wherein the teeth have a dielectric surface contact area greater than a dielectric surface contact area that would be produced

by a single pass roughening, and some of the teeth comprise hooked teeth.

87. The device of claim 83, wherein the conductive layer fills the cavities sufficiently to produce a peel strength greater than a peel strength that would be produced by a single desmear process, and Some of the teeth mechanically grip the dielectric material, more than by adherence.

88. The device of claim 83, wherein the conductive layer fills the cavities sufficiently that separation of the conductive layer from the dielectric material requires destroying integrity of at least one of the conductive layer and the portion of the dielectric material.

89. An electrical device including:

a dielectric material comprising a surface with cavities remaining after removal of some of the dielectric material;

a conductive layer built up on the dielectric material so as to fill the cavities and form substantially angular teeth set in the dielectric material; and wherein

the conductive layer is a portion of circuitry of an electrical device, and a plurality of the teeth being are at least 1 tenth of a mil deep and less than 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth

engages a portion of the dielectric material at the slope.

90. The device of claim 89, wherein, prior to the conductive layer of material being built up thereon, the surface with the cavities has a gloss sufficient to produce a surface gloss measurement at an angle of 60 degrees of less than 10%.

91. The device of claim 89, wherein the teeth have a dielectric surface contact area greater than a dielectric surface contact area that would be produced by a single pass roughening, and some of the teeth comprise hooked teeth.

92. The device of claim 89, wherein the the conductive layer fills the cavities sufficiently so as to produce a peel strength greater than a peel strength that would be produced by a single desmear process, and Some of the teeth mechanically grip the dielectric material, more than by adherence.

93. The device of claim 89, wherein the conductive layer built up is built up sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of at least one of the conductive layer and the dielectric material.

94. An electrical device including:

a conductive layer of material built up on a surface of a layer of a dielectric material, the layers joined in a saw tooth manner made of both materials in an interlocking bite; wherein

the conductive layer is a portion of circuitry of an electrical device, the conductive layer is comprised of teeth such that a sample of the circuitry has a frequency of the teeth sufficient to provide at least 5,000 of the teeth per linear inch, the teeth the teeth set respectively in cavities of the bite and a plurality of the teeth are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface, and one of the teeth engages a portion of the dielectric material at the slope.

95. The device of claim 94, wherein the electrical device comprises a micro via interconnect.

96. The device of claim 94, wherein, prior to the conductive layer of material being built up thereon, the surface has a gloss sufficient to provide a surface gloss measurement at an angle of 60 degrees of less than 10%.

97. The device of claim 94, wherein the teeth have a dielectric surface contact area that is greater than a dielectric surface contact area that would be produced by a single pass roughening, and some of the teeth comprise hooked teeth.

98. The device of claim 94, wherein the conductive layer built up is built up sufficiently to produce a peel strength greater than a peel strength that would be produced by a single desmear process, and some of the

teeth mechanically grip the dielectric material, more than by adherence.

99. The device of claim 94, wherein the conductive layer built up is built up sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of at least one of the conductive layer and the dielectric material.

100. An electrical device including:

a conductive layer built up so as to fill undercuttings with respect to a surface of a dielectric material So as to form teeth in cavities, a plurality of the undercuttings being obtuse to the surface, wherein

the conductive layer is a portion of circuitry of an electrical device, and a plurality of the teeth are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

101. An electrical device including:

a dielectric material surface with cavities sufficient to produce a surface gloss measurement at an angle of 60 degrees of less than 10%; and

electrical device circuitry comprised of a conductive layer built up so as to fill in the cavities and form teeth, wherein a plurality of the cavities are obtusely angled with respect to the surface, and a plurality of the teeth are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

102. The device of claim 101, wherein the teeth have a dielectric surface contact area that is greater than a dielectric surface contact area that would be produced by a single pass roughening, and some of the teeth comprise hooked teeth.

103. The device of claim 101, wherein the conductive layer fills in the cavities sufficiently to produce a peel strength greater than a peel strength that would be produced by a single desmear process, and some of the teeth mechanically grip the dielectric material, more than by adherence.

104. The device of claim 101, wherein the conductive layer is sufficiently built up that separation of the conductive layer from the dielectric material destroys integrity of at least one of the conductive layer and the dielectric material.

105. An electrical device including:

a dielectric material; and

electrical device circuitry comprising a conductive layer built up on the dielectric material at a dielectric surface having an area greater than a dielectric surface area that would be produced by a single pass roughening; and wherein

the conductive layer is comprised of plurality of the teeth within cavities that are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

106. The device of claim 105, wherein the electrical device comprises a micro via interconnect.

107. The device of claim 105, wherein the conductive layer built up is built up in the cavities sufficiently to produce a peel strength greater than a peel strength that would be produced by a single desmear process, and some of the teeth mechanically grip the dielectric material, more than by adherence.

108. The device of claim 105, wherein the conductive layer built up is built up sufficiently that separation of the conductive layer from the dielectric material requires destroying integrity of at least one of the conductive layer and the dielectric material.

109. An electrical device including:

a dielectric material comprising a surface;

a conductive layer forming a portion of circuitry of an electrical device; and

means for joining the conductive layer to the dielectric material, the means including a structuring of teeth built up on the dielectric material and comprised of the conductive layer and angled sufficiently for mechanically gripping the dielectric material in three dimensions,

wherein a plurality of the teeth are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

110. An electrical device including:

a dielectric material comprising a surface; and

means for joining a conductive layer built up on the dielectric material so as to produce a peel strength greater than a peel strength that would be produced by a single desmear process, wherein the conductive layer is a portion of circuitry, and portions of the conductive layer are in cavities obtuse to a top surface of the dielectric material, wherein the means for joining is comprised of teeth, and a

plurality of the teeth that are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

111. An electrical device including:

a dielectric material; and

electrical device circuitry comprising a conductive layer built up on a surface of the dielectric material so as to produce teeth set in cavities and a peel strength greater than a peel strength that would be produced by a single desmear process; and wherein

plurality of the teeth that are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

112. The device of claim 111, wherein the electrical device comprises a circuit board.

113. The device of claim 111, wherein the conductive layer built up is built up sufficiently that separation of the conductive layer from the dielectric

material would destroy integrity of at least one of the conductive layer and the dielectric material.

114. An electrical device including:

a dielectric material having a surface remaining from removal of a portion of the dielectric material; and

means for mechanically gripping a conductive layer to the surface of the dielectric material so that the conductive layer is burrowed in and under the top surface of the dielectric material, wherein the conductive layer forms a portion of circuitry of an electrical device, wherein the means for mechanically gripping is comprised of teeth, and a plurality of the teeth are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

115. An electrical device including:

a dielectric material; and

electrical device circuitry comprising a conductive layer built up on the dielectric material sufficiently that separation of the conductive layer from the dielectric material would require destroying integrity of the conductive layer and of the dielectric

material, wherein the conductive layer is comprised of teeth in cavities, a plurality of the teeth being within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

116. An electrical device including:

a dielectric material having a surface with a gloss sifficient for surface gloss measurement at an angle of 60 degrees of less than 10%; and

circuitry of an electrical device comprised of a conductive layer on the dielectric material, wherein the conductive layer is comprised of teeth in cavities, a plurality of the teeth being within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

117. The device of claim 116, wherein the conductive layer built up on the dielectric material is built up sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of the conductive layer.

118. The device of claim 116, wherein the conductive layer built up on the dielectric material is built up sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of the dielectric material.

119. The device of claim 116, wherein the conductive layer built up on the dielectric material is built up sufficiently that separation of the conductive layer from the dielectric material would destroy integrity of the conductive layer and the dielectric material.

120. An electrical device including:

a dielectric material having a surface; and

means for joining a conductive layer built up on the dielectric material at a surface having a contact area greater than a dielectric surface contact area that would be produced by a single pass roughening, wherein the conductive layer is a portion of circuitry of an electrical device, wherein the conductive layer is comprised of teeth in cavities, a plurality of the teeth being within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

121. An electrical device including:

a dielectric material including a surface; and

means for joining a conductive layer built up on the dielectric material sufficiently that separation of the conductive layer from the dielectric material requires destroying integrity of at least one of the conductive layer and the dielectric material, said means for joining comprising filled cavities that form a portion of circuitry of the electrical device comprised of teeth, a plurality of the teeth being within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep, and

wherein at least one of the cavities includes an upgrade slope with respect to the surface of the dielectric material, and one of the teeth engages a portion of the dielectric material at the slope.

122. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has a frequency of the teeth sufficient to provide at least 5,000 said teeth per linear inch.

123. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has a frequency of the teeth sufficient to provide at least 10,000 said teeth per linear inch.

124. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has a frequency of

the teeth sufficient to provide at least 15,000 said teeth per linear inch.

125. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has a frequency of the teeth sufficient to provide at least 25,000 said teeth per square inch.

126. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 whereto:

> a sample of the circuitry has a frequency of the teeth sufficient to provide at least 100,000 said teeth per square inch.

127. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 whereto: a sample of the circuitry has at least 200,000 said teeth per square inch.

128. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has at least 20% of the teeth have a shape that mechanically grips the dielectric material.

129. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has at least 50% of the teeth structured obtusely with respect to a line within a plane defined by a surface of the dielectric material that was removed.

130. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has at least 20% of the teeth that are at least 1 tenth of a mil deep.

131. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has at least 50% of the teeth that are at least 1 tenth of a mil deep.

132. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has at least 20% of the teeth that are within the range of 1 tenth of a mil deep to 1.75 tenths of a mil deep.

133. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has at least 50% of the teeth that are within the range of 1 tenth of a mil deep to 2 tenths of a mil deep.

134. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has at least 20% of the teeth that are in the range of 1.5 tenths of a mil deep to 1.75 tenths of a mil deep.

135. The device of any one of claims 83, 89, 93, 100, 101, 105, 109, 110, 111, 114, 115, 116, 120, or 121 wherein: a sample of the circuitry has at least 50% of the teeth that are in the range of 1.5 tenths of a mil deep to 1.75 tenths of a rail deep.

136. The device of claim 124, wherein the circuitry of the electrical device is comprised of multi-layer

circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

137. The device of claim 125, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

138. The device of claim 126, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

139. The device of claim 127, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

140. The device of claim 128, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

141. The device of claim 129, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

142. The device of claim 130, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

143. The device of claim 131, wherein the circuitry of the electrical device is comprised of multi-layer

circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

144. The device of claim 132, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

145. The device of claim 133, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

146. The device of claim 134, wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

147. The device of claim 135 wherein the circuitry of the electrical device is comprised of multi-layer circuitry, one of said layers comprising said teeth and another of said layers comprising corresponding teeth.

148. The device of claim 122, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

149. The device of claim 123, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

150. The device of claim 124, wherein the circuitry is comprised of double sided circuitry, one side

comprising said teeth and another side comprising corresponding teeth.

151. The device of claim 125, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

152. The device of claim 126, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

153. The device of claim 127, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

154. The device of claim 128, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

155. The device of claim 129, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

156. The device of claim 130, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

157. The device of claim 131, wherein the circuitry is comprised of double sided circuitry, one side

comprising said teeth and another side comprising corresponding teeth.

158. The device of claim 132, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

159. The device of claim 133, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

160. The device of claim 134, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

161. The device of claim 135, wherein the circuitry is comprised of double sided circuitry, one side comprising said teeth and another side comprising corresponding teeth.

162. A process of making the electrical device product of any one of claims 83, 89, 94, 100, 101, 105, 109, 110, 111, 114, 116, 120, or 121, the method including: forming means for joining by building up a conductive layer on a dielectric material surface remaining from removal of a portion of the dielectric material to form a portion of circuitry in the electrical device.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,501,582 B2
APPLICATION NO. : 10/790363
DATED : March 10, 2009
INVENTOR(S) : McDermott et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 9, line 35, after the delete top.

Column 10, line 14, after surface, insert ----.

Column 11, line 31, insert -- a-- before portion.

Column 11, lines 35-36, delete cavities are obtusely angled and.

Column 12, line 47, delete top.

Column 17, line 21, delete top.

Column 24 line 33, delete method and there insert -- process --.

Column 24 line 38, add the following claims:

163. The process of any one of claims 1, 7, 12, 18, 19, 23, 27, 28, 32, 33, 38, 39, further including subjecting the dielectric material to a first etching of the dielectric material and a second etching of the dielectric material.

164. The device of any one of claims 83, 89, 94, 100, 101, 109, 110, 111, 114, 115, 116, 120, and 121, wherein the dielectric material is nonhomogeneous.

165. The device of any one of 83, 89, 94, 100, 101, 109, 110, 111, 114, 115, 116, 120, and 121, wherein the metal layer is comprised of a conductive coating.

Signed and Sealed this
Eleventh Day of May, 2010
/s/ David J. Kappos
David J. Kappos
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,501,582 B2
APPLICATION NO. : 10/790363
DATED : March 10, 2009
INVENTOR(S) : McDermott et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Delete the title page and substitute therefore the attached title page showing the corrected number of claims in the patent.

Column 9, line 35, after the delete top.

Column 10, line 14, after surface, insert ----.

Column 11, line 31, insert -- a-- before portion.

Column 11, lines 35-36, delete cavities are obtusely angled and.

Column 12, line 47, delete top.

Column 17, line 21, delete top.

Column 24 line 33, delete method and there insert -- process --.

Column 24 line 38, add the following claims:

163. The process of any one of claims 1 7, 12, 18, 19, 23, 27, 28, 32, 33, 38, 39, further including subjecting the dielectric material to a first etching of the dielectric material and a second etching of the dielectric material.

164. The device of any one of claims 83, 89, 94, 100, 101, 109, 110, 111, 114, 115, 116, 120, and 121, wherein the dielectric material is nonhomogeneous.

165. The device of any one of 83, 89, 94, 100, 101, 109, 110, 111, 114, 115, 116, 120, and 121, wherein the metal layer is comprised of a conductive coating.

This certificate supersedes the Certificate of Correction issued May 11, 2010.

Signed and Sealed this
Twenty-second Day of June, 2010

/s/ David J. Kappos
David J. Kappos
Director of the United States Patent and Trademark Office

CERTIFICATE OF CORRECTION (continued)

(12) United States Patent
McDermott et al.

(10) Patent No.: US 7,501,582 B2
(45) Date of Patent: Mar. 10, 2009

(54) ELECTRICAL DEVICE AND METHOD FOR MAKING SAME

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 98 days.

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and a continuation of application No. 08/905,619, filed on Aug. 4, 1997, now Pat. No. 6,141,870.

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H0SK 1/03 (2006.01)

(52) U.S. Cl. 174/255: 174/256: 174/257

(58) Field of Classification Search 174/255-262; 20/850–853; 216/15-16
See application file for complete search history.

(56) References Cited

U.S. PATENT DOCUMENTS

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Primary Examiner-Tuan T. Dinh

(57) ABSTRACT

A multilayer electrical device, such as a printed circuit board, having a tooth structure including a metal layer set in a dielectric. The device includes a base; a conductive layer adjacent to the base; a dielectric material adjacent to conductive layer, a tooth structure including a metal layer set in the dielectric material to join the dielectric material to the metal layer, and wherein the metal layer forms a portion of circuitry in a circuit board having multiple layers of circuitry.

165 Claims, 2 Drawing Sheets
(1 of 2 Drawing Sheet(s) Filed in Color)