United States Court of Appeals for the Federal Circuit

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SAMSUNG ELECTRONICS CO., LTD., MICRON TECHNOLOGY, INC., SK HYNIX INC.,
Appellants

v.

ELM 3DS INNOVATIONS, LLC,
Appellee

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2017-2474, 2017-2475, 2017-2476, 2017-2478, 2017-2479, 2017-2480, 2017-2482, 2017-2483, 2018-1050, 2018-1079, 2018-1080, 2018-1081, 2018-1082

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Appeals from the United States Patent and Trademark Office, Patent Trial and Appeal Board in Nos. IPR2016-00386, IPR2016-00387, IPR2016-00388, IPR2016-00390, IPR2016-00391, IPR2016-00393, IPR2016-00394, IPR2016-00395, IPR2016-00687, IPR2016-00691, IPR2016-00708, IPR2016-00770, IPR2016-00786.

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Decided: June 12, 2019

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RUFFIN B. CORDELL, Fish & Richardson PC, Washington, DC, argued for all appellants. Appellants Micron Technology, Inc., SK Hynix Inc. also represented by CHRISTOPHER DRYER, TIMOTHY W. RIFFE, ROBERT ANDREW SCHWENTKER, ADAM SHARTZER; CRAIG E. COUNTRYMAN, RYAN LYNN FREI, OLIVER RICHARDS, San Diego, CA.

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WILLIAM MEUNIER, Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C., Boston, MA, argued for appellee. Also represented by KEVIN AMENDT, SANDRA BADIN, MATTHEW STEPHEN GALICA, MICHAEL NEWMAN, MICHAEL TIMOTHY RENAUD, JAMES M. WODARSKI.

Before MOORE, REYNA, and CHEN, *Circuit Judges.*

MOORE, *Circuit Judge*.

Samsung Electronics Co., Ltd., Micron Technology, Inc., and SK Hynix Inc. (collectively, "Petitioners") appeal from the final written decisions of the Patent Trial and Appeal Board in thirteen inter partes reviews holding that they did not establish the unpatentability of 105 claims across eleven patents ("Challenged Patents"). Given that each challenged claim requires a low-tensile-stress dielectric, and substantial evidence supports the Board's finding that a person of ordinary skill in the art would not have reasonably expected success in combining the prior art to meet this limitation, we affirm.

BACKGROUND

Appellee Elm 3DS Innovations LLC ("Elm") is the owner of the Challenged Patents,[1] which share a specification and all relate to "stacked integrated circuit memory."[2] '672 patent at 1:7–8. The Challenged Patents are the subject of co-pending litigation between Elm and Petitioners.

The Board instituted inter partes review based on thirteen petitions filed by Petitioners. Among others not at issue on appeal, the petitions challenged the following claims: claims 17–18, 22, 84, 95, 129–32, 145–46, and 152 of the '672 patent (IPR2016-00386); claims 1–2, 8, 14, 31–32, 44, 46, and 52–54 of the '778 patent (IPR2016-00387); claims 10–12, 18–20, 60–63, 67, 70–73, and 77 of the '239 patent (IPR2016-00388 and IPR2016-00393); claims 1–3, 30–31, 33, 40–41, and 44 of the '542 patent (IPR2016-00390); claims 30, 34, 36, 135–138, and 147 of the '862 patent (IPR2016-00391); claims 36 and 51 of the '617 patent (IPR2016-00394); claims 1, 10–11, and 13–14 of the '732 patent (IPR2016-00395); claims 1, 7, 17–18, and 33 of the '119 patent (IPR2016-00687); claims 1 and 20–23 of the '004 patent (IPR2016-00691); claims 1, 12–13, 24, 36–38, 53, 83, 86–87, and 132 of the '499 patent (IPR2016-00708 and IPR2016-00770); and claims 58, 60–61, and 67 of the '570 patent (IPR2016-00786). Each ground challenging the claims was based on obviousness and asserted either U.S. Patent No. 5,202,754 ("Bertin") or a 1996 article by Kee-Ho Yu, et. al., titled "Real-Time Microvision System with Three-Dimensional Integration Structure" ("Yu") as the

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[1] The patents at issue are U.S. Patent Nos. 8,653,672; 8,841,778; 7,193,239; 8,629,542; 8,796,862; 8,410,617; 7,504,732; 8,928,119; 7,474,004; 8,907,499; and 8,933,570.

[2] For simplicity, this opinion cites only to the specification of the '672 patent.

primary reference in combination with, relevant here, U.S. Patent No. 5,354,695 ("Leedy").[3]

The Board held that Petitioners had not met their burden of demonstrating that the claims were unpatentable. Specifically, it found that the prior art did not disclose the "substantially flexible" limitation. It also found that Petitioners did not demonstrate a motivation to combine Bertin or Yu with Leedy or a reasonable expectation of success in doing so. Petitioners timely filed notices of appeal, and the appeals were consolidated. We have jurisdiction pursuant to 28 U.S.C. § 1295(a)(4)(A).

Discussion

I. Claim Construction

"We review the Board's constructions based on intrinsic evidence de novo and its factual findings based on extrinsic evidence for substantial evidence." *HTC Corp. v. Cellular Commc'ns Equip., LLC*, 877 F.3d 1361, 1367 (Fed. Cir. 2017). The Board construes claims in an unexpired patent according to their broadest reasonable interpretation in light of the specification. 37 C.F.R. § 42.100(b) (2017).[4] Claims of an expired patent are construed according to the standard applied by district courts. *See In re CSB-Sys. Int'l, Inc.*, 832 F.3d 1335, 1341 (Fed. Cir. 2016) (referencing *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed.

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[3] Claim 1 of the '499 patent was challenged based on U.S. Patent No. 5,731,945, which contains the same disclosure as Bertin and adds details not relevant to this appeal.

[4] The Board's decisions issued prior to the effective date of the U.S. Patent and Trademark Office's change to the claim construction standard applied in inter partes review. *See* Changes to the Claim Construction Standard for Interpreting Claims in Trial Proceedings Before the Patent Trial and Appeal Board, 83 Fed. Reg. 51,340 (Oct. 11, 2018).

Cir. 2005) (en banc)). While some patents were expired at the time of the Board's final written decision and others were not, the parties agree that the different claim construction standards do not impact the outcome. Appellants' Br. 44; Appellee's Br. 41. The parties have not contested the Board's application of the *Phillips* claim construction standard.

All challenged claims except for claims 1 and 14 of the '778 patent use "substantially flexible" in at least one of two ways. The first is to modify the term "semiconductor substrate." Claim 129 of the '672 patent illustrates the use in this context (emphasis added):

> An integrated circuit structure comprising:
>
> > a first substrate comprising a first surface supporting interconnect contacts;
> >
> > *a substantially flexible semiconductor second substrate* comprising a first surface and a second surface at least one of which supports interconnect contacts, wherein the second surface is opposite the first surface and wherein the second surface of the second substrate is formed by removal of semiconductor material from the second substrate and is smoothed or polished after removal of the semiconductor material; and
> >
> > conductive paths between the interconnect contacts supported by the first surface of the first substrate and of the interconnect contacts supported by the second substrate;
> >
> > wherein the first substrate and the second substrate overlap fully or partially in a stacked relationship; and

> wherein the integrated circuit structure further comprises a low-stress silicon-based dielectric material having a stress of 5×10^8 dynes/cm^2 tensile or less.

"Substantially flexible" is also used to modify "circuit layers," and other similar terms.[5] Claim 30 of the '862 patent illustrates how "substantially flexible" is used in this context (emphasis added):

> A stacked circuit structure comprising:
>
> a plurality of stacked, thin, *substantially flexible circuit layers* at least one of which comprises a thinned, substantially flexible monocrystalline semiconductor substrate of one piece;
>
> wherein at least one of the substantially flexible circuit layers comprises at least one memory array comprising memory cells and a low stress silicon-based dielectric material; and
>
> at least one vertical interconnection that passes through at least one of the plurality of stacked, thin, substantially flexible circuit layers.

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[5] *See, e.g.*, '239 patent at Claim 60 ("substantially flexible" die); '004 patent at Claim 1 ("substantially flexible integrated circuits"); '732 patent at Claim 1 ("substantially flexible integrated circuit layer"). The parties do not treat this difference in terminology as affecting the construction of "substantially flexible." Accordingly, our construction of "substantially flexible" applies across all its uses.

In each context, the Board relied on a general-purpose dictionary to construe "substantially flexible" to mean "largely able to bend without breaking." *E.g.*, J.A. 31.

"Claim terms generally are construed in accordance with the ordinary and customary meaning they would have to one of ordinary skill in the art in light of the specification and the prosecution history." *Aventis Pharma S.A. v. Hospira, Inc.*, 675 F.3d 1324, 1329 (Fed. Cir. 2012) (citing *Phillips*, 415 F.3d at 1312). Extrinsic evidence may also be considered in construing a claim, though "it is less significant than the intrinsic record in determining the legally operative meaning of claim language." *Phillips*, 415 F.3d at 1317 (internal quotation marks omitted). We will deviate from a claim term's ordinary meaning "when a patentee sets out a definition and acts as its own lexicographer" or "when the patentee disavows the full scope of a claim term either in the specification or during prosecution." *Aventis*, 675 F.3d at 1330 (quoting *Thorner v. Sony Computer Entm't Am. L.L.C.*, 669 F.3d 1362, 1365 (Fed. Cir. 2012)).

The parties dispute the meaning of "substantially flexible." "Where multiple patents derive from the same parent application and share many common terms, we must interpret the claims consistently across all asserted patents." *SightSound Techs., LLC v. Apple Inc.*, 809 F.3d 1307, 1316 (Fed. Cir. 2015) (internal quotation marks omitted). The parties do not argue that the definition of "substantially flexible" depends on the patent or claim in which it is used. Because the Challenged Patents derive from the same parent application and use "substantially flexible" throughout, we construe that term the same way for each Challenged Patent.

Petitioners argue the intrinsic record supports a construction of "substantially flexible" substrate as a "substrate that has been thinned to a thickness of less than 50 µm and subsequently polished or smoothed." Appellants'

Br. 36. Specifically, they rely on the specification's disclosure of step "2A" in a fabrication sequence for a "3DS memory circuit," which states: "Grind the backside or exposed surface of the second circuit substrate to a thickness of less than 50 µm and then polish or smooth the surface. The thinned substrate is now a substantially flexible substrate." '672 patent at 9:3–6; *see also id.* at 2:66–67, 3:5–8 (stating that a feature of the stacked circuit assembly technology includes "[t]hinning of the memory circuit to less than about 50 µm in thickness forming a substantially flexible substrate"). Though these disclosures refer to the substrate being substantially flexible, Petitioners argue they apply with equal force to the claims reciting "substantially flexible" circuit layers, and similar limitations, because the prosecution history requires that a substantially flexible circuit layer includes a substantially flexible substrate.

Elm responds that the Board's construction is consistent with the ordinary meaning of "substantially flexible" and the specification's distinction between flexible and rigid substrates. It criticizes Petitioners' proposed construction as departing from the ordinary meaning, since the flexibility of a material depends on more than how thin and polished it is. Citing the declaration of Petitioners' expert Dr. Paul Franzon, Elm argues the flexibility of a semiconductor substrate depends on the substrate's elastic modulus, crystal orientation, and dimensions. Appellee's Br. 48–49 (citing J.A. 2191–92 ¶ 71).

Neither party's construction is quite right. We begin our analysis with the claim language. The claims indicate that, at least in some situations, thinning and polishing a substrate is one way of forming a substantially flexible substrate. For example, claim 31 of the '778 patent recites "the semiconductor substrate is thinned and polished or smoothed such that the semiconductor substrate is substantially flexible." *See also* '862 patent at Claim 147 (reciting "the polished or smoothed backside [of a thinned, monocrystalline semiconductor substrate] enables the . . .

substrate to be substantially flexible, and the polished or smoothed backside reduces the vulnerability of the . . . substrate to fracture as a result of flexing"). But that does not mean this is the only way to achieve substantial flexibility. The claim on which claim 31 depends recites "the semiconductor substrate is substantially flexible," '778 patent at Claim 2, implying that it covers substantially flexible substrates formed in ways other than the one recited in claim 31, *Clearstream Wastewater Sys., Inc. v. Hydro-Action, Inc.*, 206 F.3d 1440, 1446 (Fed. Cir. 2000) ("Under the doctrine of claim differentiation, it is presumed that different words used in different claims result in a difference in meaning and scope for each of the claims."). Claim 51 of the '617 patent recites "the bottomside of the first substrate is polished to make the substrate substantially flexible," with no specific "thinned" limitation. Conversely, claim 8 of the '778 patent lacks a polishing limitation, reciting a substrate that "is formed from a semiconductor wafer and is thinned and substantially flexible." The claims alone do not support limiting "substantially flexible" to Petitioners' proposed construction.

The prosecution history, on the other hand, shows that "substantially flexible" is narrower than the Board's construction of "largely able to bend without breaking." *E.g.*, J.A. 31. During prosecution of the application that led to the '499 patent, the examiner objected to the use of the term "substantially flexible" because it rendered the claim's scope unclear. J.A. 10260. Elm responded that "the meaning of [substantially flexible] as used in the claims is clearly explained in the specification," citing to step 2A in the fabrication sequence. J.A. 10275. "As described in this passage," Elm continued, "a semiconductor substrate is caused to be substantially flexible by thinning it to 50 microns or less and polishing or smoothing the thinned semiconductor substrate to relieve stress. The phrase 'substantially flexible' is used in the claims consistent with this description, which is unambiguous." *Id.* To overcome the examiner's objection, Elm clearly and unambiguously disclaimed claim scope. For a semiconductor substrate to be "substantially flexible" according to the claims, it must be thinned to 50 microns or less and polished or smoothed.

This definition of "substantially flexible" applies to all its uses. In response to a rejection of claims reciting a substantially flexible circuit layer in an application related to the Challenged Patents, Elm stated that "a substantially flexible semiconductor substrate is a *necessary* but not a *sufficient* condition for a substantially flexible circuit layer." J.A. 10316 (emphasis in original). Reinforcing this point, Elm in a response involving another related application explained:

> Two features are *required* to achieve substantial flexibility. One is that the semiconductor material must be sufficiently thin, e.g., 50 microns or less. . . . The other is that the dielectric material used in processing the semiconductor material must be sufficiently low stress. Otherwise, substantial flexibility is defeated. As set forth in the present specification, stress of 5 x 10^8 dynes/cm^2 or less has been demonstrated to satisfy this requirement.

J.A. 16038 (emphasis added). *See also* J.A. 10314 ("[A] circuit layer requires one or more dielectric layers. . . . For a circuit layer to be substantially flexible, Applicant has found that the dielectric material must have low tensile stress, for example, 5 x 10^8 dynes/cm^2 tensile."). Considered in its entirety, the prosecution history clearly and unambiguously demonstrates that a substantially flexible circuit layer, and similar terms, must contain a substantially flexible semiconductor substrate and a sufficiently low tensile stress dielectric material. We see nothing in the specification or prosecution history that limits the dielectric to a particular stress value. Both merely provide as an example that a tensile stress of 5 x 10^8 dynes/cm^2 is sufficient.

This is not, however, the end of the construction. The prosecution history makes clear that "substantially flexible" cannot be read to cover rigid substrates and circuit layers. *See* J.A. 15397 (criticizing the prior art substrate because it is "rigid"); J.A. 16039 (stating the prior art "describe[s] a stacked integrated circuit formed on a *rigid* carrier . . . , suggesting that the stacked integrated circuit is in fact *inflexible*" (emphasis in original)). Based on expert testimony from Dr. Franzon, the Board found that "there are a number of factors that, within the context of semiconductor processing, determine the flexibility of a semiconductor substrate," including the type of semiconductor substrate, the crystal orientation of the material, and the physical dimensions of the substrate. *E.g.*, J.A. 27 (citing J.A. 2191–92 ¶ 71). This suggests thinning the semiconductor substrate to 50 µm and subsequently polishing or smoothing it is necessary but not necessarily sufficient to make the substrate substantially flexible. To ensure that the construction of "substantially flexible" cannot be read to cover a rigid substrate or circuit layer, we interpret a substantially flexible semiconductor substrate as a semiconductor substrate that is thinned to 50 µm and subsequently polished or smoothed such that it is largely able to bend without breaking. Likewise, we interpret a substantially flexible circuit layer as a circuit layer that is largely able to bend without breaking and contains a substantially flexible semiconductor substrate and a sufficiently low tensile stress dielectric material.

II. Obviousness

We review the Board's legal determinations de novo and its underlying factual findings for substantial evidence. *Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2013). Obviousness is a question of law based on underlying facts. *Id.* Whether there was a motivation to combine references and a reasonable expectation of success in doing so to meet the limitations of the claimed invention are questions of fact. *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1367–68 (Fed. Cir. 2016).

Each ground of unpatentability relied on either Bertin or Yu in combination with Leedy, along with other references not relevant on appeal. Bertin discloses "[a] fabrication method and resultant three-dimensional multichip package having a densely stacked array of semiconductor chips interconnected at least partially by means of a plurality of metallized trenches." J.A. 1206 at Abstract. "[P]rocessing begins with a semiconductor device 50 (preferably comprising a wafer) having a substrate 52 and an active layer 54, which is typically positioned at least partially therein." J.A. 1216 at 3:50–53. A dielectric layer is grown over the active layer. *Id.* at 3:60–62.[6] Yu discloses a fabrication process for a 3D integration structure in which a silicon wafer is glued to quartz glass, thinned and polished, and bonded to a thick wafer. The structure includes a "field oxide," depicted in two figures as silicon dioxide. J.A. 1350. Leedy discloses a method of fabricating "integrated circuits from flexible membranes formed of very thin low stress dielectric materials, such as silicon dioxide or silicon nitride, and semiconductor layers." J.A. 1229 at Abstract.

Regarding the Bertin-Leedy combinations, Petitioners proposed depositing a low-stress dielectric material using plasma-enhanced chemical vapor deposition ("PECVD"), as disclosed in Leedy, instead of growing the dielectric layer, as disclosed in Bertin. The Board found that a person of ordinary skill in the art would not have been motivated to make such a combination and would not have had a reasonable expectation of success in doing so. It credited the

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[6] A dielectric is an insulator used in electric circuits. J.A. 2375 ¶ 33.

testimony of Elm's expert Dr. Alexander Glew that PECVD was incompatible with Bertin's integrated circuit. Given the complexity involved in integrated circuit fabrication, it found Dr. Franzon's testimony that PECVD had certain benefits and that Leedy and Bertin are in the same technological field was insufficient to meet Petitioners' burden. As a result, it found Petitioners failed to adequately explain "how [Bertin's] fabrication process would be changed to use [Leedy's] dielectric material, which is formed in a quite different manner than [Bertin's] dielectric layer." J.A. 77. The Board's finding as to a lack of reasonable expectation of success is supported by substantial evidence.

Bertin discloses that "[a] dielectric layer 60, for example, [silicon dioxide], is grown over active layer 54 of device 50." J.A. 1216 at 3:60–62. Dr. Glew testified that a silicon dioxide dielectric that is grown directly over circuit components must be high-purity to not damage the circuit components. J.A. 2415 ¶ 128. As a result, one of ordinary skill in the art would have known from Bertin's description that the dielectric layer 60 "was grown at high temperatures using thermal oxidation." J.A. 2415–16 ¶ 128; *see also* J.A. 1527 (acknowledging in the Petition that Bertin discloses "thermally grown oxides"). Thermal oxidation is a process in which silicon at the surface of a wafer is converted to high-purity silicon dioxide by exposing it to oxygen at high temperatures, typically between 900 °C and 1200 °C. J.A. 2387–88 ¶¶ 66–67.

Substantial evidence supports the Board's finding that Petitioners did not adequately explain how Bertin's fabrication process would be changed to use Leedy's dielectric material. The Petition asserted that Leedy's dielectric material could "easily be used in place of" Bertin's dielectric using PECVD. J.A. 1527. In support of this argument, Dr. Franzon testified that PECVD "was a commonly available deposition technique that could have been used in place of" Bertin's technique for growing dielectrics. J.A. 2207 ¶ 101. He also testified that Leedy explains that "its dielectric deposition processes are compatible with conventional integrated circuit fabrication methods." J.A. 2206–07 ¶ 101. For example, Leedy states that "[t]he dielectric membrane is compatible with most higher temperature [integrated circuit] processing techniques." J.A. 1296 at 5:32–33.

Evidence shows that selecting a dielectric and a method of forming that dielectric is more complicated than Petitioners suggest. A specific dielectric, like silicon dioxide, can have "vastly different characteristics and behaviors" depending on how it is made. J.A. 2386 ¶ 63. Dr. Glew identified eighteen factors to be considered when selecting a dielectric and method of formation. Those factors include:

> (1) dielectric constant, (2) breakdown field strength, (3) leakage, (4) surface conductance, (5) moisture absorption or permeability to moisture, (6) stress, (7) adhesion to aluminum, (8) adhesion to dielectric layers above or below, (9) stability, (10) etch rate, (11) permeability to hydrogen, (12) amount of incorporated electrical charge or dipoles, (13) amount of impurities, (14) quality of step coverage, (15) the thickness and uniformity of the film, (16) ability to provide good doped uniformity across a wafer, (17) defect density, [and] (18) amount of residual constituents that outgas during later processing.

J.A. 2421 ¶ 139. Dr. Glew stated that most of these factors are unknown here with respect to Leedy's dielectric, so a person of ordinary skill in the art could not conclude that it would have been obvious to make the proposed substitution. In light of the complexity of semiconductor fabrication, the Board found Petitioners' explanation lacking.

The Board's finding that PECVD is "quite different" from thermal oxidation is supported by substantial evidence. J.A. 77. As the name suggests, PECVD is a deposition process, unlike thermal oxidation, which is a growth process. PECVD is performed at 400 °C or less and uses plasma to create a reaction between the surface of a wafer and chemical vapors that include the atoms or molecules to be deposited. In contrast to thermal oxidation, which yields a high-purity dielectric, Dr. Glew testified that dielectrics deposited using PECVD "include impurities that make them unusable for a variety of applications requiring higher purity." J.A. 2392 ¶ 77. According to Dr. Glew, this creates a problem when attempting to implement Leedy's dielectric into Bertin using PECVD because the dielectric layer of Bertin must be highly pure to not damage the circuit components. J.A. 2415–16 ¶ 128. The dielectric produced using PECVD would not be sufficiently pure. J.A. 2416 ¶ 130. He also testified that PECVD "cannot be used because positive ions present in the plasma can strike and damage the wafer and the exposed active components in and on its surface." J.A. 2423 ¶ 142.

Petitioners argue the Board erred when it declined to resolve a dispute about front-end-of-line and back-end-of-line processing steps, especially when it relied on Dr. Glew's testimony that assumed Bertin's dielectric was grown during the front-end-of-line phase of the fabrication process. Dr. Glew's testimony was that if Leedy's dielectric replaced Bertin's at the same phase in the fabrication process, PECVD could not be used "because the resulting dielectric would not (1) be sufficiently pure; (2) have the ability to adhere sufficiently to the semiconductor wafer; and (3) be able to withstand high temperatures of the remaining [front-end-of-line] steps," which generally occur at higher temperatures than the back-end-of-line steps, "without changing its form." J.A. 2422–23 ¶ 142. We see no legal error in the Board's decision. First, the Board found that even assuming Petitioners' contentions were accurate, their explanation was lacking. Second, we understand the Board's opinion as finding it unnecessary to decide this issue because, at least as to Dr. Glew's first two points, the timing would not matter. Though Petitioners disputed these facts in their Reply below, they did so based on attorney argument without premising that argument on the timing of applying PECVD. J.A. 1811–12. Moreover, "[t]he possibility of drawing two inconsistent conclusions from the evidence does not prevent an administrative agency's finding from being supported by substantial evidence." *In re Applied Materials, Inc.*, 692 F.3d 1289, 1294 (Fed. Cir. 2012).

Petitioners also argue the Board improperly required proof that unclaimed elements were combinable. "It is well-established that a determination of obviousness based on teachings from multiple references does not require an actual, physical substitution of elements." *In re Mouttet*, 686 F.3d 1322, 1332 (Fed. Cir. 2012). "What matters in the § 103 nonobviousness determination is whether a person of ordinary skill in the art, having all the teachings of the references before him, is able to produce the structure defined by the claim." *Orthopedic Equip. Co., Inc. v. United States*, 702 F.2d 1005, 1013 (Fed. Cir. 1983). The Board did not require unclaimed elements be combinable. Rather, it repeatedly stated that integrated-circuit technology is complex and, as such, looked for specific evidence that a person of ordinary skill in the art would have reasonably expected success in combining Bertin's fabrication process and Leedy's dielectric material. Petitioners specifically argued in its Petition that "PECVD . . . could have been used in place of the dielectric growing techniques described in Bertin to obtain the predictable result of stacked [integrated circuits] having low tensile stress dielectrics." J.A. 1528. The Board ultimately determined that Petitioners' evidence in support of that combination was insufficient. We will not fault the Board for analyzing Petitioners' obviousness grounds in the way presented in the Petition.

Finally, Petitioners argue there was a reasonable expectation of success because the Challenged Patents incorporate Leedy by reference. The patents state that "dielectrics in low stress . . . such as low stress silicon dioxide and silicon nitride . . . are discussed at length in [Leedy], incorporated herein by reference." '672 patent at 8:46–53. Petitioners argue that the failure to mention any technical problems with using Leedy's dielectrics indicates that doing so was trivial. The Board considered this argument and rejected it. We find the Petitioners' argument too speculative to warrant a conclusion that the Board's factual finding lacked substantial evidence.

The arguments related to the Yu-Leedy combinations were substantially similar to the Bertin-Leedy combinations. According to the Petition, it would have been obvious to replace Yu's silicon dioxide and processes for forming it with the dielectric and deposition process taught by Leedy. "Using [Leedy's] dielectric materials and deposition techniques in the manufacture of Yu's 3D LSI results in" the combination disclosing the low-tensile-stress-dielectric limitation. J.A. 1558. Dr. Franzen's testimony in support of this combination was identical to the combination in the Bertin-Leedy grounds. *See* J.A. 2206–08 ¶¶ 99–103. The Board found that Petitioners failed to meet their burden for substantially the same reasons.

The evidence discussed as to why a person of ordinary skill in the art would not have reasonably expected success in making the proposed combination applies equally here. Dr. Glew testified that Yu identifies its dielectric as a "field oxide," which one of ordinary skill in the art would have understood is a highly pure dielectric grown directly on the silicon substrate at high temperatures using thermal oxidation. J.A. 2418–19 ¶¶ 134–35 (citing J.A. 1350). His testimony about why a person of ordinary skill in the art would not have reasonably expected success using PECVD to deposit Leedy's dielectric was likewise the same. Petitioners raise no argument on appeal that distinguishes the

Bertin-Leedy grounds from the Yu-Leedy grounds. Substantial evidence supports the Board's finding of a lack of reasonable expectation of success.

This issue is dispositive as to all challenged claims. All claims except claims 60, 67, 70, and 77 of the '239 patent; claims 1 and 44 of the '542 patent; claim 1 of the '119 patent; and claim 58 of the '570 patent explicitly require a low tensile stress dielectric. These claims recite either a substantially flexible die or integrated circuit, meaning they too require a low tensile stress dielectric under the proper claim construction. We thus affirm the Board's finding as to a lack of reasonable expectation of success and need not reach Petitioners' remaining arguments.

CONCLUSION

Because we hold that substantial evidence supports the Board's finding of a lack of reasonable expectation of success, we need not address the Board's separate findings that the prior art does not teach the "substantially flexible" limitation or that a person of ordinary skill in the art would have lacked a motivation to combine. For the foregoing reasons, we affirm.

AFFIRMED