United States Court of Appeals for the Federal Circuit

TRUSTEES OF BOSTON UNIVERSITY,
Plaintiff-Cross-Appellant

v.

EVERLIGHT ELECTRONICS CO., LTD., EVERLIGHT AMERICAS, INC., EPISTAR CORPORATION, LITE-ON INC., LITE-ON SERVICE USA, INC., LITE-ON TECHNOLOGY CORPORATION, LITE-ON TRADING USA, INC.,
Defendants-Appellants

2016-2576, 2016-2577, 2016-2578, 2016-2579, 2016-2580, 2016-2581, 2016-2582, 2016-2591, 2016-2592, 2016-2593, 2016-2594, 2016-2595

Appeals from the United States District Court for the District of Massachusetts in Nos. 1:12-cv-11935-PBS, 1:12-cv-12326-PBS, 1:12-cv-12330-PBS, Judge Patti B. Saris.

Decided: July 25, 2018

EDWARD R. REINES, Weil, Gotshal & Manges LLP, Redwood Shores, CA, argued for plaintiff-cross-appellant. Also represented by ERIK PAUL BELT, McCarter & English, LLP, Boston, MA; ALFONSO CHAN, RUSSELL J.

DEPALMA, CHRISTOPHER LIIMATAINEN EVANS, MICHAEL W. SHORE, Shore Chan DePumpo LLP, Dallas, TX.

KEVIN RUSSELL, Goldstein & Russell, P.C., Bethesda, MD, argued for all defendants-appellants. Defendants-appellants Everlight Electronics Co., Ltd., Everlight Americas, Inc., Lite-On Inc., Lite-On Service USA, Inc., Lite-On Technology Corporation, Lite-On Trading USA, Inc. also represented by CHARLES HARDY DAVIS, THOMAS GOLDSTEIN.

RICHARD C. VASQUEZ, Vasquez Benisek & Lindgren, LLP, Lafayette, CA, for defendant-appellant Epistar Corporation. Also represented by ERIC W. BENISEK, JEFFREY T. LINDGREN, ROBERT MCARTHUR, STEPHEN C. STEINBERG.

Before PROST, *Chief Judge*, MOORE and REYNA, *Circuit Judges.*

PROST, *Chief Judge*.

Plaintiff-cross-appellant Trustees of Boston University ("BU") sued defendants-appellants Everlight Electronics Co., Ltd. and Everlight Americas, Inc. (together, "Everlight"); Epistar Corp. ("Epistar"); Lite-On Inc., Lite-On Service USA, Inc., Lite-On Technology Corp., and Lite-On Trading USA, Inc. (together, "Lite-On") (collectively, "Defendants") for infringing BU's U.S. Patent No. 5,686,738 (the "'738 patent"). A jury found that Defendants infringed the '738 patent and failed to prove the patent's invalidity.

Defendants then renewed their motion for judgment as a matter of law ("JMOL") that the '738 patent is invalid for not meeting the enablement requirement of 35 U.S.C. § 112. The district court denied Defendants' motion, and Defendants appeal that denial. BU cross-appeals on other issues.

We reverse because the asserted claim of the ’738 patent is not enabled as a matter of law. We dismiss BU’s cross-appeal as moot.

BACKGROUND

I

Light-emitting diodes (“LEDs”) are semiconductor devices that emit light when an electric current is applied. They provide illumination in products such as printers, phones, and televisions. LEDs typically consist of multiple layers, including a substrate, an n-type semiconductor layer, and a p-type semiconductor layer.[1]

These layers are solid-state materials, which generally have one of three types of crystal lattice structures: (1) monocrystalline, a single-crystalline structure with long-range order; (2) polycrystalline, where multiple smaller crystal structures with short-range order combine to form a single structure that lacks long-range order; and (3) a mixture of polycrystalline and amorphous regions—i.e., non-crystal regions with inconsistent spacing among atoms. Solid-state materials can also just be amorphous.

Epitaxy is a process used to fabricate semiconductor layers. During epitaxy, molecules of a semiconductor material are deposited on a substrate, and the deposited layer attempts to mimic the substrate’s crystal lattice structure as the layer grows. Ideally, the lattice structures of the substrate and the deposited semiconductor layer will be the same; otherwise, the deposited molecules

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[1] The terms “n-type” and “p-type” refer to different types of impurities added to these layers that affect their conductivity.

will strain against their own structure when attempting to mimic the substrate's structure, creating a problem known as lattice mismatch. Such mismatch introduces stress into the growing layer and can create defects in that layer.

Gallium nitride ("GaN") is a semiconductor that emits blue light in LEDs. Fabricating monocrystalline GaN layers (or "films") has proved difficult because of the lack of available substrates with a matching lattice structure. For example, although sapphire has properties that make it a good substrate candidate, GaN films grown directly on sapphire were defective because of the differences in the materials' lattice structures.

The '738 patent relates to the preparation of monocrystalline GaN films via molecular beam epitaxy. '738 patent col. 1 ll. 12–15. It addresses the GaN lattice-mismatch problem with a two-step growth process. *See id.* at col. 2 ll. 14–17 ("A film is epitaxially grown in a two step process comprising a low temperature nucleation step and a high temperature growth step."). In the first step, the substrate is exposed to gallium and nitrogen at a temperature between 100 °C and 400 °C. *Id.* at col. 2 ll. 17–19; *see id.* at col. 4 ll. 31–34. An amorphous film of GaN—the "buffer layer"—grows on the substrate as GaN is deposited. *Id.* at col. 2 ll. 40–41, col. 4 ll. 31–36.

In the second step, temperature is raised to between 600 °C and 900 °C in order to crystallize the amorphous buffer layer. *Id.* at col. 2 ll. 42–43, col. 4 ll. 34–36 ("As the temperature increases to 600° C[], the amorphous film crystallizes."). Monocrystalline GaN can then be grown on the crystallized buffer layer. *Id.* at col. 4 ll. 36–37 ("Any further growth takes place on the crystallized GaN buffer layer."), col. 4 ll. 47–49 ("The growth layer of GaN 'recognizes' the GaN buffer layer . . . on which it can grow without defects."); *see id.* at col. 2 ll. 41–45 ("The amorphous film can be crystallized by heating at 600°–900° C[]

. . . . Subsequent treatment at higher temperatures, preferably 600º–900º C[], results in the epitaxial growth of monocrystalline near-intrinsic GaN film."), col. 4 ll. 25–27 (explaining that, after "ensur[ing] that the GaN buffer layer had crystallized," the "Ga shutter was opened once again to grow the GaN monocrystalline film").

Claim 19 was the only claim tried to the jury. It reads:

> A semiconductor device comprising:
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> a substrate, said substrate consisting of a material selected from the group consisting of (100) silicon, (111) silicon, (0001) sapphire, (11–20) sapphire, (1–102) sapphire, (111) gallium aresenide, (100) gallium aresenide, magnesium oxide, zinc oxide and silicon carbide;
>
> *a non-single crystalline buffer layer*, comprising a first material grown on said substrate, the first material consisting essentially of gallium nitride; and
>
> a growth layer *grown on* the buffer layer, the growth layer comprising gallium nitride and a first dopant material.

'738 patent col. 7 l. 42–col. 8 l. 9 (key limitations emphasized).

II

The district court construed two terms relevant here. First, it construed "grown on" to mean "formed indirectly or directly above." J.A. 246. Under this construction, claim 19's growth layer and buffer layer do not have to be in direct contact; there can be intervening layers between them. Second, the district court construed "a non-single crystalline buffer layer" to mean "a layer of material that is not monocrystalline, namely, [1] polycrystalline, [2] amorphous or [3] a mixture of polycrystalline and amorphous, located between the first substrate and the first growth layer."[2] J.A. 253–54 (numbers added for clarity). And, while the district court did not specifically construe "growth layer," BU does not dispute that "growth layer" includes within its scope a monocrystalline growth layer.

Assuming a monocrystalline growth layer, together these constructions raise six permutations for the relationship between claim 19's growth layer and buffer layer: (1) monocrystalline growth layer formed *indirectly* on a polycrystalline buffer layer; (2) monocrystalline growth layer formed *indirectly* on a buffer layer that is a mixture of polycrystalline and amorphous; (3) monocrystalline growth layer formed *indirectly* on an amorphous buffer layer; (4) monocrystalline growth layer formed *directly* on a polycrystalline buffer layer; (5) monocrystalline growth layer formed *directly* on a buffer layer that is a mixture of polycrystalline and amorphous; and (6) monocrystalline growth layer formed *directly* on an amorphous buffer layer. The enablement issue in this case concerns this sixth permutation—a monocrystalline growth layer formed directly on an amorphous buffer layer.

Following a trial, a jury determined that Defendants directly infringed claim 19; Epistar induced Everlight and Lite-On to infringe; Epistar and Everlight willfully in-

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[2] Neither side challenges the district court's construction of "a non-single crystalline buffer layer." And although Defendants separately challenge the district court's construction of "grown on" as improperly extending to indirect contact, their enablement argument does not depend on the success of their claim-construction argument. We therefore assume for purposes of this opinion that these constructions by the district court are correct.

fringed; and Defendants did not prove the '738 patent's invalidity. J.A. 333–35.

Defendants renewed their motion for JMOL that claim 19 of the '738 patent is invalid under § 112 for lack of enablement. J.A. 2455, 2461. The district court denied the motion. It concluded that the '738 patent did not have to enable a device with a monocrystalline growth layer formed directly on an amorphous buffer layer, as long as it enabled a device with a monocrystalline growth layer formed *indirectly* on an amorphous buffer layer. J.A. 14.

The district court also recounted the evidence presented on the issue. After doing so, the court noted that "[i]t is less clear whether the patent teaches how to grow a monocrystalline GaN layer directly on an amorphous buffer layer, with no intervening layers." J.A. 20. Yet the court ultimately found that even if the '738 patent had to enable such a device, a reasonable jury could have concluded that Defendants failed to show that claim 19 was not enabled.

The district court entered final judgment as to Lite-On. As to Epistar and Everlight, the court entered a judgment that was final except for a new trial on damages. Defendants appeal the denial of their JMOL on enablement, among other issues. BU cross-appeals the district court's denial of the full extent of attorneys' fees requested under 35 U.S.C. § 285, its denial of enhanced damages under 35 U.S.C. § 284, and its calculation of prejudgment interest.

We have jurisdiction under 28 U.S.C. §§ 1295(a)(1) and 1292(c)(2). *See Robert Bosch, LLC v. Pylon Mfg. Corp.*, 719 F.3d 1305, 1320 (Fed. Cir. 2013) (en banc).

DISCUSSION

I

We review the denial of a motion for JMOL under the regional circuit's law. *LifeNet Health v. LifeCell Corp.*, 837 F.3d 1316, 1322 (Fed. Cir. 2016). The First Circuit reviews JMOL denials and legal decisions made therein de novo, *Mass. Eye & Ear Infirmary v. QLT Phototherapeutics, Inc.*, 552 F.3d 47, 57 (1st Cir. 2009), and reverses only if, viewing the evidence in the light most favorable to the non-movant, reasonable persons could not have concluded as the jury did, *Negron-Rivera v. Rivera-Claudio*, 204 F.3d 287, 289–90 (1st Cir. 2000).

A patent's specification must "contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains . . . to make and use the same." 35 U.S.C. § 112 para. 1 (2006).[3] Whether a claim satisfies § 112's enablement requirement is a question of law we review de novo; however, in the context of a jury trial, we review the factual underpinnings of enablement for substantial evidence. *See Koito Mfg. Co. v. Turn–Key–Tech, LLC*, 381 F.3d 1142, 1149 (Fed. Cir. 2004). Facts supporting an invalidity conclusion must be shown by clear and convincing evidence. *AK Steel Corp. v. Sollac & Ugine*, 344 F.3d 1234, 1238–39 (Fed. Cir. 2003).

"[T]o be enabling, the specification of a patent must teach those skilled in the art how to make and use the full

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[3] Paragraph 1 of 35 U.S.C. § 112 was replaced with newly designated § 112(a) by section 4(c) of the Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112–29, sec. 4(c), 125 Stat. 284, 296 (2011). Section 4(e) of the AIA applied that change "to any patent application that is filed on or after" September 16, 2012. *Id.* sec. 4(e), 125 Stat. at 297. Because the application resulting in the '738 patent was filed before that date, we refer to the pre-AIA version of § 112.

scope of the claimed invention without 'undue experimentation.'" *Genentech, Inc. v. Novo Nordisk A/S*, 108 F.3d 1361, 1365 (Fed. Cir. 1997) (alteration in original) (quoting *In re Wright*, 999 F.2d 1557, 1561 (Fed. Cir. 1993)). Enablement is determined as of the patent's effective filing date. *E.g.*, *Plant Genetic Sys., N.V. v. DeKalb Genetics Corp.*, 315 F.3d 1335, 1339 (Fed. Cir. 2003).[4]

Defendants contend that claim 19 is not enabled because the '738 patent's specification does not teach one of skill in the art how to make the claimed semiconductor device with a monocrystalline growth layer grown directly on an amorphous buffer layer.

In fact, Defendants' expert testified that it is impossible to epitaxially grow a monocrystalline film directly on an amorphous structure. *See* J.A. 2311–12. BU's expert agreed. J.A. 2274; *see* J.A. 17–18 (district court acknowledging the experts' agreement on this issue). We can safely conclude that the specification does not enable what the experts agree is physically impossible.

Defendants also argue that the specification teaches only epitaxy. BU disagrees and contends that the '738 patent does not teach epitaxy. Initially, BU's contention is difficult to credit. The '738 patent's specification is concise—just over four columns of text—and focuses on epitaxy. Indeed, it is saturated with the word "epitaxy" or variants thereof. '738 patent Abstract ("This invention

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[4] The '738 patent's specification references the application leading to the patent as a continuation of another application, which itself was a continuation of a now-abandoned application filed March 18, 1991. '738 patent col. 1 ll. 4–10. Thus, the '738 patent's effective filing date is March 18, 1991. *See* 35 U.S.C. § 120; *z4 Techs., Inc. v. Microsoft Corp.*, 507 F.3d 1340, 1344 (Fed. Cir. 2007).

relates to a method of preparing highly insulating GaN single crystal films in a molecular beam epitaxial growth chamber."), col. 1 ll. 12–15 ("This invention relates to a method of preparing monocrystalline gallium nitride thin films by electron cyclotron resonance microwave plasma assisted molecular beam epitaxy (ECR-assisted MBE)."), col. 2 ll. 9–11 ("The method accorrding [sic] to this invention for preparing highly insulating near-intrinsic monocrystalline GaN films uses ECR-assisted MBE."), col. 2 ll. 14–17 ("A film is epitaxially grown in a two step process . . . ."), col. 3 ll. 38–39 ("The ECR-MBE system used in this invention is shown in FIG. 1.").

BU nonetheless explains that the '738 patent does not teach epitaxy because epitaxy involves a crystalline layer on top of another crystalline layer. Therefore, according to BU, a crystalline layer on top of an amorphous structure is not "epitaxy." *See* Cross-Appellant's Br. 58 (citing its expert's testimony at J.A. 2382–83). The district court relied on this argument and related testimony in denying JMOL. J.A. 18–19 (recounting BU's expert's testimony that the '738 patent does not teach epitaxy—"strictly speaking"). But this semantic argument does not help us determine where the specification teaches growing a monocrystalline layer directly on an amorphous layer—if not by "epitaxy," by any other name. *See Sitrick v. Dreamworks, LLC*, 516 F.3d 993, 1000 (Fed. Cir. 2008) ("An enablement analysis begins with the disclosure in the specification.").

Nor does BU direct us to any specific passage of the specification that purportedly teaches how to grow a monocrystalline layer directly on an amorphous layer. It instead relies on its expert's testimony concerning the specification. For example, BU cites testimony that by following the "boundaries within the teachings of the '738 patent, you could realize with not much experimentation . . . the amorphous buffer layer, or some sublayer of the amorphous buffer layer, and then a monocrystalline gallium nitride [layer] on top." Cross-Appellant's Br. 59 (alterations in original) (quoting J.A. 2269). This testimony is entirely conclusory and therefore insufficient. *See, e.g.*, *MobileMedia Ideas LLC v. Apple Inc.*, 780 F.3d 1159, 1172 (Fed. Cir. 2015) ("Conclusory statements by an expert . . . are insufficient to sustain a jury's verdict."). The same goes for BU's expert's testimony that the "elements of the claim itself teach[] how to do that accurately." Cross-Appellant's Br. 59 (quoting J.A. 2265).

BU also relies on testimony of the '738 patent's inventor concerning "lateral epitaxial growth."[5] *Id.* (citing J.A. 4063–64, 4066–67). BU characterizes this testimony and this phenomenon as demonstrating that the '738 patent's buffer layer can be purely amorphous with a monocrystalline GaN growth layer on top. BU glosses over key details in this testimony. The inventor described "lateral epitaxial overgrowth" as a phenomenon whereby a crystal grows faster in the lateral direction than in the vertical direction. J.A. 4062. But he described this phenomenon in the context of a monocrystalline layer growing on a buffer layer that had at least partially crystallized. J.A. 4063–64. In BU's relied-upon testimony, the inventor never described a monocrystalline growth layer on an amorphous buffer layer without also mentioning some level of crystallinity in the buffer layer. *See* J.A. 4063–64, 4066–67.

BU further points to testimony indicating that others have successfully grown a monocrystalline layer directly on an amorphous buffer layer. J.A. 4096–97, 4300–01. For example, the patent's inventor testified that he had done so and that others recently reported such an accomplishment in a scientific journal. J.A. 4096–97. The

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[5] The cited testimony actually refers to "lateral epitaxial *over*growth." J.A. 4062, 4066 (emphasis added).

district court acknowledged that this research occurred after the '738 patent issued but admitted the evidence solely to rebut the argument that such growth was impossible by any means. *See* J.A. 17 & n.3. Likewise, BU's expert testified that he had grown a monocrystalline GaN film on an amorphous material and that it was "not fundamentally impossible" to do so.[6] J.A. 4300.

But the inquiry is not whether it was, or is, possible to make the full scope of the claimed device—a scope that here covers a monocrystalline growth layer directly on an amorphous layer. The inquiry is whether the patent's specification taught one of skill in the art how to make such a device without undue experimentation as of the patent's effective filing date. Viewed in this light, BU's evidence is not probative of enablement. BU does not even suggest that these results were accomplished by following the specification's teachings, or that achieving these results was within an ordinary artisan's skill as of the patent's effective filing date. *See Enzo Biochem, Inc. v. Calgene, Inc.*, 188 F.3d 1362, 1376 (Fed. Cir. 1999) (finding a patentee's evidence of enablement "inconclusive" because the patentee "did not prove that the alleged post-filing successes were accomplished by following the teachings of the specification[]"). Simply observing that it could be done—years after the patent's effective filing date—bears little on the enablement inquiry.

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[6] Defendants assert, and BU does not dispute, that this work was also done years after the '738 patent's effective filing date. According to BU's expert, this work was done "when [he] was working for Nitronics [sic, Nitronex]." J.A. 4300–01. His C.V. indicates that he was employed with Nitronex between 2000 and 2009. J.A. 2219.

BU lastly argues that the ’738 patent need not enable the claimed device with a monocrystalline growth layer directly on an amorphous buffer layer. BU notes that there is no dispute as to enablement of five out of the six referenced permutations and argues “[t]hat is sufficient.” Cross-Appellant’s Br. 60. We disagree. Our precedents make clear that the specification must enable the full scope of the claimed invention. *E.g.*, *Sitrick*, 516 F.3d at 999 (“The full scope of the claimed invention must be enabled.”); *Liebel-Flarsheim Co. v. Medrad, Inc.*, 481 F.3d 1371, 1378–79 (Fed. Cir. 2007) (“That full scope must be enabled . . . .”); *AK Steel*, 344 F.3d at 1244 (“[T]he applicant’s specification must enable one of ordinary skill in the art to practice the full scope of the claimed invention.”); *Genentech*, 108 F.3d at 1365 (similar); *see Nat’l Recovery Techs., Inc. v. Magnetic Separation Sys., Inc.*, 166 F.3d 1190, 1195–96 (Fed. Cir. 1999) (“The enablement requirement ensures that the public knowledge is enriched by the patent specification to a degree at least commensurate with the scope of the claims. The scope of the claims must be less than or equal to the scope of the enablement.”).

This is not to say that the specification must expressly spell out every possible iteration of every claim. For instance, “a specification need not disclose what is well known in the art.” *Genentech*, 108 F.3d at 1366; *see Nat’l Recovery Techs.*, 166 F.3d at 1196 (“The scope of enablement . . . is that which is disclosed in the specification plus the scope of what would be known to one of ordinary skill in the art without undue experimentation.”). “[T]he artisan’s knowledge of the prior art and routine experimentation can often fill gaps, interpolate between embodiments, and perhaps even extrapolate beyond the disclosed embodiments, depending upon the predictability of the art.” *AK Steel*, 344 F.3d at 1244. But this gap-filling is merely supplemental; it cannot substitute for a basic enabling disclosure. *See Genentech*, 108 F.3d at 1366. Such a disclosure is missing here.

In sum, Defendants showed that epitaxially growing a monocrystalline layer directly on an amorphous layer would have required undue experimentation—indeed, that it is impossible. Defendants also note the absence of any *non*-epitaxial teaching in the specification of how to do this. For its part, BU does not specifically direct us to any such teaching in the specification. Instead, it cites conclusory or unsupportive expert testimony and evidence that some persons were able to grow a monocrystalline layer directly on an amorphous layer—years after the patent's effective filing date, via methods BU does not suggest were taught by the specification or otherwise within an ordinary artisan's skill as of that filing date. Although we review the evidence in the light most favorable to BU, the jury's verdict on enablement here cannot be sustained. We conclude that claim 19 is not enabled as a matter of law and therefore reverse the district court's denial of Defendants' motion for JMOL on this issue.

We note finally that, to some extent, BU created its own enablement problem. BU sought a construction of "a non-single crystalline buffer layer" that included a purely amorphous layer. *See* J.A. 253–54 (reciting BU's proposed construction as "*a layer of material that is not monocrystalline*, located between the first substrate and the first growth layer" (emphasis added)). Having obtained a claim construction that included a purely amorphous layer within the scope of the claim, BU then needed to successfully defend against an enablement challenge as to the claim's full scope. *See Liebel-Flarsheim*, 481 F.3d at 1380. Put differently: if BU wanted to exclude others from what it regarded as its invention, its patent needed to teach the public how to make and use that invention. That is "part of the *quid pro quo* of the patent bargain." *Sitrick*, 516 F.3d at 999 (quoting *AK Steel*, 344 F.3d at 1244).

II

Our reversal of the district court's denial of JMOL on enablement renders claim 19 invalid, mooting the issues raised in BU's cross-appeal as well as Defendants' other appealed issues. We therefore dismiss the cross-appeal as moot.

CONCLUSION

For the foregoing reasons, we (1) reverse the district court's denial of Defendants' motion for JMOL that claim 19 is invalid for failing to meet the enablement requirement of 35 U.S.C. § 112 and (2) dismiss BU's cross-appeal as moot.

REVERSED-IN-PART AND DISMISSED-IN-PART

COSTS

The parties shall bear their own costs.