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WENDEROTH, LIND & PONACK, L.L.P.
1025 Connecticut Avenue, NW
Suite 500
Washington, DC 20036

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kmiller@wenderoth.com

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte MASAYA ODA, RIE TOKUDA, HITOSHI KAMBARA, KATSUAKI KAWARA, and TOSHIMI HITORA

Appeal 2021-003734
Application 15/717,145
Technology Center 2800

Before TERRY J. OWENS, LINDA M. GAUDETTE, and LILAN REN, *Administrative Patent Judges.*

GAUDETTE, *Administrative Patent Judge.*

DECISION ON APPEAL[1]

The Appellant[2] appeals under 35 U.S.C. § 134(a) from the Examiner's decision finally rejecting claims 1, 2, 5, 6, 8, 10–12, 14, 17–19, and 21–34.[3]

We affirm.

[1] The following documents are of record: Specification filed September 27, 2017, as amended ("Spec."); Final Office Action dated May 20, 2020 ("Final Act."); Appeal Brief filed January 19, 2021 ("Appeal Br.") and Claims Appendix (Appeal Br. 24–28) filed; and Examiner's Answer dated March 22, 2021 ("Ans.").

[2] "Appellant" refers to "applicant" as defined in 37 C.F.R. § 1.42. The Appellant identifies the real party in interest as FLOSFIA, INC. Appeal Br. 3.

[3] We have jurisdiction under 35 U.S.C. § 6(b).

CLAIMED SUBJECT MATTER

Claim 1, reproduced below, is illustrative of the claimed subject matter:

> 1. A semiconductor device comprising:
>
> a semiconductor layer comprising a crystalline oxide semiconductor with a corundum structure comprising α-Ga_2O_3 or a crystalline oxide semiconductor with a corundum structure comprising a mixed crystal of α-Ga_2O_3, the mixed crystal of α-Ga_2O_3 further comprising aluminum and/or indium; and
>
> a Schottky electrode that is positioned on the semiconductor layer,
>
> the semiconductor layer comprising a surface area that is 3 mm^2 or less, and
>
> the semiconductor layer comprising a dielectric breakdown field that is 10 MV/cm or more.

Appeal Br. 24.

REFERENCES

Girdhar	US 2011/0156682 A1	Jun. 30, 2011
Lutz	US 9,070,571 B2	Jun. 30, 2015
Oda '005	US 2016/0149005 A1	May 26, 2016
Hilsenbeck	US 2016/0155714 A1	Jun. 2, 2016
Tomai	US 2016/0211386 A1	July 21, 2016
Aketa	US 2016/0254357 A1	Sept. 1, 2016
Oda '439	US 9,966,439 B2	May 8, 2018
Sasaki	US 2019/0148563 A1	May 16, 2019
Oda '202	WO 2015/005202 A1	Jan. 15, 2015

Shinohara, Heteroepitaxy of Corundum-Structured α-Ga_2O_3 *Thin film on a-AlzO3 Substrates by Ultrasonic Mist Chemical Vapor Deposition,* Japanese Journal of Applied Physics, Vol. 47, No. 9, pp. 7311–7313 (2008).

Lee, *Enhanced thermal stability of alpha gallium oxide films supported by aluminum doping, Japanese Journal of Applied Physics 54, 030301* (2015) HTTP://DX.DOI.ORG/10.7557/JJAP64.030301

Masataka, *Development of gallium oxide power devices,* Phys. Status Solidi A 211, No. 1, 21–26 (2014)

REJECTIONS[4]

The Examiner maintains the following rejections under 35 U.S.C. § 103:

1. Claims 1, 2, 5, 8, 10, 11, 17, 18, 21, 22, 24, and 30–32 over Tomai in view of Shinohara, Aketa, and Sasaki, as evidenced by Lee, Higashiwaki, and Hilsenbeck. *See* Final Act. 2–3.

2. Claims 6 and 19 over Tomai in view of Shinohara, Aketa, Sasaki, and Lutz, as evidenced by Lee, Higashiwaki, and Hilsenbeck. *See* Final Act. 14.

3. Claim 12 over Tomai in view of Shinohara, Aketa, Sasaki, and Girdhar, as evidenced by Lee, Higashiwaki, and Hilsenbeck. *See* Final Act. 16.

4. Claims 23, 27, and 28 over Tomai in view of Shinohara, Aketa, Sasaki, and Oda, as evidenced by Lee, Higashiwaki, and Hilsenbeck. *See* Final Act. 17.

[4] The Examiner withdraws the rejection of claims 1, 2, 5, 6, 8, 10–12, 14, 17–19, and 21–34 as indefinite under 35 U.S.C. § 112. *See* Ans. 3.

5. Claims 14, 26, 29, and 34 over Tomai in view of Shinohara and Sasaki, as evidenced by Lee, Higashiwaki, and Hilsenbeck. *See* Final Act. 19.

6. Claim 25 over Tomai in view of Shinohara, Sasaki, and Oda, as evidenced by Lee, Higashiwaki, and Hilsenbeck. *See* Final Act. 22.

7. Claim 33 over Tomai in view of Shinohara, Sasaki, and Aketa, as evidenced by Lee, Higashiwaki, and Hilsenbeck. *See* Final Act. 23.

ISSUES

The Appellant argues the rejection of independent claim 1, and relies on the same arguments in addressing the rejections of independent claims 17 and 29. *See* Appeal Br. 11–21. In addressing the rejections of various dependent claims, the Appellant merely asserts that the secondary references fail to cure the deficiencies in the references cited in the rejections of independent claims 1, 17, and 29. *See generally* Appeal Br. 19–22. The Appellant's arguments raise the following issues for our consideration: Has the Appellant identified reversible error in the Examiner's findings that the applied prior art discloses or suggests a semiconductor layer comprising (1) "a crystalline oxide semiconductor with a corundum structure comprising α-Ga_2O_3, or a crystalline oxide semiconductor with a corundum structure comprising a mixed crystal of α-Ga_2O_3, the mixed crystal of α-Ga_2O_3 further comprising aluminum and/or indium" (2) "a surface area that is 3 mm^2 or less," and (3) "a dielectric breakdown field that is 10 MV/cm or more" (claim 1)? *See* Ans. 3; *see generally* Appeal Br. 11–19.

For the reasons explained in the Answer, we are not persuaded that the Examiner reversibly erred. Therefore, we sustain all grounds of rejection

based on the Examiner's fact finding and reasoning in the Final Office Action and the Answer.

OPINION

The Examiner found that Tomai discloses a Schottky electrode positioned on a crystalline oxide semiconductor layer comprising Ga_2O_3. Final Act. 3. As found by the Examiner (*id.*), Tomai discloses that "[w]hen the gallium oxide is polycrystalline, the gallium oxide may have an α, β, γ, δ, or ε crystal form, or may be a mixture thereof" (Tomai ¶ 70).

A crystalline oxide semiconductor with a corundum structure comprising α-Ga_2O_3 or a crystalline oxide semiconductor with a corundum structure comprising a mixed crystal of α-Ga_2O_3, the mixed crystal of α-Ga_2O_3 further comprising aluminum and/or indium

The Appellant argues that although Tomai lists more than one crystal form, Tomai indicates a preference for β-Ga_2O_3. If, by this statement, the Appellant is contending that Tomai teaches away from using α-Ga_2O_3, we do not find the argument persuasive because Tomai does not clearly discourage the use of α-Ga_2O_3. *See Santarus, Inc. v. Par Pharm., Inc.*, 694 F.3d 1344, 1356 (Fed. Cir. 2012); *Syntex (U.S.A.) LLC v. Apotex, Inc.,* 407 F.3d 1371, 1379–80 (Fed. Cir. 2005); *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004).

The Appellant also argues that Tomai fails to enable α-Ga_2O_3. Appeal Br. 13. "[B]oth claimed and unclaimed materials disclosed in a patent are presumptively enabling." *In re Antor Media Corp.*, 689 F.3d 1282, 1287 (Fed. Cir. 2012) (citing *Amgen Inc. v. Hoechst Marion Roussel, Inc.*, 314 F.3d 1313, 1354 (Fed. Cir. 2003)). That presumption places the burden on the Appellant to rebut the presumption of operability by a preponderance of the evidence. *See id.* at 1288 (citations omitted). "[T]o be enabling, the specification of a patent must teach those skilled in the art how to make and use the full scope of

the claimed invention without 'undue experimentation.'" *In re Wright*, 999 F.2d 1557, 1561 (Fed. Cir. 1993). The following factors are considered in determining whether undue experimentation would have been required to make and use an invention: "(1) the quantity of experimentation necessary, (2) the amount of direction or guidance presented, (3) the presence or absence of working examples, (4) the nature of the invention, (5) the state of the prior art, (6) the relative skill of those in the art, (7) the predictability or unpredictability of the art, and (8) the breadth of the claims." *In re Wands*, 858 F.2d 731, 737 (Fed. Cir. 1988).

The Appellant argues that Tomai does not enable α-Ga_2O_3 because "Examples 1–24 shown in Tables 1–3 and discussed in paragraphs [0129]–[0178] of Tomai, and the X-ray diffraction charts (XRD) of the oxide semiconductor film show polycrystalline, amorphous, or micro-crystalline structures," but "Tomai is silent about a specific crystal structure of a corundum structure." Appeal Br. 13. The Appellant's argument is not sufficient to overcome the presumption of enablement because it addresses only one of the seven factors relevant to enablement: absence of working examples. *Cf. Hybritech Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1384 (Fed. Cir. 1986) ("[A] patent need not teach, and preferably omits, what is well known in the art.").

> The Examiner found that the ordinary artisan would have modified the semiconductor device of Tamai by forming a corundum-structured α-Ga_2O_3 with wider band gap using mist chemical vapor deposition (CVD) as taught by Shinohara (and evidenced by Lee) to have a crystalline oxide semiconductor with a corundum structure comprising α-Ga_2O_3 in order to provide improved power semiconductor device comprising wide-bandgap corundum-structured oxide crystal having high quality,

> excellent crystallographic properties and smooth surface morphologies.

Final Act. 4 (citing Shinohara Abstract, p. 7311, col. 1, p. 7313, col. 1; Lee, Abstract, p. 030301-1, col. 1).

The Appellant argues that the ordinary artisan would not have been motivated to use, or had a reasonable expectation of success in using, a corundum-structured α-Ga_2O_3 layer. Appeal Br. 14–15. The Appellant argues that Shinohara describes "success in forming heteroepitaxy of corundum-structured α-Ga_2O_3 thin films on α-Al_2O_3 substrates by mist chemical vapor deposition (CVD) at low temperatures of 430–470°C," but "indicates that even with slightly changed condition(s) of forming films, α-Ga_2O_3 films were not obtained." *Id.* at 14. The Appellant argues that Lee discloses enhanced thermal stability of α-Ga_2O_3 films by aluminum doping, but, like Shinohara, does not disclose using an α-Ga_2O_3 film as a layer in a semiconductor device. *Id.*

The Appellant's arguments are not persuasive of reversible error because they focus on individual reference teachings, and fail to consider what the ordinary artisan would have understood from the combined references' teachings. Tomai discloses that, "from the viewpoint of operational stability," the gallium oxide preferably includes β-Ga_2O_3 as the main component. Tomai ¶ 70. But Shinohara specifies that the β-phase is more stable than the other phases only at temperatures higher than 450 °C. Shinohara p. 7311, col. 1. Shinohara discloses that α-Ga_2O_3 can be successfully grown on α-Al_2O_3 (sapphire) substrates using ultrasonic mist chemical vapor deposition, "which is a simple, safe, cost-effective, and environmentally friendly growth method." *Id.* at 7311, cols. 1–2. Shinohara discloses that "α-Ga_2O_3 epilayers

have exhibited excellent crystallographic properties and smooth surface morphologies." *Id.* at 7311, col. 1. Lee likewise discloses that "high-quality single-crystalline α-Ga_2O_3 films can be synthesized on sapphire (α-Al_2O_3) substrates by the mist chemical vapor deposition (CVD) method." Lee p. 030301-1, col. 1. Lee evidences that at the time of the invention, it was known that a small amount of "Al doping allows the higher temperature growth of α-Ga_2O_3, followed by a higher thermal stability." Lee p. 030301-2, col. 1. Tomai discloses that an "oxide semiconductor that includes Ga as the main component . . . may be formed by . . . a mist CVD method" (Tomai ¶ 112) and the substrate may be sapphire (*id.* at Table 3 (Example 18)).

Despite Tomai's stated preference for β-Ga_2O_3, the above disclosures support the Examiner's finding that the ordinary artisan would have been motivated to use an α-Ga_2O_3 layer in Tomai's semiconductor device to achieve the benefit of an "improved power semiconductor device with improved performance characteristics by utilizing a wider-bandgap corundum-structured oxide crystal having high quality, excellent crystallographic properties and smooth surface morphologies" (Ans. 5). The ordinary artisan would have had a reasonable expectation of success in making this modification to Tomai's device based on the secondary references' teachings of methods for improving α-phase stability.

A surface area that is 3 mm^2 or less

The Examiner found that the ordinary artisan would have modified the Tomai/Shinohara semiconductor device

> by using the specific range of sizes of wide bandgap semiconductor element as taught by Aketa[, i.e., a square chip shape having a size between 0.5 mm and 20 mm so that a surface area is between 0.25 (sic, 2.5) mm^2 and 400 mm^2,] to

> have a semiconductor device comprising the semiconductor layer of Ga_2O_3 comprising a surface area that is 3 mm^2 or less in order to provide a Schottky barrier diode comprising a semiconductor material that has high mobility and wide energy gap, and to be used for a power device having small size and that allows an improvement in breakdown voltage.

Final Act. 4. The Appellant argues that Aketa paragraph 86, relied upon by the Examiner for a teaching of the diode dimensions, relates to the dimensions of a 4H-SiC Schottky barrier diode, and Aketa does not disclose or suggest what dimensions should be used for a Ga_2O_3 Schottky barrier diode. Appeal Br. 16.

The Appellant's argument is not persuasive because it does not address the Examiner's finding as to the understanding of the ordinary artisan. Specifically, the Examiner finds that the ordinary artisan would have understood from Tomai that, because an "oxide semiconductor that includes Ga as the main component has a wide band gap as compared with crystalline Si as well as SiC" (Tomai ¶ 111; *see also id.* ¶ 5 ("Ga_2O_3 has attracted attention as a material having a band gap wider than that of SiC.")), a Ga_2O_3 Schottky barrier diode's dimensions would be smaller than those specified for the 4H-SiC Schottky barrier diode (*see id.* at ¶ 4 ("[S]ince the band gap of Si is as narrow as 1.1 eV, it is necessary to increase the size of the element in order to improve the breakdown characteristics.")). Ans. 7. In other words, the evidence supports a finding that Tomai and Aketa suggest a Ga_2O_3 Schottky barrier diode surface area that overlaps to an even greater extent with the claimed "3 mm^2 or less" than the explicitly-described 4H-SiC Schottky barrier diode's surface area.

A dielectric breakdown field that is 10 MV/cm or more

Relying on Sasaki's and Shinohara's teachings, and supporting evidence in Higashiwaki, the Examiner found that the ordinary artisan would

have recognized that "by optimizing the thickness of the wider band gap (α-Ga_2O_3) semiconductor layer and the donor concentration in the wider band gap semiconductor layer, [a] semiconductor Schottky device would have a high withstand voltage and a high breakdown field." Final Act. 5. In the Answer, the Examiner further finds that the Specification evidences that "a crystalline α-Ga_2O_3 oxide semiconductor film of Tomai/Shinohara formed by a mist CVD method would inherently have a dielectric breakdown field of 10 MV/cm or more as one of the properties of the α-Ga_2O_3 oxide semiconductor. Ans. 9.

The Appellant's arguments do not address and, therefore, fail to identify error in the Examiner's inherency finding, which is supported by the Specification disclosure relied on by the Examiner. Specifically, the Examiner quotes Specification page 37, lines 1–3 and page 40, lines 11–13, which state, respectively, "[a] crystalline oxide semiconductor film may be preferably formed by a mist CVD" and "[i]f conditions that are preferable are applied to the processes to form the semiconductor layer, a dielectric breakdown field of the semiconductor layer is expected to be 10 MV/cm or more." Ans. 9. *See Millennium Pharm., Inc. v. Sandoz Inc.*, 862 F.3d 1356, 1364–65 (Fed. Cir. 2017) ("A result is obvious when it is . . . a 'property that is necessarily present' when applying a process disclosed in the prior art." (quoting *Par Pharm., Inc. v. TWI Pharm., Inc.*, 773 F.3d 1186, 1195 (Fed. Cir. 2014))); *In re Kubin*, 561 F.3d 1351, 1357 (Fed. Cir. 2009) ("Even if no prior art of record explicitly discusses the . . . [limitation], [Appellants'] application itself instructs that [the limitation] is not an additional requirement imposed by the claims on the [claimed invention], but rather a property necessarily present in [the claimed invention]."); *Ex parte Obiaya*,

227 USPQ 58, 60 (BPAI 1985) ("The fact that appellant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the difference would otherwise have been obvious.").

DECISION SUMMARY

Claims Rejected	35 U.S.C. §	Reference(s)/Basis	Affirmed	Reversed
1, 2, 5, 8, 10, 11, 17, 18, 21, 22, 24, 30–32	103	Tomai, Shinohara, Aketa, Sasaki, Lee, Higashiwaki, Hilsenbeck	1, 2, 5, 8, 10, 11, 17, 18, 21, 22, 24, 30–32	
6, 19	103	Tomai, Shinohara, Aketa, Sasaki, Lutz, Lee, Higashiwaki, Hilsenbeck	6, 19	
12	103	Tomai, Shinohara, Aketa, Sasaki, Girdhar, Lee, Higashiwaki, Hilsenbeck	12	
23, 27, 28	103	Tomai, Shinohara, Aketa, Sasaki, Oda, Lee, Higashiwaki, Hilsenbeck	23, 27, 28	
14, 26, 29, 34	103	Tomai, Shinohara, Sasaki, Lee, Higashiwaki, Hilsenbeck	14, 26, 29, 34	
25	103	Tomai, Shinohara, Sasaki, Oda, Lee, Higashiwaki, Hilsenbeck	25	

Claims Rejected	35 U.S.C. §	Reference(s)/Basis	Affirmed	Reversed
33	103	Tomai, Shinohara, Sasaki, Aketa, Lee, Higashiwaki, Hilsenbeck	33	
Overall Outcome:			1, 2, 5, 6, 8, 10–12, 14, 17–19, 21–34	

TIME PERIOD FOR RESPONSE

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

AFFIRMED