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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte CHUNG-CHI KO, PEI-WEN HUANG, CHUN-YI LEE,
KUANG-YUAN HSU, and TZE-LIANG LEE

Appeal 2019-002800
Application 14/043,279
Technology Center 2800

BEFORE JAMES C. HOUSEL, MICHELLE N. ANKENBRAND, and
BRIAN D. RANGE, *Administrative Patent Judges*.

HOUSEL, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

Pursuant to 35 U.S.C. § 134(a), Appellant¹ appeals from the Examiner's decision to reject claims 1–5, 8–10, 34–36, 38–40, 42, 43, and 46–49. We have jurisdiction under 35 U.S.C. § 6(b).

¹ We use the word Appellant to refer to “applicant” as defined in 37 C.F.R. § 1.42(a). Appellant identifies the real party in interest as Taiwan Semiconductor Manufacturing Company Limited. Appeal Brief (“Appeal Br.”) filed January 2, 2018, p. 1.

We AFFIRM.²

CLAIMED SUBJECT MATTER

The claims are directed to porous low-k dielectric interconnect structures. Spec. 1, Title. Appellant discloses that porous low dielectric constant (low-k) materials are utilized to reduce interconnect delay and capacitance, wherein the interconnect opening through this dielectric material is sealed with a pore sealing layer to avoid a number of potential diffusion and etch issues. *Id.* ¶¶ 1, 10. Before the interconnect opening is filled with conductive material, the bottom of this pore sealing layer is etched. *Id.* ¶ 11. However, Appellant teaches that etching of this bottom can be difficult, such that polymeric residues may remain or the surface of the underlying conductive layer may be damaged, which may adversely affect via resistance, yield, and reliability. *Id.* ¶ 12.

To address this issue, Appellant’s interconnect opening stops on an underlying etch stop layer over which the pore sealing layer is applied. *Id.* ¶ 13. Appellant teaches that the bottom of the pore sealing layer then is etched, which also extends the opening through the etch stop layer to expose the underlying conductive layer. *Id.* According to the Specification, because there is no pore seal layer on the etch stop layer sidewalls, the lower portion of the extended opening is “opened up,” thereby giving a larger critical dimension for the conductive interconnect providing lower resistance and

² Our Decision additionally refers to the Specification (“Spec.”) filed October 1, 2013, the Final Office Action (“Final Act.”) dated July 14, 2017, the Examiner’s Answer (“Ans.”) dated January 17, 2019, and the Reply Brief (“Reply Br.”) filed February 25, 2019.

better electrical conductivity. *Id.* ¶ 14. Claim 1, reproduced below from the Claims Appendix to the Appeal Brief, is illustrative of the claimed subject matter. The limitation at issue is italicized.

1. A semiconductor device comprising:
 - a first conductive layer;
 - a second conductive layer disposed over the first conductive layer;
 - an etch stop layer (ESL) and a porous low-k dielectric layer disposed between the first conductive layer and the second conductive layer, wherein the porous low-k dielectric layer is disposed over the ESL;
 - an opening extending downwardly through both the porous low-k dielectric layer and the ESL and stopping at the first conductive layer, wherein the opening includes an upper opening portion that defines dielectric sidewalls in the porous low-k dielectric layer and a lower opening portion that defines ESL sidewalls in the ESL;
 - a pore seal layer disposed on the dielectric sidewalls but not covering the ESL sidewalls, the pore seal layer having a bottom surface which is co-planar with an upper surface of the ESL and which extends inwardly into the opening beyond uppermost portions of the ESL sidewalls; and
 - a conductive material formed in the opening to form an interconnect structure to couple the first conductive layer and the second conductive layer, the conductive material having an upper portion disposed along inner sidewalls of the pore seal layer to fill the upper opening portion and having a lower portion in the lower opening portion, *the lower portion of the conductive material being bulbous in shape with outermost sidewalls that undercut the bottom surface of the pore seal layer;*
- wherein a first width is measured between the inner sidewalls of the pore seal layer and a second width is measured between the uppermost portions of the ESL sidewalls, the first width being less than the second width.

Independent claims 5 and 40 recite semiconductor devices similarly including conductive material filling an opening (trench and via) and having a bulbous-shaped lower portion whose outermost sidewalls undercut the bottom surface of the pore seal material layer. Appeal. Br. 18, 20 (Claims App'x).

REFERENCES

The prior art the Examiner relies upon is:

Name	Reference	Date
Abell et al. ("Abell")	US 2006/0022348 A1	Feb. 02, 2006
Besling	US 2009/0321945 A1	Dec. 31, 2009
Hsieh et al. ("Hsieh")	US 2011/0217838 A1	Sept. 08, 2011
Appellant's Admitted Prior Art ("AAPA"), Spec. ¶ 11, Figs. 1a and 1b.		

REJECTIONS

The Examiner maintains, and Appellant requests our review of, the following grounds of rejection under 35 U.S.C. § 103:

1. Claims 1, 2, 4, 35, and 36 as unpatentable over AAPA in view of Abell;
2. Claim 3 as unpatentable over AAPA and Abell, further in view of Hsieh; and
3. Claims 5, 8–10, 34, 38–40, 42, 43, and 46–49 as unpatentable over AAPA in view of Abell and Besling.

OPINION

After review of the Examiner's and Appellant's opposing positions and the appeal record before us, we determine that Appellant's arguments are insufficient to identify reversible error in the above rejections. *In re Jung*, 637 F.3d 1356, 1365 (Fed. Cir. 2011). Accordingly, we affirm the

stated obviousness rejections for substantially the fact findings and the reasons set forth in the Final Office Action and the Examiner's Answer. We offer the following for emphasis only.

Appellant argues claims 35 and 38 as a separate group, but does not argue the remaining claims separately. In accordance with 37 C.F.R. § 41.37(c)(1)(iv), claims 2–5, 8–10, 34, 36, 39, 40, 42, 43, and 46–49 stand or fall with claim 1, which we select as representative. We address claims 35 and 38 separately in our opinion below.

Claim 1

The Examiner rejected claim 1 under 35 U.S.C. § 103 as unpatentable over AAPA in view of Abell. In particular, the Examiner found that Appellant admitted that a semiconductor device substantially as recited in claim 1 was known, except that the pore sealing layer is deposited after etching through the etch stop layer in the this device. Final Act. 2–3 (citing Spec. Fig 1). However, the Examiner found that Abell teaches that it was known in the art to etch an opening through a porous low-k dielectric, apply a pore seal material to the opening, and then etch through the etch stop layer. *Id.* at 3. Therefore, the Examiner concluded that it would have been obvious to etch through the etch stop layer after deposition of the pore sealing material in preparing the AAPA interconnect “since applying the pore seal material after etching the etch stop layer can cause a build-up of this material in the bottom of the opening, which can be difficult to remove without damaging the underlying first conductive layer.” *Id.*

The Examiner further determined that etching the etch stop layer after applying the pore seal material would necessarily result in the lower portion of the conductive material filling the opening being bulbous in shape with

sidewalls that undercut the bottom surface of the pore seal layer, as claim 1 recites. Final Act. 3. In this regard, the Examiner found that the modified process of forming the AAPA interconnect structure as Abell suggests is identical to the process of forming the interconnect structure of claim 1. *Id.* at 3–4. As such, the Examiner determined that this modified process of forming the AAPA interconnect structure as Abell suggests inherently would have resulted in the same bulbous-shaped lower portion of the conductive via whose sidewalls undercut the bottom surface of the pore seal layer as recited in claim 1. *Id.* at 4.

Appellant argues that the proposed combination of AAPA and Abell does not teach a conductive material having a bulbous-shaped lower portion whose sidewalls undercut a bottom surface of the pore seal layer. Appeal Br. 7–13. In particular, Appellant contends that AAPA individually does not describe this feature, noting that the lower portion of the conductive feature is neither bulbous-shaped nor undercuts a bottom surface of the pore seal layer because the lower portion’s sidewalls are tapered and lined with the pore seal material. *Id.* at 7–8. However, the Examiner did not rely on AAPA for teaching this feature. “Non-obviousness cannot be established by attacking references individually where the rejection is based upon the teachings of a combination of references. . . . [The reference] must be read, not in isolation, but for what it fairly teaches in combination with the prior art as a whole.” *In re Merck & Co.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986).

In addition, Appellant contends that Abell individually fails to disclose this feature because Abell’s conductive material has vertical sidewalls extending continuously from its upper surface to its lower surface. Appeal Br. 8–9. Appellant asserts that Abell teaches “a highly directional,

vertical etch” (i.e., anisotropic etching) because otherwise the etch would remove the entire diffusion barrier rather than just the bottom of the diffusion barrier opening. *Id.* at 10. Appellant also asserts that such etching was well known in the art and explains the difference between isotropic etching (material is removed in all directions) and anisotropic etching (material is removed in a highly directional manner). *Id.* at 11.

Appellant’s arguments are not persuasive of reversible error because the rejection is based on the teaching of AAPA modified to form the opening in two steps separated by the deposition of the pore seal layer. *See* Ans. 6. As the Examiner finds, Abell teaches that the etch stop layer may be etched through after deposition of the pore seal layer rather than before deposition (as AAPA teaches). Abell ¶ 50. Doing so would result in the same sequence of steps Appellant uses to produce the claimed semiconductor device. Further, the Examiner found that Appellant’s argument that Abell must be utilizing “a highly directional, vertical etch” is contrary to its own disclosure. Indeed, Appellant’s Specification discloses that the etch process used to remove both the pore seal layer at the bottom of the opening and the underlying etch stop layer portion “needs to be highly anisotropic, wherein very little lateral etch is applied.” Spec. ¶ 36. Appellant fails to dispute or otherwise address this apparent inconsistency.

Still, Appellant discloses that this highly anisotropic etching process produces the recited bulbous-shaped lower portion and undercut beneath the pore seal layer. Since this process is the same as the process Appellant asserts that Abell employs, it would necessarily produce the same result in the AAPA etch stop layer when modified in view of Abell’s teaching.

Appellant further contends that Abell must be considered as a whole and, therefore, Abell's diffusion barrier must be included, which would result in a conductive feature whose sidewalls are flush with the sidewalls of the pore seal layer. *Id.* at 12. According to Appellant, even if the etch "has some small lateral component, the only undercut would be under the diffusion barrier." *Id.* at 11. Therefore, when combined together, Appellant urges that Abell's resulting structure would result in a conductive feature that neither is bulbous-shaped nor undercuts a bottom surface of the pore seal layer. *Id.* at 9–12.

This argument is also not persuasive of reversible error. As the Examiner found, Abell discloses that the diffusion barrier is optional. Ans. 7; Abell ¶ 38 ("a diffusion barrier is optionally applied"). It was, therefore, proper for the Examiner to omit the diffusion barrier when modifying the AAPA structure in view of Abell. Without the optional diffusion barrier, the resulting modified AAPA structure would, again, necessarily produce the same structure as recited in claim 1.

Appellant also argues that Abell, Figure 5, teaches that the etch stop layer is etched before depositing the pore sealing layer. Appeal Br. 12–13. However, we note that this embodiment is a different one from that described in Figures 3A–3C and paragraph 50 on which the Examiner relies. As such, Abell, Figure 5 and paragraph 55, are not relevant to the merits of the rejection before us.

Appellant next argues that the Examiner has failed to provide rationale or evidence tending to show inherency. Appeal Br. 14–15. We disagree. The Examiner has explained how Abell suggests modifying formation of the AAPA structure to etch the etch stop layer after the pore

seal layer is deposited and has noted that the resulting process is the same as Appellant's. It is thus reasonable to conclude that, given the same process, the resulting products would be the same, i.e., a conductive material having a bulbous-shaped lower portion whose sidewalls undercut the pore seal layer. *See* Final Act. 3–4; Ans. 3–4. Accordingly, the Examiner has established a sound basis for believing that the AAPA structure, modified in view of Abell, would inherently have the same bulbous shape and undercut as recited in claim 1. Moreover, a sound basis does not turn on absolute certainty; rather, a sound basis requires the Examiner “to make sufficient factual findings, such that it can reasonably infer that the prior art product and that of the [claim] at issue are the same.” *Howmedica Osteonics Corp. v. Zimmer Inc.*, 640 Fed. Appx. 951, 958 (Fed. Cir. 2016).

We note that Appellant argues that the Examiner did not correct or clarify Appellant's interpretation of the proposed combination of AAPA and Abell until the Examiner's Answer. Reply Br. 4–5. This argument is procedural in nature and is not directly connected with the merits of the rejections before us. In situations where Appellant believes that a new ground of rejection is set forth in an Examiner's Answer, the appropriate course of action is to petition the Director under 37 C.F.R. § 1.181. *See* 37 C.F.R. § 41.40.

Claims 35 and 38

Claim 35 depends from claim 1 and claim 38 depends from claim 5. Each of claims 35 and 38 further requires that the sidewalls of the conductive material make direct contact with at least a portion of the etch stop layer sidewalls. Appeal. Br. 19–20 (Claims App'x). The Examiner finds that modifying the AAPA structure in view of Abell would inherently

result in the conductive material directly contacting at least a portion of the etch stop layer sidewalls. Final Act. 4, 7. Appellant argues that AAPA and Abell both depict a pore seal layer separating the conductive material from the etch stop layer sidewalls. Appeal Br. 15. However, this argument fails to consider Abell’s alternative embodiment on which the rejection relies, wherein the etch stop layer is etched after the pore seal layer is deposited. *See* Abell ¶ 50. As such, this argument fails to address the rejection and, therefore, fails to identify reversible error therein.

CONCLUSION

Upon consideration of the record, and for the reasons given above and in the Final Office Action and the Examiner’s Answer, the decision of the Examiner rejecting claims 1–5, 8–10, 34–36, 38–40, 42, 43, and 46–49 under 35 U.S.C. § 103 as unpatentable over AAPA in view of Abell alone, or further in view of Besling or Hsieh, is *affirmed*.

DECISION SUMMARY

In summary:

Claims Rejected	35 U.S.C. §	Basis/References	Affirmed	Reversed
1, 2, 4, 35, 36	103	AAPA, Abell	1, 2, 4, 35, 36	
3	103	AAPA, Abell, Hsieh	3	
5, 8–10, 34, 38–40, 42, 43, 46–49	103	AAPA, Abell, Besling	5, 8–10, 34, 38–40, 42, 43, 46–49	
Overall Outcome			1–5, 34–36, 38–40, 42, 43, 46–49	

Appeal 2019-002800
Application 14/043,279

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). *See* 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED