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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte BO-JIUN LIN, HAI-CHING CHEN, and TIEN-I BAO

Appeal 2016-006741
Application 13/790,850
Technology Center 2800

Before DONNA M. PRAISS, WESLEY B. DERRICK, and CHRISTOPHER L. OGDEN, *Administrative Patent Judges*.

OGDEN, *Administrative Patent Judge*.

DECISION ON APPEAL

Appellant[1] appeals under 35 U.S.C. § 134(a) from the Examiner's final decision rejecting claims 1–3, 5–9, 12, 13, and 21–26 in the above-identified application.[2] We have authority pursuant to 35 U.S.C. § 6(b). For substantially the reasons set forth by the Examiner in the Final Action,[3] the

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[1] Appellant is Taiwan Semiconductor Manufacturing Company, LTD., which according to the Appeal Brief, is the real party in interest. Appeal Brief 1, Dec. 22, 2015 [hereinafter Appeal Br.].
[2] *See* Appeal Br.; Reply Brief, June 27, 2016 [hereinafter Reply Br.].
[3] Final Office Action, Apr. 24, 2015 [hereinafter Final Action].

Answer,[4] and the Advisory Action,[5] and additional reasons that we provide below primarily for emphasis, we affirm.

BACKGROUND

Appellant's Specification relates to "forming damascene structures in integrated circuit manufacturing processes." Spec.[6] ¶ 1. Figure 6, reproduced below, illustrates certain aspects of the invention:

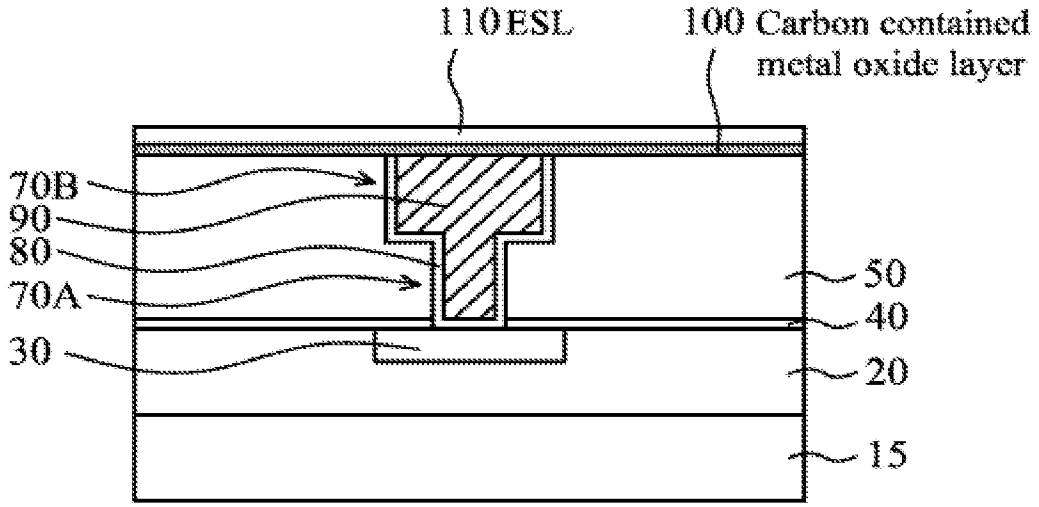

FIG. 6

Figure 6 depicts a damascene structure at a particular manufacturing stage. Spec. ¶ 12. The structure includes substrate **15**, above which there is dielectric insulating layer **20**, and etched into layer **20** is conductive member **30** electrically connecting to an underlying semiconductor device. *Id.* ¶ 13. On top of layers **20** and **30** is etching stop layer **40**. *Id.* Over etching stop

[4] Examiner's Answer, Apr. 27, 2016 [hereinafter Answer].
[5] The Examiner incorporated the Advisory Action by reference into the Answer. Advisory Action 17, July 14, 2015.
[6] Specification, Mar. 8, 2013 [hereinafter Spec.].

layer **40**, there is dielectric insulating layer **50**, *id.* ¶ 14, in which is formed damascene opening **70** (including **70A** and **70B**), *id.* ¶ 17. Damascene opening **70**, which is filled with a copper conductive layer **90**, *id.* ¶ 19, is lined with diffusion barrier blanket **80** which "prevents copper from diffusing into surrounding materials such as insulating layer **50**," *id.* ¶ 18 (boldface added). Above insulator **50** and the conductive layer **90** is carbon containing metal-oxide layer **100**, formed by a sol-gel process. *Id.* ¶ 21. Finally, there is etch stop layer **110** above carbon containing metal-oxide layer **100**. *Id.* ¶ 23.

Representative claim 1 reads as follows:

> 1. A method for forming an interconnect structure, comprising:
> forming an insulating layer on a substrate;
> forming a damascene opening through a thickness portion of the insulating layer;
> forming a diffusion barrier layer to line the damascene opening;
> forming a conductive layer overlying the diffusion barrier layer to fill the damascene opening;
> forming a carbon-containing metal oxide layer on the conductive layer and the insulating layer comprising *using a precursor formed by a sol-gel process, the sol-gel process comprising:*
> *mixing a metal-oxide source and a carbon source to form a mixture,*
> *adding water to the mixture,*
> *after adding the water to the mixture, stirring the water and the mixture, and*
> *after stirring the water and the mixture, adding an acid to the mixture to form the precursor*; and
> forming an etch stop layer over the carbon-containing metal oxide layer.

Appeal Br. 55 (emphasis of key limitations added). Independent claim 7 includes substantially similar limitations. *Id.* at 56–57. Independent claim 25 is similar to claim 1, and includes further details with respect to the sol-gel process corresponding to the above-emphasized language in claim 1, which reads as follows:

> 25. A method for forming a copper damascene, comprising:
> . . . .
> . . . the sol-gel process comprising:
> mixing a metal-oxide source and a chelating agent having a carbon source to form a homogenous solution, the metal-oxide source comprising aluminum-sec-butoxide, the carbon source comprising acetylacetone, ethylacetoacetate, or a combination thereof,
> adding water to the homogenous solution to form a mixture,
> after adding the water, stirring the mixture,
> after stirring the mixture, adding nitric acid to the mixture, and
> after adding the nitric acid, aging the mixture for about 24 hours to form the precursor;
> . . . .

Id. at 58–59.

The Examiner maintains the following rejections:[7]

1. Claims 1–3, 5–9, 12, 13, and 21–24 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Yu[8] in view of the teachings of Makino,[9] Yoldas,[10] Huashi,[11] and Nanao.[12] *See* Final Action 3–11.

2. Claims 25 and 26 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Banerji[13] in view of the teachings of Makino, Yoldas, and Nanao. *Id.* at 12–16.

We summarize these rejections and Appellant's arguments as follows:

Rejection 1

The Examiner finds that Yu discloses all the limitations of claim 1 except for the recited step of forming the precursor for the carbon-containing metal oxide layer using a sol-gel process. Final Action 4–5; *see also* Answer 23. According to the Examiner, Makino discloses a sol-gel process for making the precursor recited in claim 1, except that Makino does not explicitly disclose, "after adding the water to the mixture, stirring the water and the mixture, and after stirring the water and the mixture, adding an acid

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[7] The Examiner has withdrawn a rejection under 35 U.S.C. § 112, second paragraph. *See* Advisory Action 2; *see also* Answer 2.
[8] Yu et al., US 2010/0308463 A1 (published Dec. 9, 2010) [hereinafter Yu].
[9] Makino et al., US 2011/0274878 A1 (published Nov. 10, 2011) [hereinafter Makino].
[10] Bulent E. Yoldas, *Alumina Sol Preparation from Alkoxides*, 54 CERAMIC BULL. 289 (1975) [hereinafter Yoldas].
[11] Liu Huashi et al, *Chemical Modification of Ethylacetoacetate with ASB in Aqueous Medium*, 24 J. WUHAN U. TECH.-MATER. SCI. ED. 68 (2009) [hereinafter Huashi].
[12] Nanao et al., US 4,668,299 (issued May 26, 1987) [hereinafter Nanao].
[13] Banerji et al., US 7,858,510 B1 (issued Dec. 28, 2010) [hereinafter Banerji].

to the mixture to form the precursor." Final Action 5 (citing Makino ¶¶ 6, 9, 13, 38, 41, 43, 49–50).

Nevertheless, the Examiner finds that Makino generally teaches adding water and acid to the mixture. *See* Final Action 17 (citing Makino ¶¶ 50–51). In addition, the Examiner finds that Makino teaches an embodiment in which the solvent is an alcohol (rather than water), and explicitly teaches adding acid after stirring the solvent with the mixture. *Id.* at 5 (citing Makino ¶ 120). The Examiner finds that "it is known in the art that water is a suitable alternative solvent [to] alcohol in preparing alumina sol using sol gel method." *Id.*[14]

As additional support for the stirring and acid-adding steps, the Examiner finds that Yoldas teaches that, in a sol-gel process for forming an alumina precursor, "an acid is added to a mixture containing water and a metal-oxide source [aluminum alkoxide] after stirring the mixture containing water and a metal-oxide source." *Id.* (citing Yoldas 289). The Examiner likewise cites Huashi as teaching a sol-gel process for forming an aluminum precursor that includes stirring water in the mixture (of metal-oxide source and carbon source) and then adding diluted nitric acid to the mixture to form the precursor. *Id.*

The Examiner determines that a person of ordinary skill in the art would have been motivated to combine the teachings of Makino, Yoldas, and Huashi into the disclosure of Yu "for the purpose of providing an alternative method to form an aluminum oxide-containing precursor layer from a

[14] *See, e.g.*, Makino ¶ 52 (noting, after discussing hydrolysis in water, "An organic solvent may be used as the solvent . . . . Examples of the organic solvent include monohydric alcohols.").

solution." *Id.* at 6. In particular, the Examiner determines that "the alternative method has advantages such that . . . simple and nonexpensive equipment can be employed, a large film can be prepared, a cheap product can [be] provided because of high productivity and that a uniform film having an excellent stoichiometric property can be prepared." *Id.* (citing Makino ¶ 6; Nanao 2:53–68, 3:1–14, 3:60–68, 4:1–5). The Examiner also determines that "it would have been obvious to try one of the known methods with a reasonable expectation of success." *Id.*

Rejection 2

The Examiner finds that Banerji discloses all the limitations of claim 25 except for the recited step of forming the precursor for the carbon-containing metal oxide layer using a sol-gel process. Final Action 12–14; *see also* Answer 23. According to the Examiner, Yoldas discloses a sol-gel process for forming an alumina precursor that includes mixing a metal-oxide source (aluminum-sec-butoxide) and water, followed by stirring, and then adding nitric acid and aging for sufficient time to form a precursor. *Id.* at 14 (citing Yoldas 289).

The Examiner also finds that Makino teaches a similar sol-gel process that includes mixing the metal oxide source with a chelating agent having a carbon source from a genus that would include acetylacetone. *Id.* (citing Makino ¶¶ 42–44, 48–50). The Examiner then cites Nanao as teaching that the chelating agent in a similar sol-gel process may specifically include acetylacetone. *Id.* (citing Nanao col. 5). The Examiner finds that in view of the teachings of Yoldas, the 24-hour aging limitation would have been merely a matter of optimization. *See id.* at 14–15.

The Examiner determines that a person of ordinary skill in the art would have been motivated to combine the teachings of Yoldas, Makino, and Nanao into the disclosure of Banerji "for the purpose of providing an alternative method to form an aluminum oxide-containing precursor layer from a solution." *Id.* at 15. In particular, the Examiner determines that "the alternative method has advantages such that . . . simple and nonexpensive equipment can be employed, a large film can be prepared, a cheap product can [be] provided because of high productivity and that a uniform film having an excellent stoichiometric property can be prepared." *Id.* (citing Nanao 2:53–68, 3:1–14, 3:60–68, 4:1–5). The Examiner also determines that "Applicant did not invent/modify the sol gel method. Applicant only applies a known sol gel method. Therefore, it would be obvious to one of ordinary skill in the art to use any well[-]known material/process step of the sol gel method in the rejection." *Id.*

Summary of Appellant's Arguments

In the Appeal Brief, Appellant argues the claims as a group within each rejection. *See* Appeal Br. 8–53. Therefore, consistent with 37 C.F.R. § 41.37(c)(1)(iv), we limit our discussion to independent claims 1 and 25. Claims 2, 3, 5–9, and 12–13 fall with claim 1, and claim 26 falls with claim 25.

Regarding claims 1 and 25, Appellant argues (1) that the Examiner's proposed prior art combination represents a substantial reconstruction and redesign of the elements disclosed by Yu or Banerji,[15] respectively, *see*

[15] In general, Appellant presents separate arguments for each of two embodiments disclosed by Banerji for forming the carbon-containing metal oxide layer. *See* Appeal Br. 36–37. In the "first embodiment," an

Appeal Br. 16–20, 38–41; (2) that the Examiner's proposed prior art combination removes or changes the principles of operation of Yu and Banerji, respectively, *see id.* at 20–24, 38–43; (3) that Yu and Banerji, respectively, teach away from the proposed art combination, *see id.* at 24–28, 43–46; (4) that the Examiner's modification of Yu or Banerji, respectively, renders the process inoperable for its intended purpose, *see id.* at 28–30, 47–51; and (5) that the Examiner has not provided a prima facie case, *see id.* at 30–36, 51–53.

DISCUSSION

The Examiner's Prima Facie Case of Unpatentability

According to the Supreme Court,

> If a person of ordinary skill can implement a predictable variation, § 103 likely bars its patentability. For the same reason, if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 417 (2007). The Examiner's determination in rejecting claims 1 and 25 is that persons of ordinary skill in the art, in view of the cited secondary references, would have recognized

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organoaluminum reactant is contacted with the copper surface in a vacuum to form an aluminum-containing layer, the top portion of this layer is passivated, and the bottom portion of the layer is allowed to diffuse into the copper. *See id.*; Banerji, Fig. 3B. The "second embodiment" is substantially the same as the first, except that the entire aluminum-containing layer is modified to form an immobile compound (the metal oxide layer, according to the Examiner), and there is no diffusion into the copper. *See* Appeal Br. 37; Banerji, Fig. 3B.

that they could use a known sol-gel process to obtain advantages over the vacuum processing deposition step disclosed in Yu or Banerji. *See* Answer 17, 23; Final Action 5–6, 15.

The Examiner's rejections establish a prima facie case of unpatentability, because the rejections include "some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006). Appellant's arguments to the contrary are unpersuasive of reversible error for the reasons stated by the Examiner. *See* Answer 19, 22–23; *see generally* Advisory Action.

In particular, Appellant's argument that "Yoldas describes a completely different process" than Makino, and that "Huashi describes a different process that arrives at a different result" from Makino or Yoldas, *see* Appeal Br. 32; *see also id.* at 52; Reply Br. 7–8, is unpersuasive of reversible error in the Examiner's rejection. The Examiner cites each secondary reference for its particular teachings with respect to a known, "conventional sol-gel method for forming carbon contained metal oxide layer." Answer 23. "The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference . . . . Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art." *In re Keller*, 642 F.2d 413, 425 (CCPA 1981); *see also KSR*, 550 U.S. at 401 ("[T]he [obviousness] analysis need not seek out precise teachings directed to the challenged claim's specific subject matter, for a court can consider the inferences and creative steps a person of ordinary skill in the art would employ.").

Appellant's argument that the Examiner failed to consider the invention as a whole, *see* Appeal Br. 34–35, 53, is also unpersuasive of reversible error. The Examiner's rejection includes an explicit rationale that addresses every claim limitation and articulates a rational explanation for why a person of ordinary skill in the art would have been motivated to substitute the known sol-gel process (with specific details found within the teachings of Makino, Yoldas, Huashi, and Nanao) for the vacuum process in either Yu or Banerji. *See* Final Action 5–6, 15. The Examiner has established, on this record, a prima facie case of unpatentability that considers claims 1 and 25 as a whole.

Teaching Away

The Supreme Court has held that "when the prior art teaches away from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious." *KSR*, 550 U.S. at 416. Consistent with this, the Federal Circuit's predecessor held in *In re Ratti*, 270 F.2d 810 (CCPA 1959), that it would not have been obvious to replace a "cylindrical sheet metal reinforcing member" in a seal with "an annular set of outwardly biased spring fingers," because the prior art teaching "points away from the addition of any spring element." *Id.* at 812–13. In particular, the court held that the substitution "would require a substantial reconstruction and redesign of the elements shown in [the seal] as well as a change in the basic principles under which the [seal's] construction was designed to operate." *Id.* at 813.

Similarly, the Federal Circuit has stated that "[i]n cases involving mechanical device or apparatus claims, we have held that '[i]f references taken in combination would produce a "seemingly inoperative device," . . .

such references teach away from the combination and thus cannot serve as predicates for a prima facie case of obviousness.'"). *In re Urbanski*, 809 F.3d 1237, 1234 (Fed. Cir. 2016) (quoting *McGinley v. Franklin Sports, Inc.*, 262 F.3d 1339, 1354 (Fed. Cir. 2001)) (citing *In re Gordon*, 733 F.2d 900, 902 (Fed. Cir. 1984)).

Appellant argues that replacing the metal oxide layer deposition step in Yu or Banerji[16] amounts to a substantial reconstruction and redesign of the method in Yu or Banerji, because the vacuum processing step represents each primary reference's sole contribution to the art. *See* Appeal Br. 16–20 (citing *Ratti*), 38–41. This argument is unpersuasive of reversible error. Unlike the apparatus invention at issue in *Ratti*, claims 1 and 25 are method claims. Whereas in *Ratti*, the prior art combination would have required a substantial reconstruction and redesign of a prior art apparatus, here the prior art combination would simply replace a vacuum processing step with a sol-gel processing step for forming the same structure. We are not persuaded by Appellants' contention that because the vacuum steps were the sole inventive contributions in Yu or Banerji, a skilled artisan would have been dissuaded from making this substitution.

Appellant also argues that the Examiner's proposed combination removes or changes the basic principles upon which either Yu's or Banerji's[17] method operates. *See id.* at 20–24, 38–43. According to Appellant, Yu's process operates on the principle of introducing a free

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[16] This argument relates only to Banerji's "first embodiment." *See* Appeal Br. 38.
[17] This argument relates only to Banerji's "first embodiment." *See* Appeal Br. 42.

metallic atom (e.g., aluminum) onto a copper surface in order to "pin" surface copper atoms, control electromigration, and promote adhesion. *See* Appeal Br. 21–22. Appellant argues that Banerji's basic principle of operation is to cause a dopant to diffuse into copper in order to provide a protective cap. *See id.* at 38–43.

Appellant interprets the principle of operation in Yu and Banerji too narrowly. Yu's and Banerji's methods operate on the principle of "forming layers of material on a partially fabricated integrated circuit." Yu 2; Banerji 1:23–24. Although Yu and Banerji disclose particular details for the step of forming a carbon-containing metal oxide layer, the Examiner's rejection wholly substitutes this step for a sol-gel process as taught by the secondary references. Appellant does not persuasively show that a skilled artisan would have been led away from making this substitution by relying on teachings in Yu or Banerji made in the context of forming a carbon-containing metal oxide layer using a vacuum processing step.

Appellant also argues that the Examiner's rejection does not consider the references "as a whole," and if considered as a whole, Yu and Banerji would have led a skilled artisan on a path that adopts the specific inventive contributions of Yu and Banerji, and thus diverges from claims 1 and 25. *See id.* at 25–28, 43–46, 49; Reply Br. 4–6, 8–9, 11, 13, 14, 17, 20, 21. These arguments are not persuasive of reversible error. While Yu and Banerji teach benefits and goals applicable to a vacuum process,[18] Appellant

[18] For example, Appellant argues that with respect to Banerji's "second embodiment," the reference "clearly states that . . . 'it is highly important to provide an oxide-free copper surface to prevent a reaction . . . to prevent aluminum oxide formation' and that 'immediate aluminum oxide formation on copper surface is **not desired**.'" Appeal Br. 46 (citing Banerji 20:57–65).

has not directed us to any teaching in either Yu or Banerji that disparages the use of a sol-gel process, or would discourage a skilled artisan from replacing the disclosed vacuum process with a sol-gel process.

Finally, Appellant argues that the prior art combination in the Examiner's rejections would render Yu and Banerji[19] inoperable for its intended purpose. *See* Appeal Br. 28–30, 47–51. Appellant argues that "the intended purpose of Yu is the formation of an adhesion layer to achieve increased adhesion and electromigration performance," and that "the intended purpose of Banerji's first embodiment is the formation of a protective cap for improved electromigration performance." *Id.* at 28, 47. Appellant regards "the reaction of a free metal atom M2 with copper oxide" and "the controlled introduction of dopants in copper," respectively, as necessary parts of Yu's and Banerji's intended purposes. *Id.* at 28, 47.

Appellant interprets the intended purposes of Yu and Banerji's methods too narrowly. As applied in the Examiner's rejections, Yu and Banerji teach processes for forming Damascene interconnect structures on a semiconductor. Yu ¶¶ 50–51; Figs. 1A–1E; Banerji 8:31–54, 20:48–51, Figs 1A–1E, 3B. Appellant has not directed us to persuasive evidence in this appeal record that a person of ordinary skill in the art would have understood, in light of the teachings of Yu or Banerji, that substituting a sol-gel process for the disclosed vacuum process would have rendered the process inoperable for forming a Damascene interconnect structure.

Appellant does not point to any evidence in this appeal record that a skilled artisan would have considered this guidance applicable in the context of a sol-gel process.

[19] This argument only relates to Banerji's "first embodiment." *See* Appeal Br. 47.

For the above reasons and those stated by the Examiner, we affirm the Examiner's rejection of claims 1–3, 5–9, 12, 13, and 21–26.

DECISION

The Examiner's decision is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended. *See* 37 C.F.R. § 1.136(a)(1)(iv) (2016).

AFFIRMED