

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY LIMITED,

Petitioner,

v.

ALIDDOUBLE, INC.,

Patent Owner.

IPR2023-00373

U.S. Patent No. 9,431,455

PATENT OWNER'S RESPONSE

UNDER 37 C.F.R. § 42.107

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<i>Rembrandt Wireless Techs., LP v. Samsung Elecs. Co.</i> , 853 F.3d 1370 (Fed. Cir. 2017)	<i>passim</i>

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TABLE OF EXHIBITS

Exhibit No.	Exhibit Name
2011	Declaration of Ron Maltiel
2012	Curriculum Vitae, Ron Maltiel
2013	Xiao, Chapter 10 - CVD and Dielectric Thin Film
2014	Stefanov, Design and Performance of a Pinned Photodiode CMOS Image sensor (2018)
2015	Plasma-Therm: PECVD and HDPCVD Basics (2015)
2016	Wolf & Tauber, Silicon Processing for the VLSI Era, Volume 1: Process Technology

I. INTRODUCTION

Alidouble, Inc. (“Alidouble” or “Patent Owner”) submits this Patent Owner’s Response to Taiwan Semiconductor Manufacturing Company Ltd.’s (“Petitioner” or “TSMC”) Petitioner challenging Claims 1 – 3, 5 – 7, 9 – 12 & 15 - 19 of U.S. Patent No. 9,431,455 (Ex. 1001, hereinafter the “’455 Patent”). For the reasons discussed below, the Petitioner has not shown that the references or combinations of references upon which Petitioner relies satisfies Petitioner’s burden to establish by a preponderance of the evidence that claims 1 - 3, 5 - 7, 9 - 12 & 15 - 19 of the ‘455 Patent are unpatentable. *See* 35 U.S.C. § 316(e).

II. THE ‘455 PATENT

The ‘455 Patent is entitled *Back-end Processing Using Low-Moisture Content Oxide Cap Layer*, was filed on November 9, 2014, and issued to Amos Fenigstein, Yakov Roizin, and Avi Strum as inventors on August 30, 2016. Ex. 1001 (hereinafter “’455 patent”).

The ‘455 Patent is directed to semiconductor fabrication processes and particularly back-end-of-the-line (BEOL) processes, ‘455 Patent, 1:7–9, for fabricating image sensors with structures/processes that control hydrogen at beneficial levels and that advantageously achieve improved step coverage of the passivating oxide over metallization layers. ‘455 Patent, Abstract, 4:45-50. The abstract of ‘455 Patent discloses:

[a] method for fabricating image sensors and other semiconductor ICs *that controls the amount of hydrogen generated during back-end processing.*”

Id., Abstract (emphasis added). Instead of blocking the generation and migration of hydrogen altogether, the ‘455 Patent describes that

“[w]hat is needed is a modified back-end processing methodology and associated modified back-end metallization structure *that facilitates control over the generation and migration of mobile hydrogen atoms/ions, thus improving a semiconductor device's operating performance* (e.g., improving image quality of CMOS image sensors).

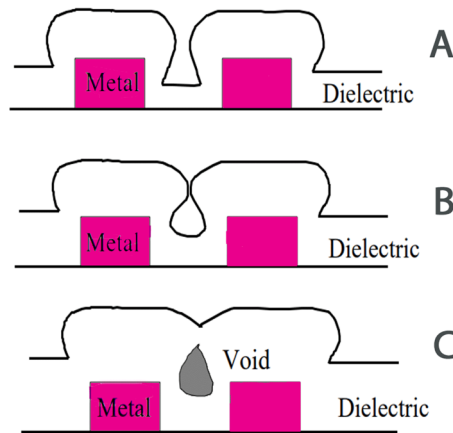
Id. at 4:45-50 (emphasis added).

In addition, the ‘455 Patent overcomes the challenges relating to image sensors with multiple metal layers and high density of metal lines by planarizing each layer of the metal lines patterns with TEOS interlayer dielectric ILD. ‘455 Patent, 9:51-60; Ex. 2001 (Declaration of Ron Maltiel, hereinafter “Maltiel Decl.”) ¶ 46. An ILD with TEOS oxide covers underlying gaps and contours with excellent results making a reliable insulator that helps to improve product yield. ‘455 Patent at 5:13-15; Maltiel Decl., ¶ 46. Poor step coverage can lead to defects such as voids and stringers. Maltiel Decl., ¶ 47. Voids are empty spaces that can occur in a semiconductor device that have negative consequences, such as causing electrical shorts, contaminating the insulator, reducing insulator stability, changing local capacitance, and stringers between metal lines. *Id.*

Figures A - C below show that a void will form between two closely spaced metal lines as the thickness of the deposited layer increases from A to C. This is

because the top of the gap will be close to the depositing dielectric before the bottom and sidewalls of the gap are completely filled – forming a void. *Id.* at ¶ 48 (Ex. 2013).

Void Formation Process

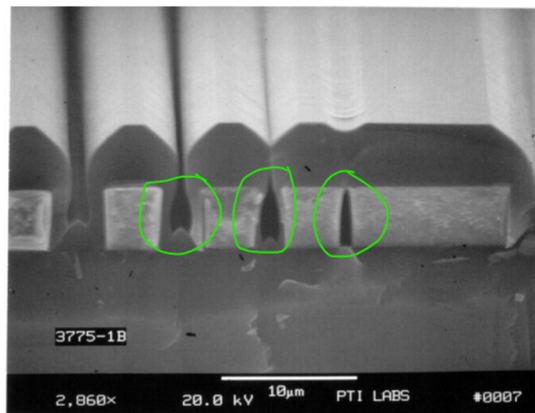


Hong Xiao, Ph. D.

www2.austin.cc.tx.us/HongXiao/Book.htm

Id. The figure below shows several are examples of keyhole voids. *Id.* at ¶ 49 (Ex. 2013).

- As aspect ratio increases → keyhole more readily formed



Plasma-Therm

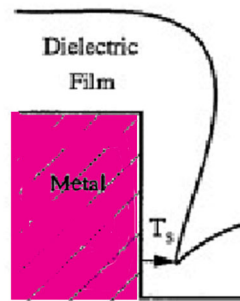
ADVANCED VACUUM
A Plasma-Therm Company

25

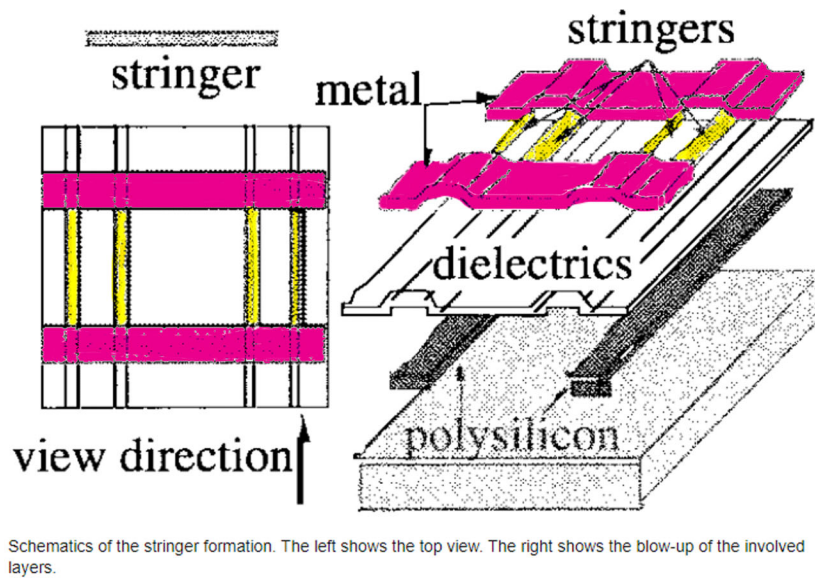
Id. (Ex. 2015).

The figure below shows an example of poor step coverage of dielectric on the bottom of metal layer lead to non-conformal deposition. The arrow T_s points to the area where the dielectric has not been deposited properly.

Step Coverage



Id. at ¶ 50 (Ex. 2013). Poor step coverage may also lead to the formation of stringers in subsequent fabrication steps where a subsequent metal layer is deposited. *Id.* at ¶ 51. Stringers are long, thin lines of metal that may cause electrical shorts and other problems. *Id.* The figure below shows stringers, which are residues of metal that remain after the etching of metal lines. The stringers are yellow in the figure, and they are located between two separate metal lines, which are pink:



Id. at ¶ 52 (Ex. 2016).

TEOS oxide is a dielectric that exhibits excellent conformal deposition – step coverage. Maltiel Decl., ¶ 53. TEOS oxide is used as an insulator between metal lines. *Id.* USG is undoped silicate glass which has high deposition at low temperatures and similar properties to silicon dioxide. FSG is a fluorine-containing silicon dioxide that improves capacitance between metal. *Id.*

TEOS oxide, however, contains trace amounts of hydrogen and water. Maltiel Decl., ¶ 54. The control of hydrogen accumulation in and around the transistor channel area of the CMOS gate oxide – silicon interface. *Id.* Some hydrogen at the gate oxide – silicon interface is essential for image sensors, as it is a key factor in the performance and reliability as hydrogen passivates interface states at the gate oxide - silicon interface, and hydrogen passivates defects deep in the substrate beneath the transistor layer:

The importance of hydrogen for the performance of CMOS devices is well known in semiconductor industry. A certain amount of hydrogen at the Silicon-Gate Oxide interface is needed to passivate the Surface States ... At the same time, excess amounts of hydrogen are responsible for device instabilities... Hydrogen atoms are also known to interact with the bulk silicon defects created by ionizing radiation

‘455 Patent, 2:18-34 (emphasis added); Maltiel Decl., ¶ 54.

The ‘455 Patent describes placing a cap layer (yellow in figure 2)¹ of high-density low moisture content oxide material on top of the TEOS layer to prevent hydrogen from diffusing through the TEOS. Maltiel Decl., ¶ 55.

The ‘455 Patent teaches using a high-density, low-moisture oxide layer above every ILD layer except the topmost ILD to provide a partial barrier to hydrogen diffusion:

According to an exemplary embodiment, cap layers consisting essentially of high-density silane oxide are provided over the ILD layers in each of the lower metallization layers (i.e., the first “M1” layer and all subsequent metallization layers except for the uppermost “last metallization layer). Forming high-density low-moisture (e.g., silane oxide) cap layers on every lower metallization layer minimizes/eliminates hydrogen generation during all back-side

¹ “High density, low moisture oxide” is a plasma oxide and is the same as or equivalent to “plasma oxide described in Oshima or Nagai. Neither high density, low moisture oxide, nor “plasma oxide” is TEOS oxide. Oshima, ¶ 0002 (Ex. 1005(hereinafter “Oshima”)); Nagai, 22:21-34 (Ex. 1006 (hereinafter “Nagai”)); Maltiel Decl., ¶ 98.

60. The use of high density, low moisture oxide cap barrier layer is a critical component of the '455 Patent invention as it (i) protects the TEOS oxide from a subsequent plasma etching of metal; and (ii) as a cap layer, does not block the migration of hydrogen from the TEOS oxide layer to the gate oxide – silicon interface. Maltiel Decl., ¶ 63. A layer of high density, low moisture oxide between the TEOS oxide layer and the metallization layer would block the migration of hydrogen from the TEOS oxide layer to the gate oxide – silicon interface. The combination of TEOS oxide on the metallization layer with a cap layer of high density, low moisture oxide on the TEOS oxide provides for control – but not elimination – of hydrogen and improved gap filling passivation of the metallization layer. '455 Patent, 5:37 – 6:24; Maltiel Decl., ¶ 63

The fabrication process is shown in Figures 3(A)-(C) of the '455 Patent. The process starts with metal deposition (135, pink) over the cap layer (135, yellow), followed by metal patterning using photoresist (150; orange) and etching:

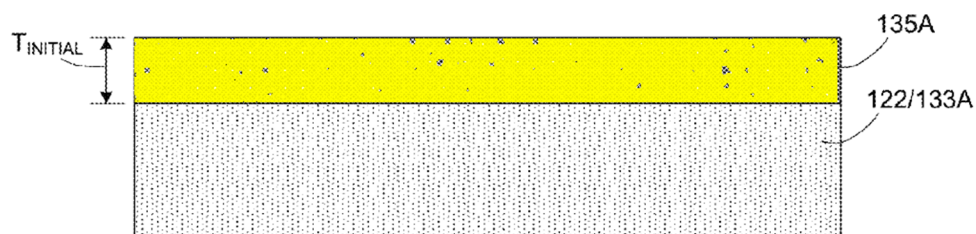


FIG. 3(A)

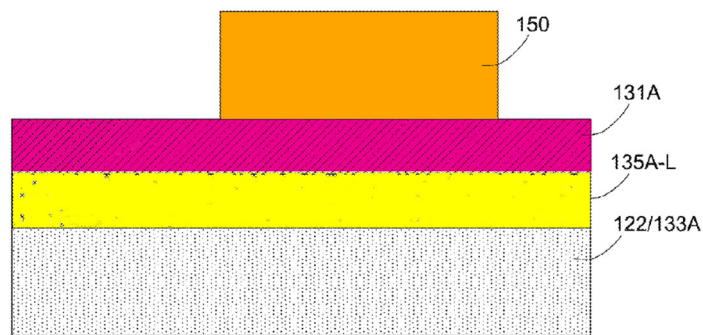


FIG. 3(B)

'455 Patent at 13:10-21, Figs. 3(A), 3(B). The final remaining thickness of the cap barrier layer underneath the metal in Figure 3(C) must be at least 100 Å:

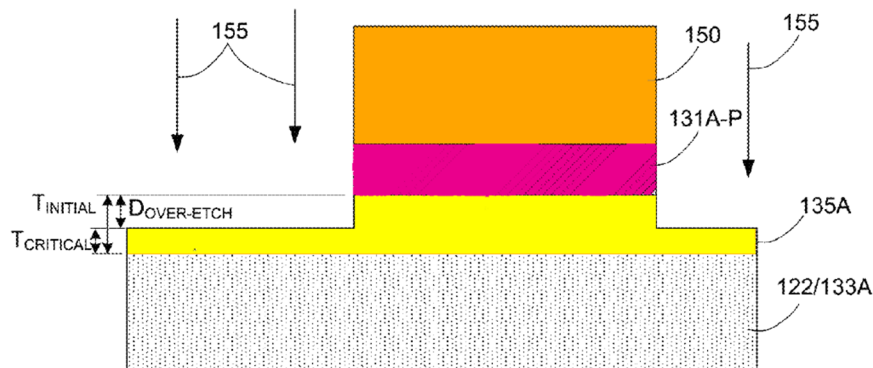


FIG. 3(C)

Id. at 13:21-46, Fig. 3(C). This is critical to ensure the device's performance and reliability, as the oxide cap barrier layer protects the TEOS layer underneath and improves the device's electrical properties. 'Maltiel Decl., ¶¶ 60-62.

III. PERSON OF ORDINARY SKILL

The '455 Patent describes and claims an invention relating to “[a] method for fabricating image sensors and other semiconductor ICs that controls the amount of hydrogen generated during back-end processing. ‘455 Patent, Abstract, 1:7-9.

After reviewing the ‘455 Patent’s specification, claims and prosecution history, in my opinion, a POSITA would have at least a bachelor’s degree in electrical engineering, chemical engineering, or material science. Maltiel Decl., ¶ 26. In addition, a POSITA would have 3-5 years’ experience that includes some experience in image sensors. *Id.*

IV. CLAIM CONSTRUCTION

A. Claim Construction Standard

In *inter partes* review, patent claims are construed under the *Phillips* standard, 37 C.F.R. § 42.100, according to their “ordinary and customary meaning.” *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312-17 (Fed. Cir. 2005) (*en banc*); 37 C.F.R. § 42.100(b). Under *Phillips*, “the ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention.” *Id.* at 1313. “Importantly, the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification.” *Id.*

B. Claim Constructions

Claims 1, 17 & 19 are independent claims that are to be interpreted in relevant part consistently.

1. Claim Construction – Claim 1

a. Construction Of Claim Terms

Claim 1 includes the limitations:

forming a plurality of metallization layers over the pre-metal dielectric layer, wherein forming at least one of said metallization layers includes:

forming a patterned metal structure;

forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure;
and

forming a cap layer over the ILD layer over said ILD layer of all of said plurality of metallization layers except an uppermost said metallization layer;

wherein forming the cap layer comprises forming a high-density, low-moisture content oxide material having a minimum thickness of 100 Å.

‘455 Patent, 17:64-18:7. Based on the language of Claim 1 and based on the specification, a POSITA would understand that Claim 1 requires the “TEOS-based oxide” be in contact with the “patterned metal structure” and be between the “patterned metal structure and the “high-density, low-moisture content oxide material.” Maltiel Decl., ¶ 64.

From the language of Claim 1, a POSITA (who has experience and education in integrated circuit processing) would understand that the requirement of “forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure” and then forming a “cap layer over [over the ILD layer] said ILD layer of all of said plurality of metallization layers except for

an uppermost said metallization layer” requires by the order of processing that the TEOS layer be between the metallization layer and the cap – high density, low moisture – layer. ‘455 Patent, Claim 1; Maltiel Decl., ¶ 67.

The logical order of forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure compels that the TEOS oxide is in contact with the metal structure with the high density, low moisture oxide above the TEOS oxide. Maltiel Decl., ¶ 71. As the Federal Circuit has observed:

a claim “requires an ordering of steps when the claim language, as a matter of logic or grammar, requires that the steps be performed in the order written, or the specification directly or implicitly requires” an order of steps.

Mformation Techs., Inc. v. Research In Motion Ltd., 764 F.3d 1392, 1398 (Fed. Cir. 2014) (citing *TALtech Ltd. V. Esquel Apparel, Inc.*, 279 Fed. Appx. 974, 978 (Fed. Cir. 2008)).

The POSITA would understand that the ‘455 Patent explains the import of hydrogen for image sensors and how to control hydrogen. In the specification, starting from the first sentence of the abstract, the ‘455 Patent discloses the control of hydrogen:

A method for fabricating image sensors and other semiconductor ICs that controls the amount of hydrogen generated during back-end processing.

‘455 Patent, Abstract; Maltiel Decl., ¶ 65.

From the specification, a POSITA would understand that hydrogen may advantageously diffuse into the transistors of an image sensor and impact its dark current and pattern sensitivity. ‘455 Patent, 2:18-40; Maltiel Decl. ¶ 66. A POSITA would then understand that the specification describes structures that will control hydrogen in image sensors:

image sensor (CIS) imagers and CCD not always show improvement [in dark current] when the amounts of hydrogen are high. In particular, increased dark current in the outermost pixels of the imager, as well as patterns related to peripheral layout features.

‘455 Patent, 2:61-65; Maltiel Decl., ¶ 66. “Dark current” is a problem with image sensors and is not a problem with non-volatile memories or capacitive memories.

Id.

A POSITA’s understanding would be consistent with the specification’s description of an objective of the ‘455 Patent:

What is needed is a modified back-end processing methodology and associated modified back-end metallization structure *that facilitates control over the generation and migration of mobile hydrogen atoms/ions, thus improving a semiconductor device’s operating performance*

‘455 Patent, 4:45-50 (emphasis added); Maltiel Decl., ¶ 68.

A POSITA would understand that if the “high density, low moisture” oxide layer is below a TEOS layer and above the lower metallization layer, then the high density, low moisture oxide would block the migration of hydrogen, negating an objective of the ‘455 Patent because the high density, low moisture oxide layer

would prevent hydrogen atoms/ions in the TEOS oxide layer from migrating to the silicon - gate oxide interface. ‘455 Patent, 2:18-24; Maltiel Decl., ¶ 69.

In addition, a POSITA would understand the specification that describes a metallization layer with a TEOS oxide ILD layer immediately above and a cap layer of high density, low moisture oxide above the ILD layer and that this description is consistent with the disclosure of the ‘455 Patent’s Figures as where the TEOS oxide layer is illustrated, it is in contact with a metallization layer, and where a high density, low moisture oxide is illustrated, a TEOS oxide layer is between the high density, low moisture cap layer and the metallization layer. ‘455 Patent, 4:53-7:5, Fig. 1 & Fig. 2; Maltiel Decl., ¶ 70.

A POSITA also would understand an objective of the invention to be to improve step coverage – gap filling – with TEOS oxide directly over the metallization layer and the high density, low moisture oxide layer over the TEOS oxide layer:

The use of TEOS-based oxide to form the ILD layer assures superior coverage of underlying metallization structures due to its excellent gap filling characteristics.

Id. at 5:12-15 & 5:47-52; Maltiel Decl., ¶ 71. A POSITA would understand that the TEOS oxide layers advantageous gap filling characteristic would be negated if it were not directly on the metallization layer as the high density, low moisture

oxide does not have the advantageous gap filling characteristics of TEOS oxide.

‘455 Patent, 5:53-56; Maltiel Decl., ¶ 71.

A POSITA would understand that the advantages of the described and claimed combination of TEOS oxide layer and high density, low moisture oxide layer is only obtained if the TEOS oxide layer is generated first over the metallization layer and the high density, low moisture layer is generated second over the TEOS oxide layer. ‘455 Patent, 11:1-16; Maltiel Decl., ¶ 71.

A POSITA would also understand that there are no disclosures in the ‘455 Patent’s specification or in the prosecution history of the ‘455 Patent that teach a high density, low moisture oxide layer generated first over a metallization layer with as TEOS oxide layer over the high density, low moisture oxide layer. Maltiel Decl., ¶ 72.

From the ordinary and customary meaning of the claim limitation, including its logical sequence of layers generated upon layers, and from the specification, including its objectives and requirements, a POSITA would understand that Claim 1 requires the “TEOS-based oxide” be in contact with the “patterned metal structure” and be between the “patterned metal structure and the “high-density, low-moisture content oxide material.” Phillips, 415 F.3d at 1312-17; Mformation Techs, 764 F.3d at 1398.

2. Claim Interpretation For Claims 17 & 19

a. Claim 17

Claim 17 includes the limitations:

forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structured, and

forming a cap layer of the ILD layer,

wherein forming the cap layer comprises forming a high-density, low moisture content oxide material having a minimum thickness of 100 Å

‘455 Patent, 20:14-20.

For the reasons discussed above with reference to Claim 1 and based on the language of Claim 17 and on the specification, a POSITA would understand that Claim 17 requires the “TEOS-based oxide” be in contact with the “patterned metal structure” and be between the “patterned metal structure and the “high-density, low-moisture content oxide material.” Maltiel Decl., ¶ 74. *Information Techs.*, 764 F.3d 1392, 1398.

b. Claim 19

Claim 19 includes the limitations:

a back-end metallization structure formed on the pre-metal dielectric layer, the back-end metallization structure including a plurality of metallization layers formed in a stack, each of the metallization layers including a patterned aluminum layer and an interlevel dielectric (ILD) layer comprising TEOS-based oxide that is formed over the patterned aluminum layer,

wherein at least one of the plurality of metallization layers includes a cap layer formed on the ILD layer, and

wherein the cap layer of all of said plurality of metallization layers except an uppermost said metallization layer comprises a silane oxide layer having a minimum thickness of 100 Å.

‘455 Patent, 20:47-59.

For the reasons discussed above with reference to Claim 1 and based on the language of Claim 19 and on the specification, a POSITA would understand that Claim 19 requires the “TEOS-based oxide” be in contact with the “patterned metal structure” and be between the “patterned metal structure and the “high-density, low-moisture content oxide material.” Maltiel Decl., ¶ 76. Mformation Techs., 764 F.3d 1392, 1398.

V. SUMMARY OF PETITIONER’S CITED REFERENCES

Petitioner cites two references, Oshima and Nagai, as primary references. Petitioner further cites five references, Lee, Crook, Miyazaki, Wang, and Omi, as secondary references with which Petition combines the primary references.

A. Oshima

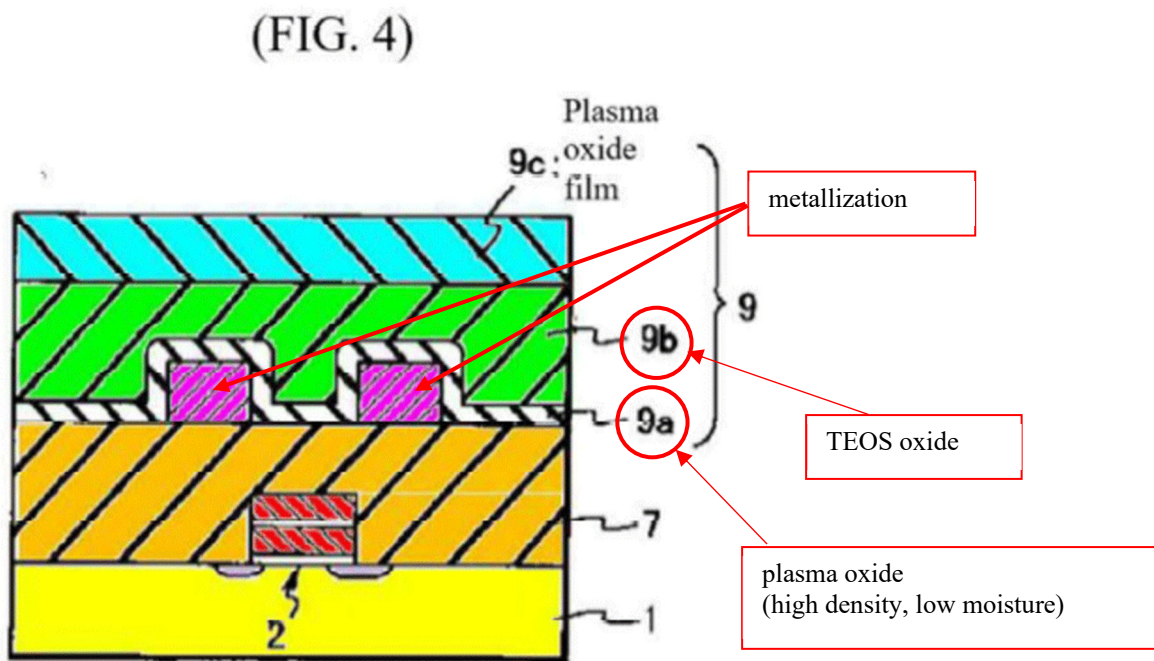
Where the ‘455 Patent describes and claims methods for fabricating an image sensor, Petitioner’s primary reference describes a non-volatile memory. Ex. 1005 (“Oshima”), Abstract. Non-volatile memories are not strictly comparable to image sensors. Maltiel Decl., 78. Where the ‘455 Patent discloses the advantage presence and diffusion of hydrogen, Maltiel Decl., 78, Oshima seeks to prevent the presence of hydrogen and to prevent the diffusion of any hydrogen that is present.

Oshima, Abstract, ¶ 0007; Maltiel Decl. ¶ 78.

Petitioner described Oshima:

Next, Oshima teaches forming, in order, *a plasma oxide film 9a*, a TEOS oxide film 9b (green), and a plasma oxide film 9c (cyan).

Petition, at 12 (emphasis added). While Petitioner focuses on “TEOS oxide film 9b” and “plasma oxide file 9c”, *id.*, “plasma oxide film 9a” is most important, Oshima, Fig. 4; Maltiel Decl., ¶ 79, because Oshima discloses that the plasma oxide film 9a – not the TEOS oxide 9b – in direct contact with metallization. Specifically, Oshima deposits high density, low moisture oxide – “plasma oxide film 9a” – directly on the identified metallization layer. Oshima, Fig. 4; Maltiel Decl., ¶ 79.



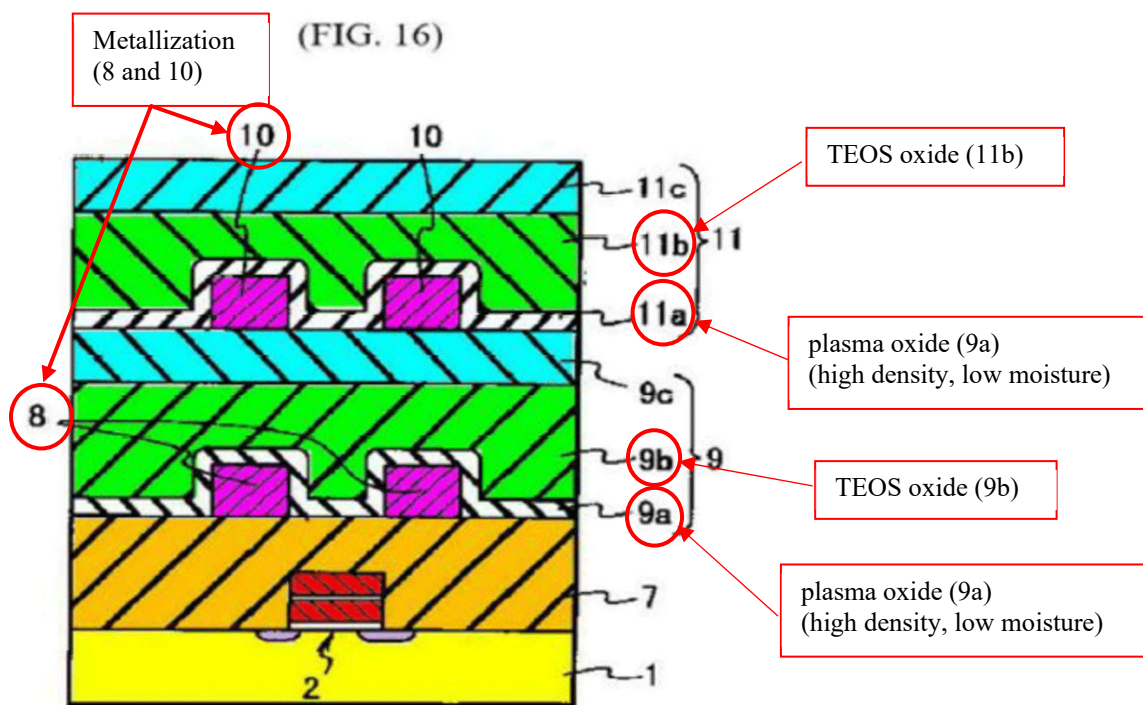
Maltiel Decl., ¶ 79. Petitioner recreated Figure 4 from Oshima, as Figure 4 shows,

layer 9a is plasma oxide film – high density, low moisture silicon oxide. Figure 4 also shows that layer 9b is TEOS oxide. Petitioner, 13. As Petitioner described Oshima:

Next, Oshima teaches forming, *in order*, a plasma oxide film 9a, a TEOS oxide film 9b (green), and a plasma oxide film 9c (cyan). *Id.* at [0023] [0027], Fig. 4; Ex. 1020 ¶52. The plasma oxide film 9a is a silicon oxide film deposited by plasma CVD using mixed gas containing silane (SiH₄) and N₂O gas. *Id.* at [0023], [0002]. The TEOS oxide film 9b is deposited by CVD using a source gas of TEOS and F₂. *Id.* at [0023].

Petitioner, 13 (emphasis added). The Petitioner described Oshima discloses again with reference to Figure 16, high density, low moisture oxide over the metallization layer with TEOS oxide over the high density, low moisture oxide.

Id. at 13 – 14.



Petitioner, 14 (annotated). Similarly, from Figure 16, and the Petitioner, layer 11a

– on the metallization layer 10 is high density, low moisture oxide. Oshima, ¶¶ 0040 - 45 - – and layer 11b is TEOS oxide. Petitioner 14; Oshima, *Id.*; Maltiel Decl., ¶ 81.

Unlike the ‘455 Patent, Oshima consistently discloses a plasma oxide layer on the metallization layer with a TEOS oxide layer over the plasma oxide layer. Maltiel Decl., ¶ 82.

The Institution Decision characterized Oshima:

Oshima teaches forming a first trace layer from aluminum or a similar trace material. *Id.* ¶¶ 21-22. A “*plasma oxide film ... is deposited on the "first trace layer," and a "TEOS oxide film ... is further deposited thereupon.*” *Id.* ¶ 23. “After the TEOS oxide film ... has been leveled, annealing is performed,” and then a “plasma oxide film ... is deposited over the entire surface of the TEOS oxide film.” *Id.* ¶ 27. This film has “the thickness required to prevent hydrogen diffusion without accruing defects.” *Id.* Above this layer, Oshima teaches forming a second metal trace layer, then “*a plasma oxide film, “and “a TEOS oxide film, “and “a plasma oxide film.*” *Id.* ¶¶ 44-45. Finally, Oshima teaches forming a third metal trace layer, then “a passivation film.” *Id.* 146. The passivation film includes a “TEOS oxide film” and a “plasma nitride film.” *Id.* 139.

Institution Decision, 13 – 14 (emphasis added).

In all in disclosures, Oshima discloses depositing “plasma oxide film” – high density, low moisture oxide – on the metallization layer first, then depositing TEOS oxide. Maltiel Decl., ¶ 83. Oshima never discloses or suggests the teaching of the ‘455 Patent of depositing TEOS oxide on the metallization layer, then depositing high density, low moisture oxide on the TEOS oxide layer. Maltiel

Decl., ¶ 84.

Oshima discloses that its objective is to *prevent* the diffusion of hydrogen, hence the high density, low moisture plasma oxide over the metallization layer – with an objective of no hydrogen from the TEOS oxide layer migrating to the silicon substrate interface. Oshima ¶ 0007; Maltiel Decl., ¶ 85. In contrast, one of the ‘455 Patent’s objectives – in both the specification and the claims is to “control” the quantity and migration of hydrogen. ‘455 Patent, 4:45-50; Maltiel Decl., 85.

B. Nagai

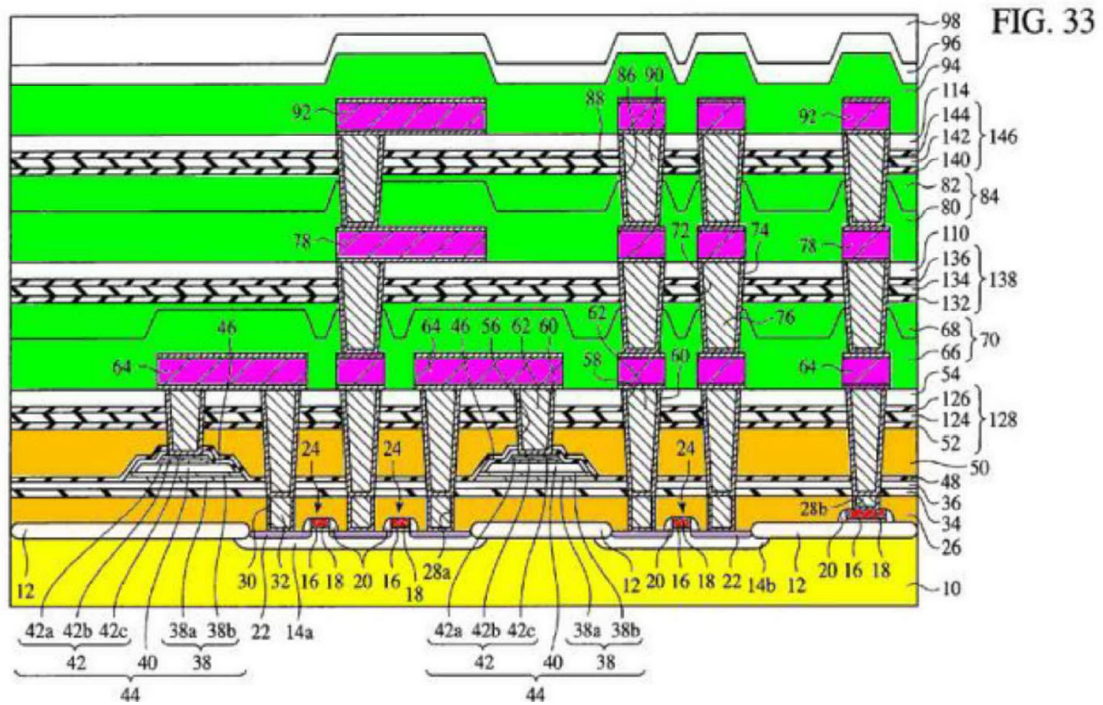
Petitioner’s second primary reference Nagai describes a capacitive memory; it does not describe an image sensor. EX. 1006 (“Nagai”), 2:32-34; Maltiel Decl., 86. As Nagai’s description is a capacitive memory, Nagai’s objective is to limit the presence and to prevent the diffusion of hydrogen. Nagai, 2:24; Maltiel Decl., 86.

Petitioner describes Nagai:

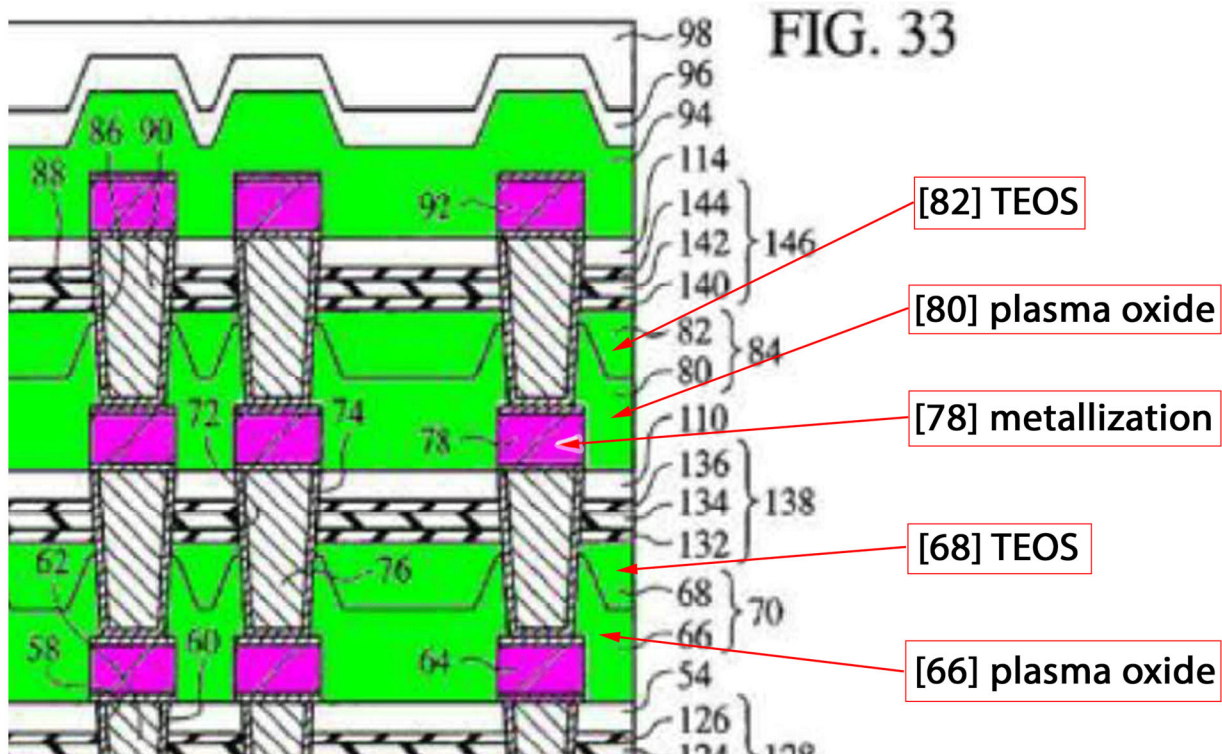
Over each metal interconnection, silicon oxide films 70, 84, and 94 are formed, each by plasma TEOS CVD. Ex. 1006 at 22:21 34, 23:31 43, 24:43 49. Over the silicon oxide film 94, silicon nitride film 96 and polyimide film 98 are formed. Ex. 1020 ¶60.

Petition at 17. Petitioner’s description is inaccurate and incomplete. Petitioner fails to recognize that each of “silicon oxide films 70, 84, and 94” are themselves composed of layers. Taking each in turn, “[I]nter-layer insulation film 70” is

composed of “silicon oxide film 66” that is “high density plasma enhanced CVD” and then silicon oxide film 68 that is formed by plasma TEOS CVD.” Nagai, 22:21–34; Maltiel Decl., 88.



Petitioner, 18 (annotated).



Nagai at Fig. 33 (enhanced portion).

Thus, contrary to the ‘455 Patent’s specification and claims, Nagai at 22:21-34 discloses a high density, low moisture oxide layer directly on the metallization layer that thereby prevents diffusion of hydrogen. Maltiel Decl., 89. Nagai does not disclose the ‘455 Patent’s advantageous use of TEOS oxide on a metallization layer with a cap layer of high density, low moisture oxide on the TEOS oxide. Maltiel Decl., 89.

Petitioner’s description of “silicon oxide film 84” is inaccurate and incomplete. Nagai discloses that “silicon oxide film 84” is composed of multiple, different oxide films:

Next, the layer film 78 is patterned by photolithography. Thus, the interconnection (the second metal interconnection) 78 of the layer film is formed (see FIG. 18).

Next, the silicon oxide film 80 of a 750 nm-thickness is formed by, e.g., high density plasma enhanced CVD.

Next, the silicon oxide film 82 of a 1100 nm-thickness is formed by plasma *TEOS CVD*. The silicon oxide film 80 and the silicon oxide film 82 form the inter-layer insulation film 84.

The silicon oxide film 80 is formed by high density plasma enhanced CVD, and then the silicon oxide film 82 is formed by plasma TEOS CVD here.

Nagai, 23:31-43 (emphasis added). Petitioner fails to recognize that Nagai teaches a high density, low moisture oxide layer directly over the metallization layer with a TEOS oxide layer on the high density, low moisture oxide. Nagai, 23:31-43; Maltiel Decl., 90.

Finally, Petitioner's description of "silicon oxide film 94" is inaccurate and incomplete.

Nagai states:

Next, the silicon oxide film 94 of a 700 nm-thickness is formed by, e.g., high density plasma enhanced CVD.

The silicon oxide film 94 is formed here *by high density plasma enhanced CVD*.

Nagai, 24:43-46. As with all Nagai's disclosures, the disclosure here is high density, low moisture oxide directly on the metallization layer with a TEOS oxide layer on top of the high density, low moisture oxide. *Id.*; Maltiel Decl., 91. Nagai

at 24:43-46 does not disclose a TEOS oxide layer directly on the metallization layer with a high density, low moisture oxide cap. Maltiel Decl., 92.

C. Lee

Petitioner includes Lee to close Petitioner's admitted deficiency in Oshima:

that Oshima does not expressly disclose [generation] of silane oxide by way of reacting silane (SiH_4) gas with oxygen gas, which is required by claim limitations 2[c] and 7[b].

Petition, 46. Petitioner does not contend that Lee discloses any other limitations of any challenged claim. Lee does not disclose, teach, or suggest depositing TEOS oxide on a metallization layer and depositing high density, low moisture oxide on the layer of TEOS oxide. Maltiel Decl., ¶ 93.

D. Crook

Petitioner includes Crook to close Petitioner's admitted deficiency in Oshima:

Crook discloses treating TEOS-based oxide with a hydrogen plasma to control moisture reabsorption after deposition at lower temperatures.

Petition, 53. Petitioner does not contend that Crook discloses any other limitations of any challenged claim. Crook does not disclose, teach, or suggest depositing TEOS oxide on a metallization layer and depositing high density, low moisture oxide on the layer of TEOS oxide. Maltiel Decl., ¶ 94.

E. Miyazaki

Petitioner does not contend that Miyazaki discloses any other limitations of any challenged claim. Miyazaki does not disclose, teach, or suggest Miyazaki does not disclose, teach, or suggest depositing TEOS oxide on a metallization layer and depositing high density, low moisture oxide on the layer of TEOS oxide. Maltiel Decl., ¶ 95. Petitioner only contends that Miyazaki discloses forming protective films generally.

F. Wang

Petitioner does not contend that Wang discloses any other limitations of any challenged claim. Wang does not disclose, teach, or suggest Wang does not disclose, teach, or suggest depositing TEOS oxide on a metallization layer and depositing high density, low moisture oxide on the layer of TEOS oxide. Maltiel Decl., ¶ 96. Wang discloses a Damascus metallization process that is based on copper – and similar metals – and does not utilize aluminum unlike the ‘455 Patent. Maltiel Decl., ¶ 96. The metallization process that Wang discloses does not have the same challenges as the process of the ‘455 Patent or of Petition’s primary references Oshima or Nagai. Maltiel Decl., ¶ 96.

G. Omi

Petitioner does not contend that Omi discloses any other limitations of any challenged claim. Omi does not disclose, teach, or suggest depositing TEOS oxide

on a metallization layer and depositing high density, low moisture oxide on the layer of TEOS oxide. Maltiel Decl., ¶ 97.

VI. THE CITED REFERENCES DO NOT INVALIDATE THE CHALLENGED CLAIMS

“In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.” *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016). The burden of persuasion never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015).

A. Ground 1: Oshima Does Not Anticipate Claims, 1, 5, 6, 9, & 19

As a first matter, Oshima discloses a non-volatile memory. Oshima, Abstract; Maltiel Decl., ¶ 99. An objective of Oshima is to prevent – ideally eliminate – generation or migration, or both, of hydrogen. Oshima, Abstract & ¶0007; Maltiel Decl., ¶ 99. In contrast, the ‘455 Patent discloses an image sensor that advantageously includes controlled amounts of hydrogen; the ‘455 Patent states its objective as, among other things, controlling generation and migration of hydrogen. Maltiel Decl., ¶ 99.

As is discussed in the claim construction section, *supra*, claims 1 and 19 require that “forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure” and then forming a “cap layer over [over the ILD layer] said ILD layer of all of said plurality of metallization layers except

for an uppermost said metallization layer.” Thus, claims 1 and 19 require by the order of processing that the TEOS layer be between a metallization layer and the cap – high density, low moisture – layer. Maltiel Decl., ¶ 101.

Oshima fails to teach or suggest the layer structure of TEOS oxide over a metallization layer with a high density, low moisture oxide cap over the TEOS oxide. *See* Section V.A above; Maltiel Decl. ¶ 102.

1. Oshima Does Not Anticipate Claim 1

Oshima does not disclose or suggest the limitations from Claim 1 of:

forming a plurality of metallization layers over the pre-metal dielectric layer, wherein forming at least one of said metallization layers includes:

forming a patterned metal structure;

forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure; and

forming a cap layer over the ILD layer over said ILD layer of all of said plurality of metallization layers except an uppermost said metallization layer;

wherein forming the cap layer comprises forming a high-density, low-moisture content oxide material having a minimum thickness of 100 Å.

‘455 Patent, Claim 1; Section V.A; Maltiel Decl. ¶ 103. Accordingly, Oshima does not anticipate Claim 1.

2. Oshima Does Not Anticipate Claim 5

Claim 5 depends from Claim 1. ‘455 Patent, Claim 5. As Oshima does not anticipate Claim 1, Oshima cannot anticipate Claim 1’s dependent claim, Claim 5. *See* Section V.A above; Maltiel Decl., ¶ 104.

3. Oshima Does Not Anticipate Claim 6

Claim 6 depends from Claim 5 that depends from Claim 1. ‘455 Patent, Claim 6. As Oshima does not anticipate Claim 1 and Claim 5, Oshima cannot anticipate dependent Claim 6. *See* Section V.A above; Maltiel Decl., ¶ 105.

4. Oshima Does Not Anticipate Claim 9

Claim 9 depends from Claim 1. ‘455 Patent, Claim 9. As Oshima does not anticipate Claim 1, Oshima cannot anticipate dependent Claim 9. *See* Section V.A above; Maltiel Decl., ¶ 106.

5. Oshima Does Not Anticipate Claim 19

Oshima does not disclose or suggest the limitations from Claim 19 of:

- a back-end metallization structure formed on the pre metal dielectric layer, the back-end metallization structure including a plurality of metallization layers formed in a stack, each of the metallization layers including a patterned aluminum layer and an interlevel dielectric (ILD) layer comprising TEOS-based oxide that is formed over the patterned aluminum layer,
- wherein at least one of the plurality of metallization layers includes a cap layer formed on the ILD layer, and
- wherein the cap layer of all of said plurality of metallization layers except an uppermost said metallization layer

comprises a silane oxide layer having a minimum thickness of 100 Å.

‘455 Patent, Claim 19. Maltiel Decl., ¶ 107. Accordingly, Oshima does not anticipate Claim 19.

B. Ground 2: Oshima In View Of Lee Does Not Render Obvious Claims 2, 3, Or 7

Petitioner contends only that Lee discloses a method of forming silane oxide. Section V.C. Petitioner does not contend that Lee discloses the limitations of Claim 1 of:

forming a plurality of metallization layers over the pre-metal dielectric layer, wherein forming at least one of said metallization layers includes:

- forming a patterned metal structure;
- forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure; and
- forming a cap layer over the ILD layer over said ILD layer of all of said plurality of metallization layers except an uppermost said metallization layer;

wherein forming the cap layer comprises forming a high-density, low-moisture content oxide material having a minimum thickness of 100 Å.

‘455 Patent, Claim 1. Accordingly, Oshima in view of Lee cannot, and does not, render Claim 1 obvious because the above-quoted limitations of Claim 1 are not disclosed, taught or suggested in the cited prior art. Maltiel Decl., ¶ 108.

Accordingly, a POSITA would not understand that Claim 1 is obvious by Oshima

in view of Lee. Petitioner has failed to carry its burden of establishing that Oshima renders Claims 1, 5, 6, 9, or 19 obvious.

1. Oshima In View Of Lee Does Not Render Claim 1 Obvious

Oshima in view of Lee does not render Claim 1 obvious as Oshima does not render Claim 1 obvious and Lee does not rectify the inadequacies of Oshima.

Maltiel Decl., ¶ 109.

2. Oshima In View Of Lee Does Not Render Claim 2 Obvious

As Claim 2 depends from Claim 1 and as Oshima in view of Lee does not render Claim 1 obvious, Oshima in view of Lee cannot render Claim 2 obvious. Maltiel Decl., ¶ 110. Oshima in view of Lee does not render Claim 2 obvious as Oshima does not render Claim 1 obvious and Lee does not, and Petitioner does not contend that it does, cure the deficiencies of Oshima. Maltiel Decl., ¶ 110. *See Rembrandt Wireless Techs., LP v. Samsung Elecs. Co.*, 853 F.3d 1370, 1380 (Fed. Cir. 2017) (citing *In re Fine*, 837 F.2d 1071, 1075 (Fed. Cir. 1988) ("Dependent claims are nonobvious under section 103 if the independent claims from which they depend are nonobvious.")).

3. Oshima In View Of Lee Does Not Render Claim 3 Obvious

As Claim 3 depends from Claim 2 that depends from Claim 1. As Oshima in view of Lee does not render Claim 1 or Claim 2 obvious, Oshima in view of Lee cannot render Claim 2 obvious. Maltiel Decl., ¶ 111. Oshima does not render

Claim 1 obvious and Lee does not, and Petitioner does not contend that it does, cure the deficiencies of Oshima.. Maltiel Decl., ¶ 111. *See Rembrandt Wireless*, 853 F.3d at 1380.

4. Oshima In View Of Lee Does Not Render Claim 7 Obvious

As Claim 7 depends from Claim 1 and as Oshima in view of Lee does not render Claim 1 obvious, Oshima in view of Lee cannot render Claim 7 obvious. Maltiel Decl., ¶ 112. Oshima does not render Claim 1 obvious and Lee does not, and Petitioner does not contend that it does, cure the deficiencies of Oshima.. Maltiel Decl., ¶ 112. *See Rembrandt Wireless*, 853 F.3d at 1380.

C. Ground 3: Oshima In View of Crook Does Not Render Obvious Claim 10

Petitioner only contends that Crook discloses a method of treating TEOS oxide. Section V.D. Petitioner does not contend that Crook discloses the limitations of Claim 1 of:

- forming a plurality of metallization layers over the pre-metal dielectric layer, wherein forming at least one of said metallization layers includes:
 - forming a patterned metal structure;
 - forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure;
 - and
 - forming a cap layer over the ILD layer over said ILD layer of all of said plurality of metallization layers except an uppermost said metallization layer;

wherein forming the cap layer comprises forming a high-density, low-moisture content oxide material having a minimum thickness of 100 Å.

‘455 Patent, Claim 1.

Claim 10 depends from Claim 1. Oshima in view of Crook cannot, and does not, render Claim 10 obvious as the Oshima does not render Claim 1 obvious and Crook does not, and Petitioner does not contend that it does, cure the deficiencies in Oshima. Maltiel Decl., ¶ 114. *See Rembrandt Wireless*, 853 F.3d at 1380.

D. Ground 4: Nagai Does Not Anticipate Claims 1, 8, Or 11

As a first matter, Nagai discloses a capacitive memory. Nagai, 2:32-34; Maltiel Decl., ¶ 115. An objective of Nagai is to prevent – ideally eliminate – generation or migration, or both, of hydrogen. Nagai, 2:24; Maltiel Decl., ¶ 115. In contrast, the ‘455 Patent discloses an image sensor that advantageously includes controlled amounts of hydrogen; the ‘455 Patent states its objective as, among other things, controlling generation and migration of hydrogen. Maltiel Decl., ¶ 116. Properly construed, Claim 1 requires that “forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure” and then forming a “cap layer over [over the ILD layer] said ILD layer of all of said plurality of metallization layers except for an uppermost said metallization layer.” Thus, claim 1 requires an order of processing such that the TEOS layer is

disposed between the metallization layer and the cap – high density, low moisture oxide layer - cap - layer. Maltiel Decl., ¶ 116.

Nagai fails to teach or suggest the layer structure of TEOS oxide over a metallization layer with a high density, low moisture oxide cap over the TEOS oxide. *See* Section V.B above; Maltiel Decl., ¶ 117.

Petitioner has failed to carry its burden of establishing that Nagai anticipates Claims 1, 8, or 11.

1. Nagai Does Not Anticipate Claim 1

Oshima does not disclose or suggest the limitations from Claim 1 of:

forming a plurality of metallization layers over the pre-metal dielectric layer, wherein forming at least one of said metallization layers includes:

forming a patterned metal structure;

forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure; and

forming a cap layer over the ILD layer over said ILD layer of all of said plurality of metallization layers except an uppermost said metallization layer;

wherein forming the cap layer comprises forming a high-density, low-moisture content oxide material having a minimum thickness of 100 Å.

‘455 Patent, Claim 1; Section V.B; Maltiel Decl. ¶ 118. Accordingly, Nagai does not anticipate Claim 1.

2. Nagai Does Not Anticipate Claim 8

Claim 8 depends from Claim 1. ‘455 Patent, Claim 8. As Nagai does not anticipate Claim 1, Oshima cannot anticipate Claim 1’s dependent claim, Claim 8.

3. Nagai Does Not Anticipate Claim 11

Claim 11 depends from Claim 1. ‘455 Patent, Claim 11. As Nagai does not anticipate Claim 1, Nagai cannot anticipate dependent Claim 6.

E. Ground 5: Nagai In View Of Miyazaki Does Not Render Obvious Claim 12

Claim 12 depends from Claim 1. Petitioner only contends that Miyazaki discloses forming protective films generally. Section V.F. Petitioner does not contend that Miyazaki discloses the limitations of Claim 1 of:

- forming a plurality of metallization layers over the pre-metal dielectric layer, wherein forming at least one of said metallization layers includes:
 - forming a patterned metal structure;
 - forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure; and
 - forming a cap layer over the ILD layer over said ILD layer of all of said plurality of metallization layers except an uppermost said metallization layer;
- wherein forming the cap layer comprises forming a high-density, low-moisture content oxide material having a minimum thickness of 100 Å.

‘455 Patent, Claim 1. Accordingly, Nagai in view of Miyazaki cannot, and does not, render Claim 12 obvious because these limitations of Claim 12 are not

disclosed, taught or suggested in the cited prior art. Maltiel Decl., ¶¶ 121.

F. Ground 6: Nagai In View Of Lee Does Not Render Obvious Claim 15

Claim 6 depends from Claim 5, and Nagai in view of Lee does not disclose, teach, or suggest the limitations of Claim 6 Maltiel Decl., ¶¶ 122. Accordingly, a POSITA would not understand that Claim 6 is obvious by Nagai in View of Lee. *See Rembrandt Wireless*, 853 F.3d at 1380.

G. Ground 7: Nagai In View Of Wang Does Not Render Obvious Claim 16

1. Motivation To Combine

As discussed above in Section V.F, Wang uses copper metal that requires a Damascus metal definition process that does not utilize aluminum and that does not have the same challenges as the aluminum metal definition process Nagai discloses. Wang, 3:47-49; Maltiel Decl., ¶ 123. Accordingly, a POSITA would not be motivated to combine Nagai with Wang. Maltiel Decl., ¶ 123.

2. The Scope Of The Cited Prior Art Does Not Disclose, Teach, Or Suggest Claim 16

Claim 16 depends from Claim 1, and Nagai in view of Wang does not disclose, teach, or suggest the limitations of Claim 1. Maltiel Decl., ¶ 124. Accordingly, a POSITA would not understand that Claim 6 is obvious by Nagai in View of Wang. *See Rembrandt Wireless*, 853 F.3d at 1380.

H. Ground 8: Nagai In View Of Omi Does Not Render Claims 17 Or 18 Obvious

1. Claim 17

Petitioner contends that Omi discloses using TEOS oxide for an “inter-layer TEOS insulating film. Petition, 24. Petitioner does not contend that Omi discloses, teaches, or suggests:

forming a plurality of metallization layers over the pre-metal dielectric layer, wherein forming at least one of said metallization layers includes:

forming a patterned metal structure; forming an interlevel dielectric (ILD) layer comprising a TEOS-based oxide over the patterned metal structure; and

forming a cap layer over the ILD layer, wherein forming the cap layer comprises forming a high density, low-moisture content oxide material having a minimum thickness of 100 Å,

wherein said semiconductor integrated circuit comprises an array of image sensing pixels disposed inside a rectangular imaging region of said semiconductor substrate

‘455 Patent, Claim 1; Maltiel Decl., ¶ 125. As discussed above in Section V.B, Nagai does not disclose these limitations. Maltiel Decl., ¶ 125. In addition, Omi does not disclose, teach, or suggest these limitations. *Id.* Accordingly, Nagai in view of Omi does not render Claim 17 obvious. *Id.*

2. Claim 18

Claim 18 depends from Claim 17, and Nagai in view of Omi does not disclose, teach, or suggest the limitations of Claim 17. Maltiel Decl., ¶ 126.

Accordingly, Nagai in View of Omi does not render Claim 18 obvious. Maltiel Decl., ¶ 126.

VII. CONCLUSION

For these reasons, Patent Owner submits that Petitioner has failed to meet its burden of proving that any challenged claim of the '455 patent is unpatentable.

DATE: October 11, 2023

Respectfully Submitted,

/s/ Eric Cohen
Eric Cohen
Registration No. 27,429

Counsel for Patent Owner Alidouble Inc.

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24, I hereby certify that the foregoing Patent Owner Response contains 7162 words as measured by the word processing software used to prepare the document, excluding the cover page, signature block, and portions exempted under 37 C.F.R. § 42.24.

DATE: October 11, 2023

Respectfully Submitted,

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Counsel for Patent Owner Alidouble Inc.

CERTIFICATE OF SERVICE

Pursuant to 37 CFR § 42.6(e), the undersigned hereby certifies that a copy of the Patent Owner's Response Under 37 C.F.R. §42.107 by P-TACS electronic notification and electronic mail to each of the following individuals on the date indicated below:

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