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BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte YASUYUKI HOSHI, YUICHI HARADA, and TAKASHI SHIIGI

Appeal 2019-000114
Application 15/250,005
Technology Center 2800

Before JEFFREY B. ROBERTSON, JEFFREY R. SNAY, and MICHAEL G. MCMANUS, *Administrative Patent Judges*.

SNAY, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

Pursuant to 35 U.S.C. § 134(a), Appellant[1] appeals from the Examiner's decision rejecting claims 1, 3, and 5–12. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM-IN-PART.

[1] We use the word Appellant to refer to "applicant" as defined in 37 C.F.R. § 1.42. Appellant identifies the Fuji Electric Co., Ltd. as the real party in interest. Appeal Brief, February 26, 2018, 3.

BACKGROUND

The invention relates to a semiconductor device and its method of manufacture. Spec. 1. Claims 1 reads as follows:

> 1. A semiconductor device, comprising:
>
> a substrate formed of a wide-band-gap semiconductor material that has a band gap greater than that of silicon, the substrate having a front surface and a back surface;
>
> a deposit layer formed of the wide-band-gap semiconductor material and having an impurity concentration lower than that of the substrate, the deposit layer having a first side and a second side opposite to the first side, and being deposited on the front surface of the substrate that is located on the second side;
>
> a semiconductor region selectively disposed in the deposit layer on the first side thereof;
>
> a semiconductor layer formed of the wide-band-gap semiconductor material, disposed on a surface of the deposit layer on the first side and a surface of the semiconductor region formed in the deposit layer, the semiconductor layer having selectively disposed therein a first region, a second region and a contact region;
>
> a gate electrode disposed, via a gate insulating film, on the semiconductor layer and the first region;
>
> an interlayer insulating film covering the gate electrode;
>
> a source electrode in contact with the contact region and the second region;
>
> a drain electrode disposed on the back surface of the substrate;
>
> a plating film selectively disposed on the source electrode; and
>
> a pin electrode in contact with the plating film, wherein
>
> the substrate, the deposit layer, and the first and second regions formed in the semiconductor layer are of a first conductivity type,
>
> the semiconductor region, the semiconductor layer and the contact region formed therein are of a second conductivity type,
>
> the source electrode has a first titanium nitride (TiN)

> film, and a first titanium (Ti) film, a second TiN film, a second Ti film, and a metal film containing aluminum (Al) sequentially formed on the first TiN film, and
>
> the first TiN film is formed on, and in direct contact with, the interlayer insulating film.

Appeal Br.[2] 15–16 (Claims Appendix) (emphasis added to highlight a key recitation in dispute). Claim 7 recites a method for making a device essentially as recited in claim 1. Claim 12 is similar to claim 1 and requires a second protective film that is a polyamide. Each remaining claim on appeal depends from claim 1 or 7.

REJECTIONS

I. Claims 1, 3, and 5–9 stand rejected under 35 U.S.C. § 103 as unpatentable over Applicant's Admission of Prior Art ("AAPA")[3] and Moon.[4]

II. Claims 10 and 11 stand rejected under 35 U.S.C. § 103 as unpatentable over AAPA, Moon, and Wanlass.[5]

III. Claim 12 stands rejected under 35 U.S.C. § 103(a) as unpatentable over AAPA and Merchant.[6]

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[2] Appellant's Claims Appendix and arguments are found in Appellant's Supplemental Appeal Brief, filed April 4, 2018, which we cite as "Appeal Br." in this Decision.
[3] The Examiner relies on Figure 3 of the Specification as Admitted Prior Art. Final Act. 2–3.
[4] US 2006/0183327 A1, published August 17, 2006.
[5] US 6,069,047, issued May 30, 2000.
[6] US 6,410,986 B1, issued June 25, 2002.

OPINION

Rejection I: obviousness over AAPA and Moon

With regard to Rejection I, Appellant argues only claim 1. *See* Appeal Br. 7–14. We focus our remarks on Appellant's arguments concerning claim 1. Claims 3 and 5–9 stand or fall with claim 1.

Claim 1 requires, *inter alia*, a source electrode having a first TiN film formed on and in direct contact with an interlayer insulating film, and a first Ti film, second TiN film, second Ti film, and Al-containing metal film sequentially formed on the first TiN film. The Examiner finds AAPA includes all of the features recited in claim 1 except the above-noted source electrode structure. Final Act. 2–4. Rather, AAPA provides a source electrode having "a two-layer structure of a first Ti film 21 and an Al–Si film 24." Spec. 4. The Examiner further finds that Moon teaches a source electrode having barrier layers in the form of a TiN/Ti/TiN/Ti layered structure which advantageously provides increased oxidation resistance. Final Act. 4 (citing Moon ¶¶ 31, 46).

Appellant argues Moon's disclosed increase in oxidation resistance requires a nitrogen rich region formed at the top surface of the barrier layer, and that the presence of such a nitrogen rich region would fail to meet the source electrode structure recited in claim 1. Appeal Br. 7–9; Reply Br. 3. Appellant also argues that removing Moon's nitrogen-rich regions would change the principle of operation of the barrier layers and would render them unsatisfactory for their intended purpose. Appeal Br. 12–14.

Appellant's arguments are not persuasive of reversible error. Moon expressly teaches using TiN/Ti/TiN/Ti barrier layer stacks to provide increased oxidation resistance. Moon ¶ 46 ("Barrier layer stacks comprising

. . . TiN/Ti/TiN/Ti . . . may be formed. A multi-layer stack of barrier layers provides increased oxidation resistance."). Appellant correctly notes that Moon further discloses providing nitrogen-rich regions. Moon teaches forming such regions through nitridation of deposited Ti or TiN layers. *See e.g.* Moon ¶ 28 ("[T]he top surface of the barrier layer **106** is exposed to a nitridation treatment **108**, as shown in **Fig. 2** in a cross-sectional view, to form a barrier layer **106'** having a nitrogen rich region **110** disposed at a top surface thereof."). *See also id.* ¶ 46 ("[A] plurality of barrier layers may be deposited and exposed to the nitridation treatment . . . to form a multi-stack of enhanced barrier layers."). Thus, Moon teaches sequentially formed TiN/Ti/TiN/Ti layers that are subjected to nitridation. Appellant does not point to, and we do not see, language in claim 1 that would preclude Moon's nitridation step, or that would require any of the recited Ti or TiN layers to be free of nitrogen-rich regions.

Appellant also argues Moon teaches use of barrier layers to prevent copper diffusion, whereas AAPA does not disclose copper as a material component of the semiconductor device. Appeal Br. 9–12; Reply Br. 5. This argument also is not persuasive. AAPA includes "a metal film containing aluminum" as a source electrode material. Spec. 6. Moon teaches copper provides certain advantages relative to aluminum in integrated circuits, including "decreased resistivity, resulting in increased speed, decreased RC time delay, and the ability to form thinner conductive lines." Moon ¶ 4. As such, Moon provides a reason to include copper in the semiconductor device of AAPA. *See also*, *id.* ¶ 31 ("The conductive material **112** may comprise copper, aluminum, tungsten, or combinations or alloys thereof."). Moreover, Appellant's argument neither refutes nor

addresses the Examiner's stated reason for adopting Moon's barrier layers in AAPA—namely, increased oxidation resistance. *See id.* ¶ 11 ("The novel barrier layers described herein have improved copper diffusion barrier properties *and* increased oxidation resistance.") (emphasis added).

For the foregoing reasons, Rejection I is sustained.

Rejection II: obviousness over AAPA, Moon, and Wanlass

Appellant does not separately argue Rejection II except to rely on the arguments presented in connection with claim 1. Appeal Br. 14. We sustain Rejection II for the reasons set forth above regarding claim 1.

Rejection III: obviousness over AAPA and Merchant

With regard to the Examiner's rejection of claim 12, Appellant argues the Examiner erred in finding AAPA includes a second protective film that is polyamide. Appeal Br. 14. We agree.

Claim 12 requires a polyamide second protective film. The Examiner finds AAPA includes a "second protective film (17) [which] is a polyamide film." Final Act. 10. In support of that finding, the Examiner solely relies on the fact that the Specification identifies reference numeral 17 in Figure 2 as a polyamide film. Ans. 9. However, as Appellant correctly observes, Figure 2 in the Specification corresponds to an embodiment of the invention, not admitted prior art. *See, e.g.,* Spec. 7. The Examiner does not identify evidence sufficient to support a finding that reference numeral 17 in Figure 3, which corresponds to AAPA, is a polyamide film.

For the foregoing reason, we do not sustain Rejection III.

CONCLUSION

The Examiner's decision rejecting claims 1, 3, and 5–11 is affirmed.

The Examiner's decision rejecting claim 12 is reversed.

DECISION SUMMARY

In summary:

Claims Rejected	35 U.S.C. §	Reference(s)/Basis	Affirmed	Reversed
1, 3, 5–9	103	AAPA, Moon	1, 3, 5–9	
10, 11	103	AAPA, Moon, Wanlass	10, 11	
12	103	AAPA, Merchant		12
Overall outcome			1, 3, 5–11	12

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

AFFIRMED-IN-PART