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UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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Ex parte YUTO YAKUBO,
SUGURU HONDO, AKIHISA SHIMOMURA,
SHUNPEI YAMAZAKI,
and SHUHEI NAGATSUKA

_____

Appeal 2018-005730
Application 14/704,101
Technology Center 2800

_____

Before ADRIENE LEPIANE HANLON, CATHERINE Q. TIMM, and N. WHITNEY WILSON, *Administrative Patent Judges*.

HANLON, *Administrative Patent Judge*.

DECISION ON APPEAL

A. STATEMENT OF THE CASE

The Appellant[1] filed an appeal under 35 U.S.C. § 134(a) from an Examiner's decision finally rejecting claims 1–7, 12–18, 23, and 24 under 35 U.S.C. § 103 as

[1] We use the word Appellant to refer to "applicant" as defined in 37 C.F.R. § 1.42. The Applicant and the real party in interest are identified as Semiconductor Energy Laboratory Co., Ltd. Appeal Brief dated December 7, 2017 ("Appeal Br."), at 1.

unpatentable over Yamazaki 170[2] in view of Park[3] and Yamazaki 114.[4,5] Claims 8–11 and 19–22 are also pending but have been withdrawn from consideration. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM.

Representative claim 1 is reproduced below from the Claims Appendix to the Appeal Brief. The limitation at issue is italicized.

1. A transistor comprising:

a first oxide semiconductor layer;

a second oxide semiconductor layer over the first oxide semiconductor layer;

a source electrode and a drain electrode over the second oxide semiconductor layer;

a third oxide semiconductor layer over the source electrode, the drain electrode and the second oxide semiconductor layer;

a gate insulating layer over the third oxide semiconductor layer; and

a gate electrode layer over and in contact with the gate insulating layer,

wherein cutoff frequency of the transistor at a source-drain voltage of higher than or equal to 1 V and lower than or equal to 2 V is higher than 1 GHz,

wherein a channel length is less than 100 nm,

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[2] US 2012/0001170 A1, to Yamazaki, published January 5, 2012 ("Yamazaki 170").
[3] US 2010/0176383 A1, to Park et al., published July 15, 2010 ("Park").
[4] US 2012/0319114 A1, to Yamazaki et al., published December 20, 2012 ("Yamazaki 114").
[5] In the Final Office Action dated August 9, 2017 ("Final Act."), claim 23 is not included in the statement of the rejection but is addressed in the body of the rejection. *See* Final Act. 3, 9. The statement of the rejection has been corrected to include claim 23.

> wherein the gate insulating layer includes a region in contact with a top surface of the third oxide semiconductor layer,
>
> wherein the gate electrode layer partly overlaps with the first oxide semiconductor layer, the second oxide semiconductor layer and the third oxide semiconductor layer,
>
> wherein the third oxide semiconductor layer is in contact with side surfaces of the second oxide semiconductor in a channel length direction and a channel width direction,
>
> wherein the third oxide semiconductor layer is in contact with side surfaces of the first oxide semiconductor in a channel length direction and a channel width direction,
>
> wherein the second oxide semiconductor layer includes a plurality of c-axis aligned crystals, and
>
> wherein the second oxide semiconductor layer includes a region in which concentration of hydrogen measured by secondary ion mass spectrometry is lower than 2×10^{20} atoms/cm^3.

Appeal Br. 8–9.

Claim 12, the other independent claim on appeal, is said to "differ[] from claim 1 only in that claim 12 recites a maximum oscillation frequency . . . as opposed to the cutoff frequency recited in claim 1." Appeal Br. 3 (emphasis omitted). Claim 12 recites that the "maximum oscillation frequency of the transistor at a source-drain voltage of higher than or equal to 1 V and lower than or equal to 2 V is higher than 1 GHz." Appeal Br. 10.

B. DISCUSSION

1. Claims 1–7 and 23

The Examiner finds Yamazaki 170 discloses a transistor as recited in claim 1 with the exception of the following two limitations: "the second oxide semiconductor layer includes a plurality of c-axis aligned crystals" and "the cutoff frequency of the transistor at a source-drain voltage of higher than or equal to 1 V and lower than or equal to 2 V is higher than 1 GHz." Final Act. 5.

The Examiner finds Yamazaki 114 discloses a second oxide semiconductor layer including a plurality of c-axis aligned crystals. Final Act. 5. The Examiner concludes, and the Appellant does not dispute, that it would have been obvious to one of ordinary skill in the art to modify the second oxide semiconductor layer of Yamazaki 170 with a plurality of c-axis aligned crystals to increase electron mobility as disclosed in Yamazaki 114. Final Act. 5 (citing Yamazaki 114, at ¶ 90).

As for the claimed cutoff frequency, the Examiner finds that "because the structure taught [in] the prior [art] is identical or substantially similar to that of the claims, the claimed properties or functions are presumed to be inherent. . . . The burden is on Applicant to rebut such evidence." Final Act. 5–6 (citing *In re Best*, 562 F.2d 1252, 1254 (CCPA 1977)).

As the Court stated in *Best*, 562 F.2d at 1255, where the claimed and prior art products are identical or substantially identical, the United States Patent and Trademark Office (USPTO) can require an applicant to prove that the prior art products do not necessarily or inherently possess the characteristics of the claimed product. Whether the rejection is based on inherency or obviousness, the burden of proof is the same, and its fairness is evidenced by the inability of the USPTO to manufacture products or to obtain and compare prior art products. *Id*.

The Appellant does not direct us to any error in the Examiner's finding that the structure of the modified Yamazaki 170 transistor is substantially the same as the structure of the transistor recited in claim 1. Nonetheless, the Appellant argues that the Specification describes at least three properties, in addition to the claimed structural limitations, that affect a transistor cutoff frequency. Appeal Br. 4. Those properties are said to be (1) the ratio of elements that make up an oxide semiconductor in the transistor; (2) the transistor's channel width to length (W/L)

ratio; and (3) the internal capacitance of the transistor in a region where the gate electrode overlaps with the source or drain electrode (C_{ov}).[6] Appeal Br. 4 (citing Spec. ¶¶ 257–259, 285–287, 294–299; Figs. 20, 24).

As for the first property (i.e., the ratio of elements), the Appellant argues:

> The specification presents experimental results from testing the cutoff frequencies of two different transistors (Transistor A and Transistor B) in figures 20 and 24 . . . . ([Spec.] at [0285]). Transistor A and Transistor B differed only in the ratio of elements used in one of the oxide semiconductor layers (semiconductor layer 662).[7] ([Spec.] at [0257]-[0259]; and Table 3 . . .). Figures 20 and 24 clearly show that Transistor A's cutoff frequency was different from that of Transistor B. For instance, FIG. 24 shows a 9.9GHz cutoff frequency (f_T) for Transistor A but a 20.1GHz cutoff frequency for Transistor B. (See also [Spec.] at [0293]). Thus, the specific ratio of elements that make up an oxide semiconductor layer affect a transistor's cutoff frequency.

Appeal Br. 4–5 (footnote omitted).

The Examiner finds, and the Appellant does not dispute, that the Appellant's disclosed ratio of elements is taught in the prior art. In particular, the Examiner finds:

> According to Appellant's arguments on pages 4-5 [of the Appeal Brief] and table 3 [on page 61 of the Specification], and figures 20 and 24, if the oxide semiconductor has a stoichiometric composition of In:Ga:Zn = 1:1:1 then it will have a cutoff frequency of 9.9 GHz.

[6] The Appellant discloses that C_{ov} represents capacitance of a region where the gate electrode overlaps with the source or drain electrode. Spec. ¶ 295.
[7] The ratio of elements in semiconductor layer 662 of Transistor A is In:Ga:Zn = 1:1:1, and the ratio of elements in semiconductor layer 662 of Transistor B is In:Ga:Zn = 4:2:4.1. Spec. ¶ 259, Table 3.

> Yamazaki [170] teaches in ¶ 0091 the ratio of In:Ga:Zn = 1:1:1. Additionally, Yamazaki [114] also teaches the ratio of In:Ga:Zn = 1:1:1. ¶ 0078.

Ans. 4.[8]

As for the channel width to length (W/L) ratio, the Appellant discloses that the cutoff frequencies of Transistor A and Transistor B, having a channel width W of 60 nm and a channel length L of 60 nm (Spec. ¶ 270), are as follows:

Transistor A: 4.9 GHz at V_D = 1.0 V and 9.7 GHz at V_D = 2.0 V

Transistor B: 11 GHz at V_D = 1.0 V and 19 GHz at V_D = 2.0 V

Spec. ¶¶ 286–87.

The Appellant also discloses that Transistor A and Transistor B, having a channel width W of 18 μm and a channel length L of 60 nm, have the following cutoff frequencies:

Transistor A: 9.9 GHz at V_D = 2.0 V

Transistor B: 20.1 GHz at V_D = 2.0 V

Spec. ¶ 293.

We find that the cutoff frequencies of Transistor A, having W/L ratios of 60 nm/60 nm and 18 μm/60 nm, are substantially identical at V_D = 2.0 V. *See* Spec. ¶¶ 286, 293. Similarly, we find that the cutoff frequencies of Transistor B, having W/L ratios of 60 nm/60 nm and 18 μm/60 nm, are very close at V_D = 2.0 V. *See* Spec. ¶¶ 287, 293. Thus, on this record, it appears that the two channel width to length (W/L) ratios disclosed in the Appellant's Specification[9] do not have a

[8] Examiner's Answer dated March 12, 2018.
[9] *See* Reply Brief dated May 14, 2018, at 4 (contending that the W/L ratios of 18μm/60nm and 60nm/60nm "span a range of channel widths 300 times greater than the lower bound of the range (e.g., 18μm is 300 times larger than 60nm)").

significant effect on cutoff frequency once the ratio of elements making up the oxide semiconductor layer(s) is selected.[10]

As for C_{ov}, the Appellant discloses that "C_{ov} is dominant in C_{gs} [gate-source capacitance] and C_{gd} [gate-drain capacitance] and that higher cutoff frequency f_T can be obtained by reducing C_{ov}." Spec. ¶ 299. The Appellant, however, does not direct us to any evidence establishing how much the gate electrode must overlap with the source or drain electrode to achieve a cutoff frequency within the range recited in claim 1. *See* Ans. 5 ("Looking at the cited paragraphs we find no direction on *how much overlap* between the gate electrode and the source or drain electrode is required to reduce C_{ov} to get the required cutoff frequency" (emphasis added).). Conversely, the Appellant does not identify the C_{ov} of a transistor with a cutoff frequency outside the range recited in claim 1.

In sum, we find that a preponderance of the evidence of record supports the Examiner's finding that the modified transistor of Yamazaki 170, which comprises an oxide semiconductor layer having a stoichiometric composition of In:Ga:Zn = 1:1:1, inherently has a cutoff frequency within the range recited in claim 1. Therefore, the obviousness rejection of claims 1–7 and 23 is sustained.

2. Claims 12–18 and 24

Claim 12 recites that the "maximum oscillation frequency of the transistor at a source-drain voltage of higher than or equal to 1 V and lower than or equal to 2 V is higher than 1 GHz." Appeal Br. 10.

[10] Notably, the cutoff frequencies disclosed in paragraphs 286, 287, and 293 of the Specification fall within the range recited in claim 1. The Appellant does not direct us to any example of a transistor having the claimed structure and a cutoff frequency outside the range recited in claim 1.

The Appellant does not present arguments in support of the separate patentability of claim 12.[11] Rather, the Appellant contends that the arguments presented in the Appeal Brief are "primarily in reference to claim 1" but "the rationale applies equally to the rejection of claim 12 and its dependent claims." Appeal Br. 3.

For the reasons discussed above, the Appellant's arguments are not persuasive of reversible error in the obviousness rejection of claim 1. Therefore, the obviousness rejection of claims 12–18 and 24 also is sustained.

C. CONCLUSION

The Examiner's decision is affirmed.

Claims Rejected	35 U.S.C. §	Rejection(s)/Basis	Affirmed	Reversed
1–7, 12–18, 23, 24	103	Yamazaki 170, Park, Yamazaki 114	1–7, 12–18, 23, 24	

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

[11] The Appellant points out that the maximum oscillation frequency of Transistor A is 14.3 GHz and the maximum oscillation frequency of Transistor B is 26.7 GHz. Appeal Br. 5, n.1 (citing Spec. ¶ 293; Figs. 21, 24). Notably, the maximum oscillation frequency of Transistor A and the maximum oscillation frequency of Transistor B are both within the range recited in claim 12.