Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.
DECISION ON REHEARING

Appellant requests rehearing of a Decision on Appeal mailed September 27, 2017 affirming the Examiner’s decision that claims 1–14 and 18–20 are unpatentable over the applied prior art.

A Request for Rehearing must state with particularity the points

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1 Appellant is the Applicant, Institute of Microelectronics, Chinese Academy of Sciences, which, according to the Appeal Brief, is the real party in interest. Appeal Brief (Appeal Br.) filed April 29, 2016. Appeal Br. 3.

2 Hereinafter, “Decision.”

3 Hereinafter, “Request.”
believed to have been misapprehended or overlooked by the Board. Arguments not raised and evidence not previously relied upon in the Briefs before the Board are not permitted in a Request for Rehearing except as permitted by 37 C.F.R. §§ 41.52(a)(2) and (a)(3). See 37 C.F.R. § 41.52(a)(1) (2016).

We have reconsidered the Decision in light of Appellant’s comments in the Request and find no error in the disposition of the affirmed rejections. We remain of the opinion that the subject matter of the claims is unpatentable in view of the applied prior art.

I.

The Board’s Decision affirmed the Examiner’s rejection under 35 U.S.C. § 103(a) of claims 1, 6–8, 10, 18, and 20 over Xu ’328 in view of Gulari and Ramin.

In the Request, Appellant requests reconsideration of the rejection for claim 1. Request 2–8. Appellant argues that it is not their burden to identify an error because the Examiner has merely made allegations without meeting the Examiner’s burden of establishing a prima facie case of obviousness. Request 5. We disagree. “[T]he examiner bears the initial burden, on review of the prior art or on any other ground, of presenting a prima facie

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4 Xu et al., CN 102339858 A, published Feb. 1, 2012. The Examiner cites Xu et al. by its application number, 201010233549 (Final Office Action (Final Act.) mailed Sept. 29, 2015, Final Act. 2), instead of the publication number. Further references to Xu et al. will refer to US 2013/0099328 A1, published Apr. 25, 2013 (“Xu ’328”), which the Examiner indicates is an English language equivalent. Id.


case of unpatentability. If that burden is met, the burden of coming forward with evidence or argument shifts to the applicant.” *In re Oetiker*, 977 F.2d 1443, 1445 (Fed. Cir. 1992). Here, the Examiner has set forth a prima facie case of obviousness based upon the teachings of the prior art regarding dopants to adjust the work function of a gate electrode of a transistor. As a result, the burden has shifted to the Appellant to identify a reversible error in the Examiner’s rejection. *In re Jung*, 637 F.3d 1356, 1365 (Fed. Cir. 2011) (rejecting the argument that the Board improperly shifted the burden to identify a reversible error where the examiner established a prima facie case of unpatentability and the burden was properly shifted to the applicant to rebut it).

Appellant further disputes that the applied references, particularly Xu ’328 and Ramin, recognize aluminum and boron as equivalents for p-type doping of a metal gate layer because Ramin discloses a Group IIIa element as a dopant for polysilicon of a PMOS (p-type metal oxide semiconductor), not a dopant to alter the work function of a metal gate layer. Reply Br. 3–5. Appellant further argues that simply because two elements are equivalent in one aspect, such as for doping polysilicon gates, does not mean that the two elements are equivalent in other aspects, such as being dopants to adjust the work function of a metal gate electrode, as recited in claim 1. *Id.* at 5.

Appellant’s arguments are unpersuasive. As stated at pages 4–5 of the Decision, the Examiner finds Xu ’328 discloses the introduction of aluminum into a gate stack but does not disclose implanting dopant ions in a metal gate layer to increase an effective work function of a PMOSFET, wherein the dopant is selected from In, B, BF₂, Ru, W, and Mo. *See Final
Act. 3. The Examiner finds Ramin teaches that aluminum and boron are equivalent p-type dopants for gate electrodes. Decision 5; Final Act. 4.

Xu ’328 discloses a semiconductor device that includes a substrate \textbf{1000},\textsuperscript{7} isolation structures \textbf{1022}, an oxide layer (not depicted in the drawings of Xu ’328), a second dielectric layers \textbf{1004} and \textbf{1008} that each contain aluminum, a first dielectric layer \textbf{1006} that is a high-K gate dielectric layer, a first metal layer \textbf{1010} (i.e., metal gate layer) comprising a metal nitride including aluminum, a second metal layer \textbf{1012}, a polysilicon layer \textbf{1014}, forming a gate stack from the layers, and a sidewall spacer \textbf{1016}. Xu ’328 ¶¶ 25, 28, 32, 33, 38, 51. Xu ’328 further discloses annealing a semiconductor device after formation of source/drain regions to form Al–O dipoles. Xu ’328 ¶ 53. Specifically, the aluminum provided in the gate dielectric layers \textbf{1004} and \textbf{1008} and in the gate electrode \textbf{1010} form Al–O electric dipoles at the interface for the high-K gate dielectric layer and the metal gate layer. \textit{Id.} ¶¶ 46, 37, 56. Xu ’328 teaches that the dipoles change the energy level at the interface, which affects the gate work function. \textit{Id.} ¶¶ 37, 56. In addition, Xu ’328 discloses its invention is useful for tuning the work function of a PMOS metal gate. \textit{Id.} ¶ 20.

Ramin discloses a PMOS transistor in which a dopant is used to adjust the work function of the transistor and convert a polysilicon electrode to a fully silicided gate electrode. Ramin ¶ 9. Ramin discloses a work function adjustment by implanting a p-type dopant into an exposed gate electrode made of polysilicon. \textit{Id.} ¶¶ 9, 45. Specifically, Ramin discloses:

The PMOS work function adjustment implant \textbf{230} is now performed on the exposed region containing the PMOS transistor

\textsuperscript{7} Throughout this Decision, for clarity, we present labels to elements in figures in bold font, regardless of their presentation in the original document.
Specifically, p-type dopants selected from the Group IIIa series (e.g. B, Al, Ga, In, Tl) are implanted into the exposed gate electrode 113 of the PMOS transistor 60.

Id. ¶ 45. Thus, Ramin does not merely disclose that boron and aluminum are equivalent p-type dopants, but are equivalents for adjusting the work function of a gate electrode for a transistor. We are not saying that boron and aluminum are identical in their level of performance as dopants to adjust the work function of a gate electrode but that the applied references demonstrate they are equivalent for adjusting the work function of a gate electrode.

Appellant asserts that the mere fact that components are members of a Markush group does not establish equivalency of the components. Request 4. This argument does not address the rejection because Ramin teaches that aluminum and boron are examples of p-type dopants that can be used to adjust the work function of a gate electrode. Thus, either aluminum or boron could be used for this purpose in view of Ramin’s disclosure.

With regard to Appellant’s arguments that Xu ’328 discloses a gate electrode made of a metal nitride but Ramin discloses a gate electrode made of polysilicon, Ramin discloses that boron or aluminum can be used to adjust the work function of an electrode for a transistor. Ramin ¶¶ 9, 45. Appellant does not direct us to any evidence or persuasive technical reasoning that boron would not function to adjust the work function of the particular metal gate layer materials of Xu ’328. Appellant asserts that observations such as these improperly shifts the burden. Request 6. This is unpersuasive. As noted above, the Examiner’s prima facie case of obviousness has shifted the burden to Appellant to identify a reversible
error, not determinations by the Board regarding the merits of Appellant’s arguments, reasoning, and evidence.

Moreover, we note Schulz discloses implanting a dopant species to tune the work function of a metal gate electrode. Schulz ¶ 67. Schulz discloses that the dopant species can be boron and that the metal gate electrode material can be TiAlN (Schulz ¶ 69), which is one of the materials disclosed by Xu ’328 for its metal gate electrode (Xu ’328 ¶ 46). Therefore, the disclosure of Schulz serves as additional evidence that boron would function to adjust the work function of a metal gate electrode, including a particular metal gate electrode of Xu ’328.

Appellant contends “Schulz does not demonstrate that testing or manufacturing a metal gate doped with B or BF$_2$ ions had actually been achieved” and that “the lack of known testing or actual manufacture of a metal gate doped with B, BF$_2$ is a factor in generally demonstrating non-obviousness.” Request 7–8. These arguments are unpersuasive. A reference is presumed to be enabling. In re Sasse, 629 F.2d 675, 681 (CCPA 1980) (it is applicant’s burden to demonstrate non-enablement of a reference). Appellant merely asserts that Schulz lacks actual testing without providing any evidence or persuasive technical reasoning that the disclosure of Schulz would not enable one of ordinary skill in the art to dope a metal gate electrode of a transistor, such as a gate electrode made of TiAlN, with boron to tune its work function without undue experimentation. Therefore, Appellant has not met their burden of showing that the disclosure of Schulz

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does not enable one of ordinary skill in the art to make the transistor it discloses.

Appellant also argues that Schulz contemplates thousands of combinations of different gate materials and dopant species. Request 8. As discussed above, Schulz expressly teaches boron as a dopant species to tune the work function of a gate electrode and expressly discloses that the gate electrode material can be TiAlN. Moreover, the disclosure of many effective combinations does not negate the obviousness of any of those combinations. See, e.g., Merck & Co. v. Biocraft Labs., Inc., 874 F.2d 804, 807 (Fed. Cir. 1989) (“That the [prior art] patent discloses a multitude of effective combinations does not render any particular formulation less obvious. This is especially true because the claimed composition is used for the identical purpose taught by the prior art.”).

The 37 C.F.R. § 1.132 Declaration of Qiuxia Xu (“Declaration”) submitted February 29, 2016 includes statements regarding whether aluminum and boron are equivalents for doping metal gates. Specifically, the Declaration states aluminum ions are not compatible with CMOS Front End of Line (FEOL) processes because the aluminum ions will cause contamination; aluminum tends to form alumina, which causes degradation of performance; and the ability of aluminum to adjust an effective work function is less than that for boron or BF₂. Declaration ¶¶ 4–6. However, to the extent these statements may demonstrate differences between aluminum and boron as dopants or differences in their effectiveness as dopants, the statements fail to demonstrate that both aluminum and boron are not useful as dopants to adjust the work function of a transistor, as suggested by the disclosures of Xu ’328 and Ramin. In fact, these statements appear to be
rebutted by the disclosure of Schulz, which provides evidence that it was known to use boron to dope a metal gate electrode and tune its work function, as discussed above.

The Declaration also includes statements addressing whether it would have been obvious to select B or BF₂ over Al as a dopant. *Id.* ¶¶ 7–9. These statements are entitled to little weight because they regard legal issues without considering and discussing the prior art disclosures in a meaningful way. *In re Reuter*, 670 F.2d 1015, 1023 (CCPA 1981) (expert’s opinion on ultimate legal issue entitled to no weight); cf. *Icon Health and Fitness, Inc.* v. *Strava, Inc.*, 849 F.3d 1034, 1041 (Fed. Cir. 2017) (“[W]e frequently have affirmed PTAB determinations on obviousness that rely on expert declarations that include such statements, so long as other aspects of the declarations contain statements related to factual findings.”). In addition, these statements regard the personal knowledge of the declarant and lack factual support and are, therefore, conclusory.

In view of the above, the Declaration is entitled to little weight. Having weighed all of the evidence before us, including the Declaration and the disclosures of the applied references, we are convinced that a preponderance of the evidence supports the conclusion that the claimed invention would have been obvious to one of ordinary skill in the art.

Appellant further contends there is no basis for boron having an effect upon the work function of a gate electrode as an inherent property or characteristic that necessarily flows from the disclosures of Xu ’328 and Ramin. Request 6–7. Inherency is unnecessary here because the applied references, such as Ramin, disclose that boron functions as a dopant to adjust the work function of a transistor, as discussed above.
Appellant does not argue claims 6–8, 10, 18, and 20 separately from claim 1. Request 3–8.

Accordingly, Appellant has not persuasively shown that the Board misapprehended or overlooked any of the arguments raised in the Briefs or that the Decision to affirm the rejection of claims 1, 6–8, 10, 18, and 20 should otherwise be modified or reversed.

II.

The Board’s Decision also affirmed the following rejections under 35 U.S.C. § 103(a):

- claims 2–5 and 12–14 over Xu ’328, Ramin, and Gulari and further in view of Xu ’447;9
- claim 9 over Xu ’328, Ramin, and Gulari and further in view of Im;10
- claim 11 over Xu ’328, Ramin, and Gulari and further in view of Schulz; and
- claim 19 over Xu ’328, Ramin, and Gulari and further in view of Mollard.11

Appellant does not argue these claims separately from claim 1.

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9 Xu et al., CN 102280376 A, published Dec. 14, 2011. The Examiner cites Xu et al. by its application number, 201010199981 (Final Act. 5), instead of the publication number. Further references to Xu et al. will refer to US 2012/0094447 A1, published Apr. 19, 2012 (“Xu ’447”), which the Examiner indicates is an English language equivalent. Id.

10 Im et al., US 8,354,671 B1, issued Jan. 15, 2013 (“Im”).

Request 8–9. As discussed above, Appellant has not persuasively shown that the Board misapprehended or overlooked any of the arguments raised in the Briefs or that the Decision to affirm the rejection of claim 1 should otherwise be modified or reversed. Therefore, Appellant has not persuasively shown that the Decision to affirm the rejections of claims 2–5, 9, 11–14, and 19 should otherwise be modified or reversed.

III.

Appellant’s Request for Rehearing has been granted to the extent that the Decision has been reconsidered in light of Appellant’s arguments. However, the Request is otherwise denied, and the Decision is not modified in any respect.

This Decision on the Request for Rehearing incorporates our Decision, mailed September 27, 2017, and is final for the purposes of judicial review. See 37 C.F.R. § 41.52(a)(1).

IV.

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

REHEARING DENIED