Trials@uspto.gov
571-272-7822

Paper 40
Entered: March 28, 2023

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AMPEREX TECHNOLOGY LIMITED,
Petitioner,

v.

MAXELL, LTD.,
Patent Owner.

IPR2021-01440
Patent 8,691,446 B2

Before KRISTINA M. KALAN, WESLEY B. DERRICK, and ELIZABETH M. ROESEL, *Administrative Patent Judges.*

ROESEL, *Administrative Patent Judge.*

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

A. Background and Summary

Amperex Technology Limited ("Petitioner") filed a Petition (Paper 2, "Pet.") seeking an *inter partes* review of claims 1–5 (the "challenged claims") of U.S. Patent No. 8,691,446 B2 (Ex. 1001, "the '446 Patent"). Maxell, Ltd. ("Patent Owner") filed a Preliminary Response. Paper 9. We instituted an *inter partes* review. Paper 17 ("Institution Decision" or "Inst. Dec."). After institution, Patent Owner filed a Patent Owner Response (Paper 22, "PO Resp."), Petitioner filed a Reply (Paper 25, "Pet. Reply"), and Patent Owner filed a Sur-reply (Paper 30, "PO Sur-reply"). We held an oral hearing on January 10, 2023, and a transcript is in the record. Paper 36 ("Tr.").[1]

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a). For the following reasons, we determine that Petitioner has shown by a preponderance of the evidence that all challenged claims of the '446 Patent are unpatentable.

B. Related Matters

The parties identify the following district court litigation as a related matter: *Maxell, Ltd. v. Amperex Tech. Ltd.*, No. 6:21-cv-00347-ADA (W.D. Tex.). Pet. 71; Paper 8, 2 (Patent Owner's updated mandatory notices).

Also pending before us are IPR2021-01441 and IPR2021-01443, which involve the same parties, similar technology, and in IPR2021-01443, a related patent. IPR2021-01442 involves the same parties.

[1] As agreed by the parties, oral arguments for three cases, IPR2021-01440, IPR2021-01441, and IPR2021-01443, were consolidated in a single hearing. Related case IPR2021-01442 was heard separately.

C. The '446 Patent (Ex. 1001)

The '446 Patent was issued on an application filed October 25, 2007, and asserts priority based on a Japanese application filed October 26, 2006 (the "foreign priority date"). Ex. 1001, codes (22), (30).

The '446 Patent discloses a nonaqueous secondary battery with a positive electrode having a positive electrode mixture layer, a negative electrode, and a nonaqueous electrolyte. Ex. 1001, code (57), 2:53–62. The positive electrode mixture layer has a density of 3.5 g/cm^3 or larger, and the nonaqueous electrolyte contains a compound having two or more nitrile groups in the molecule. *Id.* The positive electrode contains, as an active material, at least two lithium-containing transition metal oxides having different compositions of elements and different average particle sizes. *Id.* at 28:38–43 (claim 1); *see also id.* at 8:19–15:17 (discussing average particle size and composition of the positive electrode active material).

Positive electrode active material (A) has the largest average particle size, for example, 5 μm or more, and positive electrode active material (B) has the smallest average particle size, for example, 10 μm or less. Ex. 1001, 9:15–22, 9:26–27, 9:36–37. Positive electrode active material (B) has formula (1), $Li_xM^1_yM^2_zM^3_vO_2$, and positive electrode active material (A) has formula (2), $Li_aM^1_bM^2_cM^3_dO_2$. *Id.* at 10:60–11:20. In these formulae, M^1 represents at least one transition metal selected from Co, Ni and Mn; M^2 represents at least one metal selected from Mg, Ti, Zr, Ge, Nb, Al, and Sn; and M^3 represents an element other than Li, M^1, and M^2. *Id.* In formula (1), x, y, z, and v are defined by the equations, $0.97\leq x\leq 1.02$, $0.8\leq y<1.02$, $0.002\leq z\leq 0.05$, and $0\leq v\leq 0.05$, and in formula (2), a, b, c, and d are defined by the equations, $0.97\leq a<1.02$, $0.8\leq b<1.02$, $0\leq c\leq 0.02$, and $0\leq d\leq 0.02$. *Id.* The '446 Patent discloses, for example, "a combination of the positive

electrode active material (A) consisting of $LiCo_{0.998}Mg_{0.0008}Ti_{0.0004}Al_{0.0008}O_2$, and the positive electrode active material (B) consisting of $LiCo_{0.334}Ni_{0.33}Mn_{0.33}Mg_{0.0024}Ti_{0.0012}Al_{0.0024}O_2$." *Id.* at 15:10–17.

D. Illustrative Claim

Petitioner challenges all claims 1–5 of the '446 Patent. Pet. 1. Claims 1 and 3 are independent. Claim 1 is illustrative of the claimed subject matter and is reproduced below.

> 1. A nonaqueous secondary battery comprising: a positive electrode having a positive electrode mixture layer, a negative electrode, and a nonaqueous electrolyte,
>
> wherein the positive electrode contains, as an active material, at least two lithium-containing transition metal oxides having different average particle sizes,
>
> wherein said at least two lithium-containing transition metal oxides having different average particle sizes have different compositions of elements between them,
>
> said lithium-containing transition metal oxide having the smallest average particle size is a lithium-containing transition metal oxide represented by the formula (1):
>
> $$Li_xM^1_yM^2_zM^3_vO_2 \quad (1)$$
>
> wherein M^1 represents at least one transition metal element selected from Co, Ni and Mn, M^2 represents Mg and at least one metal element selected from the group consisting of Ti, Zr, Ge, Nb, Al and Sn, M^3 represents an element other than Li, M^1 and M^2, and x, y, z and v are numbers satisfying the equations respectively: $0.97 \leq x < 1.02$, $0.8 \leq y < 1.02$, $0.002 \leq z \leq 0.05$, and $0 \leq v \leq 0.05$,
>
> the positive electrode mixture layer has a density of at least 3.5 g/cm^3, and
>
> the nonaqueous electrolyte contains a compound having at least two nitrile groups in the molecule.

Ex. 1001, 28:35–60.

E. Asserted Challenges to Patentability

Petitioner raises the following challenges to patentability.

Claims Challenged	35 U.S.C. §[2]	References/Basis
1–5	103(a)	Choi,[3] Kim[4]
1–5	103(a)	Koshiishi,[5] Abe[6]

Pet. 1.

F. Testimonial Evidence

The record includes the Declaration of Dr. Walter van Schalkwijk (Ex. 1003) filed with the Petition, the deposition testimony of Dr. van Schalkwijk (Ex. 2016) filed with the Patent Owner Response, the Declaration of Dr. Brett Lucht (Ex. 2008) filed with the Preliminary Response, the Supplemental Declaration of Dr. Brett Lucht (Ex. 2015) filed

[2] The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. § 103, effective March 16, 2013. Because the '446 Patent was filed before this date, we refer to the pre-AIA version of Title 35. Ex. 1001, code (22).

[3] Ex. 1005, CN 1822414A, published August 23, 2006, including certified English translation ("Choi"). Petitioner asserts, without disagreement from Patent Owner, that Choi is prior art to the '446 Patent under pre-AIA 35 U.S.C. §§ 102(a) and (b). Pet. 6.

[4] Ex. 1006, US 2005/0208371 A1, published September 22, 2005 ("Kim"). Petitioner asserts, without disagreement from Patent Owner, that Kim is prior art to the '446 Patent under pre-AIA 35 U.S.C. §§ 102(a) and (b). Pet. 6.

[5] Ex. 1007, CN 1848492A, published October 18, 2006, including certified English translation ("Koshiishi").

[6] Ex. 1008, US 2004/0013946 A1, published January 22, 2004 ("Abe").

with the Patent Owner Response, and the deposition testimony of Dr. Lucht (Ex. 1030) filed with the Reply.

II. ANALYSIS

A. Legal Standards

"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) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify "with particularity . . . the evidence that supports the grounds for the challenge to each claim")); *see also* 37 C.F.R. § 42.104(b) (requiring a petition for *inter partes* review to identify how the challenged claim is to be construed and where each element of the claim is found in the prior art patents or printed publications relied upon).

A patent claim is unpatentable under 35 U.S.C. § 103 if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved based on underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when presented, objective evidence of nonobviousness, i.e., secondary considerations. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

Additionally, the obviousness inquiry typically requires an analysis of "whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue." *KSR*, 550 U.S. at 418 (citing

In re Kahn, 441 F.3d 977, 988 (Fed. Cir. 2006) (requiring "articulated reasoning with some rational underpinning to support the legal conclusion of obviousness")). Petitioner cannot satisfy its burden of proving obviousness by employing "mere conclusory statements," but "must instead articulate specific reasoning, based on evidence of record, to support the legal conclusion of obviousness." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016).

B. Level of Ordinary Skill in the Art

Petitioner contends that a person of ordinary skill in the art ("POSITA") would have had "at least a bachelor's degree in chemistry, chemical engineering, or materials science, as well as five or more years of experience in the field of batteries and battery materials." Pet. 7 (citing Ex. 1003 ¶ 11). Patent Owner does not address the level of ordinary skill in the art. *See generally* PO Resp.

We find that Petitioner's articulation of the level of ordinary skill in the art is consistent with the scope and content of the '446 Patent and the asserted prior art. We apply Petitioner's definition of a POSITA, with the caveat that the phrases "at least" and "or more" do not require significantly more education or experience than is explicitly set forth in Petitioner's definition.

C. Claim Construction

In an *inter partes* review, we apply the same claim construction standard as would be used by a district court to construe a claim in a civil action involving the validity or infringement of a patent. 37 C.F.R. § 42.100(b). Under that standard, claim terms are given their ordinary and customary meaning, as would have been understood by a person of ordinary

skill in the art at the time of the invention, in light of the language of the claims, the specification, and the prosecution history of record. *Id.*; *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–19 (Fed. Cir. 2005) (en banc); *Thorner v. Sony Comput. Entm't Am. LLC*, 669 F.3d 1362, 1365–66 (Fed. Cir. 2012).

Petitioner contends that the proper construction of "different compositions of elements" in claims 1 and 3 and "composition of elements . . . is different" in claim 2 is "the plain and ordinary meaning of the terms, i.e. different elements or different amounts of the same elements between the at least two lithium-containing transition metal oxides." Pet. 5 (citing Ex. 1003 ¶ 126). Patent Owner neither opposes this construction, nor proposes any express construction of its own. *See* PO Resp.

We apply Petitioner's unopposed claim construction, which is supported by the specification of the '446 Patent. Ex. 1001, 11:21–25 (In formula (2), "M_1, M_2 and M_3 are selected from the same elements as in the formula (1), but the elements selected or the constituting element ratios selected in the individual positive electrode active materials having different average particle sizes may differ from each other."). The specification provides several examples in which the cathode active material is a mixture of two lithium-containing transition metal oxides having different average particle sizes and different amounts of the same elements. Ex. 1001, 22:44–49, 25:58–65, 26:32–38, 26:48–54, 26:64–27:3; *see also* Ex. 1003 ¶ 123 (discussing Examples 1, 6, and 9–11).

We determine that no other claim term requires express construction for purposes of resolving the controversy. *Realtime Data LLC v. Iancu*, 912 F.3d 1368, 1375 (Fed. Cir. 2019) ("The Board is required to construe 'only those terms . . . that are in controversy, and only to the extent

necessary to resolve the controversy.'" (quoting *Vivid Techs., Inc. v. Am. Sci. Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999))).

D. Petitioner's Challenge based on Choi and Kim

Petitioner contends that claims 1–5 are unpatentable as obvious based on Choi and Kim. Pet. 8–38. Patent Owner opposes. PO Resp. 2–24. We provide an overview of the references before turning to the parties' arguments and our analysis.

1. Choi (Ex. 1005)

Choi discloses a composite cathode active material for a lithium battery. Ex. 1005, codes (54), (57). The composite cathode active material includes a large diameter active material and a small diameter active material. *Id.* at code (57), 2 (claim 1), 7.[7] The large diameter active material is selected from compounds of Formulae 1 and 2, such as $LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$, $LiNiO_2$, $LiNi_{0.9}Co_{0.1}O_2$, $LiNi_{0.9}Co_{0.1}Al_{0.1}O_2$, and the small diameter active material is selected from carbon-based materials, such as graphite, and compounds of Formulae 2–4, such as $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$, $LiMn_2O_4$, $LiNi_{0.5}Mn_{0.5}O_2$, $LiCo_{0.95}Mg_{0.05}O_2$, $LiCoPO_4$ and $LiNi_{1/2}Mn_{3/2}O_4$. *Id.* at 2 (claims 1 and 7), 5–6, 8, 10.

2. Kim (Ex. 1006)

Kim discloses a cathode having a protection layer formed by a complex between the surface of a cathode active material, such as a lithium-containing transition metal oxide, and an aliphatic nitrile compound, such as

[7] We cite to Exhibit 1005 using the page numbers added by Petitioner in the lower right corner of each page.

succinonitrile, as an electrolyte additive. Ex. 1006, code (57), ¶¶ 8, 13, 32, 37–39.

3. Motivation to Combine

Petitioner contends that Choi discloses a nonaqueous secondary battery including all limitations of the challenged claims, except for the limitation, "the nonaqueous electrolyte contains a compound having at least two nitrile groups in the molecule," which Petitioner contends is disclosed by Kim. Pet. 9–38. Petitioner contends "a POSITA would have looked to Kim and its inclusion in its electrolyte of a compound having at least two nitrile groups in the molecule to improve thermal stability" of Choi's battery. Pet. 10 (citing Ex. 1003 ¶ 142). According to Petitioner, Kim teaches that the addition of an aliphatic nitrile compound (including a compound with two nitrile groups) to the electrolyte improves thermal stability and discharge characteristics of the battery. Pet. 11 (citing Ex. 1006 ¶¶ 32, 37, 41, 42; Ex. 1003 ¶¶ 144, 145).

Patent Owner argues that the Petition fails to allege a sufficient motivation to combine Choi and Kim. PO Resp. 2–11. According to Patent Owner, Choi and Kim disclose completely dissimilar cathode technologies, and a POSITA would not have been motivated to combine the cathode in Choi with the electrolyte in Kim. *Id.*

For the reasons discussed below, we determine that the preponderance of the evidence favors Petitioner regarding motivation to combine.

a) Petitioner shows that a POSITA would have been motivated by a desire for increased thermal stability and improved discharge characteristics

Petitioner shows persuasively that a desire for increased thermal stability and improved discharge characteristics would have motivated a

POSITA to modify the electrolyte in Choi's battery by including a dinitrile compound as taught by Kim. Pet. 10–12; Ex. 1003 ¶¶ 140–146.

Petitioner presents undisputed testimony that a POSITA "would have understood that improving thermal stability is critical to improving battery safety." Ex. 1003 ¶ 141. The parties agree that both Choi and Kim are directed to improving thermal stability and discharge characteristics of a lithium battery. Pet. 10–11; Ex. 1003 ¶¶ 141, 142, 146; PO Resp. 6 ("Choi . . . addresses the problem that Kim seeks to solve: thermal stability.");[8] Ex. 2015 ¶ 10 (same). For example, Choi states that "a need exists for composite cathode active materials . . . capable of providing lithium batteries with improved high voltage stability, thermal stability and high rate discharge characteristics." Ex. 1005, 5. Kim is concerned with avoiding thermal runaway caused, for example, by exposure to high temperature. Ex. 1006 ¶¶ 8, 12, 32, 33; *see also* Ex. 1003 ¶¶ 43, 64 (explaining thermal runaway and equating it to "spontaneous thermal decomposition").

Furthermore, the parties agree that Choi and Kim teach different ways to improve thermal stability. Ex. 1003 ¶¶ 141, 144; Ex. 2015 ¶¶ 10, 11 (Dr. Lucht: "Choi, however, addressed thermal stability differently [than Kim], by using complex lithium-containing transition metal oxides enhanced with dopants."); *see* PO Resp. 7 (same). Choi teaches a composite cathode active material that includes large and small diameter particles. Ex. 1005, 7. According to Choi, high thermal stability is possible by using highly stable and highly conductive materials as the small diameter active materials. *Id.* at 7, 9–10. Kim, on the other hand, teaches improving thermal stability by

[8] We omit italicization of the Choi and Kim references when quoting from Patent Owner's briefs and declarations.

providing a cathode protection layer formed by a complex between the surface of a cathode active material and an aliphatic nitrile compound. Ex. 1006, code (57), ¶¶ 1, 32, 33.

Petitioner shows persuasively that Kim discloses the same types of cathode and anode active materials as Choi. Pet. 10–11 (citing Ex. 1003 ¶ 142; Ex. 1005, 4–12; Ex. 1006 ¶¶ 2–10, 69, 72). Petitioner's contention is supported by Dr. van Schalkwijk's testimony (Ex. 1003 ¶ 142), as well as the disclosures of the references. Dr. van Schalkwijk testifies that Kim "teaches the same types of cathode and anode materials as Choi, namely lithium-cobalt-based oxide cathode active materials and carbon (or graphite) anode active materials." Ex. 1003 ¶ 142. Dr. van Schalkwijk's testimony is supported by Choi and Kim, both of which disclose lithium-containing transition metal oxides as cathode active materials. Ex. 1005, 8, 10 (disclosing Formulae 1–4, which are lithium-containing oxides of cobalt, nickel, and/or manganese, and examples of these oxides); Ex. 1006 ¶ 69 ("the lithium secondary battery contains a lithium-containing transition metal oxide as a cathode active material").[9] Choi and Kim also both disclose carbon (or graphite) anode active materials. Ex. 1005, 9, 14; Ex. 1006 ¶¶ 72, 73.

Petitioner also shows persuasively that Kim "identifies limitations of these cathode and anode active materials, including gas generation at high temperatures, which may result in thermal runaway." Pet. 10–11 (citing

[9] Although we stated in the Institution Decision that Choi and Kim disclose overlapping sets of exemplary cathode active materials (Inst. Dec. 19 (citing Ex. 1005, 7, 10, 13–15; Ex. 1006 ¶ 69)), we do not rely on this overlap as part of our reasoning in this Decision because the overlapping materials are outside the scope of the challenged claims.

Ex. 1003 ¶ 142; Ex. 1005, 4–12; Ex. 1006 ¶¶ 2–10, 69, 72). For example, Kim discloses that, when a cathode active material such as a lithium-containing metal oxide, is overcharged and reaches a critical temperature, it may become thermally unstable and release oxygen, which may cause an exothermic chain reaction, resulting in thermal runaway. Ex. 1006 ¶ 9. As further discussed in subsection b) below, we find that Kim's teachings concerning gas generation, thermal runaway, and a protection layer formed by a complex between the surface of a cathode active material and an aliphatic nitrile compound are not limited to any particular class of cathode active materials. Ex. 1006, code (57), ¶¶ 1–10, 32, 34, 35, 41.

We are also persuaded by Petitioner's contention and Dr. van Schalkwijk's testimony that "Kim teaches a similar nonaqueous electrolyte to Choi." Pet. 11; Ex. 1003 ¶ 143. Both Choi and Kim teach an electrolyte solution comprising (1) a nonaqueous organic solvent such as ethylene carbonate, propylene carbonate, dimethyl carbonate, diethyl carbonate, methyl ethyl carbonate, and γ-butyrolactone; and (2) a lithium salt such as $LiClO_4$, $LiCF_3SO_3$, $LiPF_6$, $LiBF_4$, $LiAsF_6$, and $LiN(CF_3SO_2)_2$. Ex. 1005, 13; Ex. 1006 ¶¶ 62, 63.

We agree with Petitioner that Kim teaches that the addition of a dinitrile compound to the electrolyte improves thermal stability and discharge characteristics so as to avoid thermal runaway. Pet. 11 (citing Ex. 1003 ¶¶ 144, 145; Ex. 1006 ¶¶ 32, 37, 41, 42). For example, Kim discloses:

> The present inventors have found that, when a protection layer is formed on a cathode by complexation between the surface of a cathode active material and an aliphatic nitrile compound, such as succinonitrile, the safety of a battery upon overcharge and/or physical impact (e.g., high temperature

> exposure by heating) from the outside of the battery can be improved.

Ex. 1006 ¶ 32.

> [T]he aliphatic nitrile compound has an advantage in that it can provide a thermally stable electrode since it more strongly protects the electrode surface at a higher temperature than ambient temperature.

Id. ¶ 41.

> Moreover, the complex formed on the cathode surface by the aliphatic nitrile compound can control exothermic heat caused by a reaction between the electrolyte solution and the cathode and exothermic heat caused by the structural breakdown of the cathode, and reduce exothermic heat generation. This can prevent the fire or explosion of the battery from occurring due to the acceleration of combustion and the generation of thermal runaway.

Id. ¶ 42. In view of the foregoing teachings of Kim, we credit

Dr. van Schalkwijk's testimony that:

> In light of these disclosures [in Kim], a person of ordinary skill in the art would have been motivated to improve the properties and benefits of the Choi battery by including the electrolyte additive of Kim to increase thermal stability and improve discharge characteristics in the resultant batteries. Accordingly, a person of ordinary skill in the art would have been motivated to apply the electrolyte additive teachings of Kim to the battery of Choi.

Ex. 1003 ¶ 145.

> Kim explicitly teaches that the lithium secondary batteries are in need of improved thermal stability and discharge characteristics and further teaches that its aliphatic nitrile electrolyte additive improves thermal stability and discharge characteristics of its battery. . . . In light of these teachings, a person of ordinary skill in the art would have expected the addition of the aliphatic nitrile compound of Kim to the battery of Choi to be effective.

Id. ¶ 146 (citing Ex. 1006 ¶¶ 32, 41, 42).

b) Petitioner establishes a motivation to combine despite differences in cathode materials

Patent Owner argues that Choi discloses "complex" lithium-containing transition metal oxides that "include dopants" and lead to improved charge/discharge characteristics and greater stability, as compared with conventional lithium batteries that use "basic transition metal oxides such as $LiCoO_2$." PO Resp. 4–5 (citing Ex. 1005, 1, 4, 20). According to Patent Owner, Kim discloses "the same kind of basic lithium-containing transition metal oxides criticized in Choi as lacking [these] benefits." *Id.* at 6 (citing Ex. 1005, 4). Patent Owner argues that "because Choi disclosed a much more complex cathode active material compared to Kim, with enhancements not even contemplated by Kim, a POSITA would not be motivated to combine these two wholly different references disclosing starkly contrasting technologies." *Id.* (citing Ex. 2008 ¶ 33); *see also* PO Sur-reply 4 (similar argument).

Having considered both Petitioner's and Patent Owner's arguments, we are persuaded that a POSITA would have been motivated to combine the teachings of Choi and Kim as set forth by Petitioner. As discussed above, Choi and Kim both disclose lithium-containing transition metal oxides as cathode active materials. Ex. 1005, 8, 10; Ex. 1006 ¶ 69; *see also* Ex. 1003 ¶ 142 ("Kim . . . teaches the same types of cathode and anode materials as Choi."). Patent Owner and Dr. Lucht assert that Kim does not describe the particle size of the cathode material and does not disclose "complex" lithium-containing transition metal oxides including "dopants." PO Resp. 5–6; PO Sur-reply 2–4; Ex. 2008 ¶¶ 33–36. Kim's silence on particle size and dopants does not, however, mean that Kim's cathode active material is "wholly different" from Choi's cathode active material, as asserted by

Patent Owner and Dr. Lucht. PO Resp. 6; Ex. 2008 ¶ 35. Patent Owner does not dispute that Choi and Kim both disclose lithium-containing transition metal oxides as cathode active materials. PO Resp. 5 (discussing Kim and citing Ex. 1006 ¶ 69); *see also* Ex. 2008 ¶ 36 (same). Moreover, Dr. Lucht does not explain how Kim's silence on particle size and dopants would have affected a POSITA's motivations and expectations regarding the electrolyte—the modification of Choi proposed by Petitioner. For this reason and as further explained below, Dr. Lucht's testimony that "Kim . . . discloses a wholly different cathode active material technology than Choi" (Ex. 2008 ¶ 35) is not sufficient to rebut Dr. van Schalkwijk's testimony that a POSITA would have been motivated to include the aliphatic nitrile compound of Kim as an electrolyte additive in the battery of Choi "to increase thermal stability and improve discharge characteristics in the resultant batteries" and would have expected the addition of the aliphatic nitrile compound to be effective. Ex. 1003 ¶¶ 145, 146.

As discussed above, Choi and Kim teach different ways to improve thermal stability. Whereas Choi's small diameter cathode active materials confer thermal stability (Ex. 1005, 7, 10), Kim teaches that thermal stability and discharge characteristics are improved by a protective layer formed by a complex between the surface of a cathode active material and an aliphatic dinitrile compound. Ex. 1006, code (57), ¶¶ 32, 33, 37–42. According to Kim, a "polar cyano group with high dipole moment in the aliphatic nitrile compound forms a bond with a transition metal, such as cobalt, in the cathode" and "X-ray photoelectron spectroscopy data . . . show a complex is formed by a bond between a cobalt metal oxide and the cyano group of the dinitrile compound." *Id.* ¶¶ 39, 40, Figs. 1, 2. Because Choi's cathode active material likewise contains a transition metal, such as cobalt, the

references support a reasonable inference that the same sort of cyano group complex would be formed if a dinitrile compound were included in Choi's electrolyte. Ex. 1005, 5–6; Ex. 1006 ¶¶ 37–40. On this record, there is no evidence that Choi's dopants would have interfered with complexation between the surface of a cathode active material and an aliphatic nitrile compound or formation of a protective layer on the cathode, as described by Kim. To the contrary, Dr. van Schalkwijk testified that the addition of small amounts of an additive element, such as magnesium, to the cathode "wouldn't change . . . the types of results they were looking for in terms of film formation on what is substantially lithium cobalt oxide or lithium nickel oxide." Ex. 2016, 37:18–40:3 (discussing Kim).

In our Institution Decision, we observed that "Dr. Lucht does not say that Kim's teachings about an aliphatic nitrile compound are inapplicable to Choi's cathode materials." Inst. Dec. 19. On this record, there is still no such testimony from Dr. Lucht. At the oral hearing, Patent Owner's counsel conceded that Patent Owner is not arguing that the result would be different when combining a dinitrile (or mononitrile) compound with a "complex" cathode material, as compared with a "basic" cathode material. Tr. 32:7–20. Accordingly, Patent Owner's distinction between "complex" and "basic" lithium-containing transition metal oxides (PO Resp. 5–7; Ex. 2008 ¶¶ 34–36; Ex. 2015 ¶¶ 10–12) does not undermine Dr. van Schalkwijk's testimony that a POSITA would have been motivated to include an aliphatic nitrile in the electrolyte to increase the thermal stability and improve the discharge characteristics of Choi's battery and would have expected that the electrolyte additive would have been effective. Ex. 1003 ¶¶ 141, 142, 144–146.

c) Choi's improved thermal stability does not undermine Petitioner's showing of motivation to combine

Patent Owner argues that a "POSITA would not have been motivated to combine the electrolyte of Kim with the cathode active material of Choi because Choi already sufficiently addresses" the thermal stability problem "by using complex lithium-containing transition metal oxides enhanced with dopants." PO Resp. 6–8 (citing Ex. 2015 ¶¶ 10–12); *see also* PO Sur-reply 6–7 (similar argument).

After considering the arguments and evidence, we are persuaded by Petitioner's contention that a POSITA would have understood that thermal stability could be "***further*** improved by using an electrolyte including an aliphatic dinitrile compound, such as succinonitrile." Pet. Reply 5 (citing Ex. 1003 ¶¶ 134–147; Ex. 1006 ¶¶ 32, 37, 41, 42, 72). At the oral hearing, Patent Owner's counsel conceded, "I don't believe there is anything in the record to say that thermal stability could not have been further improved" by a dinitrile compound in the electrolyte when using a complex cathode material as disclosed in Choi. Tr. 28:2–13.

An expectation of further improvement is supported by undisputed evidence that Kim's aliphatic dinitrile compound confers thermal stability by a ***different mechanism*** than Choi's complex lithium-containing transition metal oxides. Ex. 1003 ¶¶ 141, 144; Ex. 1005, 7, 9–10; Ex. 1006, code (57), ¶¶ 32, 33, 37–42; Ex. 2015 ¶¶ 10, 11. We are persuaded by Petitioner's contention that "a POSITA would recognize that one could achieve additional benefits" by using "electrolyte additives (like Kim's)" such as "'inhibit[ing] the side reaction and gas generation caused by a reaction between the electrolyte solution and the cathode,' which is not addressed by

Choi's cathode material." Pet. Reply 6 (citing Ex. 1006 ¶ 41; Ex. 2016, 26:16–33:20).

We credit the following deposition testimony of Dr. van Schalkwijk, which provides persuasive support for Petitioner's position regarding motivation to combine.

> THE WITNESS: A person of ordinary skill working to make a lithium-ion battery that has high voltage stability, thermal stability, high rate discharge characteristics and improve volumetric capacity, in other words, volumetric energy density or capacity.
>
> A person of ordinary skill will seek out a cathode that would provide as much of that as possible. Good characteristics -- its formulation would have good characteristics -- for giving those battery characteristics on discharge and cycle life.
>
> But a person of ordinary skill would also have understood that the electrolyte is an important part of the battery, and that inclusion of a proper electrolyte to impart properties of the battery that would enhance safety, cycle life, thermal resistance to temperature excursions would have also been looking for those characteristics.
>
> So they would have sought out Choi and Kim as a combination to achieve the desired battery with the desired characteristics.

Ex. 2016, 28:22–29:18. We also credit Dr. van Schalkwijk's testimony about improving Choi's thermal stability:

> Q Choi says that it's thermally stable. So what is there to be improved?
>
> A Thermally stable can always be improved to be stable to a higher temperature.

Id. at 67:20–23. Although the foregoing exchange arose in the context of discussing the references asserted in IPR2021-01441, we find that the testimony is equally applicable to the combination of Choi and Kim. In this

regard, we note that the Choi reference discussed in the testimony (IPR2021-01441, Ex. 1005) has essentially the same disclosure and stems from the same Korean patent application as the Choi reference asserted here (Ex. 1005). The foregoing testimony shows that a POSITA would have been motivated to modify the electrolyte of Choi to improve thermal stability, even though Choi teaches that its cathode active materials improve thermal stability.

d) Petitioner shows that a POSITA would have considered a dinitrile compound

Patent Owner argues that a POSITA would not have been motivated to add a dinitrile compound to Choi's electrolyte because Choi discloses two mononitrile solvents (benzonitrile and acetonitrile) and, according to Patent Owner, Kim teaches that the use of a mononitrile compound would have been sufficient to gain the benefits described in Kim. PO Resp. 8–11 (citing Ex. 1005, 10; Ex. 1006 ¶ 45; Ex. 2008 ¶¶ 37–39; Ex. 2015 ¶ 13; Ex. 2016, 34:5–18, 37:6–16). Patent Owner relies on the following disclosure in Kim:

> Although the present invention exemplifies the compounds of formula 1 as the aliphatic nitrile compounds, ***compounds having a nitrile group only at one side*** in the aliphatic nitrile compounds of formula 1 are also within the scope of the present invention since they ***have a high possibility to show the equivalent safety and/or improvement in the cycle life characteristics of the battery to the compounds of formula 1***.

Ex. 1006 ¶ 45 (emphasis added by Patent Owner); PO Resp. 10; PO Sur-reply 8.

After considering the arguments and evidence, we are persuaded by Petitioner's contention that a POSITA would have been motivated to use a dinitrile compound. Pet. 10–11; Pet. Reply 6–8. We agree with Petitioner that the above-quoted sentence is "speculative" (Pet. Reply 7), as it states

there is a "high possibility" of equivalence between an aliphatic mononitrile and an aliphatic dinitrile. Ex. 1006 ¶ 45.

Moreover, we are persuaded by Dr. van Schalkwijk's explanation that a POSITA would have expected better performance from a dinitrile compound than a mononitrile compound. In response to Patent Owner's cross-examination, Dr. van Schalkwijk explained that it is preferable "to have more than one nitrile group in close proximity to each other to effect a good film" and the mononitrile molecules benzonitrile and acetonitrile have "a lot of non-nitrile part . . . such that even putting two acetonitriles next to each other or two benzonitriles next to each other [is] not as efficient as two nitriles in the same molecule separated by a group in the middle, an organic carbon-based group in the middle." Ex. 2016, 35:13–23.

Dr. van Schalkwijk further explained that "an excessively large amount of the aliphatic nitrile compound can cause an excessive increase in the viscosity of the electrolyte solution and a reduction in the ion activity of the electrolyte solution." *Id.* at 41:12–23. But by "having more than one nitrile group on each molecule gives you . . . more film formation with less [nitrile] material," which avoids an adverse effect on the conductivity of the electrolyte, "which is supremely important." *Id.* at 41:24–42:5. According to Dr. van Schalkwijk, this explains why a POSITA would want to use a dinitrile, rather than a mononitrile. *Id.* at 42:6–10; *see* Pet. Reply 7–8 (relying on the foregoing testimony of Dr. van Schalkwijk).

Dr. van Schalkwijk's testimony is consistent with Abe, which compares dinitrile compounds with a mononitrile compound as an electrolyte additive. Ex. 1008 ¶ 108, Table 1; *see* Pet. Reply 8 (discussing Abe). Abe discloses that "the use of the electrolytic solution containing an appropriate amount of a dinitrile compound gives a favorabl[e] effect to a

lithium secondary battery . . . as compared with an electrolytic solution containing no dinitrile compound." Ex. 1008 ¶ 108 (discussing results in Table 1). Abe describes the improvement as "enhancement of a discharge capacity retention without lowering the initial discharge capacity after a long term charge-discharge cycles." *Id.* Abe further discloses that "the use of a mononitrile compound in place of a dinitrile compound give almost no favorable effect to the discharge capacity retention." *Id.*

We find that Dr. van Schalkwijk's deposition testimony and Abe, as discussed above, support Petitioner's position regarding a motivation to combine.

For these reasons, we determine that Petitioner has met its burden of proof to show a motivation to combine Choi and Kim.

4. Independent Claim 1

The parties' dispute for claim 1 focuses on the composition of the lithium-containing transition metal oxide. Petitioner contends that formula (1), $Li_xM^1_yM^2_zM^3_vO_2$, as recited in claim 1, is taught by Choi's Formula 2, $Li_xCo_{1-y-z}Ni_yM_zO_{2-\alpha}X_\alpha$, where $0.90 \leq x \leq 1.1$, $0 \leq y \leq 0.9$, $0 \leq z \leq 0.5$, $0 \leq \alpha \leq 2$, M is at least one selected from Al, Ni, Mn, Cr, Fe, Mg, Sr, V or rare earth elements, and X is selected from O, F, S and P. Pet. 18–24 (citing Ex. 1005, 5–6).

Patent Owner argues that Choi does not disclose three aspects of the lithium-containing transition metal oxide of claim 1: (1) the required presence of Mg and another element that satisfies M^2; (2) the molar amount of M^2; and (3) an element that satisfies M^3. PO Resp. 11–20. We discuss each of these aspects below and then address the remaining limitations of claim 1.

a) Element M^2

Claim 1 recites that, in formula (1), "M^2 represents Mg and at least one metal element selected from the group consisting of Ti, Zr, Ge, Nb, Al and Sn." Ex. 1001, 28:50–52.

Petitioner contends that M^2 is taught by M in Choi's Formula 2, where "M is at least one element selected from Al, Ni, Mn, Cr, Fe, Mg, Sr, V or rare earth elements." Pet. 21 (citing Ex. 1005, 5–6). According to Petitioner, a "POSITA would have been motivated to select Mg and Al, from the elements taught by Choi." *Id.* (citing Ex. 1003 ¶¶ 185–187; Ex. 1024[10]).

Patent Owner argues that Choi does not disclose the required presence of "Mg and at least one metal element selected from the group consisting of Ti, Zr, Ge, Nb, Al and Sn," as recited in claim 1. PO Resp. 12–15.

For the reasons discussed below, we determine that the preponderance of the evidence favors Petitioner's position regarding element M^2.

There is no dispute that Choi discloses Mg and Al as possible constituents of a cathode active material. PO Resp. 13–14; Ex. 1005, 5–6 (disclosing Formula 2, $Li_xCo_{1-y-z}Ni_yM_zO_{2-\alpha}X_\alpha$, where "M is at least one element selected from Al, Ni, Mn, Cr, Fe, Mg, Sr, V or rare earth elements").

Undisputed evidence shows that a POSITA would have had several reasons to select Mg and Al from the options Choi discloses for element M. These undisputed reasons include: (1) that Mg would enhance the cathode material's electronic conductivity; (2) that Al would provide structural

[10] S. Madhavi et al., *Cathodic properties of (Al, Mg) co-doped $LiNi_{0.7}Co_{0.3}O_2$*, Solid State Ionics 152–153, 199–205 (2002) ("Madhavi").

enhancement to the cathode; (3) that Mg and Al would be less likely to disrupt the structure of the cathode material because they are the smallest elements in Choi's list; and (4) that Mg and Al would not be oxidized or reduced because they each have singular oxidation states. Pet. 21 (citing Ex. 1003 ¶¶ 186, 187; Ex. 1024).

We credit the following unrebutted testimony of Dr. van Schalkwijk:

> First, each doping element (e.g., Mg, Al, etc.) plays a different role in modifying the material properties of the host material (e.g., lithium cobalt oxide). . . . Mg atoms were first successfully doped into the $LiCoO_2$ lattice, the result being an increase in the electronic conductivity of the material. . . . Mg doping also altered the phase transition behavior of the delithiation process, which is the removal of lithium ions from the cathode during battery charging. . . . Mg's effect was to increase the charge voltage available to the cathode; however, this was not a large effect because the solubility of Mg in the cathode was quite small, i.e. only small amounts of Mg could be doped into $LiCoO_2$. . . . Al was another dopant that was used at the time of Choi and the '446 Patent. . . . However, it did not enhance the conductivity of the cathode as much as the effect from Mg doping. The strength of Al was that it was able to affect the same structural enhancements to the cathode, and it was much more soluble in the cathode, i.e. more aluminum could be doped into the cathode. . . . The motivation to use two dopants (and Mg and Al were common co-dopants) was the structural enhancement of the larger concentration of Al and the electronic conductivity enhancement due to the Mg. . . .
>
> Moreover, Mg and Al are the smallest elements in the list taught by Choi, which means that Mg and Al are less likely to disrupt the structure of the positive electrode active material. . . . Additionally, Mg and Al have singular oxidation states of +2 and +3, respectively. . . . As such, a person of ordinary skill in the art would have been motivated to select Mg and Al from the list of elements for "M" taught by Choi.

Ex. 1003 ¶¶ 186, 187 (citing Exs. 1022,[11] 1024).

We also credit Dr. van Schalkwijk's deposition testimony explaining how Mg alters the phase transition behavior of the delithiation process "so that the battery reaction is much more reversible." Ex. 2016, 88:22–90:4. When asked whether the other elements Choi lists for M would also have that benefit, Dr. van Schalkwijk answered that "[m]agnesium has the biggest benefit of conductivity and phase transition alteration." *Id.* at 90:5–9. Dr. van Schalkwijk also explained how Al provides structural support to the cathode material. *Id.* at 90:10–20; *see also* Ex. 1003 ¶ 44 (explaining how Al "enhance[s] the structure and hold[s] the lithium-containing layer a bit wider" as lithium ions are removed during battery charging). When asked how the structural benefit of aluminum compares with Choi's other elements, Dr. van Schalkwijk answered that "manganese has multiple oxidation states" and "doesn't do anything structural," and that chromium, iron, strontium, and vanadium either have "multiple oxidation states," are "too large," or both. Ex. 2016, 90:25–91:12. When asked about the rare earth elements, as listed by Choi, Dr. van Schalkwijk responded that they are "physically too large" and "most of them would be cost prohibitive." *Id.* at 91:19–92:7; *see* Pet. Reply 10 (citing Dr. van Schalkwijk's deposition testimony).

Dr. van Schalkwijk's testimony is supported by Tukamoto, which discloses that Mg doping of $LiCoO_2$ can significantly increase its conductivity without degrading electrochemical performance, with only a

[11] H. Tukamoto and A.R. West, *Electronic Conductivity of $LiCoO_2$ and Its Enhancement by Magnesium Doping*, J. Electrochem. Soc. 144, 3164–168 (1997) ("Tukamoto").

small reduction in capacity and good reversibility. Ex. 1022, 2, 6.[12] Tukamoto Table I provides conductivity data for $LiCoO_2$ with various dopants, including Al, Ni, Mn, Cr, Fe, Mg, Sr, and V, which Choi lists as options for M in Formula 2, and six rare earth elements, Sc, Y, La, Ce, Pr, and Nd, which are also options for Choi's M. *Id.* at 3. The data show that doping with Mg resulted in the highest conductivity. *Id.* ("of these various dopants only Mg led to a significant increase in conductivity").
Dr. van Schalkwijk's testimony is supported by Tukamoto's conclusion that "Mg-doped $LiCoO_2$, remains as a single-phase material throughout the charge/discharge cycle, in contrast to $LiCoO_2$, and this may lead to improved long-term stability on cycling." *Id.* at 6.

Dr. van Schalkwijk's testimony is further supported by Madhavi, which discloses that Al and Mg doping of $LiNi_{0.7}Co_{0.3}O_2$ improves reversibility, capacity retention, and thermal stability, as compared to undoped cathode material. Ex. 1024, 1, 7. According to Madhavi, doping $LiNi_{0.7}Co_{0.3}O_2$ with Mg and Al resulted in the formation of a single crystalline phase with a well-defined layer structure and no impurity phases. *Id.* at 2. Madhavi teaches that doping with Al and Mg provides benefits that doping with Al alone does not provide. *Id.* at 3 (Table 1 showing discharge capacity); *id.* at 6 (discussing capacity-fading); *id.* at 7 (discussing heat evolution and decomposition temperature).

Petitioner shows persuasively that using both Mg and Al as dopants provides additional benefits over using one element alone. Pet. 23 n.4

[12] We cite to Exhibits 1022 and 1024 using the page numbers added by Petitioner in the lower right corner of each page.

(citing Ex. 1017[13] ¶ 96, Table 2). Sato Table 2 shows that doping $LiCoO_2$ with both Al and Mg provides better charge/discharge characteristics than doping with either element alone or undoped material. Ex. 1017, Table 2.

Dr. Lucht does not controvert Dr. van Schalkwijk's testimony that the small size and singular oxidation states of Mg and Al would have prompted a POSITA to select these elements from Choi's list of options for M. Ex. 1003 ¶ 187 (citing Ex. 1024); *see also* Ex. 2016, 97:22–99:24 (explaining why singular oxidation states for Mg and Al makes them better additive metals than the others listed by Choi). Dr. Lucht agrees that size and oxidation state of a dopant are considerations when developing a lithium-ion battery. Ex. 1030, 116:16–118:4. According to Dr. Lucht, the size of dopants should be similar to the size of the other metals "so they don't disrupt the overall crystal structure of the material." *Id.* at 117:16–118:4; *see* Pet. Reply 10 (citing Dr. Lucht's deposition testimony).

Patent Owner does not dispute Petitioner's evidence that a POSITA would have selected Mg and Al from the elements Choi teaches for M. Instead, Patent Owner argues that, in Choi's Formula 2, "M isn't required at all," and Mg and Al are just "one pair of elements out of a possible 600 pairs of elements from Choi's list of 25 possible elements." PO Resp. 14 (referring to Choi's list of eight elements plus seventeen rare earth elements that are options for M); PO Sur-reply 11 (similar argument). Patent Owner argues that Petitioner and Dr. van Schalkwijk rely on "improper hindsight bias," that none of Choi's examples incorporates either Mg or Al, and that

[13] US 2005/0266315 A1, published December 1, 2005 ("Sato").

Choi discloses only one compound containing Mg, and that compound does not include Al. PO Resp. 14 (citing Ex. 1005, 10, 13–16); PO Sur-reply 11.

For the reasons discussed above, we find that Petitioner and Dr. van Schalkwijk do not rely on improper hindsight bias and instead rely on undisputed evidence from before the foreign priority date of the '446 Patent showing that a POSITA would have had multiple reasons to select Mg and Al from the elements Choi teaches for M. Pet. 21, 23 n.4; Pet. Reply 10; Ex. 1003 ¶¶ 186, 187; Exs. 1017, 1022, 1024; Ex. 2016, 88:22–92:7, 97:22–99:24. Although Choi does not disclose any example compounds that contain both Mg and Al, the absence of such an example is not dispositive. *In re Mills*, 470 F.2d 649, 651 (CCPA 1972) (When evaluating obviousness, "[a]ll the disclosures in a reference must be evaluated, including nonpreferred embodiments, . . . and a reference is not limited to the disclosure of specific working examples." (citation omitted)). Choi's examples illustrate the effects of particle size on electrode density, discharge capacity, and thermal stability. Ex. 1005, 10–17. Petitioner has provided other evidence to illustrate how the selection of a dopant affects conductivity, capacity retention, and thermal stability. Ex. 1003 ¶¶ 186, 187; Exs. 1017, 1022, 1024; Ex. 2016, 88:22–92:7, 97:22–99:24.

Petitioner's unrebutted evidence that a POSITA would have selected Mg and Al from the elements Choi teaches for M distinguishes this case from the precedent cited by Patent Owner.[14] PO Sur-reply 11–13. In

[14] *In re Baird*, 16 F.3d 380, 383 (Fed. Cir. 1994) ("A disclosure of millions of compounds does not render obvious a claim to three compounds, particularly when that disclosure indicates a preference leading away from the claimed compounds.").

contrast to *Baird*, Petitioner's evidence shows that a POSITA would have been led toward, not away from, the claimed invention.

For these reasons, we determine that Petitioner has met its burden of proof for element M^2 as recited in claim 1.

b) Molar Amount of M^2

Claim 1 recites that, in formula (1), the molar amount[15] of M^2 is z, where z satisfies the equation, $0.002 \leq z \leq 0.05$. Ex. 1001, 28:48–56.

Petitioner contends that the molar amount of M^2 is taught by Choi, which discloses that, in Formula 2, the subscript for M is z, where $0 \leq z \leq 0.5$. Pet. 22 (citing Ex. 1005, 5–6). Petitioner contends that the concentration of element M, in this case Mg and Al, is a result-effective variable that would have been optimized by a POSITA's routine experimentation. *Id.* at 22–23 (citing Ex. 1003 ¶¶ 188, 189; Exs. 1017, 1018,[16] 1022).

Patent Owner contends that Choi does not disclose the molar amount of M^2, as recited in claim 1. PO Resp. 15–17.

For the reasons discussed below, we determine that the preponderance of the evidence favors Petitioner's position regarding the molar amount of M^2.

It is undisputed that Choi's disclosed range ($0 \leq z \leq 0.5$) encompasses the claimed range ($0.002 \leq z \leq 0.05$), which is sufficient to establish prima facie obviousness. Pet. 22; PO Resp. 15; Ex. 1005, 5–6; *E.I. DuPont de Nemours & Company v. Synvina C.V.*, 904 F.3d 996, 1006 (Fed. Cir. 2018) ("'[a] *prima facie* case of obviousness typically exists when the ranges of a

[15] In formula (1), the molar amounts of the elements Li, M^1, M^2, and M^3 are denoted by the subscripts x, y, z, and v, respectively. Ex. 1001, 28:48.

[16] US 2006/0194109 A1, published August 31, 2006 ("Watanabe").

claimed composition overlap the ranges disclosed in the prior art'" (quoting *In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003)). It is also undisputed that Choi discloses a specific cathode active material containing an amount of Mg within the claimed range. Ex. 1005, 10 (disclosing $LiCo_{0.95}Mg_{0.05}O_2$ as an example of a small diameter cathode active material); *see* PO Resp. 14 (asserting "Choi discloses only one compound containing Mg, but it does not include Al" (citing Ex. 1005, 10)); Pet. Reply 12.

Petitioner shows persuasively that, while Choi discloses the possibility of excluding "M" from Formula 2, a POSITA would have understood that the inclusion of Mg and Al would provide benefits and enhancements to the cathode. Pet. 22 (citing Ex. 1003 ¶ 188; Ex. 1024). We credit Dr. van Schalkwijk's unrebutted testimony that a POSITA "would have understood that including Mg would increase the electronic conductivity of the material, alter the phase transition behavior of the de-lithiation process, and increase the charge voltage available to the cathode" and "including an additional dopant such as Al would provide structural enhancements to the cathode." Ex. 1003 ¶ 188 (citing Exs. 1022, 1024). Dr. van Schalkwijk's testimony is supported by the teachings of Tukamoto and Madhavi, as discussed above.

Undisputed evidence establishes that a POSITA would have understood that the concentration of Mg and Al in the cathode active material is a result-effective variable, and the optimum range of Mg and Al concentration would have been discovered by a POSITA by routine experimentation. Pet. 22 (citing Ex. 1003 ¶ 189); *see In re Applied Materials, Inc.*, 692 F.3d 1289, 1295 (Fed. Cir. 2012) (where the prior art discloses overlapping ranges, "it is not inventive to discover the optimum or workable ranges by routine experimentation," if the parameter is known to

be a result-effective variable) (quoting *In re Aller*, 220 F.2d 454, 456 (CCPA 1955)).

> We credit Dr. van Schalkwijk's unrebutted testimony that a POSITA would have used the smallest amount of Mg and Al possible to stabilize the structure because the Mg and Al do not participate in the electrochemical reaction, and Mg and Al are present at the expense of Co and/or Ni, which are electrochemically active and, therefore, contribute to the battery's capacity.

Ex. 1003 ¶ 189 (citing Ex. 1017 ¶¶ 29, 96, Table 2; Ex. 1018 ¶ 36; Ex. 1022, Fig. 6). We also credit Dr. van Schalkwijk's deposition testimony explaining that a POSITA would have determined the smallest amount of magnesium (Mg) and aluminum (Al) that stabilizes the structure by looking at battery cycling data and X-ray or other analysis of the cathode structure to determine whether solubility limits have been reached. Ex. 2016, 104:19–106:3; *see* Pet. Reply 12 (citing this testimony).

Dr. van Schalkwijk's testimony is supported by Tukamoto Figure 6, which compares the discharge profile (potential versus capacity) of Mg-doped cathode compositions with various Mg contents, namely $LiMg_xCo_{1-x}O_2$, where x = 0.01, 0.05, and 0.08. Ex. 1022, Fig. 6. Tukamoto observes that, as the amount of Mg increases, the discharge capacity decreases, which Tukamoto attributes to reduced Co^{3+} content in the composition since "only Co^{3+} and not Co^{4+} may be oxidized upon removal of Li during charging." *Id.* at 5. Tukamoto also observes that, "in compositions with low Mg content, e.g., x = 0.01, . . . there is a flat potential range toward the end of the discharge cycle" and "[a]t higher Mg contents, this flat region is lost, and instead a gradual decay in potential occurs." *Id.* at 5–6 (citing Fig. 6). Tukamoto's observations indicate that, of the three

cathode compositions, the one with the lowest Mg content, i.e., x = 0.01, had the best discharge characteristics. *Id.*

Dr. van Schalkwijk's testimony is further supported by Sato, which discloses a cathode active material of the formula, $Li_tCoM_sO_2$, where M is "at least one element selected from Mg and Al." Ex. 1017 ¶ 27. Sato teaches that, "when s is larger than 0.03, the initial capacity is disadvantageously lowered" and "[t]herefore, it is preferred that s falls in the range: $0 \leq s \leq 0.03$." *Id.* ¶ 29. Similarly, Sato teaches that

> in the . . . cathode active material represented by a general formula: $Li_tCoM_sO_2$, when the metal M is at least one member selected from Al and Mg and s falls in the range: $0 \leq s \leq 0.03$, not only can the capacity retaining ratio after the 150th cycle be improved, but also the lowering of the initial capacity can be suppressed.

Id. ¶ 101 (discussing Table 2). Further support for Dr. van Schalkwijk's testimony is provided by Sato's disclosure of a cathode active material of the formula, $Li_{1.00}CoAl_{0.015}Mg_{0.015}O_2$, which Sato teaches has optimum capacity retention and initial capacity and which has a molar amount of Mg and Al (M^2) falling within the claimed range. Ex. 1017 ¶¶ 96, 101, Table 2 (Example 8); *see* Pet. 23 n.4 (discussing Sato Table 2 and example with the above formula).

Dr. van Schalkwijk's testimony is still further supported by Watanabe, which discloses cathode active materials of the formula $Li_xCo_{1-y}M_yO_2$, where element M is preferably at least one of Mg, Al, and Mn, and x and y fall within the ranges $1.0 \leq x \leq 1.03$ and $0.005 \leq y \leq 0.15$. Ex. 1018 ¶¶ 32, 36. Watanabe teaches that "element M contributes to stabilization of the crystal structure of the composite oxide," and to produce this effect, "at least $0.005 \leq y$ is required to be satisfied." *Id.* ¶ 36. Watanabe cautions that,

"when 0.15<y, the problem of capacity degradation of the positive electrode active material arises." *Id.*; *see* Pet. 23 n.4 (discussing Watanabe).

Patent Owner does not dispute Petitioner's evidence that a POSITA would have understood that the concentration of Mg and Al in the cathode active material is a result-effective variable that would have been optimized through routine experimentation. Instead, Patent Owner argues that "limiting the amount of the Mg-containing M^2" to the claimed range is "critical," that Choi's range is "substantially larger" than the '446 Patent's range, and that Choi provides "no reason to select an amount of M^2" within the claimed range. PO Resp. 15–16 (citing Ex. 1001, 12:5–6, 12:30–32; Ex. 2008 ¶¶ 44–46); PO Sur-reply 12–13.

In IPR proceedings,

> "where there is a range disclosed in the prior art, and the claimed invention falls within that range, the burden of production falls upon the patentee to come forward with evidence" of teaching away, unexpected results or criticality, or other pertinent objective indicia indicating that the overlapping range would not have been obvious in light of that prior art.

DuPont, 904 F.3d at 1008 (quoting *Galderma Labs., L.P. v. Tolmar, Inc.*, 737 F.3d 731, 738 (Fed. Cir. 2013)). Here, Patent Owner does not meet its burden to produce evidence of non-obviousness of the claimed range for the molar amount of M^2.

Patent Owner directs us to the '446 Patent's teachings that, by requiring Mg, "the safety of the battery is more effectively improved," but that a large quantity of Mg should be avoided because "the load characteristic of the battery tends to decrease." PO Resp. 15 (citing Ex. 1001, 12:5–6; 12:30–32); PO Sur-reply 13 (same). We agree with Petitioner, however, that these teachings are ***not*** unexpected. Pet.

Reply 11–12. The unrebutted evidence discussed above demonstrates that a POSITA would have known to use as small an amount of Mg and Al as necessary to stabilize the structure without substantively interfering with the electrochemical reaction and also would have understood that amounts within the claimed range would provide these beneficial results. Ex. 1003 ¶¶ 188, 189; Ex. 1017 ¶¶ 29, 96, 101, Table 2; Ex. 1018 ¶ 36; Ex. 1022, Fig. 6; Ex. 2016, 104:19–106:3. Petitioner's evidence meets the applicable legal standard, which does not require identifying disclosure of the optimum or workable ranges in the prior art. *In re Aller*, 220 F.2d at 456 ("[W]here the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation.").

Furthermore, Patent Owner presents no data, comparative or otherwise, to back up the statements in the '446 Patent regarding safety and load characteristics of the battery. Patent Owner's reliance on conclusory statements in the specification is not enough to satisfy its burden to come forward with evidence of unexpected results or criticality. *In re De Blauwe*, 736 F.2d 699, 705 (Fed. Cir. 1984) ("It is well settled that unexpected results must be established by factual evidence. Mere argument or conclusory statements in the specification does not suffice.").

We have also considered Dr. Lucht's testimony. Ex. 2008 ¶¶ 44–46. Dr. Lucht relies on the same specification statements and presents no objective evidence of unexpected results or criticality for the molar range for M^2. *Id.* Dr. Lucht's testimony is therefore not sufficient to satisfy Patent Owner's burden of production. *See In re Lindner*, 457 F.2d 506, 508 (CCPA 1972) (mere conclusory statements in the specification and affidavits

are entitled to little weight and are not sufficient to show unexpected properties for the claimed compositions).

For these reasons, we determine that Petitioner has met its burden of proof for the molar amount of M^2 as recited in claim 1.

c) Element M^3

Claim 1 recites that, in formula (1), "M^3 represents an element other than Li, M^1 and M^2," in other words, an element other than Li, Co, Ni, Mn, Mg, Ti, Zr, Ge, Nb, Al, and Sn. Ex. 1001, 28:49–53. Claim 1 further recites that, in formula (1), the molar amount of M^3 is "v," where "$0 \leq v \leq 0.05$." *Id.* at 28:53–56.

Petitioner contends that M^3 is taught by X in Choi's Formula 2, where "X is selected from O, F, S and P." Pet. 23 (citing Ex. 1005, 5–6). Petitioner asserts that the amount of element M^3 in formula (1) in claim 1 may be zero and that Choi similarly teaches that the amount of element X in Formula 2 may be zero. Pet. 23–24 (citing Ex. 1001, 14:5–6; Ex. 1005, 5–6). Petitioner contends that a POSITA would have omitted element X from Choi's Formula 2 to make it easier to synthesize. Pet. 24 (citing Ex. 1003 ¶ 191).

Patent Owner argues that Choi does not disclose element M^3, which "must be a metal," and Choi "requires that X be a nonmetal." PO Resp. 17–18 (citing Ex. 1001, 14:7–16; Ex. 2008 ¶ 49). In addition, Patent Owner argues that "[n]othing disclosed in Choi about X matters, because X ***must be excluded*** for Choi to provide an O_2 oxide like the '446 Patent." *Id.* at 19 (citing Ex. 2015 ¶ 14).

For the reasons discussed below, we determine that the preponderance of the evidence favors Petitioner's position regarding element M^3.

We agree with Petitioner that it would be improper to read M^3 as limited to a metal. Pet. Reply 13. The portion of the '446 Patent specification cited by Patent Owner (Ex. 1001, 14:7–16) merely provides examples of element M^3 and does not demonstrate either patentee lexicography or a disavowal of claim scope. *Thorner*, 669 F.3d at 1365 ("To act as its own lexicographer, a patentee must 'clearly set forth a definition of the disputed claim term' other than its plain and ordinary meaning."); *id.* ("The standard for disavowal of claim scope is similarly exacting."). Understanding M^3 as not limited to a metal is consistent with the specification's description of elements M^1, M^2, and M^3, where M^1 represents a "transition metal element," M^2 represents a "metal element," and M^3 represents "an element other than Li, M^1 and M^2." Ex. 1001, 10:65–11:2, 13:66–14:2.

Regardless of the breadth of element M^3, however, there is no dispute that formula (1) in claim 1 can omit element M^3 altogether and that Choi similarly discloses that Formula 2 can omit element X. Pet. 23–24; PO Resp. 19 ("Choi teaches that the value of α (indicating the amount of X) is $0 \leq \alpha \leq 2$" and "the amount 'v' for M^3 can be in the range $0 \leq v \leq 0.05$, meaning that M^3 could be excluded"). In other words, element M^3 is ***optional*** in claim 1, and Choi's element X is likewise optional. *See* Ex. 1001, 14:2–6 (disclosing that the cathode active material "may contain no M^3").

Furthermore, undisputed evidence demonstrates a POSITA would have had a reason to omit X in Choi's Formula 2. Dr. van Schalkwijk testifies that a POSITA "would have understood that by setting 'α' at 0, [Choi's] Formula 2 would provide an oxide O_2, as the value of oxygen in Formula 2 ('$O_{2-\alpha}$') is dependent upon the value of 'α.'" Ex. 1003 ¶ 191 (citing Ex. 1005, 5–6). Patent Owner and Dr. Lucht agree that, when the

value of "α" is zero, Choi's Formula 2 is an oxide O_2. PO Resp. 19; Ex. 2015 ¶ 14. We credit Dr. van Schalkwijk's unrebutted testimony that a POSITA "would have understood that providing an oxide would make the positive electrode active material easier to synthesize because [if X were included] extra materials would have to be carefully added to the formulation to substitute for any amount of oxygen." Ex. 1003 ¶ 191. Dr. van Schalkwijk's testimony is consistent with Choi's exemplary cathode active materials, all but one of which are oxides that omit element X. Ex. 1005, 10; *see also* Ex. 1017 ¶ 39 (describing a method of synthesizing a lithium-transition metal composite oxide).

For these reasons, we determine that Petitioner has met its burden of proof for element M^3 as recited in claim 1.

d) Remaining Limitations of Claim 1

Based on the undisputed argument and evidence presented by Petitioner, we find that Choi teaches or suggests all remaining limitations of claim 1, except for the dinitrile compound limitation, which is taught or suggested by Kim. Pet. 13–20, 24–25; Ex. 1003 ¶¶ 148–184, 192–199; Ex. 1005, 4–13; Ex. 1006 ¶¶ 32, 37, 38.

5. Independent Claim 3

Claim 3 is similar to claim 1, except that claim 3 specifies the composition of "a lithium-containing transition metal oxide ***other than*** a lithium-containing transition metal oxide ***having the smallest average particle size***" and recites formula (2) instead of formula (1).[17] Ex. 1001, 29:12–30:9 (claim 3) (emphasis added).

[17] Formula (2), $Li_aM^1_bM^2_cM^3_dO_2$, differs from formula (1), $Li_xM^1_yM^2_zM^3_vO_2$, only with respect to the molar amounts of M^2 and M^3, which are $0 \leq c \leq 0.02$

Petitioner contends that formula (2), as recited in claim 3, is taught by Choi's Formulae 1 and 2.[18] Pet. 37 (addressing element of claim 3 by cross-referencing discussion of corresponding elements of claims 1 and 2); *see also* Pet. 25–34 (addressing claim 2).

Petitioner presents essentially the same contentions for element M^2, the molar amount of M^2, and element M^3 for claim 3 as we have discussed above for claim 1. *Compare* Pet. 28–30, 32–34, 37 (addressing claim 3), *with* Pet. 21–24 (addressing claim 1). For both claims 1 and 3, Patent Owner argues that Choi does not disclose the required presence of Mg and another M^2 element, that Choi does not disclose the claimed molar amount of M^2, and that Choi does not disclose element M^3. *Compare* PO Resp. 20–24 (addressing claim 3), *with id.* at 11–20 (addressing claim 1). We find that Petitioner has met its burden of proof for element M^2, the molar amount of M^2, and element M^3, as recited in claim 3, for the same reasons as discussed above for claim 1.

Based on the undisputed argument and evidence presented by Petitioner, we find that Choi teaches or suggests all remaining limitations of claim 3, except for the dinitrile compound limitation, which is taught or suggested by Kim. Pet. 13–20, 24–25, 35–37; Ex. 1003 ¶¶ 244–308; Ex. 1005, 4–13; Ex. 1006 ¶¶ 32, 37, 38.

---

and $0 \leq d \leq 0.02$ in formula (2) instead of $0.002 \leq z \leq 0.05$ and $0 \leq v \leq 0.05$ as in formula (1), respectively. Ex. 1001, 28:48–56, 29:28–30:7.

[18] Choi's Formula 1 ($Li_xCo_{1-y}M_yO_{2-\alpha}X_\alpha$) differs from Choi's Formula 2 ($Li_xCo_{1-y-z}Ni_yM_zO_{2-\alpha}X_\alpha$) in only two respects: (1) Formula 1 does not list Ni alongside Co as a transition metal; and (2) in Formula 1, the molar amount of element M is $0 \leq y \leq 0.9$ instead of $0 \leq z \leq 0.5$ as in Formula 2. Ex. 1005, 5–6. In both Choi Formula 1 and Choi Formula 2, however, element M could include Ni. *Id.* at 6.

6. Dependent Claims 2, 4, and 5

Petitioner contends that the additional limitations of dependent claims 2, 4, and 5 are taught or suggested by Choi. Pet. 25–35, 38. Patent Owner does not present arguments for dependent claims 2, 4, and 5 apart from its arguments for independent claims 1 and 3. *See* PO Resp. 12 (asserting that "[d]ependent claim 2 depends from claim 1 and, due to the dependence on claim 1, is not obvious"); *id.* at 21 (asserting that "[d]ependent claims 4 and 5 depend from claim 3 and, due to the dependence on claim 3, are not obvious").

Based on the undisputed argument and evidence presented by Petitioner, we find that Choi teaches or suggests the additional limitations of dependent claims 2, 4, and 5. Pet. 25–35, 38; Ex. 1003 ¶¶ 200–243, 309–328; Ex. 1005, 5–6, 10, 13, 14. For the same reasons as set forth above for independent claims 1 and 3, we determine that Petitioner has met its burden of proof for the limitations of dependent claims 2, 4, and 5 that are incorporated by reference. *See* 35 U.S.C. 112, para. 4 (2006) ("A claim in dependent form shall be construed to incorporate by reference all the limitations of the claim to which it refers.").

7. Conclusion for Petitioner's Challenge based on Choi and Kim

We determine that Petitioner has shown by a preponderance of the evidence that claims 1–5 are unpatentable as obvious based on Choi and Kim.

E. Petitioner's Challenge based on Koshiishi and Abe

Because we determine that Petitioner has shown that all challenged claims are unpatentable based on Choi and Kim, we do not reach Petitioner's challenge based on Koshiishi and Abe. *See SAS Inst. Inc. v.*

Iancu, 138 S. Ct. 1348, 1359 (2018) (holding a petitioner "is entitled to a final written decision addressing all of the claims it has challenged"); *Boston Sci. Scimed, Inc. v. Cook Grp. Inc.*, 809 F. App'x 984, 990 (Fed. Cir. 2020) (nonprecedential) ("We agree that the Board need not address [alternative grounds] that are not necessary to the resolution of the proceeding.").

III. CONCLUSION

In summary:

Claims	35 U.S.C. §[19]	References	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1–5	103(a)	Choi, Kim	1–5	
1–5	103(a)	Koshiishi, Abe		
Overall Outcome			1–5	

[19] We do not reach Petitioner's challenge based on Koshiishi and Abe because we determine that Petitioner has shown that all challenged claims are unpatentable based on Choi and Kim.

IV. ORDER[20]

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner has shown by a preponderance of the evidence that claims 1–5 of the '446 Patent are unpatentable; and

FURTHER ORDERED that because this Decision is final, a party to the proceeding seeking judicial review of the Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

[20] Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding,* 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. § 42.8(a)(3), (b)(2).

For PETITIONER Amperex Technology Limited:

Christopher TL Douglas
Miranda Sooter
ALSTON & BIRD LLP
christopher.douglas@alston.com
miranda.sooter@alston.com

For PATENT OWNER:

Jeffrey T. Han
Eric J. Klein
Paige H. Wright
Corbin J. Cessna
Abigail Lubow
VINSON & ELKINS LLP
jhan@velaw.com
eklein@velaw.com
pwright@velaw.com
ccessna@velaw.com
alubow@velaw.com