

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHUHAI COSMX BATTERY CO., LTD.,
Petitioner

v.

NINGDE AMPEREX TECHNOLOGY LIMITED,
Patent Owner

Case IPR2025-00524
U.S. Patent No. 12,015,118

**SUPPLEMENTAL DECLARATION OF DR. SAMUEL P. GIDO, PH.D., IN
SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S.
PATENT NO. 12,015,118**

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Zhuhai CosMX Battery Co. EX1037
CosMX v. Ningde
IPR2025-00524

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I. INTRODUCTION

1. I have been retained as a technical expert on behalf of Zhuhai CosMX Battery Co., Ltd. (“Petitioner”) to provide an analysis of U.S. Patent No. 12,015,118 (“the ’118 patent”). I understand that Petitioner is requesting that the Patent Trial and Appeal Board (“PTAB” or “Board”) cancel all claims of the ’118 patent as unpatentable.

2. I previously submitted a declaration (EX1010) in this proceeding in support of the Petition. I stand by all the opinions presented in that declaration, including in view of additional materials and arguments raised in this proceeding and the co-pending district court litigation. I submit this additional declaration for the limited purpose of responding to issues raised by Patent Owner and its expert, Dr. Wheeler, in his Supplemental Declaration (EX2058).

II. MY PROFESSIONAL EXPERIENCE AND QUALIFICATIONS

3. An overview of my education, professional experience, and qualification is presented in my opening declaration, along with a copy of my *curriculum vitae* (“CV”) as Exhibit 1011. As those documents show, I am a professor of polymer science and engineering with experience in the compositions and structures of lithium-ion batteries. As such, I have *at least* the level of ordinary skill in the art of the ’118 patent, which relates generally to the field of battery materials and construction, and specifically battery construction materials and their properties.

4. I have broad expertise across the fields of polymers (plastics), polymer-nanoparticle composites, fluorinated polymers, polyolefins, porous materials, phase separations, and coating processes. I am an expert in and experienced user of a range of materials characterization techniques including scattering and spectroscopies, with a particular emphasis on microscopy, especially electron microscopy such as scanning electron microscopy (SEM) and associated analysis via energy dispersive X-ray spectroscopy (EDS).

5. Over the years I have studied materials for a broad range of applications, including batteries, fuel cells, adhesives, non-stick coatings, elastomers, composites, and nanostructures. In addition to academic research, I have done research for and/or consulted for a range of companies including W.L. Gore, Boston Scientific, FujiFilm (Japan), Kureha Chemical Industry (Japan), Sekisui Chemical Co. (Japan), Loctite Corp. (now Henkel), Rexam Graphics, St. Gobain, and Scapa Tape.

6. I have numerous publications including 14 issued patents, including patents on fluoropolymers and their applications, including batteries, fuel cell separators, and novel audio devices. I have conducted research on materials for batteries and fuel cells, including fluorinated polymers as solid electrolytes and polymer-particle composites, with funding from Kureha (Japan) and the U.S. Army.

7. One of my graduate students and I also worked on a battery research project, at the University of Massachusetts sponsored by Sekisui Chemical (Japan), in which we experimented with new materials, formulations and structures, for separators, electrolytes and electrode binders. This project involved building and testing lithium-ion battery cells, including with benchtop and pilot scale roll-to-roll coating equipment at the University of Massachusetts. These studies involved developing polymer chemistries, nano- and micro-scale composite structures, porous structures, and coating processes to enhance ion conductivity.

8. Fluoropolymers are key binder materials in the '118 patent's porous electrode compositions. I have also conducted research on materials for batteries with funding from industry and the U.S. Army, developing polymer chemistries, nano- and micro-scale composite structures and porous structures, and coating processes to enhance ion conductivity. I have published peer-reviewed papers on porous polyolefin layers and polymer solid electrolyte materials which have multiple uses, particularly in fuel cells and batteries.

9. As mentioned in my opening declaration, I have also studied the diffusion of ions through various materials, which is of particular importance to the '118 patent and the construction of battery electrodes, which require the diffusion of Li^+ ions from the current collector through the electrode material. I also have extensive experience using electron microscopy and laser diffraction to measure

particle size, and I have first-hand experience with the kind of machinery and methodology used, for example, in the Ishigaki reference to measure particle-size, i.e., D90 and D50 as a volume standard.

10. I also teach a seminar, FFYS 191POLY The Polymer Age, which focuses on popular and societal impacts of polymers, which features lithium-ion batteries with a particular focus on the materials used in their construction. As a college-level teacher of this subject matter for several years, I consider myself an expert in the field of battery materials and construction, specifically focused on materials useful in battery construction and the properties of those materials.

11. As I stated in my opening declaration, based on my analysis of the '118 patent, it is my opinion that a POSA at the date attributed to the invention would have had at least an undergraduate degree in chemistry, chemical engineering, polymer science and engineering, or materials science and engineering and two years of experience in the field of battery materials and construction. A higher level of education, such as a Master's Degree in one of these same fields, could substitute for work experience. Based on my educational background and experience, I qualify as at least a POSA at the time of the alleged invention of the patent. And, based on my experience, I have an understanding of the capabilities of a person of ordinary skill in the relevant field. I have supervised, directed, and instructed many such persons over the course of my career.

IV. ADDITIONAL MATERIALS CONSIDERED

12. Since I submitted my declaration in support of the Petition, Patent Owner has introduced new exhibits, and Petitioner has introduced additional evidence responsive to those exhibits. I have considered those additional materials in evaluating my opinions in this proceeding and present an updated list of those materials below.

Exhibit No.	Description
1001	U.S. Patent No. 12,015,118
1002	File History of U.S. Patent No. 12,015,118
1003	Chinese Publication No. 202905885 with Certified English Language Translation (“Li”)
1004	Japanese Publication No. 2013-211096 with Certified English Language Translation (“Ishigaki”)
1005	U.S. Patent Publication No. 2011/0168550 (“Wang”)
1006	U.S. Patent Publication No. 2017/0256776 (“Saka”)
1007	Excel Spreadsheet of Saka Calculations
1008	U.S. Patent Publication No. 2016/0013480 (“Sikha”)
1009	U.S. Patent Publication No. 2013/0302685 (“Kim”)
1011	<i>Curriculum Vitae</i> of Dr. Samuel P. Gido
1012	Certified Translation of the File History of Chinese Patent No. 109004170
1013	“Lithium Ion Battery Nickel Manganese Cobalt Oxide Nmc Cathode Raw Material For Lab Battery Research,” Alibaba, accessed at https://www.alibaba.com/product-detail/Lithium-Ion-Battery-Nickel-Manganese-Cobalt_1600084022147.html
1014	<i>Intentionally Left Blank</i>
1015	File History of U.S. Patent No. 11,664,528
1016	File History of U.S. Patent No. 11,322,774

Exhibit No.	Description
1017	File History of U.S. Patent No. 10,693,181
1018	ISO 13320-1 standard
1019	<i>Intentionally Left Blank</i>
1020	Kim, J., et al., “Structure Dependent Electrochemical Behaviors of Hard Carbon Anode Materials Derived from Natural Polymers for Next-Generation Sodium Ion Battery” <i>Polymers</i> , 15(22):4373 (Nov. 2023)
1021	Malvern Instruments Ltd., “A basic guide to particle characterization,” accessed at https://www.malvernpanalytical.com/en/learn/knowledge-center/whitepapers/wp120620basicguidepartchar
1022	“Battery Capacity,” accessed at https://www.pveducation.org/pvcdrom/battery-characteristics/battery-capacity
1023	“What is the difference between hard carbon black and soft carbon black?,” <i>Dery Chemical</i> , accessed at https://www.dr-carbonblack.com/what-is-the-difference-between-hard-carbon-black-and-soft-carbon-black
1024	“Overview of carbon black industry in China,” Henan Jinhe Industry Co., Ltd., accessed at https://www.jinhetec.com/blog/overview-of-carbon-black-industry-in-china-53773.html
1025	Abanades, A., et al., “Experimental analysis of direct thermal methane cracking,” <i>International Journal of Hydrogen Energy</i> , Vol. 36, pp. 12877-86 (Aug. 2011)
1026	Kim, M., et al., “Preparation of high-crystallinity synthetic graphite from hard carbon-based carbon black,” <i>Applied Physics</i> , Vol. 127:156 (Feb. 2021)
1027	Dick, J.S., et al., “Alternate Instrumental Methods of Measuring Scorch and Cure Characteristics,” <i>Polymer Testing</i> , Vol. 14, pp. 45-84 (April 1994)
1028	Schlögl, R., “Part A: 2.1.10 Carbons,” Department of Inorganic Chemistry, Fritz-Haber-Institute of the MPG (2008)

Exhibit No.	Description
1029	“PGR and IPR Institution Rates over Time,” Biologics HQ, accessed at https://biologicshq.com/stats_entry/pgr-and-ipr-institution-rates-over-time/ (last accessed Aug. 4, 2025)
1030	Declaration of John C. Evans
1031	“Particle Size Distribution,” <i>Anton Paar Wiki</i> , accessed at https://wiki.anton-paar.com/en/particle-size-distribution/ (last accessed March 3, 2026)
1032	“Particle size analysis – Laser diffraction methods,” ISO 13320:2009, accessed at https://www.iso.org/standard/44929.html (last accessed at March 3, 2026)
1033	“Top 10 Errors in Particle Analysis and How to Avoid Them,” Microtrac MRB White Paper
1034	“Explanation of Data Reported by Microtrac Instruments,” Microtrac MRB
1035	<i>Intentionally left blank</i>
1036	Deposition Transcript of Dean R. Wheeler, Ph.D. (March 30, 2026)
1037	<i>Intentionally left blank</i>
1038	Particle Size Analyzer Function and Features, https://www.microtrac.com/products/particle-size-shape-analysis/laser-diffraction/bluewave/ , last accessed on April 29, 2026
1039	Kim, Y. “Lithium Nickel Cobalt Manganese Oxide Synthesized Using Alkali Chloride Flux: Morphology and Performance As a Cathode material for Lithium Ion Batteries,” <i>ACS Appl. Mater. Interfaces</i> , 4 (2012), 2329-2333
1040	National Center for Biotechnology Information (2026). PubChem Compound Summary for CID 172866199, Carbon Black. Retrieved April 29, 2026, from https://pubchem.ncbi.nlm.nih.gov/compound/172866199 .
1041	“Solef PVDF for Li-Ion Batteries,” Syensqo
1042	“Kynar HSV 302 Powder,” Technical Data Sheet, Kynar

Exhibit No.	Description
1043	Pushnov, A.S. Calculation of average bed porosity. <i>Chem Petrol Eng</i> 42, 14–17 (2006).
1044	Akimoto et al. “Synthesis and Structure Refinement of LiCoO ₂ Single Crystals” <i>J. of Solid State Chemistry</i> , vol. 141, 298-302, 1998.
1045	Oljaca et al., “Novel Li(Ni _{1/3} Co _{1/3} Mn _{1/3}) O ₂ cathode morphologies for high power Li-ion batteries,” <i>Journal of Power Sources</i> , 248 (2014) 729-738

13. I confirm that to the best of my knowledge the accompanying exhibits are true and accurate copies of what they purport to be, and that an expert in the field would reasonably rely on them to formulate opinions such as those set forth in this Declaration.

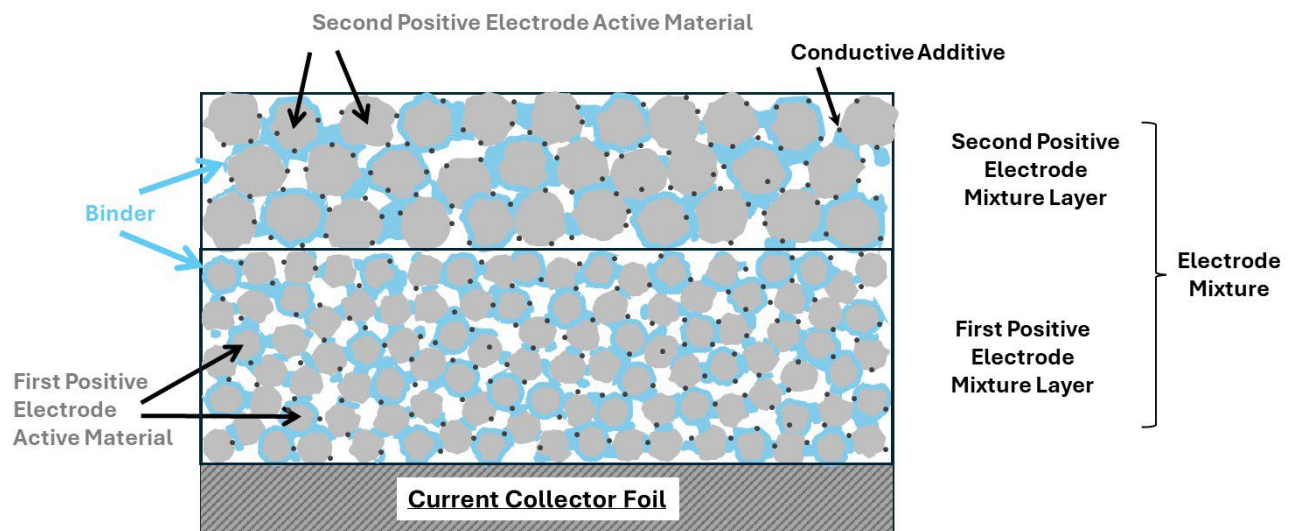
IV. CLAIM CONSTRUCTION

14. My understanding of Patent Owner and Dr. Wheeler’s position is that they do not dispute my interpretations of any of the ’118 patent claim terms. I also understand that no claim construction positions taken on either side in the parallel district court are inconsistent with my claim interpretations in my opening declaration. It appears that Dr. Wheeler only takes issue with how I have compared claim terms like “compaction density” and “Dv50,” as construed, to prior art disclosures of similar concepts, like “press density” or “D50.” *See, e.g.*, EX2058, ¶¶18, 19, 20, 33, 34, 40-42, 50, 89, 95, 97, 116. This does not appear to be a claim construction dispute, but rather a dispute about how the prior art discloses the subject matter of the claims as properly construed.

V. GROUND 1: CLAIMS 1-20 ARE ANTICIPATED BY ISHIGAKI

15. I understand that neither Patent Owner nor Dr. Wheeler raises any new disputes that Ishigaki discloses an electrode comprising a current collector foil, a first layer comprising a first material, and a second layer comprising a second material, wherein the first layer is arranged between the current collector and the second material, and the first layer is formed on a surface of the current collector. *See, e.g.*, EX1004, ¶¶14, 153, 347, 348, 366. Ishigaki therefore anticipates these limitations of independent claims 1, 10, and 19 for all the reasons stated in my opening declaration and that the Board already credited in the institution decision. EX1010, ¶¶72-80, 133-40, 181-88; Paper 11, 28, 29, 38, 39.

16. Below is a revised version of Demonstrative 1 from my opening declaration, in which I depict the components of Ishigaki's layers with more detail, showing the active material, binder, conductive additive, and pores.



Gido Demonstrative 1A, illustrating certain disclosures in Ishigaki.

1. Ishigaski discloses a particle size of 90% accumulative volume of the first active material is less than 40 μm .

17. Ishigaki discloses that the first positive electrode active material has particles with 90% cumulative diameter less than 10 μm . EX1004, ¶38. This limitation of claims 1, 10, and 19 is therefore satisfied.

18. I understand that Patent Owner disputes that Ishigaki discloses a particle size of 90% accumulative volume (Dv90) less than 40 μm (as required by claims 1, 10, and 19) because Dr. Wheeler contends that Ishigaki is unclear as to whether its reported D90 value of < 10 μm corresponds to a volume-weighted distribution (Dv90), as opposed to some other distribution (like number-based, Dn90). Paper 22, 1, 8-15; EX2058, ¶¶31-42, 48-50. I disagree. Ishigaki's teachings are clear and a POSA would not be confused.

19. Ishigaki states "the 90% cumulative diameter (D90) are measured by a well-known laser diffraction/scattering particle size distribution measuring device... and a *particle diameter standard as a volume standard*." EX1004, ¶39 (emphasis added). Ishigaki's particle size is therefore measured by volume, which corresponds to Dv90 (the volume standard). EX1018 (ISO 13320-1 standard explaining that laser diffraction is a volume-based measurement).

20. Indeed, a POSA would understand a volume-weighted distribution to be the default parameter of standard laser diffraction/scattering particle size distribution measuring. That is because laser diffraction devices inherently

measure volume-weighted distributions. Dv90 is their default output and is well known to be their most accurate output (which is intrinsic to the physical principles of how the technique works). While the machine can convert the Dv90 output to some other distribution, like number-weighted, those outputs are known to be “less accurate and the volume distribution should be used whenever possible.” EX1033, 6. In the absence of a specific teaching that Ishigaki’s D90 laser diffraction based on a volume standard is based on some other distribution, a POSA would understand it to be referring to Dv90.

21. Dr. Wheeler introduces a product data sheet (EX2051) for a well-known laser diffraction machine, the Microtrac S3500, which he contends can output D90 measurements with number-weighted distributions. EX2058, ¶¶38, 39. While Dr. Wheeler’s observation about the machine’s capabilities is correct, he neglects to include all of the information that appears on the websites that he references. In EX2051, 5, a hyperlink points to a landing page for the Microtrac S3500, and a “Downloads” tab which contains the product data sheet and also contains additional documents relevant to this discussion. Of note are EX1033 (a white paper titled “Top 10 Errors in Particle Analysis and How to Avoid Them”) and EX1034 (a technical note titled “Explanation of Data Reported by Microtrac Instruments”), both of which provide context conveniently ignored by Dr. Wheeler.

22. These additional materials, which would be available to a POSA from the same websites and provide more specific information about that same machine, confirm what I explained in my deposition: number-based distributions and averages are conversion values that are disfavored in the art. Indeed, Microtrac even explains that distributions are inherently volume-weighted, i.e., Dv90. As noted in EX1033, 6 (emphasis added):

Laser diffraction relates all signals to a sphere of equal effect and thus provides volume-based distributions. Since a collective signal and not individual incidents are evaluated here, *laser diffraction cannot determine number distributions*.

Additionally:

Converting laser diffraction results to number distributions is also possible, but since only a simple spherical model is available here, this is less accurate, and the *volume distribution should be used whenever possible*.

EX1033, 6 (emphasis added). In other words, the manufacturer of the machine on which PO bases its argument confirms that laser diffraction provides volume-based distributions and even explains that laser diffraction cannot determine number distributions and the volume distribution should be used whenever possible.

23. Documents produced by Microtrac further show that the manufacturer explicitly uses “D50” to denote “the percentage of the *volume* (or weight if the density for all the particles is the same) that is smaller than the size indicated”. EX1034, 4 (emphasis added). As confirmed by Dr. Wheeler during his deposition, the manufacturer who published EX1034 is indeed the same as the manufacturer

who published EX2051, and “*this manufacturer is stating that D50 can represent – for their instrument can represent a volume-based distribution*”. EX1036, 45:5-19 (emphasis added).

24. Beyond these additional materials produced by Microtrac, there is still more relevant disclosure to be found linked from Patent Owner’s own Exhibits. EX2018 in particular (cited by Dr. Wheeler at EX2058, ¶¶36, 45) *directly links to* one statement supporting the fact that laser diffraction measurement devices inherently measure volume-weighted distributions and *directly references* another.

25. As seen on page 9 of EX2018, there is a hyperlink associated with the phrase “particle size distribution”, and the hyperlink points to another article from Anton Paar. The linked “Particle size distribution” website states that “[d]ifferent particle sizing techniques will also give results that are intrinsically of a specific weighting, as shown in Table 1 below”, and then Table 1 lists the laser diffraction measurement technique as being intrinsically “volume-weighted”. EX1031, 2, 3.

Weighting	Measurement technique
Number-weighted distribution (% number)	Microscopy, dynamic image analysis
Surface-weighted distribution (% in surface) (% in surface)	Gas absorption
Volume-weighted distribution (% in volume)	Sedimentation, laser diffraction, X-ray diffraction
Intensity-weighted distribution (% in intensity)	Dynamic light scattering (DLS)

Table 1: Particle size distributions delivered by different measurement techniques

EX1031, Table 1 (annotated)

26. Second, as seen on page 10 of EX2018, there is a reference to “ISO 13320:2009, Particle size analysis – Laser diffraction methods” which Dr. Wheeler confirmed he was familiar with when he formed his opinions in this proceeding. EX1036, 38:13-16. The abstract for this reference states that “ISO 13320:2009 provides guidance on instrument qualification and size distribution measurement of particles [...] through the analysis of their light-scattering properties”, and “[f]or non-spherical particles, a size distribution is reported, where the predicted scattering pattern for the *volumetric sum* of spherical particles matches the measured scattering pattern”. EX1032, 1 (emphasis added). Dr. Wheeler seemingly chose to ignore this statement, which again reiterates that laser diffraction

measurement devices work on physical principles that measure *inherently volume-weighted distributions*.

27. Dr. Wheeler’s suggestion that a POSA reading Ishigaki would simply throw up their hands and have no idea the meaning of its reported D90 value—because Ishigaki doesn’t specify that it is a volume-weighted distribution—is simply not credible. A POSA would interpret Ishigaki’s number to correspond to the default output of the well-known laser diffraction machine, which is based on a volume distribution that the machine’s own manufacturer says to use “whenever possible.” This is the standard practice in the industry.

28. Dr. Wheeler’s alternative suggestion that a POSA would interpret Ishigaki’s D90 value for secondary particles, measured with laser diffraction, to be a number-weighted distribution because of the difficulty in measuring agglomerated primary particles also makes no sense. EX2058, ¶¶43-45. PO suggests that because Ishigaki utilized particle-size counting from SEM images for primary particles, that “a POSITA would have understood that a direct, apples-to-apples comparison of the primary particle sizes to the secondary particle sizes would require the statistical approach to be the same” and therefore would have expected to use a “number-based particle distribution for both the primary particles and the secondary particles of Ishigaki”. EX2058, ¶¶47, 48. That is conjecture. Just because Dr. Wheeler can *hypothesize* a reason why a POSA might want to deviate

from the intrinsic volume-weighted distribution recommended for laser diffraction does not mean that a POSA would assume Ishigaki actually did so, absent some indication in Ishigaki. Ishigaki plainly discloses “a particle diameter standard as a volume standard,” for a measurement in which the machine outputs a volume-weighted distribution as a default. EX1004, ¶39. A white paper produced by the manufacturer which produced this machine specifically instructs a POSA to use volume-weighted measurements whenever possible. EX1033, 6. A POSA would thus understand that Ishigaki’s D90 value corresponds to a volume-weighted distribution, absent some indication otherwise.

29. A POSA would be accustomed to working with number-based distributions and averages for some particles, such as primary particles for which their agglomerated state requires image analysis rather than laser diffraction, while at the same time using volume-based size distributions and averages obtained by laser diffraction for other particles, such as the secondary particles, which can be suitably dispersed for analysis. A POSA would expect and understand this difference and would have no problem thinking about and comparing the sizes of the primary and secondary particles. This is routinely done. For instance, Oljaca et al. use a “BlueWave particle size analyzer,” which is a laser diffraction instrument produced by Microtrac (the same manufacturer cited by Dr. Wheeler for EX2051) to measure nickel-cobalt-manganese (NCM) secondary particle sizes on a volume

basis. EX1037, 731, Table 1; EX1038; EX2058, ¶¶38, 39. In the same study, they use SEM to measure primary particle sizes, which are inherently on a number basis, and which are shown in Figure 3 along with some of the SEM images. EX1037, FIG. 3.

30. If the POSA really wanted to compare the sizes of the primary and secondary particles on the same weighting basis, they would convert the primary particle number-based size distribution and averages to a volume basis for comparison to the secondary particles, rather than the other way around as speculated by Dr. Wheeler. This is because volume-based distributions are the standard for a POSA to think about and express particle size distributions and averages, and also because volume-based distributions are more technically useful to a POSA than number-based distributions. This is because volume-based distributions give more weight in the average to the larger particles, which make up proportionately more of the material and thus contribute more to material properties.

2. Ishigaki discloses a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

31. Ishigaki discloses an electrode in which a total compaction density of the first layer and the second layer is greater than 3.2 g/cc. This limitation of claims 1, 10, and 19 is therefore satisfied.

32. All of Ishigaki's teachings about the attributes of the electrode apply to both one layer and two-layer structures. When discussing the layer structure of the electrode, Ishigaki simply explains the process for making a layer and then explains that a second layer can be applied to a first layer. EX1004, ¶¶153, 347, 348. Ishigaki discloses treating the electrode mixture by pressure to increase the packing density of the positive electrode materials. This is "compaction density" because the entire layer, including active material particles, conductive additive, and polymer binder, is compacted by mechanical pressing, typically applied by a metal roller or a pair of metal rollers. EX1004, ¶24 ("[T]he positive electrode active material layer obtained by coating and drying is preferably consolidated by a hand press, a roller press, or the like in order to increase the packing density of the positive electrode active material."). The density that results from this treatment is compaction density as claimed.

33. When Ishigaki gives a specific example of a two-layer embodiment, it provides only a single density value, reflecting the total compaction density for both layers, even though those layers likely have different densities. EX1004, ¶366. Elsewhere in Ishigaki, it gives more detail regarding the various preferred compaction densities for the electrode, including a range with an upper limit of 4.2 g/cc, with more preferred embodiments at 4.0 g/cc and 3.8 g/cc. EX1004, ¶151. This numeric range overlaps the numeric range of the claims and therefore

anticipates it. This disclosure also identifies various preferred embodiments (like 4.0 g/cc and 3.8 g/cc), each of which falls within the claimed numeric range, and therefore anticipates it that way as well.

34. Ishigaki also explains why the upper limit on compaction density is what it is, since space is required in the positive electrode plate to hold the electrolyte in the electrode plate and to supply lithium ions. EX1004, ¶25. Ishigaki thus teaches a POSA the tradeoffs between maximizing energy capacity of the battery (through higher density) and providing space to hold the electrolyte (through porosity). Ishigaki teaches a POSA that a way to navigate those tradeoffs is to limit the compaction density to 3.6 g/cm³, more preferably 3.5 g/cm³, and particularly preferably 3.4 g/cm³. All of these disclosures describe additional preferred embodiments of Ishigaki in which the compaction density is greater than 3.2 g/cc.

35. I understand Patent Owner disputes this compaction density limitation for claims 1, 10, and 19. Paper 22, 16. First, Patent Owner contends that merely disclosing an overlapping range is not enough, because there is a criticality to the claimed 3.2 g/cc lower boundary. Paper 22, 36-38, 43-45, 60; EX2058, ¶¶63-66, 78-81, 103-05. As a preliminary matter, I note that the '118 patent specification does not ascribe any criticality to that range. For example, the '118 patent specification mentions compaction density greater than 3.2 g/cm³ only once,

without discussion of higher or lower compaction density or any explanation of why that particular value or range makes a difference to the alleged invention.

EX1001, 6:20-27. And while Table 1 of the '118 patent reports energy densities for fifty examples, it fails to report compaction density for any of those examples. *Id.*, Table 1. There is no discussion in the '118 patent of any critical energy density, or whether any of the examples meet or fail to meet target energy densities other than to say that they are “not substantially affected” in relation to the comparative example. *Id.*, 17:40-44. There is also no data in the '118 patent related to how achieving the claimed compaction densities substantially improved the energy densities of the claimed electrodes, were otherwise critical to producing particular energy densities or otherwise produced any unexpected results. Any incremental improvement in energy density associated with increased compaction density would be a simple difference of degree expected in the art, and not in any way a different kind of result than what would have been expected.

36. Regardless, Ishigaki directs a POSA to prefer higher density embodiments because it teaches that these embodiments are desirable from the “viewpoint of increasing capacitance density,” which a POSA would understand to mean battery capacity due to energy density. EX1004, ¶25. Ishigaki even teaches a POSA to pack the electrode active material “as densely as possible” in order to maximize the energy capacity of the battery. EX1004, ¶7. Thus, to the extent there

is anything potentially critical about the patented range of greater than 3.2 g/cc, Ishigaki teaches that criticality.

37. Furthermore, Ishigaki teaches more than merely an overlapping numeric range. Ishigaki also teaches multiple density embodiments, several of which fall within the claimed range. EX1004, ¶¶25, 151 (including embodiments with densities at an upper limit of 4.2 g/cc, more preferably 4.0 g/cc, and most preferably 3.8 g/cc). Ishigaki's teaching that higher densities increase electrical capacity, which is a goal of Ishigaki (EX1004, ¶216), while also teaching that the most preferred upper limit is lower than the working upper limit, in order to balance other tradeoffs, implies embodiments at those limits. I understand that where the prior art expressly or inherently discloses an embodiment that falls within the claimed range, there is no requirement to teach the criticality of the range.

38. I understand that Patent Owner also argues that Ishigaki's higher-density embodiments do not anticipate the claims because they are not disclosed as pertaining to two-layer structures. Paper 22, 16-20. Dr. Wheeler points out that the only example of a two-layer embodiment has a total density below the claimed range. EX2058 ¶52. I think that is too narrow a reading of what Ishigaki actually teaches, both expressly and inherently. A POSA would interpret the organization and structure of Ishigaki's disclosure to describe embodiments beyond those listed

in the section presenting working examples. Because Ishigaki discloses the attributes preferred for an electrode, regardless of whether the electrode has a one or two-layer structure, a POSA would understand Ishigaki to inherently disclose a range of compaction densities for a two-layer electrode.

39. Dr. Wheeler's basis for opining that all of Ishigaki's density disclosures are irrelevant other than the specific two-layer working example is his contention the density requirements of a two-layer structure are different than a one-layer structure. EX2058, ¶¶53-60. I disagree. First, it is not true that the density requirements of a two-layer structure are so different from a one-layer structure that a POSA would consider the density values for one to be completely inapplicable to the other. Generally, the average density of a two-layer structure delivers the same energy capacity as a one-layer structure of that density, or a gradient structure with the same average density. That is because the energy capacity of the electrode is primarily driven by the amount of active material packed into the electrode, and not the internal structure. The reason for choosing a two-layer structure or a gradient structure is because lower density electrode material will adhere better to the current collector foil, but at the expense of energy capacity. A POSA would understand that adding a higher-density layer to the lower density layer will compensate for that tradeoff.

40. Second, Dr. Wheeler explains his opinion about two-layer structures by observing that when a second layer is added to the first layer, it will re-wet the interface of the first layer and could cause further compaction. EX2058, ¶¶57, 58. I agree that this could happen, but whether it happens has nothing to do with the desired density for the overall structure. Indeed the '118 patent itself says that the two layers could have a “clear interface,” or the layers could be “bonded to each other without obvious interface by the embedding of the upper and lower layer particles and the binder between the two active material layers.” EX1001, 4:48-54. The specification presents both structures as viable options and identifies no difference in the total desired compaction density.

41. During my deposition, I analogized the process of coating the layers on the electrode with applying coats of paint. EX2050, 23:3-16; 79:9-80:19. That analogy served the purpose of answering a question about how an electrode could be applied in layers (and therefore have a two-layer structure) even if the layers had the same properties. It is not the concession that Dr. Wheeler seems to think it is. Dr. Wheeler apparently misinterpreted my comment to require that there be a “permanent ‘skin’” separating the layers. EX2058, ¶¶57, 58. I never said permanent. That is a misrepresentation of my testimony. I also never said that the skin between the layers could not be re-wet or blurred. And it would not matter. If

anything, further compaction of the re-wetted interface would only push the resulting compaction density further into the claimed numeric range.

42. The point remains that nothing about a two-layer structure dramatically changes the desired density of the overall electrode to the point that a POSA would divorce Ishigaki's disclosure of preferred electrode densities for achieving high energy capacity from Ishigaki's disclosure of a two-layer electrode.

43. Finally, Dr. Wheeler disputes my mathematical presentation of the inherent disclosure of Ishigaki based on the calculated density ranges inherent to the embodiments Ishigaki describes. EX2058, ¶¶61, 62. Specifically, Dr. Wheeler argues that my calculated theoretical maximum of 4.4 g/cc for a layer of Ishigaki's electrode neglects to consider the internal porosity of the secondary particles and does not provide for space to hold the electrolyte. EX2058, ¶¶63-65, 77, 78. Dr. Wheeler completely misses the point of calculating a *theoretical maximum* density.

44. Of course, one could not construct a working embodiment at the theoretical maximum, nor would one want to. The premise of the theoretical maximum assumes zero porosity, which does not purport to reflect a working electrode. The purpose of a theoretical maximum is to understand the absolute highest density that it is not physically possible to exceed given the materials of Ishigaki. That provides the upper boundary on my demonstrative—a boundary we know with mathematical certainty cannot be exceeded. Ishigaki's express

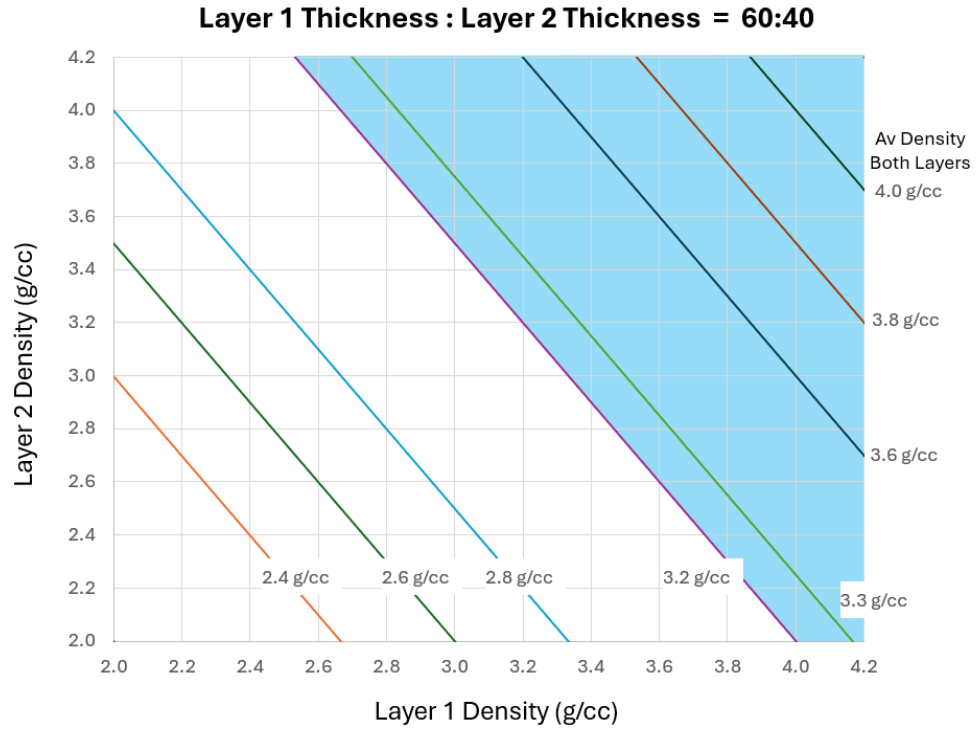
teachings provide the lower boundary of 2.0 g/cc. The inherent range is therefore between those two, and Ishigaki's other teachings will direct a POSA to where the working embodiments and preferred embodiments are within that range.

45. I do not understand Dr. Wheeler to dispute my math or suggest that my demonstratives fail to accurately depict Ishigaki's inherent disclosure. Rather, I understand that his objection is that the Board may be misled by my graphical depiction into believing that Ishigaki's *theoretical* maximum density (4.4 g/cc) is *achievable* practically. EX1036, 75:6-76:16; EX2058, ¶¶73-75. I do not agree that my use of the theoretical maximum in creating the demonstrative is misleading, as I explain what it represents and the assumptions I used. I also do not rely on a purported embodiment at the theoretical maximum to anticipate the claimed range, as there are plenty of inherently disclosed embodiments that are well below the theoretical maximum and are in what Ishigaki expressly identifies as the working range (i.e., those below 4.2 g/cc).

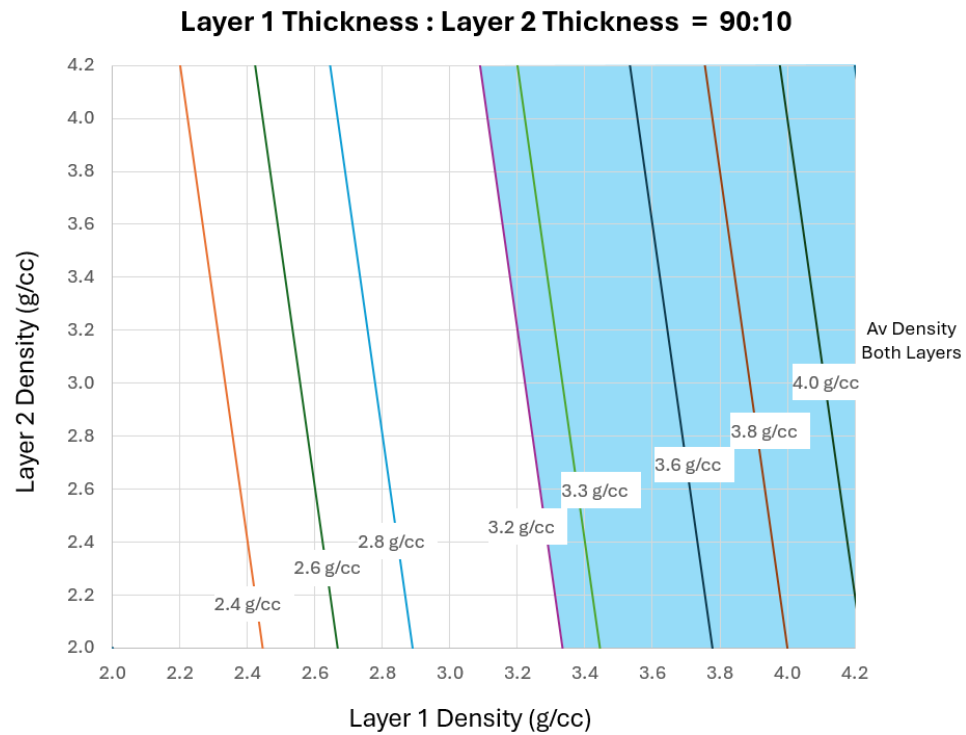
46. The purpose of representing Ishigaki's inherent teaching graphically, like I do in Gido Demonstrative 7 and Gido Demonstrative 8, is to show that there is a large area of the graph that reflects many working embodiments for a two-layer structure, with the precise layer thickness ratios claimed, that are also comfortably within the claimed numeric range for compaction density. I do not contend and do not need to contend that every single red pixel in the graph

corresponds to a working embodiment. In other words, the demonstrative shows, mathematically, that there is a large overlap between the densities inherent to Ishigaki's disclosure and the claimed numeric range, and many of Ishigaki's expressly disclosed embodiments fall within that overlap, while also meeting all the other limitations of claims 1-20 of the '118 patent.

47. In order to avoid further confusion on these issues, I have prepared the slightly modified versions of Gido Demonstratives 7 and 8, shown below (using blue and white this time instead of red and yellow). In these modified demonstratives, the graphs only include layer densities in the range (2.0 to 4.2 g/cm³) taught by Ishigaki. The graphs do not extend to the theoretical maximum density. In each of these graphs the entire area (white plus blue) is taught by Ishigaki, and the blue area represents densities of the first and second layer taught by Ishigaki that combine to produce an overall cathode compaction density greater than 3.2 g/cm³, anticipating the claim element.



48. Gido Demonstrative 7



49. Gido Demonstrative 8

50. To be clear, these graphs illustrate the same calculations and the same inherent disclosure as those presented in my opening declaration. These changes are made solely to address Dr. Wheeler's criticism that my original graphs—while accurately reflecting Ishigaki's teachings to a POSA—might mislead the Board into thinking that the *theoretical* maximum density is actually achievable. As revised above, the graphs show Ishigaki's teachings for a narrower range of embodiments that more closely align Ishigaki's inherent disclosures with Ishigaki's express disclosures.

3. Ishigaki anticipates claims 2-4, 7-9, 11-13, and 16-18 for the reasons given above and in my opening declaration.

51. I understand that neither Patent Owner nor Dr. Wheeler presents any challenges to my analysis for claims 2-4, 7-9, 11-13, and 16-18 other than to incorporate by reference their challenges to claims 1, 10, and 19. EX2058, ¶¶79-81. Those challenges fail for the reasons I explain above. Ishigaki therefore anticipates claims 2-4, 7-9, 11-13, and 16-18 for all the reasons I present in my opening declaration, the additional discussion I provide above, and the reasons provided by the Board in the Institution Decision.

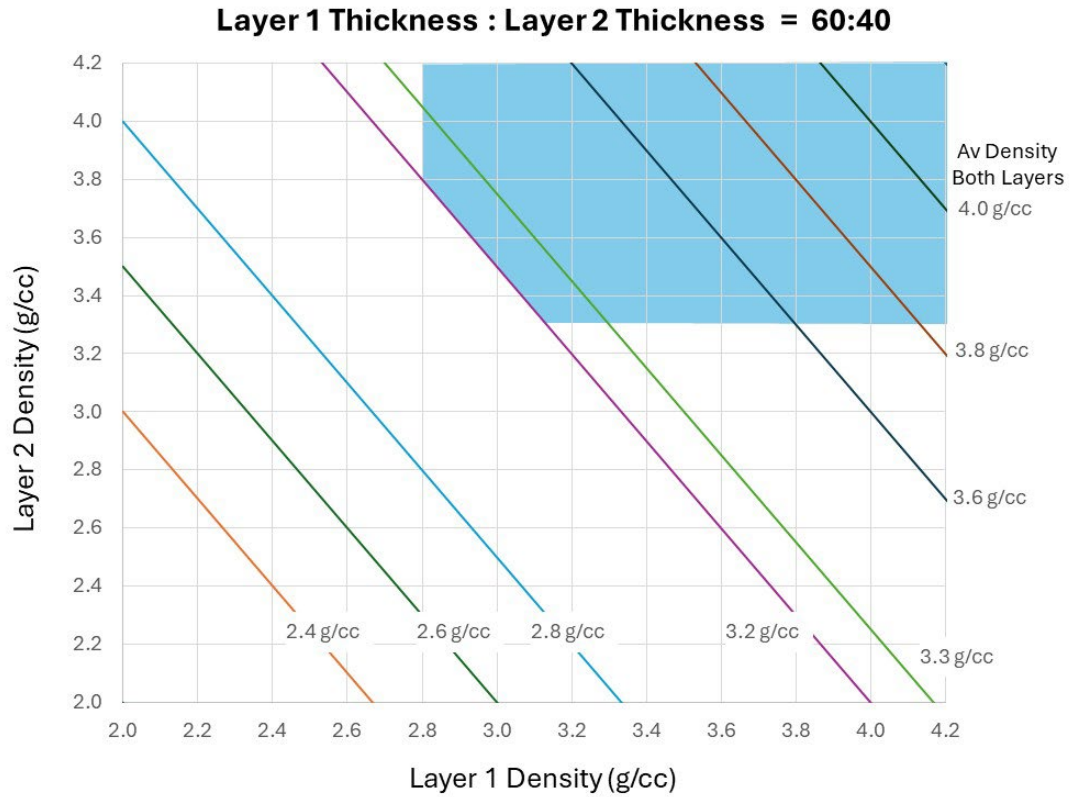
4. Ishigaki anticipates claims 5 and 14.

52. In addition to incorporating their challenges for claims 1, 10, and 19, Patent Owner and Dr. Wheeler further dispute that Ishigaki discloses an electrode wherein a compaction density of the first layer is greater than 2.8 g/cc, and a

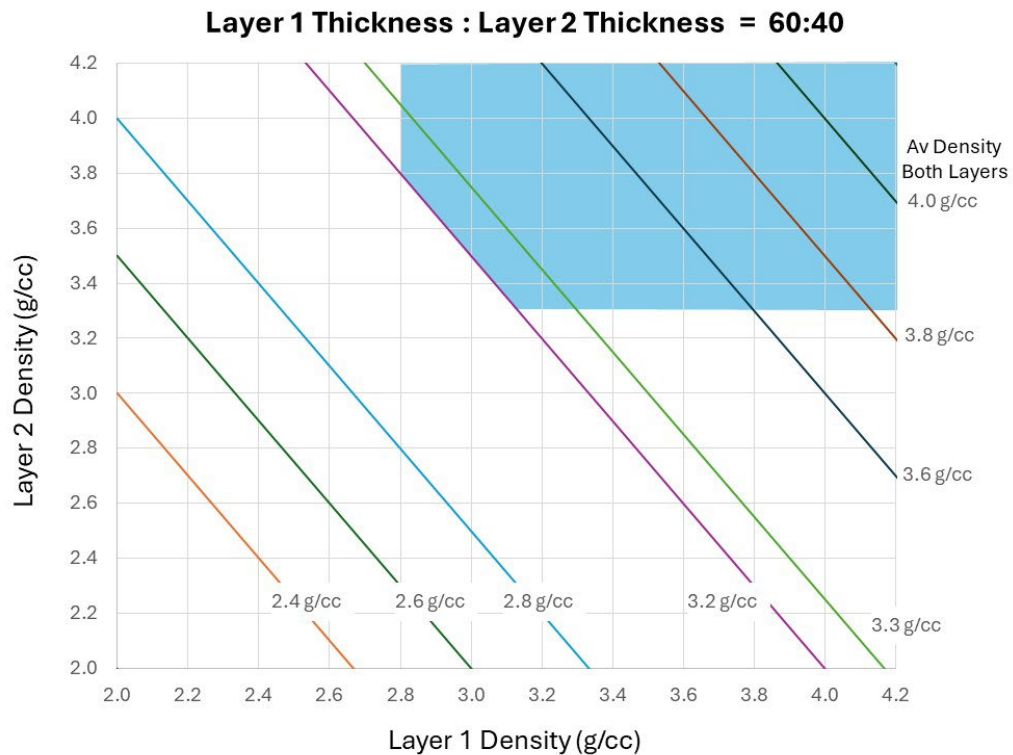
compaction density of the second layer is greater than 3.3 g/cc. Paper 22, 27;

EX2058, ¶80. Dr. Wheeler's analysis for these claims is essentially the same as his analysis for the other compaction density limitation, above. EX2058, ¶80. The only difference is that claims 5 and 14 specify density values for the two layers instead of disclosing one total compaction density for the two-layer structure.

53. My analysis above, regarding how Ishigaki inherently discloses a range of combinations for the individual densities of layers 1 and 2, applies equally to these limitations. The illustrations from my opening declaration are reproduced below for Ishigaki's cases where the thickness ratio of the first and the second layer are 60:40 and 90:10. They have now been adjusted so that the compaction densities shown on the two axes are all within the range of 2.0 to 4.2 g/cm³ taught by Ishigaki. The total colored area (white plus blue) represents combinations of the two-layer densities that follow the teachings of Ishigaki, in that they yield average combined densities ranging from 2.0 to 4.2 g/cc. The blue regions in these graphs represent combinations of the two-layer densities that anticipate '118 patent claims 5 and 14 because the first layer density is greater than 2.8 g/cc and the second layer density is greater than 3.3 g/cc.



Gido Demonstrative 9.



Gido Demonstrative 10.

54. Although Ishigaki teaches a broad range of densities, it also directs a POSA to consider the higher density embodiments (blue portions of the graphs) for purposes of increasing energy capacity. EX1004, ¶25. Accordingly, even though a POSA knows that there are various tradeoffs to balance in selecting an electrode compaction density, Ishigaki teaches how to navigate those tradeoffs, and specifically teaches that higher densities will improve energy capacity.

55. Dr. Wheeler's disagreement with my analysis in this regard appears limited to his insistence that none of Ishigaki's compaction densities are relevant other than the one two-layer working example. EX2058, ¶80. Dr. Wheeler does not seem to acknowledge that the POSA is not an automaton and anticipating disclosures can be express or inherent. Ishigaki's teachings are more than its examples.

5. Ishigaki anticipates claims 6, 15, and 20.

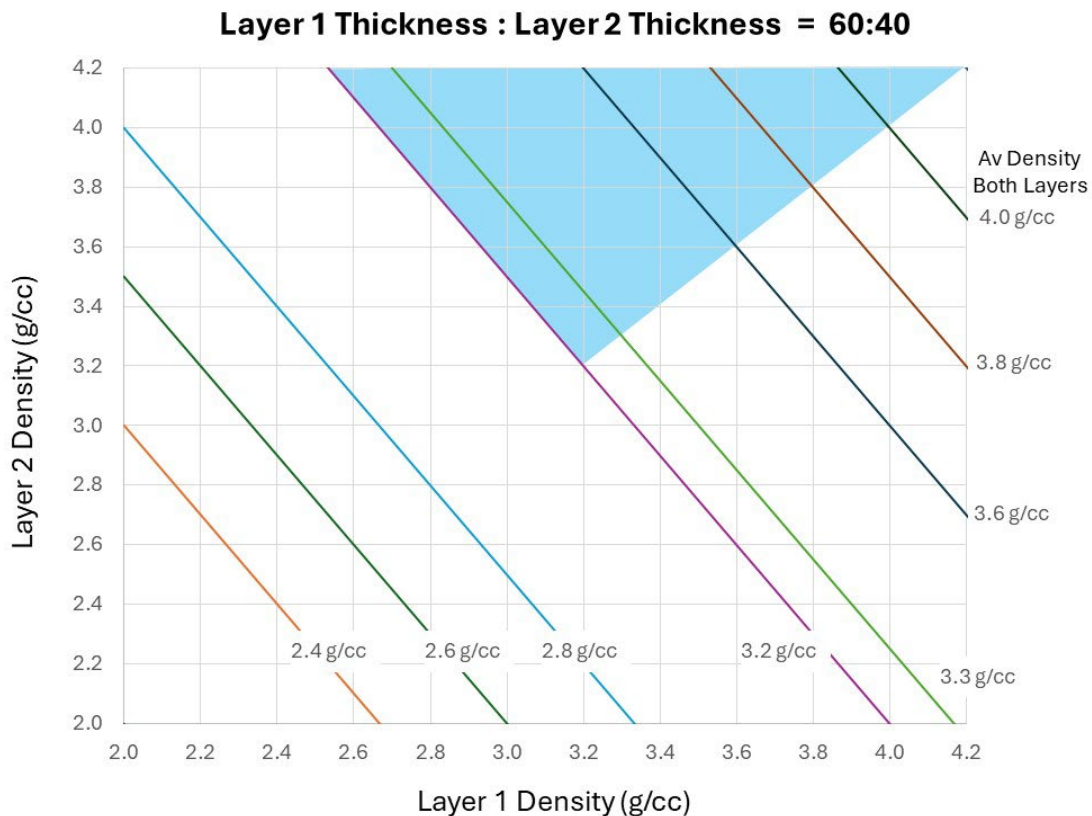
56. Ishigaki discloses that the first layer of the electrode has a lower compaction density than the second layer, as required by claims 6, 15, and 20. *See* EX1004, ¶216 ("the second positive electrode active material has a higher bulk density than the first active material"). A POSA would understand that the second layer's higher bulk density implicates a higher compaction density, because Ishigaki instructs the reader to choose a thickness ratio between the first and

second layers with increasing preference for a thicker second layer. Ishigaki explains that it prefers a thicker second layer because the objective is to obtain higher energy capacity. Increasing the ratio in favor of the second layer will only increase energy capacity if the compaction density of the second layer is also higher.

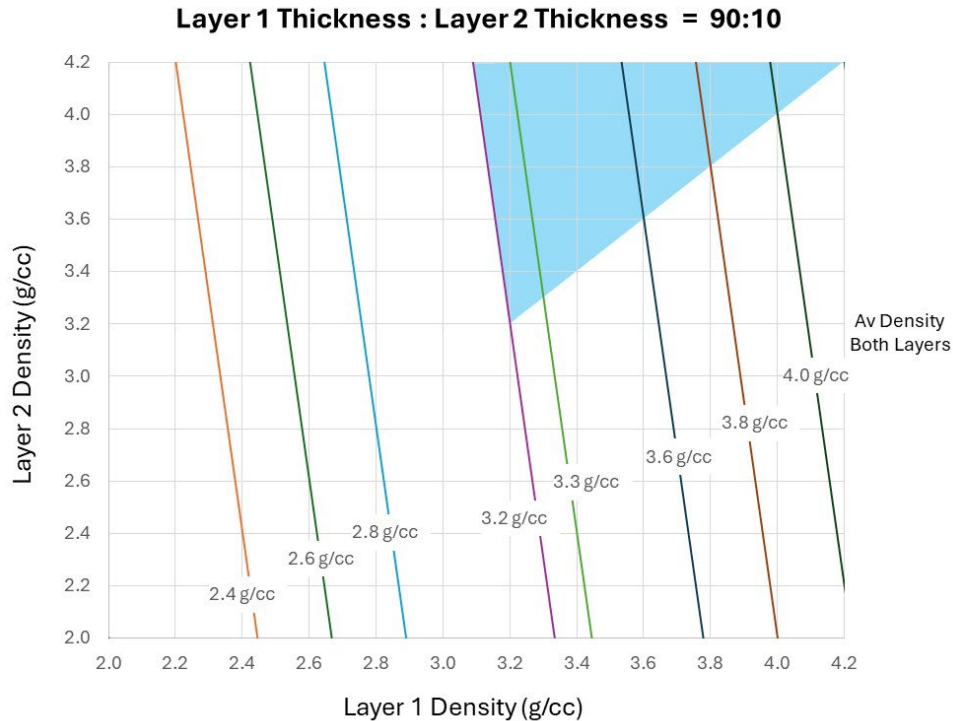
57. This is also generally consistent with how bulk density typically relates to compaction density in this context. The density of an electrode is primarily driven by the density of the active material. While there may be exceptions, a higher bulk density implies a higher tap density, a higher press density, and a higher compaction density. Absent any indication that Ishigaki's materials are exceptional in this respect, a POSA would generally understand higher bulk density to provide higher compaction density. A POSA would also understand that the *reason* Ishigaki is telling the reader to choose a higher bulk density for the second layer is so that the second layer will ultimately have a higher compaction density, and therefore higher energy capacity, all else being equal.

58. I again reproduce below my demonstratives from my opening declaration that illustrate combinations of first- and second-layer densities that follow the teachings of Ishigaki regarding the range of average (over both layers) densities from 2.0 g/cc to 4.2 g/cc. These have been slightly modified to only include values of single layer densities in the range, 2.0 g/cc to 4.2 g/cc, taught by

Ishigaki, thus the entire areas (white plus blue) of these graphs embody the most general teaching of Ishigaki. The blue regions of these graphs are combinations of layer densities that follow the additional teaching of Ishigaki, EX1004, ¶216, that the second layer density is greater than the first (and also satisfy the limitations of '118 claims 1, 10, and 19 in that they have a total compaction density greater than 3.2 g/cc), which anticipates claims 6, 15, and 20.



Gido Demonstrative 11.



Gido Demonstrative 12.

59. Once again, Dr. Wheeler's primary objection to the demonstratives presented in my original declaration appears to be his concern that the Board will not understand my use of a theoretical maximum density to provide the upper boundary. EX2058, ¶82. As shown above the demonstratives have been updated to focus on Ishigaki's disclosed density range, and the point of the illustrations remain the same and remain valid. Dr. Wheeler quotes my deposition testimony where I freely admit that not every depicted combination will be physically achievable. *Id.* But my point is not to show exactly what can be achieved practically. It is to illustrate what Ishigaki teaches, expressly and inherently, about the density ranges of its electrodes. A POSA would understand that workable

embodiments fall within the red areas of the original demonstratives and that the modified demonstratives only include area (white and blue) associated with workable embodiments. I do not rely on any embodiment at the theoretical maximum as the sole anticipating disclosure. Patent Owner's and Dr. Wheeler's challenges to these claims therefore fail.

VI. GROUND 2: CLAIMS 1-20 ARE OBVIOUS OVER ISHIGAKI AND KIM

60. To the extent the Board finds that Ishigaki does not anticipate every limitation of claims 1-20, expressly or inherently, then it is my opinion that a POSA would at least find the claims obvious in view of Ishigaki's teachings, further in view of Kim. A POSA would understand that Ishigaki's teachings about preferred compaction densities in the context of a single layer structure also apply to a two-layer structure. A POSA would understand how to apply all of Ishigaki's teachings about particle size, compaction density, and energy capacity to a two-layer structure without a comprehensive working example. And a POSA would be especially drawn to the higher density ranges of Ishigaki—those recited in claims 1, 10, and 19 for total density and claims 5, and 14 for individual layer density—from Kim's teaching of a 3.31 g/cc criticality.

61. Specifically, Kim teaches an electrode made from an active material with a press density of 3.31 g/cc or greater, and of 3.4 to 4.0 g/cc. EX1009, ¶36. Kim explains densities below 3.31 g/cc “may be too small to obtain a high

electrical capacity.” EX1009, ¶36. To the extent the claimed lower limit of 3.2 g/cc is in fact critical, Kim teaches that criticality by disclosing both the numeric value and the result it achieves: high electrical capacity. Kim’s goal of high electrical capacity is the same as Ishigaki’s goal of high capacity/energy density. EX1004, ¶25. Ishigaki even teaches a POSA to pack the electrode active material “as densely as possible” in order to maximize the energy capacity of the battery. EX1004, ¶7. A POSA would therefore already be motivated to choose densities at the higher end of the range disclosed in Ishigaki, and would thus look to the density range disclosed to confirm what densities achieve those goals.

62. Patent Owner and Dr. Wheeler’s challenges to my analysis in Ground 2 repeat the same challenges to Ishigaki’s teachings discussed above in Ground 1. Paper 22, 33, 34, 38; EX2058, ¶¶88, 89, 100, 102, 103, 109-11, 118. Those challenges are even weaker under an obviousness standard than they were under an anticipation standard. It is therefore my opinion that even if those challenges succeeded for Ground 1, they would not succeed for Ground 2. For example, even if Ishigaki does not expressly disclose that its particle size is given as a Dv90 volume-weighted distribution, a POSA reading Ishigaki would find it obvious to make an electrode with a Dv90 in the range that Ishigaki discloses for D90 measured as a volume standard. A POSA would also find it obvious to choose compaction densities for a two-layer structure within the higher range of Ishigaki’s

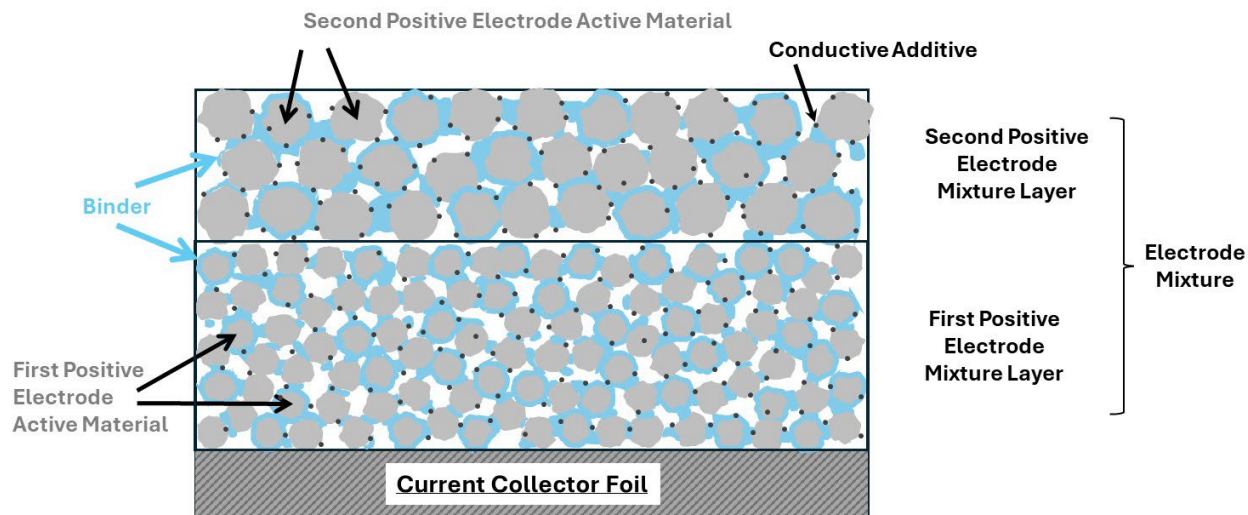
preferred densities, such as 3.8 g/cc, 4.0 g/cc, and 4.2 g/cc, especially in view of Ishigaki's teaching to compact the electrode layers "as densely as possible" to achieve high energy capacity.

63. Patent Owner and Dr. Wheeler present two main challenges to my reliance on Kim to reinforce Ishigaki's teaching, specifically for the alleged criticality of the 3.2 g/cc compaction density. First, they argue that Kim's teaching that densities below 3.31 g/cc may be too low to achieve good energy capacity relates to *press* density and not *compaction* density. EX2058, ¶¶89. Second, they argue that Kim's electrode is a single-layer structure, and therefore its teachings about density are irrelevant to a two-layer structure. EX2058, ¶¶87-88. Both challenges fail for similar reasons.

64. Dr. Wheeler does not seem to acknowledge the fundamental connection between the density of the electrode and the energy capacity of the battery: the amount of active material packed into the volume of the electrode. In light of that connection, disclosing the threshold press density of the active material that is necessary for high energy capacity in the finished battery is conceptually and numerically similar to the compaction density necessary for a high energy capacity of the finished battery.

65. To illustrate, consider the demonstrative I provided above that shows an electrode of Ishigaki configured as claimed in the '118 patent. To be clear, this

is a conceptual illustration and is not intended to be a perfectly scaled diagram, nor is it intended to be accurate in every detail.



66. The press density of the active materials roughly corresponds to the gray active material particles as shown, but without the binder and conductive additive. The addition of the binder and conductive additive only adds a negligible density because (1) the amount of binder and conductive additive are small compared to the active material, and (2) the density of the binder material (typically polyvinylidene fluoride (PVDF) at 1.8 g/cc) and conductive additive (typically carbon black at 2.0 g/cc) is much lower than the density of the active material (e.g. LCO at 5.05 g/cc and NMC at 4.8 g/cc). Additionally, the binder partly fills the interstices between active particles that are otherwise occupied by air, adding its full mass while only adding a portion of its volume. So, if anything, the compaction volume of an electrode will be slightly higher than the press density of the active material. Indeed, Kim teaches electrode layers that are over

94% active material powder with less than 3% each of vinylidene fluoride (binder) and carbon black (conductive additive). *Id.* The net effect is a compaction density that is not much different (and certainly not much lower) than the press density of the active material.

67. As I explained in my deposition, because there is such a small amount of binder and additive (less than 6% total), the density values that a POSA would expect for the compaction density of an electrode like Ishigaki are not much different numerically from the press density values given in Kim. So, while Kim discloses an energy density criticality at 3.31 g/cc press density, a POSA would understand that to correspond to a compaction density that would be about the same, or maybe a little bit higher because additive and binder are denser than air, and not likely lower than 3.2 g/cc.

68. The composition of Kim's Examples 6 through 10, which are the same in terms of component amounts, is shown in the table below. These examples only differ in the ratio of larger (15 μm) to smaller (5 μm) active material (NCM) particles as explained in Kim Examples 1 through 5, which supply the particle mixture for Examples 6 through 10 respectively. Densities for the components are given and the volumes shown in the last column are of the component materials themselves, absent any porosity obtained by dividing the weight of each component by its density. For the purposes of this calculation, I use a density of

NCM of 4.6 g/cm³. EX1039, 2332. The density of carbon black can range from 1.8 to 2.1 g/cm³. EX1040, 11-12. I will use a density of 2.0 g/cm³ for calculation purposes. The density of PVDF is 1.75-1.80 g/cm³. EX1041, 4, 6, 8, 10; EX1042, 1. I will use a density of 1.8 g/cm³ for calculation purposes.

	Weight (g)	Density (g/cm ³)	Volume (cm ³)
NCM	5.00	4.6	1.09
Carbon black	0.15	2.0	0.075
PVDF	0.15	1.8	0.083
TOTAL	5.30		1.25

69. Additionally, Kim's Table 1 gives the press densities for Examples 6 through 10, as shown in the table below. As the relative amount of the smaller particles gets larger the press density increases slightly, as seen in Examples 8, 9 and 10. The volume of the 5.0 g of active material at the press density is calculated by dividing the weight of NCM (5.0 g for Examples 6 through 10) by the reported press densities. These values are given in the second column of the table below.

70. The porosity of the pressed sample of the active material powder that was used to measure the press density can be calculated as follows:

$$\varepsilon (\text{press density}) = 1 - \frac{\rho (\text{press density})}{\rho (\text{NCM})}$$

EX1043, 14.

71. Alternatively, the porosity of the press density samples can also be calculated by subtracting the inherent volume of the 5.0 g of NCM, which is 1.09 cm³, from the total volume of this material at the press density, which is given in

the second column of the table below. This gives the void volume in the press density sample. Dividing this void volume by the total volume of the press density sample give the same porosity numbers as the equation above. The press density porosity values are given in the third column of the table.

	Press Density (g/cm ³)	Press Density Volume (cm ³)	Press Density Porosity (%)	Relative Vol CB + PVDF (%)	Max Compaction Density (g/cm ³)	Min Compaction Density (g/cm ³)
Example 6	3.32	1.51	27.8%	10.5%	3.52	3.18
Example 7	3.36	1.49	27.0%	10.6%	3.56	3.22
Example 8	3.41	1.47	25.9%	10.8%	3.61	3.26
Example 9	3.45	1.45	25.0%	10.9%	3.66	3.30
Example 10	3.42	1.46	25.7%	10.8%	3.63	3.27

72. A maximum value for the compaction density (now including all the cathode components) can be calculated assuming that all of the conductive additive and PVDF binder goes into the interstitial, i.e. porosity, space of the active material particles packed at the press density. This is very possible, since the press density samples have porosities ranging from 25.0% to 27.8%, and the relative volume of conductive additive (carbon black) plus PVDF with respect to the total volume of the press density sample is between 10.5% and 10.9%. This is shown in the fourth column of the table above. Therefore, there is plenty of space in the interstices of the press density samples to accommodate all the binder and conductive additive and still leave pore space to form a viable cathode active material layer. The maximum compaction density in this case is calculated by dividing the total weight of all materials in the Example, 5.30 g (5.00 g NCM + 0.15 g carbon black + 0.15 g PVDF), by the volume of the press density sample (column two in the table

above). These maximum values of the compaction densities for Kim's Example 6 through 10 are shown in the fifth column of the table above. They range from 3.52 to 3.66 g/cm³, and thus all exceed the claim of 3.2 g/cm³.

73. A POSA could also calculate a minimum value of the compaction density of the cathode layer based on the press density for Kim's Examples 6 through 10 by assuming that none of the conductive additive (carbon black) and PVDF binder go into the interstices of the press density sample. In this case the total sample volume is increased by the full volume of the conductive additive and PVDF binder, calculated from their densities in the first table above in this section. In this alternative calculation the weight of all the components in the cathode layer is divided by this total volume to give the minimum compaction density values shown in the last column of the table above.

74. A POSA would expect that the true compaction densities of Kim's Examples 6 through 10 would be nearer to the maximum values given in the table above because most binder and conductive additive will go into the interstitial spaces between the particles. But even in the most extreme case, where none of the conductive additive and binder goes into the interstitial space, the compaction density would still be about 3.2 g/cm³ (3.18 g/cm³ for Example 6) or greater (Examples 7 through 10).

75. I note that Dr. Wheeler cites my deposition for the proposition that I admitted “that the press density of an active material gives no indication of what the compaction density of an active layer, much less a two-layer electrode structure.” EX2058, ¶95. I made no such admission. In fact, I explained in my deposition that while press density and compaction density are not the same thing, they are overlapping and related, and I explained how a POSA would equate them numerically. EX2050, 122:1-123:18. The calculation I have added above for Kim’s Examples 6 through 10 supports this conclusion, where in each case the maximum and minimum possible compaction densities are found to tightly bracket (above and below) the press densities. I will note that the Board also correctly found that while press density and compaction density are not the same, a POSA would consider the press density of an active material that is associated with high energy capacity in a battery to be informative of the compaction density of an electrode that would also be associated with high energy capacity. Paper 11, 54.

76. Regarding a POSA’s motivation to combine Ishigaki with Kim, Dr. Wheeler argues that the ’118 patent, Ishigaki, and Kim are all directed to solving different problems. EX2058, ¶113. While it is true that each of these references includes discussion of a unique problem and proposed solution within the narrow context of battery electrode design and construction, these differences would not discourage a POSA from combining the teachings of Ishigaki and Kim to arrive at

the claims of the '118 patent. It is an overarching goal of all battery design and construction to provide the best energy capacity possible. All three references have sections that specifically discuss improving the energy capacity of battery by increasing the compaction density of the electrode material. EX1001, 1:36-41, 4:18-24, 6:7-12, 6:20-27; EX1004, ¶¶2, 216; EX1009, ¶6. All three of those sections are consistent in their messaging, consistent in the materials involved, and consistent in the numeric parameters of the electrode properties. A POSA would consider them to inform each other.

VII. GROUND 3: CLAIMS 1-20 ARE OBVIOUS IN VIEW OF WANG AND SAKA

77. I understand that Patent Owner's and Dr. Wheeler's primary challenge to my analysis in Ground 3 is their argument that a POSA would not and could not combine Wang with Saka, and that even if they did, Saka would not teach the claimed compaction densities that are missing from Wang.

78. I understand that neither Patent Owner nor Dr. Wheeler raises any new disputes that Wang discloses all of the limitations of claims 1-20 with the exception of the total compaction densities recited in the final wherein clauses of claims 1, 10, and 19, and the individual layer compaction densities of claims 5 and 14. Paper 22, 40, 50, 51. I therefore stand by my prior opinions and the findings of the Board in the Institution Decision for Ground 3 as they relate to the other

limitations of claims 1-20, including the electrode structure, particle sizes, layer thicknesses, and materials. Paper 11, 72, 73.

79. Wang repeatedly teaches a POSA to use compaction to achieve a “desired net density” in the resulting multi-layer electrode. EX1005, ¶¶67, 73, 89, 92, 106, 109. Wang does not teach what the desired net density actually is, thus contemplating that a POSA would have a desired net density or inviting a POSA to look to another reference, such as Saka, for teachings of desired electrode density (which Saka provides in a virtually identical battery electrode structure). As the Board correctly found, this is a classic motivation to combine. Paper 11, 72, 73.

80. Dr. Wheeler’s primary challenge to my analysis of Wang is that Wang discloses various porosities, and because porosity is inversely related to density, a POSA would not look outside Wang to learn a “desired net density.” Paper 22, 42, 43; EX2058, ¶124. There are two problems with this approach.

81. First, Wang does not teach a certain porosity as the end goal. Rather, it teaches a range of porosities that are possible to achieve with its method and then teaches that one can manipulate these porosities as a means for achieving the goal of a desired density. Thus, Wang teaches that it is the density that is the goal, and that its calendaring method and battery construction materials are a means that can achieve a desired density. Wang essentially tells the POSA that the density goal is external to Wang’s disclosure, and it accommodates that goal.

82. Second, Dr. Wheeler does not appear to have done the math on Wang's porosities. The porosities that Wang discloses correspond to densities that are (1) compatible with Saka's densities, and (2) within the claimed range of the '118 patent.

83. Wang teaches a range of porosities for the first layer:

In certain embodiments, the first porosity of the first porous layer 210 is greater than the second porosity of the second porous layer 220. In certain embodiments, the first layer has a porosity or "first porosity" of at least 40%, 45%, 50%, 55%, 60%, or 65% as compared to a solid film formed from the same material. In certain embodiments, the first layer has a first porosity up to 45%, 50%, 55%, 60%, 65%, or 70% as compared to a solid film formed from the same material. In certain embodiments, the second layer has a porosity or "second porosity" of at least 20%, 25%, 30%, or 35% as compared to a solid film formed from the same material. In certain embodiments, the second layer has a porosity up to 25%, 30%, 35%, or 40% as compared to a solid film formed from the same material.

EX1005, ¶56.

84. Wang also teaches ranges of layer thicknesses for both its first and second layers. For layer 1, Wang gives thickness ranges of 10 to 150 μm , 50 to 100 μm , and 50 to 200 μm . *See* EX1005, ¶¶50, 78, 81. For layer 2, Wang gives thickness ranges of 10 to 150 μm , and 50 to 100 μm . *See* EX1005, ¶¶54, 79, 83. The compaction density of each layer is calculated from maximum (zero porosity) density (ρ_{max}) and the porosity of the layer, chosen from the ranges taught by Wang. Those densities, based on the materials disclosed by Wang and recited in the limitations of claims 1-20 of the '118 patent, are calculated as follows: for the

first layer, Wang discloses a number of active materials, conductive materials, and binding agents.

85. For the purposes of this calculation, we will assume lithium cobalt dioxide (LiCoO_2) with a density of 5.05 g/cm^3 . EX1044, 299. The density of carbon black can range from 1.8 to 2.1 g/cm^3 . EX1040, 11-12. I will use a density of 2.0 g/cm^3 for calculation purposes. The density of PVDF is 1.75-1.80 g/cm^3 . EX1041, 4, 6, 8, 10; EX1042, 1. I will use a density of 1.8 g/cm^3 for calculation purposes. ρ_{max} is calculated for a 100 g basis of cathode material. Doing a calculation like this on a chosen basis (amount) of material is a well-known technique used by a POSA. The following table shows the weight in grams of each component as well as the volume of that component, calculated by dividing the weight of each component by its density.

	Weight (g)	Material density (g/cm^3)	Volume (cm^3)
Lithium cobalt dioxide	96	5.05	19.0
Carbon black	1.0	2.0	0.50
PVDF	3.0	1.8	1.67
TOTAL	100	N/A	21.2

86. Here, I have used a conductive material quantity of 1.0% by weight as one embodiment disclosed by Wang. Wang does not disclose relative material quantities of the active materials or binding agents by weight, but for now, I will use a binding agent percentage of 3.0% and a corresponding active material percentage of 96%.

87. The maximum possible density, $\rho_{\max}$, is calculated by dividing the total weight (100 g) by the total volume (21.2 cm³) and is found to be 4.72 g/cm³. The actual density, ρ , of a layer is related to the porosity, ε , and $\rho_{\max}$ by the following equation provided by Dr. Wheeler. *See* EX2015, ¶119. I agree that this is the standard equation known to a POSA relating density to porosity and the maximum possible density at zero porosity. EX1043, 14.

$$\rho = (1 - \varepsilon)\rho_{\max}$$

88. Using this equation for the materials and compositions of the first and second Wang cathode layers with minimum porosities of 40% and 20%, respectively, yields layer compaction densities of 2.83 g/cm³ and 3.78 g/cm³, respectively.

89. The “total compaction density of the first layer and the second layer” can then be calculated if the relative thicknesses of the two layers are specified. The value of the claimed element, “total compaction density of the first layer and the second layer,” is the volume weighted average of the densities of the first and second layers, which is the same thing as the thickness weighted average of the densities of the two layers.

90. Thus, based on the materials disclosed in Wang (and recited in the limitations of claims 1-20), using a first layer thickness of 50 μm (*see* EX1005, ¶¶50, 78, 81) and a second layer thickness of 100 μm (*see* EX1005, ¶¶54, 79, 83)

yields a total compaction density of the first layer and the second layer of $(2.83 \times 50 + 3.78 \times 100) / (50 + 100) = 3.46 \text{ g/cm}^3$, which is well within the claimed range of greater than 3.2 g/cc total compaction density (EX1001, claims 1, 10, and 19). Additionally, the individual first layer density of 2.83 g/cm^3 is within the range of a compaction density greater than 2.8 g/cc for the first layer, and the individual second layer density of 3.78 g/cm^3 is within the range of a compaction density greater than 3.3 g/cc for the second layer (EX1001, claims 5 and 14).

91. Though 3.0% is within typical range for a binder percentage, one could argue that because Wang does not teach this value, one *must* look elsewhere. In that case, one could look to Saka. EX1006. Saka teaches mass percentages of conductive material of 5.0 % as one embodiment of both layers (EX1006, ¶¶75, 80) and also teaches preferred ranges of binder mass percentage inclusive of 3.0 % for both layers (EX1006, ¶¶77, 80), resulting in 92 weight % of active material for both layers.

	Weight (g)	Material density (g/cm ³)	Volume (cm ³)
Lithium cobalt dioxide	92	5.05	18.2
Carbon black	5.0	2.0	2.50
PVDF	3.0	1.8	1.67
TOTAL	100	N/A	22.4

92. Using these values results in layer compaction densities of the first layer and second layer of 2.68 g/cm^3 and 3.57 g/cm^3 , respectively, and a total compaction density of the first layer and the second layer of 3.28 g/cm^3 (again using a first layer thickness of 50 μm and a second layer thickness of 100 μm). In

this scenario, the total compaction density of 3.28 g/cm^3 is again within the claimed range of greater than 3.2 g/cc total compaction density (EX1001, claims 1, 10, and 19), and the individual second layer having a layer density of 3.57 g/cm^3 is again within the range of a compaction density greater than 3.3 g/cc for the second layer (EX1001, claims 5 and 14).

93. Accordingly, a POSA practicing the method taught in Wang, who (as Dr. Wheeler suggests) would prefer to learn the range of compaction densities by calculating that information from Wang's porosity ranges, would still end up with embodiments in the claimed range for both total compaction density and individual layer compaction density. EX2058, ¶¶125-30.

94. The fact remains, however, that Wang does not teach which of these densities is a "desired net density" or why. EX1005, ¶¶67, 73, 89, 92, 106, 109. Wang teaches the general principle that higher compaction density leads to higher energy capacity but leaves it to the POSA to balance that objective against other known tradeoffs. Accordingly, Wang invites a POSA to look to other references like Saka (or as I discuss below, Li) to find particular compaction densities that give good battery performance.

95. In challenging the disclosure of Saka, Dr. Wheeler notes that Saka provides data for some examples, and reports both that the superior battery performance was achieved at 2.8 g/cc electrode density and that performance

decreased at 3.0 g/cc. EX2058, ¶132. While it is true that densities greater than 3.0 g/cc are not described as preferred embodiments, I understand that an embodiment does not need to be preferred to be rendered obvious. Saka provides multiple examples of batteries with electrode densities greater than 3.0 g/cc, and expressly discloses densities of 3.5 g/cc. The fact that these embodiments are not preferred does not mean that Saka teaches away from them.

96. I understand that teaching away requires more than disclosure that an alternative embodiment is somewhat inferior or is not a preferred embodiment. Rather, it requires clear discouragement or the suggestion that a particular combination is unlikely to work. Saka does not clearly discourage higher densities, or suggest that densities above 2.8 g/cc would not be likely to work. Even the 3.0 g/cc density embodiment that Saka reports as having decreased performance is still a working embodiment. Saka expressly teaches that compaction densities up to 3.5 g/cc will work. A POSA may have reason to prefer them, or not, depending on the POSA's priorities. Even if a POSA would not prefer these higher densities in view of Saka's teachings, they are still disclosed as working embodiments and they are still achievable using Wang's process. They are therefore obvious.

97. Dr. Wheeler also disagrees that a POSA would find the individual compaction layer densities of claims 5 and 14 obvious in view of Saka's many examples and other teachings. EX2058, ¶149. Saka teaches several working

embodiments in which the compaction density of the first layer is greater than 2.8 g/cc. EX1007. I do not understand Dr. Wheeler to raise any disputes about my density calculations in that regard. I acknowledge that none of Saka's examples have a compaction density for the second layer that is greater than 3.3 g/cc by my calculations. *See* EX1007. Many of the second layer compaction densities, however, are very close to that lower limit (around 3.1 g/cc) and a POSA would find it obvious to compact the second layer above 3.3 g/cc in view of Saka's more general teaching of electrodes with overall compaction densities up to 3.5 g/cc. *Id.*

98. Dr. Wheeler's main point of contention is once again his interpretation that Saka teaches away from these higher densities. EX2058, ¶131. I disagree. While Saka generally does not prefer higher densities, it explicitly discloses them as among its embodiments. As I explain above, I understand that is not teaching away. It would be obvious to a POSA reading Wang that Wang's process could be used to achieve all of the densities disclosed in Saka, including electrodes with a first layer greater than 2.8 g/cc and a second layer greater than 3.3 g/cc (up to 3.5 g/cc), and a POSA would have a reasonable expectation of success in doing so because densities up to 3.5 g/cc are achievable with Wang's process given the porosities and materials Wang discloses.

99. I note that the relevant expectation of success is the expectation that one could use Wang's process and materials to create a battery with the

compaction densities disclosed in Saka, specifically those densities recited in the claims, and arrive at a working battery electrode. I understand that an “expectation of success” does not require the POSA to find the best or most optimized battery. Every POSA knows that designing a battery electrode involves balancing various well-known tradeoffs. Higher energy density is always an overarching objective. It is offset by limitations like safety and rate performance. A POSA would know those limitations, and how to balance them depending on the POSA’s priorities for a particular application.

100. Dr. Wheeler notes several times in his declaration (for three out of four Grounds) that I admitted these tradeoffs during my deposition, as though that were a concession that a POSA would not always seek to maximize energy capacity. *See* EX2058, ¶¶73, 145, 160, 168. It is not a concession. Rather, I explained that a POSA would generally consider more energy density in an electrode important motivation, and a primary objective, but that a POSA would also be aware of the limitations and tradeoffs of maximizing that property. I took those tradeoffs and limitations into consideration when forming my opinions that the prior art I cite in my opening declaration would encourage a POSA to choose compaction densities in the higher end of the ranges disclosed as obvious, and that knowledge of these tradeoffs would not discourage a POSA from finding the combination obvious, or undermine their expectation of success.

VIII. GROUND 4: CLAIMS 1-20 ARE OBVIOUS IN VIEW OF WANG AND LI

101. Patent Owner and Dr. Wheeler raise the same arguments about Wang's disclosure for Ground 4 that they raise for Ground 3, namely that a POSA would not look outside Wang for a desired net density, and that a POSA would not and could not combine Wang with Li. These challenges fail for largely the same reasons as those discussed above.

102. I understand that neither Patent Owner nor Dr. Wheeler raises any new disputes that Wang discloses all of the limitations of claims 1-20 with the exception of the total compaction densities recited in the final wherein clauses of claims 1, 10, and 19, and the individual layer compaction densities of claims 5 and 14. Paper 22, 51. I therefore stand by my prior opinions and the findings of the Board in the Institution Decision for Ground 4 as they relate to the other limitations of claims 1-20, including the electrode structure, particle sizes, layer thicknesses, and materials. Paper 11, 81.

103. First, regarding a POSA's reading of Wang's invitation to look to other references (like Li) for a desired net density, Dr. Wheeler misdirects his focus on my explanation that Wang suggests that a POSA would have "a desired density in mind," and then discloses a method to achieve any desired density. EX2058, ¶¶154-161. I do not require that a POSA have a desired density in mind. Indeed, the entire reason a POSA would look to a reference like Li would be to

learn more about what kind of densities are desirable in a battery like Wang's (and Li's). My use of the phrase "in mind" merely reflects the fact that Wang specifically discloses that the objective of its calendaring process is to achieve a desired net density and then does not disclose what net densities are desired. Wang leaves it to the POSA to decide what compaction density he desires.

104. Dr. Wheeler argues first that a POSA would not look outside Wang for more information about desired compaction densities but rather would deduce that information from Wang's porosities. EX2058, ¶155. Even if that were true, Wang's porosities correspond to densities within the claimed range, as I discuss above.

105. Dr. Wheeler next argues that even if a POSA would look outside Wang to learn more about what densities are desired, he would not look to Li. EX2058, ¶¶162-173. Dr. Wheeler argues that Li's cathode is different in structure than the '118 patent, being specifically designed to bend around corners. EX2058, ¶¶164-166. But the claims do not limit the shape of the electrode, and Wang's process is capable of producing an electrode with Li's shape. Even if a POSA is not interested in Li's specific structure, a POSA would still learn from Li a general electrode compaction density that could inform many different applications. A POSA knows that the reason for achieving "desired net density" is to increase the

energy density of the cathode and therefore to increase the energy density, and the capacity, of the lithium-ion battery. EX1022, 2.

106. Finally, Dr. Wheeler argues that a POSA could not simply take Li's numeric compaction density and plug it directly into Wang's process without accounting for any differences between the materials of the two batteries. EX2058, ¶¶168-170. I do not suggest otherwise. My analysis is based on a combination of the *teachings* of the references, and not direct bodily incorporation of Li's density into Wang's battery. It is entirely possible that a POSA would need to make routine optimizations to Wang's parameters to accommodate Li's density, or even adjust Li's density slightly in view of Wang's materials. The overall effect of these modifications would be within the level of skill in the art and not require undue experimentation.

107. Li specifically discloses a compaction density of 3.8 g/cm³ for the first layer, and an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44. Those compaction densities are well within the claimed ranges of greater than 3.2 g/cc total compaction density (claims 1, 10, and 19) and compaction density greater than 2.8 g/cc for the first layer and greater than 3.3 g/cc for the second layer (claims 5 and 14). Accordingly, a POSA would not expect any slight adjustments to Wang's

parameters or Li's densities to take the resulting battery outside the scope of the claims.

IX. CONCLUSION

108. I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I could testify to the matters in this declaration competently if called upon to do so. I further declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code.

Executed on this 29th day of April, 2026 in Amherst, Massachusetts.

A handwritten signature in black ink, appearing to read "Samuel P. Guido", written in a cursive style.

Samuel P. Guido, Ph.D.