

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

**DECLARATION OF DEAN R. WHEELER, Ph.D., IN SUPPORT
OF PATENT OWNER'S PRELIMINARY RESPONSE**

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I, Dean R. Wheeler, Ph.D., do hereby declare and say as follows:

I. INTRODUCTION

1. I have personal knowledge of the facts contained in this Declaration, am of legal age, and am otherwise competent to testify.

2. I have been retained by Ningde Amperex Technology Ltd. (“ATL” or “Patent Owner”) as an independent technical expert in this proceeding before the United States Patent and Trademark Office (“PTO”) Patent Trial and Appeal Board (“PTAB”) regarding U.S. Patent No. 12,015,118 (the “’118 Patent”).

3. I understand that Zhuhai CosMX Battery Co., Ltd. (“Petitioner”) filed a petition for *Inter Partes* Review (“IPR”) of the ’118 Patent (“Petition”), in which Petitioner asserts that:

- Claims 1-20 are anticipated by Japanese Publication No. 2013-211096 (“Ishigaki” or “Ex. 1004”) (Ground 1);
- Claims 1-20 are obvious over Ishigaki and U.S. Patent Publ. No. 2013/0302685 (“Kim” or “Ex. 1009”) (Ground 2);
- Claims 1-20 are obvious over U.S. Patent Publ. No. 2011/0168550 (“Wang” or “Ex. 1005”) and U.S. Patent Publ. No. 2017/0256776 (“Saka” or “Ex. 1006”) (Ground 3);

- Claims 1-20 are obvious over Wang and Chinese Patent Publ. No. 202905885 (“Li” or “Ex. 1003”) (Ground 4).

4. I have been asked, for purposes of Patent Owner’s Preliminary Response, to analyze and respond to particular assertions in the Petition. I reserve the right to analyze and respond to other alleged patentability challenges if this proceeding is instituted.

5. As explained below, in my opinion, the Petition fails to show that claims 1-20 are anticipated or rendered obvious.

6. I am being compensated for my time spent on the present matter at my customary consulting rate of \$350 per hour for preparatory work and at my customary consulting rate of \$450 per hour for depositions/trial work. I am also being compensated for expenses incurred as a result of activities performed as an expert. My compensation is in no way contingent on the nature of my opinions, the outcome of this or any other proceeding, or any of the issues involved therein. I have no other interest in this proceeding.

II. BASIS FOR OPINIONS

A. Qualifications

7. My qualifications and professional experience are described in my *curriculum vitae*, a copy of which is provided with this Declaration as Ex. 2016. The following is a brief summary of my qualifications and professional experience.

8. I am a university professor at Brigham Young University and a consultant with 28 years of experience in the fields of electrochemical engineering, materials science, and manufacturing of battery materials. I received a B.S. in Chemical Engineering from Brigham Young University in 1996, and a Ph.D. in Chemical Engineering from the University of California, Berkeley, in 2002. My Ph.D. advisor was Professor John Newman, arguably the world's foremost leader in understanding battery materials through computer simulations. Under his direction, I acquired a deep understanding of the physics and chemistry of battery materials.

9. I have taught numerous classes on electrochemical engineering and materials science during my twenty-two years at Brigham Young University, as assistant professor, associate professor, and now, full professor. I currently serve as the department chair in the Chemical Engineering Department of Brigham Young University, supervising sixteen faculty members and six full-time staff.

10. I am an inventor on two issued patents and one patent application in the field of electrochemical devices. For example, U.S. Patent No. 11,340,261, issued in 2022, describes a flexible electric probe used to determine electrical properties of thin-film battery electrodes.

11. I have also authored or co-authored 63 peer-reviewed scientific publications. My most influential paper, "Quantifying tortuosity in porous Li-ion

battery materials,” published in the Journal of Power Sources in 2009, has been cited more than 600 times, and describes the movement of ions through various types of battery materials, including separator and electrode materials. I have also published papers on the subjects of electrode structures and compaction, interactions of solids, binders, and electrolytes, interfaces between electrodes and electrolytes, and how all these factors relate to battery longevity.¹

¹ See, e.g., Ex. 2028 (Amir-Sina Hamed, Fezzeh Pouraghajan, Fei Sun, Mojdeh Nikpour, & Dean R. Wheeler, *Interplay of Electrode Heterogeneity and Lithium Plating*, 169 J. Electrochem. Soc. 020551 (2022)); Ex. 2029 (Amir-Sina Hamed, Adrian Yao, Roxana Martin, Raymundo Roig, Michael Rivas Valadez, Donald Pile, Annadanesh Shellikeri, Baichuan Liu, and Dean R. Wheeler, *Multi-layer anodes for high-current applications*, 439 Electrochimica Acta 141649 (2023)); Ex. 2030 (Fezzeh Pouraghajan, Andrea I. Thompson, Emilee E. Hunter, Brian Mazzeo, Jake Christensen, Ram Subbaraman, Michael Wray, & Dean Wheeler, *The Effects of Cycling on Ionic and Electronic Conductivities of Li-ion Battery Electrodes*, 492 J. of Power Sources 229636 (2021)); Ex. 2031 (Amir-Sina Hamed, Edmund M. Shumway, & Dean R. Wheeler, *Electrode-Level Modeling of Silicon Anodes for Improved Cell Design*, 171 J. Electrochem. Soc. 120539 (2024)).

12. I have received more than \$7 million in government research grants to study batteries and related materials. Current research grants from NASA and the U.S. Army deal with understanding and improving electrolyte formulations and interactions with anode and cathode materials. My student assistants and I regularly fabricate and analyze battery materials in the laboratory. In particular, we routinely mix up custom-formulated electrolyte solutions, fabricate cathodes and anodes, and construct and test full lithium-based batteries. My research group is among the top users of electron microscopy at the university, which we use to analyze and understand battery electrode and separator structures. We also routinely measure the properties of battery materials and develop new diagnostic tools for making such measurements. Such training in my laboratory has allowed the students graduating from my program to go on to employment at numerous battery manufacturers and battery-related startup companies across the United States.

13. In 2016, I led the Gordon Research Conference on Batteries² as conference chair, having been nominated and voted into that position at a previous conference. This biennial international conference is attended by around two

² See Ex. 2025 (2016 *Batteries Conference GRC*, <https://www.grc.org/batteries-conference/2016/> (last visited on May 12, 2025)).

hundred of the world's thought leaders in the field of batteries. Furthermore, on three occasions I was selected to be a member of the technical review team for an ongoing \$25 million/year "Battery Hub" program funded by the U.S. Department of Energy.³ I believe my experience in such positions of leadership and responsibility, among others, reflects the stature with which I am viewed by my peers in the academic, industrial, and government battery research communities.

B. Materials Considered

14. The opinions contained in this Declaration are based on the documents I reviewed, as well as my education, years of professional experience, and knowledge. In forming my opinions expressed in this Declaration, I further reviewed the Petition, all exhibits or other material cited therein, and any additional exhibits or other material cited in this Declaration.

15. This Declaration presents the opinions I have formed at the present time, and I reserve the right to revise, supplement, or amend my opinions stated in this Declaration based on any new information that I may be asked to review.

³ See Ex. 2026 (*Hubs – Department of Energy*, <https://www.energy.gov/hubs> (last visited on May 12, 2025)); Ex. 2027 (*DOE Energy Innovation Hubs*, <https://science.osti.gov/bes/Research/DOE-Energy-Innovation-Hubs> (last visited on May 12, 2025)).

16. As I discuss below, I disagree with Dr. Gido's conclusions that the subject matter of any of claims 1-20 of the '118 patent was anticipated or would have been obvious in view of the Grounds he has identified.

III. LEGAL STANDARDS

17. In this section, I describe my understanding of certain legal standards. I have been informed of these legal standards by Patent Owner's legal counsel. I am not an attorney, and I am relying only on instructions from Patent Owner's legal counsel for these legal standards.

A. Claim Construction

18. My opinions concern what I believe the person of ordinary skill in the art ("POSITA") would have understood the meaning of certain claim terms to be based on the patent documents.

19. I have been informed that assessing the validity of a patent claim requires a two-step analysis. The first step involves the proper interpretation or construction of the claim language in order to determine its scope and meaning. The second step requires comparing the claim, as properly construed, to the alleged prior art to determine whether the limitations of the claim are met by the prior art.

20. My methodology for determining the meaning of claim phrases was first to study the patent carefully. In particular, I studied the claims themselves, followed by the background, detailed specification, figures, and other patent content.

Next, I reviewed the prosecution history looking for any clarifications or limitations that might be attached to claim terms. In some circumstances, I looked at other documents, such as references applied by the patent office.

21. I understand that in an *inter partes* review, claim terms are to be given their ordinary and customary meaning as understood by a person of ordinary skill in the art in the context of the entire disclosure at the time of the invention. I understand that one must be careful not to read a specific embodiment appearing in the written description into the claim if the claim language is broader than the embodiment. I further understand that any special definition for a claim term must be set forth with reasonable clarity, deliberateness, and precision.

22. I have been informed that this standard is the same as that used in United States district courts, in which claim terms are given their ordinary and customary meaning as would be understood by a person of ordinary skill in the art at the time of the invention having taken into consideration the language of the claims, the specification, and the prosecution history of record under the *Phillips* claim construction standard.

23. Dr. Guido construes two terms in the '118 patent claims—"compaction density" and "average particle size." Ex. 1010 ¶¶ 69-70. While I reserve the right to address these terms further if this case is instituted, for the purposes of this

declaration I will adopt Dr. Gido's proposed definitions, but by doing so I expressly take no position as to the correct construction of these terms.

B. Prior Art Status

24. I understand that the "priority date" of a patent is the date on which it is filed, or the date on which an earlier-filed patent application is filed if the patentee claims the benefit of priority to that earlier-filed patent application. I understand that a particular claim is entitled to claim the priority date of an earlier-filed application if the earlier-filed application provides written description of the subject matter of that particular claim.

25. I understand that a U.S. or foreign patent or patent application qualifies as prior art to an asserted patent if the date of issuance or publication of the patent or publication is prior to the priority date of the challenged patent.

26. I understand that a printed publication, such as an article published in a magazine or trade publication, qualifies as prior art to the challenged patent if the date of publication is prior to the priority date of the asserted patent.

27. I understand that to qualify as prior art, a reference must contain an enabling disclosure that allows one of ordinary skill to practice the reference's disclosure without undue experimentation.

C. Anticipation

28. I understand that, once the claims of a patent have been properly construed, determining anticipation of a patent claim requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

29. I understand that in order for a claim to be anticipated, each and every requirement of the claim must be found, expressly or inherently, in a single prior art reference as recited in the claim.

30. I understand that a prior art reference “inherently” discloses a limitation if that limitation is necessarily present in the prior art reference.

31. I understand, however, that inherency may not be established by probabilities or possibilities, and the mere fact that a certain thing may result from a given set of circumstances is not sufficient to establish anticipation by inherency.

32. I understand that it is impermissible for anticipation to combine multiple, separate embodiments, even if they are described in a single prior art reference.

D. Obviousness

33. I understand that a claimed invention is not patentable if the claimed invention would have been obvious to a person of ordinary skill in the field of the invention at the time of the patent claim’s effective filing date.

34. I have been informed and understand that the obviousness analysis requires evaluating the claim language as a whole, including comparing each and every limitation of the properly construed claim language to the prior art.

35. I understand that a person of ordinary skill in the art provides a reference point from which the prior art and claimed invention should be viewed. This reference point prevents one from using his or her own insight or hindsight in deciding whether a claim is obvious.

36. I have been informed and understand that an invention composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known or in the prior art, but that there must be an apparent reason or motivation to combine the known elements in the fashion claimed by the patents at issue.

37. I understand that in order to show obviousness based on a single reference or a combination of references, a particular motivation to modify the reference or combine the teachings in the references, and a reasonable expectation of success must be shown. I further understand that whether a proposed modification or combination of the prior art has a reasonable expectation of success is determined at the time the invention was made.

38. I understand that the obviousness inquiry includes consideration of various factors, such as the scope and content of the prior art, the differences between the prior art and the claims at issue, the knowledge of a person of ordinary skill in the pertinent art at the time of invention, and any objective factors indicating non-obviousness.

39. I am informed that objective factors indicating non-obviousness, also known as secondary considerations, may include (1) a long felt but unmet need in the prior art that was satisfied by the alleged invention of the patent; (2) commercial success or lack of commercial success of processes covered by the patent; (3) unexpected results achieved by the alleged invention; (4) praise of the alleged invention by others skilled in the art; (5) taking of licenses under the patent by others; and (6) deliberate copying of the alleged invention. I also understand that there must be a relationship or nexus between any such secondary indicia and the alleged invention.

40. I understand that in order to rely on a reference for obviousness, the reference must be analogous art. I also understand that to be analogous art, the reference must be either (1) from the same field of endeavor as the claimed subject matter, regardless of the problem addressed, or (2) if not in the same field of endeavor, reasonably pertinent to the particular problem with which the inventor is

involved. I am also familiar with the premise that for a reference to be reasonably pertinent, it must have logically commended itself to an inventor's attention at the time of invention.

IV. TECHNOLOGY OVERVIEW

A. Lithium Ion Batteries, Generally

41. In lithium-ion batteries, lithium ions shuttle back and forth between the negative electrode (anode) and positive electrode (cathode) during cycling. The movement of lithium ions from the anode to the cathode releases energy that powers whatever device is connected to the battery. The anode and the cathode each include an active material layer deposited on a current collector. A separator is positioned between the anode and the cathode to prevent direct contact between the electrodes, while still allowing lithium ions to pass between the electrodes. Direct contact between the anode and cathode, such as due to puncturing of the lithium-ion battery, can cause an electrical short, also referred to as a short circuit. Short circuits can result in a fire or explosion and are therefore a risk to the safety of users. Given the rapid popularization of lithium-ion batteries, and the safety risks associated with puncturing, manufacturers have placed increased attention on improving the safety performance of lithium-ion batteries.

B. Electrode Compaction Density

42. The electrodes are films. The density of the final coating (in units of mass per volume) of an electrode film (e.g., a cathode) is controlled by two factors: (1) crystalline density and relative amounts of underlying solids and binder that make up the composite; and (2) porosity of the film. With respect to (1) crystalline density and relative amounts of underlying solids and binder that make up the composite, using a “rule of mixtures,” material scientists routinely estimate the density of a solid composite of these materials at zero porosity. This represents the theoretical upper bound of density for a film made of this combination of materials, but it does not mean that a functional battery has (or can even achieve) a density equal to the upper bound. As mentioned above, lithium ions shuttle back and forth between the electrodes during cycling of the battery. This ion shuttling requires space between solids in each electrode, and so cathodes and anodes must have some space—measured as “porosity” to allow lithium ions to move.

43. The porosity of an electrode film is factor (2) impacting the density of an electrode film. Formally, porosity is represented as a volume fraction of pores or void space between solid materials, and only scales the composite density *downward* from the theoretical upper bound of density of (1) (without any pores). Porosity is controlled by (i) the way the solid materials are arranged and applied to the substrate

in the form of a liquid slurry that is coated and then dried; and (ii) the degree of calendering or compaction after the drying process, normally performed by rollers, which changes the final film thickness, and therefore, the porosity. With respect to the first factor impacting porosity, the distribution of solid particle sizes within the mixture impacts the porosity values that can be effective in a battery. For example, mixing large particles and small particles together achieves an electrode mixture that is functional at lower porosity values (and consequently, higher density values) as compared with a mixture of only large particles or only small particles. This is because the small particles are arranged within the interstices (or gaps) between the large particles, while retaining sufficient space between particles to allow lithium-ion transport through the mixture.

44. When electrode compaction is performed, a compressive force is distributed across the planar area of the electrode, to a certain level of pressure or stress. This causes the electrode to permanently or plastically deform, which results in a decrease in thickness and porosity and an increase in density of the electrode coating. If the electrode at the time of compaction comprises more than one layer, then each layer is subject to the same stack pressure and responds accordingly—in other words, it is not possible to compact one layer without simultaneously subjecting all remaining layers to the same pressure. After the compaction is

performed, there might be some recovery or springback in which elastic forces cause the electrode or a constituent layer to increase modestly in porosity from the minimum value imparted by the compaction process. The recovery process typically takes a brief period of time that depends on the timescale for viscoelastic relaxation of the polymeric materials used in the film. Temperature would be another factor controlling this process. Once this recovery is complete the overall porosity and hence density of the electrode film will be stable until further manufacturing steps are undertaken.⁴ Further, higher compressive forces applied in pursuit of higher electrode compaction densities are more likely to result in undesirable cracking or fracturing of the particles. Ex. 2040.

45. As I alluded above, some amount of porosity in cathodes and anodes is required for a functional battery, to allow lithium ions to shuttle between the two electrodes. However, the degree of porosity required for a functional battery—and more specifically the degree of porosity required to optimize the performance of a

⁴ Understanding density and porosity of battery materials is an area in which I have particular expertise. I have been performing such measurements and calculations across my entire career, including in publications given as Exs. 2028-2031.

battery—depends on a number of characteristics of each electrode and the overall goals of the electrode design. For example, a chosen porosity or compaction density of an electrode that optimizes the cell performance depends (in addition to the variety of potential measurements of “cell performance”) on the active material used, the particle size distribution of the active material used, the conductive material used (to allow electron migration during discharge), the type of electrolyte used, the degree of compaction (which impacts “tortuosity” as I have discussed in my own publications), and other characteristics of the electrodes. Exs. 2029 and 2017.⁵ Moreover, some applications do not require a maximum performance, but instead desire a cell with a higher degree of safety (even if that sacrifices performance). Such applications may require a higher porosity, and by extension, a lower compaction density for the cell. In short, it is difficult to predict an “optimal” compaction density and porosity of an electrode without extensive testing and a definition of which performance features and measurements are desirable for a specific battery’s goals.

⁵ Ex. 2017. V. Srinivasan and J. Newman, *Design and Optimization of a Natural Graphite/Iron Phosphate Lithium-Ion Cell*, 151 J. Electrochem. Soc. A1530 (2004) [<https://iopscience.iop.org/article/10.1149/1.1785013>] (last visited August 4, 2025).

C. The '118 Patent

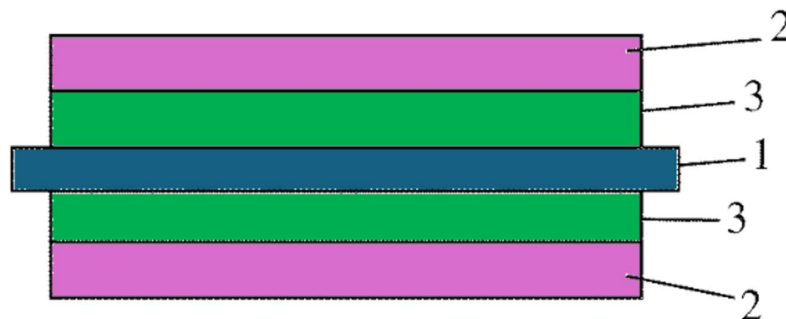
46. The '118 Patent describes an electrochemical device with a novel multi-layer electrode structure that avoids internal short circuits of the lithium-ion battery. *Id.*, 1:45-49.

47. The '118 Patent describes that its novel multi-layer electrode structure avoids short circuits caused by external forces puncturing the battery. For example, the '118 Patent describes that providing a multi-layer cathode material avoids short circuits by placing a coating of the cathode with a higher resistivity on the surface of the positive electrode current collector “to avoid direct contact between the negative electrode active material layer and the positive electrode current collector so as to prevent the most dangerous short circuit mode from occurring.” *Id.*, 3:21-30.

48. As described in the '118 Patent, a first layer, which is positioned closest to the current collector of the electrode, comprises active material particles having a 90% accumulation volume (Dv90) less than 40 μm to promote adhesion of the active material to the current collector. *Id.*, 3:50-57; 4:55-62; 17:55-60. The adhesive first layer improves safety by reducing the likelihood of the active material delaminating or otherwise separating from the current collector when the battery is punctured, and thereby maintains a barrier between the cathode current collector and the anode to

prevent a short circuit. *Id.* 4:3-12. To achieve a higher compaction density above 3.2 g/cc⁶ and increase the overall energy storage in the cell, the '118 Patent teaches the inclusion of a second layer with larger particles positioned further from the current collector than the first layer, which increases the total density of the cathode structure of the cell. *Id.*, 6:4-27. The inventors found that this structure provides improved safety, increased manufacturability of the electrode (for instance, to withstand the compacting forces when both layers are simultaneously compacted in a single calendering step), and improved energy density of the cell. *Id.*, 5:28-51; 6:7-12.

49. Figure 2 of the '118 Patent, reproduced below with color annotations, illustrates the two-layer positive electrode structure.



⁶ “g/cc,” where cc means cubic centimeter, is a commonly used alternative expression for g/cm³; the two units are used interchangeably in this declaration, depending on the source of a given density value.

50. The above figure shows a double-sided, two-layer positive electrode structure, including a current collector (1; in dark blue), “first” active material layers (3; in green), and “second” active material layers (2; in purple). *Id.*, 3:66-4:17. Each of the active material layers (“first” and “second” layers) contain a positive active material. *Id.*, 4:18-24. The active material of the “first” active material layer comprises one or more of: “lithium cobaltate, lithium manganate, lithium nickelate, lithium nickel cobalt manganese oxide, lithium iron phosphate, lithium iron manganese phosphate, lithium vanadium phosphate, lithium vanadyl phosphate, lithium-rich manganese-based materials, lithium nickel cobalt aluminate and lithium titanate, and combinations thereof.” *Id.*, 4:33-40. The active material of the “second” active material layer comprises one or more of: “lithium cobaltate, lithium nickel cobalt manganese oxide, lithium nickel cobalt aluminum oxide, lithium-rich manganese-based material, lithium iron phosphate.” *Id.*, 4:40-45.

51. The ’118 Patent points out that there is some interaction between the first active material layer and the second active material layer (including based on electron conduction and adhesion), and so the particle size ratio of the second active material layer and the first active material layer is an important factor that affects performance of the lithium-ion battery. *Id.*, 5:19-27. To avoid damage to the first active material layer during cold pressing processes and to ensure maximum

adhesion between the first active material layer and the second active material layer, the '118 Patent proposes that the ratio of the Dv50 (of the second active material layer) to the Dv50 (of the first active material layer) should be between 1:1 and 1:40. *Id.* 5:28-36.

52. The '118 Patent also explains that the thickness of the first active material layer has a natural upper limit to achieve full coverage of the current collector. "Since the particle size of the positive electrode active material in the first active material layer is small and the binder contained in the first active material layer is larger than the binder in the second active material layer, the thickness of the first active material layer cannot be too large, otherwise it will reduce the energy density of lithium-ion batteries." *Id.*, 5:56-62. The '118 Patent therefore teaches that the thickness of the first active material layer should be between 2 μm -30 μm after compaction. *Id.*, 5:62-66. The '118 Patent also teaches that the thickness of the first active material layer is not less than Dv90 of the positive electrode active material in the first active material layer to ensure good coverage. *Id.*, 5:66-6:12. To achieve high energy density, the '118 Patent teaches that the thickness of the second active material layer should be 30 μm or more. *Id.* After these layers are laminated onto the current collector, the layers should be compacted so that the first active material layer has a density greater than 2.8 g/cc, the second active material layer has a

density greater than 3.3 g/cc, and because the second active material layer is thicker than the first active material layer, the total compaction density of the two layers is greater than 3.2 g/cc. *Id.* 6:13-27.

V. LEVEL OF ORDINARY SKILL IN THE ART

53. I understand that Petitioner provides the following definition of a POSITA:

A POSA at the claimed priority date 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.

Pet., 9.

54. For purposes of this Declaration in support of Patent Owner's Preliminary Response, I offer no independent opinion of the level of ordinary skill in the art but have adopted the definition proposed by Petitioner. I reserve the right to further address the level of ordinary skill in the art if this proceeding is instituted.

55. Each of the arguments below should be considered from the perspective of a POSITA in the field of the '118 Patent and during the relevant time frame (e.g., June 2018). During that time frame, I possessed at least the qualifications of a POSITA, as defined above. Furthermore, I am familiar with the level of skill in the

art that a POSITA would have had at the time, as during the relevant time frame I regularly supervised, interacted with, and taught persons who had this level of skill.

VI. THE BOARD SHOULD NOT INSTITUTE INTER PARTES REVIEW

56. I understand that in order for an *inter partes* review to be instituted, the Petition must establish that there is a reasonable likelihood that at least one challenged claim is unpatentable. For at least the reasons I explain below, it is my opinion that the Petition fails to do so.

A. Ground 1: Ishigaki does not anticipate Claims 1-20

57. It is my understanding that, in Ground 1, Petitioner asserts, and Dr. Gido opines, that Ishigaki anticipates Claims 1-20 of the '118 Patent. Pet., 9-27; Ex. 1010 ¶¶ 72-207. These claims recite:

1. An electrode, comprising:

a current collector:

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 layer, the first layer is formed on a surface of the current collector, and a particle size of 90% accumulative volume of the first material is less than 40 μm ;

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

2. The electrode according to claim 1, wherein a thickness of the first layer is not less than the particle size of 90% accumulative volume of the first material in the first layer.

3. The electrode according to claim 1, wherein a ratio of the average particle size of the second material to the 10 average particle size of the first material is from 1:1 to 40:1.

4. The electrode according to claim 1, wherein the first material has an average particle size in a range of 0.2 μm to 15 μm .

5. The electrode according to claim 1, 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.

6. The electrode according to claim 1, wherein the first layer has a lower compaction density than the second layer.

7. The electrode according to claim 1, wherein the first material comprises one selected from the group consisting of lithium cobaltate, lithium manganate, lithium nickelate, lithium nickel cobalt manganese oxide, lithium iron phosphate, lithium iron manganese phosphate, lithium vanadium phosphate, lithium vanadyl phosphate, lithium-rich manganese-based materials, lithium nickel cobalt aluminate and lithium titanate, and combinations thereof.

8. The electrode according to claim 1, wherein the second material comprises one selected from the group consisting of lithium cobaltate, lithium nickel cobalt manganese oxide, lithium nickel cobalt aluminum oxide, lithium-rich manganese-based material, lithium iron phosphate, and combinations thereof.

9. The electrode according to claim 1, wherein the first material comprises one selected from the group consisting of artificial graphite, natural graphite, mesocarbon micro beads, soft carbon, hard carbon, silicon, silicon carbide, lithium titanate, and combinations thereof.

10. An electrochemical device, comprising an electrode, 40 wherein the electrode comprises:

a current collector;

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 layer, the first layer is formed on a surface of the current collector, and a particle size of 90% accumulative volume of the first material is less than 40 μm ;

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

11. The electrochemical device according to claim 10, wherein a thickness of the first layer is not less than the particle size of 90% accumulative volume of the first material in the first layer.

12. The electrochemical device according to claim 10, wherein a ratio of the average particle size of the second material to the average particle size of the first material is from 1:1 to 40:1.

13. The electrochemical device according to claim 10, wherein the first material has an average particle size in a range of 0.2 μm to 15 μm .

14. The electrochemical device according to claim 10, 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.

15. The electrochemical device according to claim 10, wherein the first layer has a lower compaction density than the second layer.

16. The electrochemical device according to claim 10, wherein the first material comprises one selected from the group consisting of lithium cobaltate, lithium manganate, lithium nickelate, lithium nickel cobalt manganese oxide, lithium iron phosphate, lithium iron manganese phosphate, lithium vanadium phosphate, lithium vanadyl phosphate, lithium-rich manganese-based materials, lithium nickel cobalt aluminate and lithium titanate, and combinations thereof.

17. The electrochemical device according to claim 10, wherein the second material comprises one selected from the group consisting of lithium cobaltate, lithium nickel cobalt manganese oxide, lithium nickel

cobalt aluminum oxide, lithium-rich manganese-based material, lithium iron phosphate, and combinations thereof.

18. The electrochemical device according to claim 10, wherein the first material comprises one selected from the group consisting of artificial graphite, natural graphite, mesocarbon microbeads, soft carbon, hard carbon, silicon, silicon carbide, lithium titanate, and combinations thereof.

19. An electronic device, comprising an electrochemical device, the electrochemical device comprising an electrode, wherein the electrode comprises:

a current collector;

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 layer, the first layer is formed on a surface of the current collector, and a particle size of 90% accumulative volume of the first material is less than 40 μm ;

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

20. The electronic device according to claim 19, wherein the first layer has a lower compaction density than the second layer.

58. I disagree that Ishigaki anticipates any of claims 1-20 for at least the following reasons.

1. Petitioner Fails to Show that Ishigaki discloses a particle size of 90% accumulative volume of the first material is less than 40 μm

59. Each of the Challenged Claims of the '118 Patent requires, *inter alia*, a first layer comprising a first material, wherein the first layer is arranged between the current collector and a second layer, and a particle size of 90% accumulative volume of the first material is less than 40 μm .

60. In Ishigaki, positive electrodes (i.e., cathodes) are formed by depositing one or two positive electrode active material layers onto a positive electrode current collecting foil. Ex. 1004 ¶¶ [0138], [0345]-[0366]. For example, Ishigaki states that the positive electrode active material layer “is usually made by dry-mixing a positive electrode material used in the present invention, a conductive material used in the present invention, a binder, a thickener, and the like into a sheet form,” which is then “pressed onto the positive electrode current collecting foil.” *Id.* ¶ [0138]. Ishigaki also states that the positive electrode active material layer may alternatively be made by dissolving or dispersing the materials “in a liquid medium to form a slurry, which is then coated on the positive electrode current collecting foil and dried.” *Id.* Ishigaki explains that its positive active material includes larger “secondary particles,” which

are formed from aggregating smaller “primary particles.” Ex. 1004 ¶ [0092] (“a slurry obtained by wet-pulverizing a raw material compound and additive is spray-dried to obtain a powder in which primary particles are aggregated to form secondary particles”).

61. Dr. Guido asserts that Ishigaki’s secondary particles “are the relevant comparison to the particle size recited in the ’118 patent,” (Ex. 1010 ¶ 111) and points to the secondary particles as allegedly disclosing “a particle size of 90% accumulative volume of the first material is less than 40 μm .” Ex. 1010 ¶¶ 81-84; *see also* Pet. at 14-15. Dr. Guido claims, “Ishigaki discloses that the first positive electrode active material has particles with 90% ***cumulative diameter*** less than 10 μm ... Therefore, Ishigaki discloses that a particle size of 90% ***accumulative volume*** of the first active material is less than 40 μm .” Ex. 1010 ¶ 81 (emphasis added). I disagree.

62. First, there is no disclosure of 90% accumulative volume values for any of Ishigaki’s particles, and therefore Dr. Guido’s assumption that Ishigaki’s “90% cumulative diameter” values correspond to “a 90% accumulative volume” is misguided, as I describe further below.

63. Although not mentioned in any of the disclosure related to two-layer electrode structures, including with respect to Example 2, Petitioner and Dr. Guido

point to Ishigaki's discussion of 90% cumulative diameter (D90) values as allegedly disclosing the claimed particle size of 90% accumulative volume of the first material is less than 40 μm . Ex. 1010 ¶ 81. Dr. Gido states:

Ishigaki discloses that the first positive electrode active material has particles with 90% cumulative diameter less than 10 μm . EX1004, ¶38; see also EX1004, ¶39 (“[T]he 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.”) (emphasis added). Ishigaki's particle size is therefore measured by volume, which corresponds to Dv90 (the volume standard). EX1004, ¶39; EX1018 (ISO 13320-1 standard explaining that laser diffraction is a volume-based measurement). Therefore, Ishigaki discloses that a particle size of 90% accumulative volume of the first active material is less than 40 μm .

Ex. 1010 ¶ 81. I disagree with Dr. Gido's assertion that Ishigaki's D90 metric “corresponds to Dv90” for at least the following reasons.

64. In Ishigaki's description of what is meant by “Median Diameter and 90% Cumulative Diameter (D90),” Ishigaki states:

The median diameter at the positive electrode preparation stage of the lithium transition metal compound powder of the present invention is normally 0.1 μm or more, preferably 0.3 μm or more, more preferably 0.6 μm or more, even more preferably 0.8 μm or more, and most preferably 1.2 μm or more; and normally 5 μm or less, preferably

4 μm or less, more preferably 3 μm or less, even more preferably 2.8 μm or less, and most preferably 2.5 μm or less. So long as the median diameter is within this range, the coating property during the formation of the positive electrode active material layer is favorable, and the ratio of recessed portions per unit area of the current collecting foil is low, so that safety against internal short circuits is high.

Note that in the examples and comparative examples, the median diameter at the synthesis stage is maintained as it is when stirring in a planetary centrifugal mixer and no shearing is applied.

In addition, a 90% cumulative diameter (D90) of the secondary particles of the lithium transition metal compound powder of the present invention is normally 10 μm or less, preferably 8 μm or less, more preferably 6 μm or less, and most preferably 5 μm or less; 20 and normally 0.5 μm or more, preferably 0.8 μm or more, more preferably 1 μm or more, and most preferably 1.5 μm or more. If the 90% cumulative diameter (D90) exceeds the upper limit, a reduction in battery performance may be brought about, whereas if the lower limit is exceeded, an issue may arise in the coating properties when forming the positive electrode active material layer.

Note that, in the present invention, the median diameter, as the average particle diameter, and the 90% cumulative diameter (D90) are measured by a well-known laser diffraction/scattering particle size distribution measuring device, with a set refractive index of 1.60a 0.10i, and a particle diameter standard as a volume standard. In the present

invention, for the dispersion medium used during measurement, measurement was performed using a 0.1 wt% sodium hexametaphosphate aqueous solution.

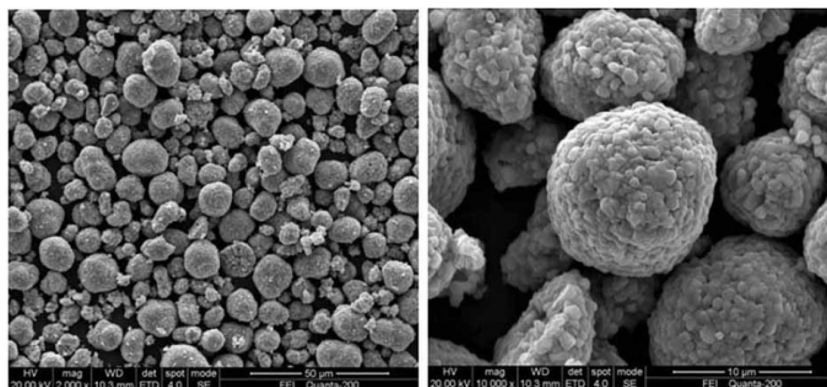
Ex. 1004 ¶¶ [0037]-[0039].

65. Ishigaki's disclosure that D90 is "measured by a well-known laser diffraction/scattering particle size distribution measuring device, with a set refractive index of 1.60a 0.10i, and a particle diameter standard as a volume standard," would at best teach a POSITA that the representative diameter of a particle could be determined from the measured volume of the particle. *Id.* ¶ [0039]. Most commonly, this determination is based on the assumption that the particle is a perfect sphere so that a particle of a certain volume is equivalent to a sphere with a single diameter. A POSITA would understand that laser diffraction/scattering does not actually measure a single particle diameter or a precise volume, but rather how much the particle diffracts light from its original path. Using Fraunhofer or Mie diffraction theory and an algorithm that assumes each particle is a perfect sphere, the volume and associated single diameter are estimated. Ex. 2018.⁷ As Dr. Gido inadvertently

⁷ Ex. 2018. Laser diffraction for particle sizing – Anton Paar, available at:

<https://wiki.anton-paar.com/en/laser-diffraction-for-particle-sizing> (last accessed on July 30, 2025).

illustrates in a pair of scanning electron microscope (SEM) images extracted from Ex. 1013 (reproduced below), common active material particles approximated as spheres are not truly such. Ex. 1010 ¶ 270.



Ex. 1010 ¶ 270 (showing SEM images on two length scales for an ensemble of not-quite-spherical active material particles).⁸

66. Dr. Guido asserts that because the laser diffraction device uses “a particle size diameter standard as a volume standard . . . Ishigaki’s particle size is therefore measured by volume, which corresponds to Dv90 (the volume standard).” Ex. 1010 ¶ 81. But this logic is unsupported and flawed because determining particle sizes

⁸ Dr. Guido cites Ex. 1013 as allegedly providing these SEM images. Ex. 1010 ¶¶ 108, 270. I note that these SEM images are not shown in Ex. 1013 itself, but they can be found on the corresponding webpage (https://www.alibaba.com/product-detail/Lithium-Ion-Battery-Nickel-Manganese-Cobalt_1600084022147.html).

(e.g. by volume) is separate from the choice of how to construct or define a particle distribution once the particle sizes are known. That is, how the diameters of individual particles are measured does not dictate how a distribution of said diameters is constructed or defined.

67. A POSITA would have understood that the particle distribution can be constructed or defined using multiple statistical approaches, including a volume-based or number-based approach. For instance, the particle distribution can be a number-based distribution constructed by counting the number of particles within each size range such that equal weight is given to all of the particles regardless of size. Alternatively, the particle distribution can be constructed using a volume-based distribution that is constructed by measuring the volume of particles within each size range such that larger particles contribute more to the distribution, given that their volume is greater. In either case, the particles must first be measured (e.g., using the above-mentioned laser diffraction/scattering particle size distribution measuring device) before the particle distribution is constructed.

68. As Dr. Guido acknowledges, “[t]hese different accumulation averages do not necessarily yield the same number values.” Ex. 1010 ¶ 83. Indeed, the D90 value of a cumulative number distribution of a set of particles differs substantially from a Dv90 value for the same particle set. This difference in values between a D90

value of a cumulative number distribution versus a Dv90 value helps explain differences in cell performance of batteries having seemingly similar cathode (or anode) compositions. As an illustrative example, consider a hypothetical set of 1000 particles in which 990 particles have a diameter of 1 μm and 10 particles have a diameter of 3.7 μm . Regardless of how the diameters themselves are measured, the D90 of a cumulative number distribution for this set of particles would be 1 μm (measured at the 900th particle, by number), while the Dv90 would be 3.7 μm (measured at the 997th particle, at which point 90% of the total volume would have been reached). A POSITA would have expected that a cell with a cathode active material having this example particle distribution would perform differently from a cell with a cathode active material particle distribution having a D90 of a cumulative number distribution of 3.7 μm , or a cell with a cathode active material particle distribution having a Dv90 of 1 μm . The measured Dv90 value will always be greater than the D90 value for any continuous non-uniform distribution (i.e. for a range of particle sizes). Indeed, Dv90 and D90 values will only be the same if all particles are the same size. A POSITA would understand that such a distribution would not occur from realistic manufacturing processes, especially in a manufacturing process that includes pulverizing or grinding of the active material, as is the case in Ishigaki. *See e.g.*, Ex. 1004 ¶ [0089].

69. Ishigaki does not describe how its D90 is constructed. Rather, Ishigaki merely describes the measurement of individual particle diameters on which the D90 values are based. *See* Ex. 1004 ¶ [0039]. For the secondary particles, Ishigaki describes that “the median diameter, as the average particle diameter, and the 90% cumulative diameter (D90) are measured by a well-known laser diffraction/scattering particle size distribution measuring device.” *Id.* Dr. Gido asserts that the use of a laser diffraction instrument in Ishigaki necessarily stipulates the type of particle distribution Ishigaki had in mind. Ex. 1010 ¶ 84. Specifically, Dr. Gido states, “This type of device and this method of particle size measurement is specifically sensitive to particle volume and thus the median diameter or average diameter it measures is Dv50 and the 90% cumulative diameter it measures is Dv90.” Ex. 1010 ¶ 84; *see also* Ex. 1010 ¶¶ 81, 105, 106. But again, the Ishigaki device *only* measures the size of the particles, and a measurement step is necessary for any method used for constructing a particle distribution—whether D90 or Dv90.

70. In my opinion, Dr. Gido cannot assert based on Ishigaki’s disclosure that Ishigaki’s “D90” is necessarily based on a cumulative volume distribution (turning it into Dv90) rather than a cumulative number distribution (D90, which is what Ishigaki uses) simply because a laser diffraction instrument is used to obtain the effective diameters. In fact, as described above, and as Dr. Gido himself admits,

a cumulative volume distribution is only one possible option for particle distribution, and these different options necessarily will have different values when characterizing the same particle set. Ex. 1010 ¶ 83.

71. Moreover, based on disclosure elsewhere in Ishigaki, and when considering Ishigaki's teachings as a whole, a POSITA would understand that Ishigaki's 90% cumulative diameter measurement (D90) is a number-based distribution, not a volume-based distribution. For example, while Ishigaki describes the secondary particle diameters as being measured using a laser diffraction instrument, Ishigaki discloses that the primary particle diameters are being measured by a completely different method, namely by means of particle size *counting* using SEM images. Ex. 1004 ¶¶ [0041], [0185]. Ishigaki does not disclose why a different size-measurement method was used for primary vs. secondary particles. However, a POSITA would understand that, in cases where the primary particles have already been aggregated into secondary particles (as described in Ex. 1004 ¶ [0042]) or in cases where primary particles are particularly difficult to disperse, it was common to use different techniques to measure the size of secondary particles and primary particles. So, the secondary particles are readily separated from one another (a requirement for measuring the volume of the particle by laser diffraction), but primary particles are connected with one another so that the volume of any individual

primary particle cannot be determined by laser diffraction, for instance while it remains a part of an agglomerated secondary particle. Therefore, in such a case, it would be common to use SEM imaging to generate images of the included primary particles, and then to manually measure diameters of primary particles visible within the generated image.

72. In SEM particle size counting, only a 2D view is made of an ensemble of particles and thus other measurement methods are more generally favored to directly measure each particle's volume. Therefore, a POSITA would understand that Ishigaki's use of SEM to measure the primary particles' diameters is indicative of a number-based (not a volume-based) distribution. Ex. 1004 ¶ [0185].

73. Ishigaki gives no explanation as to how or why the purported primary particle sizes might differ in statistical approach, if any, from the purported secondary particle sizes, but Ishigaki explains that the primary particles contribute to the performance of the cathode and therefore, in addition to stipulating limits on the size of the secondary particles, Ishigaki also stipulates limits on the size of the primary particles. Ex. 1004 ¶ [0041] ("If the average primary particle diameter exceeds the upper limit, powder packing properties may be adversely affected and the specific surface area may be reduced, which may increase the possibility of a decrease in battery performance such as rate characteristics and output

characteristics. If the lower limit is exceeded, crystals do not fully develop, which may result in issues such as poor reversibility of charging and discharging.”).

74. A POSITA would have understood that number-based and volume-based distribution methods will not yield the same values (and the Dv90 value will be larger than the D90 value for a continuous distribution of unequally-sized particles), and so comparing the size distributions of the primary particles and secondary particles would require using the same statistical approach (e.g., using a D90 or a Dv90 for both). Since volume data could not be directly obtained for the primary particles, it would have been most convenient for Ishigaki to construct a number-based distribution for both types of particles so that their respective size distributions could be directly compared.

75. In other words, a POSITA would have expected, and it would be most convenient, to use the number-based particle distribution for both the primary particles and the secondary particles of Ishigaki so that a D90 value determined for the primary particles could be directly compared to a D90 value for the secondary particles. The same principle would apply when comparing the median or average primary particle size to the median or average secondary particle size. Thus, at least because underlying volume data are unavailable for the primary particles, it is my

opinion that the D90 metric in Ishigaki corresponds to a cumulative number (not volume) distribution.

76. In addition to maintaining internal consistency with metrics for the primary particles, Ishigaki teaches a further and independent reason why secondary particle D90 is not Dv90. As Ishigaki states, and Dr. Guido relies upon, both the “median particle diameter” and “D90” for secondary particles are strongly associated with each other and determined by the same methodology. Ex. 1004 ¶ [0039]; *see also* Ex. 1010 ¶ 84. Therefore, a POSITA would take Ishigaki’s consistent use of *median diameter* as offering teachings on how Ishigaki’s *D90* is to be understood. At no point does Ishigaki define *median diameter* to be Dv50, contra Dr. Guido’s suggestion (*e.g.*, Ex. 1010 ¶ 84). Instead, a POSITA would rely on the plain and ordinary statistical meaning of *median diameter*, which is the diameter that half of the diameters in the distribution are less than and the other half are greater than. The plain-vanilla median value flows from and expressly requires the number-based distribution and not the cumulative-volume-based distribution of diameters. It would make no sense for Ishigaki to employ dissimilar distributions for D90 and its companion *median diameter* that is based on a number-based distribution. Therefore, a POSITA would conclude that D90 is likewise based on a number-based distribution.

77. Therefore, contrary to Dr. Gido's assertion, a POSITA reading Ishigaki reference would not assume that Ishigaki's D90 metric "corresponds to Dv90 (the volume standard)" but instead that it corresponds to a number-based particle distribution standard.

2. Petitioner Fails to Show that Ishigaki discloses a two-layer electrode with a compaction density of at least 3.2 g/cc

78. Each of the Challenged Claims of the '118 Patent also requires, *inter alia*, a first layer and a second layer, wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc. Petitioner fails to show that Ishigaki discloses these claim requirements.

79. Ishigaki provides a range of values for the "mixture density" of an electrode, as well as the "electrode density" of the positive active material after pressing. Ishigaki states:

The **mixture density** of the electrode of the present invention is characterized as 2.0 g/cm³ or more, and from the viewpoint of increasing capacitance density, it is preferably 2.0 g/cm³ or more, and particularly preferably 2.5 g/cm³ or more. The upper limit is not particularly limited, but since space is required in the positive electrode plate to hold the electrolyte in the electrode plate and to supply lithium ions, the upper limit is preferably 3.6 g/cm³ or less, more preferably 3.5 g/cm³ or less, and particularly preferably 3.4 g/cm³ or less.

The thickness of **the positive electrode active material layer** is usually about 10 to 200 μm .

Furthermore, the thickness of the positive electrode active material layer is usually about 10 to 200 μm .

The **electrode density** of the positive electrode after pressing has a lower limit of normally 2.0 g/cm^3 or more, preferably 2.4 g/cm^3 or more, and particularly preferably 2.6 g/cm^3 or more, and an upper limit of normally 4.2 g/cm^3 or less, preferably 4.0 g/cm^3 or less, and particularly preferably 3.8 g/cm^3 or less.

Note that **the positive electrode active material layer** obtained by coating and drying is preferably compressed by a roller press or the like in order to increase the packing density of the positive electrode active material.

Thus, the positive electrode for lithium rechargeable batteries of the present invention can be prepared.

Ex. 1004 ¶¶ [0025], [0151] (emphasis added).

80. Petitioner asserts, and Dr. Guido opines, that both the mixture densities and the electrode densities of Ishigaki allegedly anticipate “a first layer and a second layer, wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc .” Pet., 17-18; *see also*, Ex. 1010 ¶¶ 86-88. I disagree for at least the following reasons.

a. Ishigaki's single-layer density range is not applicable to a two-layer electrode structure.

81. The densities described in paragraphs [0025] and [0151] of Ishigaki, which Dr. Gido relies on, are described for single-layer cathode structures and Ishigaki provides no information suggesting that the provided densities also apply to multi-layer cathode (or anode) structures. *See* Ex. 1010 ¶¶ 87-88. Rather, both paragraphs [0025] and [0151] refer only to “the positive electrode active material *layer*,” which a POSITA would interpret as a *single* layer. Indeed, contrary to Dr. Gido's claim that “[a]ll of these disclosures describe individual preferred embodiments of Ishigaki in which the compaction density is greater than 3.2 g/cc,” and “anticipate[s] the claim limitation,” nothing in Ishigaki would lead a POSITA to consider the range of densities described in paragraphs [0025] and [0151] of Ishigaki as being applicable to a two-layer electrode structure. *Id.* ¶ 88; *see also* Ex. 1004 ¶¶ [0025], [0151]. Instead, a POSITA would understand that two-layer electrode structures would have distinct sub-structures and therefore design requirements to allow suitable movement and reaction of lithium ions and electrons throughout the entire structure once it is placed into operation. A two-layer structure

that is naively constructed without these considerations would not allow full utilization of active material. Ex. 2021.⁹

82. Moreover, a POSITA would understand that the compaction of a layer in a single-layer electrode structure would be different when a second layer is applied (to form a two-layer structure). For instance, a POSITA would understand that, in Ishigaki's two-layer system, when the second layer is applied to the first layer, complex interactions develop between the two layers during the manufacturing process that result in unexpected changes in density both before and after compaction. For example, if the first layer is separately dried, as Ishigaki suggests (Ex. 1004 ¶ [0366] ("Next, the slurry 1 was applied and dried on one side of aluminum foil (thickness 15 μ m) of the current collecting foil using a doctor blade. Then, the slurry 2 was applied to one side of the substrate using a doctor blade and dried.")), the solvent of the second layer will re-wet the first layer when the second layer is laminated on top of the first layer, which causes the two layers to partially

⁹ Ex 2021. Liu, Chen, Liu, Chu, and Tiu, "Improvement of Lithium-Ion Battery Performance by Two-Layered Slot-Die Coating Operation," Energy Technology 2017, 5, 1235–1241 [<https://onlinelibrary.wiley.com/doi/10.1002/ente.201600536>]

mix and to change the structure of the first layer. Ex. 2019 p. 51.¹⁰ This is especially true for Ishigaki, which uses the same solvent for both layers in its (only) two-layer cathode structure, with a separate drying step following the application of the first layer. Ex. 1004 ¶ [0366] (Ishigaki describing that the two slurries used to make layer 1 and layer 2 of the two-layer cathode structure are both made with N-methylpyrrolidone (NMP) and sequential drying steps). Even if the two slurry layers in Ishigaki were applied without an intervening drying step, having two adjacent wet slurry layers leads to deleterious effects such as entrainment of air bubbles between the layers and mechanical instability causing the layers to mix. Ex. 2021. Furthermore, during drying of thicker two-layer electrodes, migration of binder and settling of active particles become greater problems than in thinner single-layer electrodes. Ex. 2020.¹¹ This, in turn, will lead to distinct and unintended compositional properties in each of the layers.

¹⁰ Ex. 2019. Understanding the Mechanical and Electrochemical Impacts of Binder Systems on Silicon Anodes in Lithium-Ion Batteries – BYU Scholars Archive, available at: <https://scholarsarchive.byu.edu/etd/10449> (accessed on 30 July 2025)

¹¹ Ex. 2020. Westphal, Bockholt, Günther, Haselrieder, and Kwade, “Influence of Convective Drying Parameters on Electrode Performance and Physical Electrode

83. What's more, a POSITA would have understood that the compaction density values provided in at least Ishigaki's Paragraph [0025] would have only applied to a single-layer cathode structure because the provided values are disclosed as being sufficient to leave adequate space "to hold the electrolyte," based on the particle size distribution, active material densities, and additive concentration disclosed for Ishigaki's single-layer cathode composition. Ex. 1004 ¶ [0025]. Two-layer cathode constructions have additional variables to be considered when determining whether the construction leaves space "to hold the electrolyte." For example, a high compaction density value that is achievable for a layer including a high-density active material while still retaining sufficient space to hold the electrolyte, does not also leave sufficient space for the electrolyte in a layer using a less-dense active material. Similarly, for layers with different particle size distributions or different additive concentrations, the same density value would yield different amounts of "space" to hold the electrolyte.

84. While a POSITA would understand that a two-layer cathode structure must also include space to hold an electrolyte, a POSITA would also have

Properties" ECS Transactions, 64 (22) 57-68 (2015)
[<https://iopscience.iop.org/article/10.1149/06422.0057ecst/pdf>]

understood that the compaction-density values disclosed for Ishigaki's single-layer cathode structure would not have yielded the same "space" (i.e., porosity) for holding electrolyte in Ishigaki's two-layer cathode structure, given that the two-layers have different compositions, which in turn leads to distinct pore structures in each layer. Neither Petitioner nor Dr. Gido appreciates or addresses this distinction between single-layer and two-layer cathode structures. That is, neither Petitioner nor Dr. Gido explains that Ishigaki's disclosed compaction density values for single-layer cathode structures would have provided adequate space for a two-layer cathode structure to "hold the electrolyte," as Ishigaki requires. *See* Ex. 1004 ¶ [0025].

85. Worse still, the POSITA would have understood that substantial portions of Ishigaki's density ranges could not be applicable to a two-layer cathode structure because Ishigaki's own data show that two-layer cathode structures have *a lower compaction density* than single-layer cathode structures. Ex. 1004 ¶¶ [0348]-[0349], [0356]-[0357], [0361]-[0363], [0366].

86. Ishigaki reports mixture densities for four positive electrodes across two Examples (Example 1 and Example 2) and two comparative examples (Comparative Example 1 and Comparative Example 2). *Id.* All of Ishigaki's examples—including its only example that teaches a two-layer structure, Example

2—are **well below** the claimed 3.2 g/cc compaction density. *Id.* For example, a comparison of these four electrodes is shown in the following Table 1:

Table 1		
Electrode	Mixture Density	
	Double-sided	Single-sided
Example 1 (single-layer)	2.55 g/cm ³	2.6 g/cm ³
Example 2 (two-layer)	Not reported	2.4 g/cm ³
Comparative Example 1 (single layer)	2.54 g/cm ³	2.6 g/cm ³
Comparative Example 2 (single-layer)	2.54 g/cm ³	2.6 g/cm ³

Ex. 1004 ¶¶ [0348]-[0349] (Example 1); [0356]-[0357] (Comparative Example 1); [0361]-[0363] (Comparative Example 2); [0366] (Example 2).

87. As illustrated in Table 1, all of the electrodes described in Ishigaki have densities that fall between 2.4-2.6 g/cm³. Moreover, the only example of a two-layer cathode structure disclosed in Ishigaki is Example 2 (Ishigaki includes no other discussion of cathode structures with multiple layers), and Example 2 has the **lowest** density of all disclosed cathode structures. That is, the single-sided density for Example 2, which is the only density reported for Example 2, is 2.4 g/cm³, whereas the single-sided density of all other examples is 2.6 g/cm³. *Id.*

88. Inasmuch as the density for all of the single-layer cathode structure examples is the same (e.g., exactly the same for single-sided density and nearly the same for double-sided density) and greater than the two-layer cathode structure example, Ishigaki teaches that two-layer cathode structures have a lower density than

single-layer cathode structures. That is, contrary to Dr. Gido's assertion that a POSITA would "work in the higher density ranges taught by Ishigaki," Ishigaki's examples teach a POSITA to work in the *lower* density ranges provided in Ishigaki, and in particular, in a range below 2.6 g/cm³. Neither Petitioner nor Dr. Gido addresses these examples or provides any explanation as to why the only two-layer cathode structure example in Ishigaki is (1) at the lower limit of Ishigaki's disclosed range, (2) lower than all other disclosed examples, and (3) well below the claimed 3.2 g/cc compaction density.

89. Therefore, at least inasmuch as Ishigaki teaches that two-layer cathode structures should be provided with lower densities as compared with single-layer cathode structures—and with a density well below 3.2 g/cc—a POSITA would understand that the upper limit of Ishigaki's density range are not applicable to a two-layer electrode structure.

3. Claims 2-9, 11-18, and 20 Are Not Unpatentable

90. Claims 2-9, 11-18, and 20 are not unpatentable for the same reasons as discussed above with respect to independent claims 1, 10, and 19. I reserve the right to address claims 2-9, 11-18, and 20 individually if this proceeding is instituted.

B. Ground 2: Ishigaki and Kim do not render obvious claims 1-20.

91. It is my understanding that, in Ground 2, Petitioner asserts, and Dr. Gido opines, that Ishigaki and Kim render obvious Claims 1-20 of the '118 Patent. Pet., 27-35; Ex. 1010 ¶¶ 208-249.

92. Dr. Gido relies on the disclosure of Ishigaki for all elements of independent claims 1, 10, and 19, except for elements [1.5], [10.5], and [19.5], which recite, wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc, for which Dr. Gido allegedly relies on the disclosure of Kim. Ex. 1010 ¶¶ 216-220.

93. In particular, Dr. Gido asserts that Kim teaches “the use of lithium cobalt nickel manganese oxide as the active material, and discloses an average particle size (Dv50) from 5 – 50 µm,” and “a cathode layer density of 3.31 g/cc or greater, and preferably of 3.4 to 4.0 g/cc.” Ex. 1010 ¶ 65 (citing Ex. 1009 ¶ 36). Dr. Gido also asserts that “Kim explains that compaction densities below 3.31 g/cc ‘may be too small to obtain a high electrical capacity.’” *Id.*; *see also* ¶¶ 218-219.

94. According to Dr. Gido, a POSITA would “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 in Kim to improve the battery’s electrical capacity within his practicing the teachings of Ishigaki.” Ex. 1010 ¶ 214. I disagree.

95. First, as discussed with respect to Ground 1, and contrary to Dr. Gido's assertion, Ishigaki's examples teach a POSITA to work in the lower density ranges provided by Ishigaki for two-layer cathode structures. *Supra* Section VI.A.2.a. Moreover, Ishigaki's examples demonstrate that density values of 2.4 and 2.6 g/cm³ were sufficient to accomplish Ishigaki's objectives, thereby teaching away from increasing the density values (which a POSITA would understand to have the negative effect of reducing the amount of lithium ion transport that could occur within the active layer by reducing the gaps or interstices between particles). Ex. 1004 ¶¶ [0348]-[0349]; [0356]-[0357]; [0361]-[0363]; [0366].

96. Second, a POSITA would not be motivated to combine Kim and Ishigaki at least because Kim does not disclose density values of an electrode that a POSITA could compare to Ishigaki. Rather, Kim describes "press density" and "volume density" values of a composite cathode active material *without* conductive materials and binders or other additives that constitute Kim's "cathode active material composition" coated onto Kim's current collectors. Ex. 1009 ¶ [0040] (Kim describing that "the composite cathode active material, a conducting agent, a binder, and a solvent are mixed to prepare the cathode active material composition."). Neither of the terms "press density" or "volume density" is clearly defined and neither of which corresponds to a "mixture density" or "electrode density" as used

in Ishigaki for an entire cathode active material layer. Ex. 1009 ¶ [0035]-[0037]; Ex. 1004 ¶ [0347]. Additionally, Kim and Ishigaki describe substantially different materials, and Kim doesn't even consider *any* two-layer electrode structures. Therefore, a POSITA would not be motivated to "look to the density range disclosed in Kim to improve the battery's electrical capacity within his practicing the teachings of Ishigaki." Ex. 1010 ¶ 214.

1. Petitioner Fails to Show that Kim would motivate a POSITA to pursue compaction densities towards higher values in the range taught by Ishigaki

97. First, Ishigaki's only examples teach away from using densities at the upper end of the ranges disclosed in Ishigaki. Ex. 1004 ¶¶ [0348]-[0349]; [0356]-[0357]; [0361]-[0363]; [0366]. Ishigaki's examples would have taught a POSITA to use compaction densities of less than 2.6 g/cm³ for two-layer cathode structures, specifically to use compaction densities of 2.4 g/cm³ for two-layer cathode structures because those density values are apparently sufficient to meet Ishigaki's goals. *Id.* ¶¶ [0382]-[0383].

98. For example, Ishigaki describes that its goal is to reduce short circuits by having fewer recesses in the surface of the current collector, thereby improving adhesion. Ex. 1004 ¶¶ [0013], [0014], [0152], [0383]. Ishigaki's short circuit test illustrates that Ishigaki achieved its goal of reducing short circuits with fewer recess

when the densities of the cathodes are less than 2.6 g/cm^3 , well below the upper end of Ishigaki's disclosed density ranges. Ex. 1004 ¶¶ [0348]-[0349], [0356]-[0357], [0361]-[0363], [0366], (showing densities of Example 1, Comparative Example 1, Comparative Example 2, and Example 2); and ¶¶ [0382]-[0383] (showing short circuit test results). That is, Example 1, Example 2, Comparative Example 1, and Comparative Example 2 each have a density of 2.6 g/cm^3 or less. Ex. 1004 ¶¶ [0348]-[0349], [0356]-[0357], [0361]-[0363], [0366]. Ishigaki's tests demonstrate that other characteristics are more important for achieving Ishigaki's goals: Examples 1 and 2 each have a depression ratio and an average depth of depressions in the current collector that are lower than that of Comparative Examples 1 and 2, and Examples 1 and 2 passed the short circuit test, while Comparative Examples 1 and 2 failed. Ex. 1004 ¶¶ [0378] (Table 2 showing "Depression ratio of current collecting foil"), [0378] (Table 3 showing "Average depth of depressions in current collecting foil"), [0382] (Table 6 showing short circuit test results for electrode laminate"). Thus, Ishigaki itself teaches away from pursuing compaction densities towards higher values in the range taught by Ishigaki.

99. Second, the densities described in Kim are not "mixture densities" as used in Ishigaki.

100. Dr. Guido contends that “Kim discloses a cathode layer density of 3.31 g/cc or greater, and of 3.4 to 4.0 g/cc.” Ex. 1010 ¶ 218 (citing Ex. 1009 ¶ 36). But this is not what Kim discloses. Kim’s “press density” and “volume density” are for its *active materials* only and do not correspond to a “mixture density” or “electrode density” of **Ishigaki’s cathode (which includes a conductive material of between 1 mass% to 15 mass%)**. Ex. 1004, ¶ [0110]. For example, Kim states:

In some embodiments, the inclusion of the large-diameter active material and the small-diameter active material in a specific particle diameter ratio and in a specific weight ratio may improve volume density, and thus leading to further increased electrical capacity of a lithium battery.

In some embodiments, a *press density of the composite cathode active material* may be about 3.31 g/cm³ or greater. In some embodiments, a *press density of the composite cathode active material* may be from about 3.4 g/cm³ to about 4.0 g/cm³. In some embodiments, *volume density of the composite cathode active material* may be too small to obtain a high electrical capacity when the *press density of the composite cathode active material* is less than 3.31 g/cm³. In some embodiments, the *volume density of the composite cathode active material* may exceed a conventional density range, and the composite cathode active material may be broken if the *press density of the composite cathode active material* is greater than 4.0 g/cm³.

In some embodiments, a *press density of the large-diameter active material of the composite cathode active material* may be from about 2.5 g/cm³ to about 4.0 g/cm³, and a *press density of the small-diameter active material* may be from about 1.0 g/cm³ to about 4.0 g/cm³. As used therein, the terms “*press density*” refer to an apparent press density when *the composite cathode active material powder* is pressed at a pressure of 2.5 ton/cm². In some embodiments, *the mixture of the large-diameter active material and small-diameter active material may have a reduced press density* when the press densities of the large-diameter active material and small-diameter active material are smaller than the lower limits of the above-mentioned density ranges. In some embodiments, high-rate discharge characteristics of the lithium battery may be deteriorated when the *press densities of the large-diameter active material and small-diameter active material* are greater than the upper limits of the above-mentioned density ranges.

Ex. 1009 ¶¶ [0035]-[0037] (emphasis added).

101. In paragraph [0036] of Kim, a range of possible values is provided for the “press density of the composite cathode active material.” *Id.* ¶ [0036]. A POSITA would interpret “press density” to mean a density measurement made after a compaction process has taken place. *Id.* Additionally, a POSITA would interpret “of the composite cathode active material” to mean that the press density values do not apply to the entire cathode, but rather to *only* the active material constituent of the

cathode (e.g., an active material selected from Formulas 1-10 of Kim). *Id.* ¶ [0036]; *see also id.* ¶ [0079].

102. For instance, with respect to Example 1, Kim states that “***Li_{1.03}Ni_{0.8}Co_{0.1}Mn_{0.1}O₂ powder*** having an average particle diameter of about 15 μm and ***Li_{0.9}Ni_{0.8}Co_{0.1}Mn_{0.1}O₂ powder*** having an average particle diameter of about 5 μm were mixed in a weight ratio of about 95:5 to prepare ***a composite cathode active material.***” Ex. 1009 ¶ [0070] (emphasis added). Kim also states that a slurry used to form the cathode active material layer includes “5 g of ***the composite cathode active material powder of Example 1***, 0.15 g of a carbon conducting agent, and 0.15 g of polyvinylidene difluoride (PVDF) as a binder.” *Id.* ¶ [0079]. Thus, the term “composite cathode active material,” as used in Kim, refers only to active material constituent, and not the entire active material layer that also includes a conductive agent and binder. A POSITA would therefore understand that “press density,” as used in Kim, is a density of the active material constituent of Kim’s cathode active material layer, such as an active material constituent formed from one of Kim’s formulas 1-10, that is measured after compaction. In other words, Kim’s “press density” is a characteristic of the active material, and not a measure of density of a complete electrode. This interpretation of Kim’s press density is consistent with paragraph [0037] of Kim, which describes the press density as “an apparent press

density when the composite cathode active material powder is pressed at a pressure of 2.5 ton/cm².” *Id.* ¶ [0037].

103. In contrast to Kim, Ishigaki provides “mixture density” and “electrode density” values of a positive electrode active material layer that includes an active material, a conductive material, a binder, and a solvent that is subsequently removed by drying. Ex. 1004 ¶¶ [0151], [0349]. For instance, for Example 1 of Ishigaki, “a uniform slurry was prepared” by mixing “[t]he active material, conductive material (HS100 made by Denki Kagaku Kogyo), [a] binder PVdF (Kureha Corporation: KF Polymer L#1120) ... and N-methylpyrrolidone (NMP).” Ex. 1004 ¶ [0349]. Then, “the slurry was applied and dried on one side of aluminum foil (thickness 15 μm) of the current collecting foil using a doctor blade,” and “pressed to 2.6 g/cm³ mixture density using a roll press to produce a one-sided positive electrode.” *Id.* Thus, because Kim’s press densities only relate to the active material constituent of a cathode active material layer, Kim’s press densities are fundamentally different from, and cannot be compared to, Ishigaki’s densities.

104. Indeed, comparing Kim’s press densities to the densities disclosed in Ishigaki would be incorrectly equating numerically and conceptually distinct scientific quantities. Thus, Kim’s statement in paragraph [0036] that “a press density of the composite cathode active material may be about 3.31 g/cm³ or greater,” and

other similar statements in Kim, have no relevance to Ishigaki. *Id.* ¶ [0036]. As Dr. Gido recognizes, once conductive agents, binders, and other additives are mixed with Kim's composite cathode active material having a density of about 3.31 g/cm³ or greater, the overall density of the mixture will decrease, since those additives have densities less than 3.31 g/cm³. Ex. 1010, ¶ 85; *see also* Ex. 2038 (identifying density of carbon black as 1.8 to 2.1 g/cm³); Ex. 2039 (identifying the density of carbon black as 1.98 g/cm³ and the density of PVDF as 1.80 g/cm³).

105. Kim also does not provide a definition for the term “volume density,” but instead simply associates volume density with the “electrical capacity of a lithium battery.” *Id.* ¶¶ [0035], [0037]. For example, Kim states that “volume density of the composite cathode active material may be too small to obtain a high electrical capacity when the press density of the composite cathode active material is less than 3.31 g/cm.³” *Id.* ¶ [0036]. This disclosure of Kim suggests that volume density is distinct from press density, nevertheless a POSITA would interpret Kim's use of “volume density of the composite cathode active material” as meaning that the volume density applies to the active material itself and not to the entire cathode active material layer. *Id.* Furthermore, Kim does not provide values of volume density that a POSITA could use to compare to other values or otherwise make sense of this undefined term. *Id.* ¶¶ [0035]-[0037]. Regardless, at least because volume

density is described in Kim as being *only* applicable to the active material constituent (e.g., an active material selected from Formulas 1-10) of the cathode active material layer, Kim's volume density also cannot be compared to Ishigaki's density values. Thus, Kim does not disclose any density values that a POSITA could compare to Ishigaki.

106. Indeed, Kim does not provide any guidance as to an electrode density value achievable in an electrode layer composition that has been mixed with additives and coated (in any number of layers) onto a current collector. Instead, Kim only provides densities for the "composite cathode active material," and a POSITA would understand that, once additives, including conducting agents and binders are added to form Kim's "cathode active material composition," the density of the "cathode active material composition," would be lower than Kim's recited density of the "composite cathode active material." Ex. 1009 ¶¶ [0036], [0040]; *see also* Ex. 1004 ¶ [0110] (explaining that Ishigaki's cathodes include between 1 mass% to 15 mass% of a conductive material). Dr. Gido recognizes that conducting agents, binders, and other additives lower the overall density of a cathode. Ex. 1010 ¶ 85. And yet, Dr. Gido fails to discuss the density of a cathode (or the "cathode active material composition") including Kim's "composite cathode active material." Instead, Dr. Gido incorrectly assumes, without explanation, that the densities

provided in Kim for the “composite cathode active material” would be the same as “a cathode layer density.” Ex. 1010 ¶ 218 (*citing* Ex. 1009 ¶ [0036]). But, as established, Kim’s densities are fundamentally different from a cathode layer density, and therefore cannot be compared to Ishigaki’s densities.

107. Third, Kim does not disclose a two-layer structure at all, much less a two-layer structure having a *total* compaction density of greater than 3.2 g/cc.

108. Instead, as acknowledged by Dr. Gido, Kim discloses a composite cathode active material that is used in a single-layer structure. Ex. 1010 ¶ 65. For example, Kim teaches that “a mixture of at least two cathode active materials with different particle diameters or a cathode active material with 2 or more peaks in particle size distribution may be used to improve filling density of the cathode active material.” Ex. 1009 ¶ [0006]. Kim also teaches that “the use of at least two cathode active materials having different particle diameters may impede thermal stability of the lithium battery due to the smaller particle-diameter cathode active material that has a relatively low thermal stability and a large specific surface area cathode active material.” *Id.* To that end, Kim describes “a composite cathode active material with high energy density and improved thermal stability.” *Id.* ¶ [0008]. As described by Kim, “the composite cathode active material, a conducting agent, a binder, and a solvent are mixed to prepare the cathode active material composition,” which “may

be directly coated on a metallic current collector to prepare a cathode plate.” *Id.* ¶ [0040].

109. Thus, even if a POSITA were to consider the press densities of Kim to be compatible with the densities of Ishigaki, which they are not, Kim’s press densities are only relevant to a structure that is formed from mixing together two different active materials having two different sizes, and that is intended for use as a single-layer cathode, as Dr. Gido acknowledges. Ex. 1009 ¶ [0006]; Ex. 1010 ¶ 65 (“Kim’s electrode structure is described in terms of a single active material layer.”).

110. Dr. Gido asserts that Ishigaki “teaches a POSA to pack the electrode active material ‘as densely as possible’ in order to maximize the energy capacity of the battery,” and that “it would be well known to a POSA” to maximize the amount of active material in an electrode in order to maximize cell capacity. Ex. 1010 ¶ 214; *see also id.* ¶ 227.

111. However, a POSITA would have understood that the composition of the active material, the thickness of the electrode, the porosity of the active layer, the relative amounts of binder and carbon black in the active layer, the electrolyte, and the negative electrode, among other factors, also contribute to the performance of a battery and a battery designer must consider each of these factors in order to maintain satisfactory performance. Thus, the idea of maximizing cell capacity by

merely maximizing the amount of active material in the electrode is an oversimplification and is not instructive to a battery designer. Further, a POSITA would have understood that increasing compaction density too much reduces space for ion movement, and that applying greater compressive forces during the calendaring process in pursuit of higher compaction density leads to undesirable cracking and fracturing of the particles. Ex. 2040. It is therefore not true that a POSITA would always seek higher compaction density above all else.

112. Kim explains that the composite cathode active material of Kim, which is used in a single layer, includes “at least one large-diameter active material” and “at least one small-diameter active material” and “the inclusion of the large-diameter active material and the small-diameter active material in a specific particle diameter ratio and in a specific weight ratio may improve volume density, and thus leading to further increased electrical capacity of a lithium battery.” Ex. 1009 ¶ [0035]. Therefore, Kim’s statement that “volume density of the composite cathode active material may be too small to obtain a high electrical capacity when the press density of the composite cathode active material is less than 3.31 g/cm^3 ” is only applicable to the specific mixture of two different cathode active materials as discussed in Kim, and not to cathode active materials in general (which would have smaller densities in usable cathode compositions). Indeed, a POSITA would have understood that the

active material composition limits the theoretical maximum compaction density, and the active material particle size limits the porosity (e.g., smaller particles can fit in the gaps or interstitial spaces between the larger particles, thus decreasing the porosity and increasing possible compaction density). Kim's densities, which are specific to Kim's composite of two different cathode active materials, would not have been applicable to Ishigaki's two-layer cathode structure that is formed by separately depositing two different active materials (active material 1 and active material 3) such that they form two layers.

113. Additionally, even if each individual layer in Ishigaki's two-layer cathode structure could be found to be compatible with Kim's composite active material, which they are not, a POSITA would not assume that the compaction of a layer in a single-layer electrode structure (e.g., including Kim's composite cathode active material) is the same as a two-layer electrode structure, such that the compaction density of the layer in the single-layer electrode structure could be directly applied to the two-layer electrode structure. That is, the POSITA would understand that manufacturing complexities unique to making two-layer electrode structures would make such two-layer electrode structures distinct from one-layer electrode structures and therefore lead to differences in compaction densities between the one- and two-layer electrode structures even when such electrode

structures use the same solid constituents. Indeed, Ishigaki itself teaches that the compaction density of an active material layer in a single-layer cathode structure will not be the same as when applied to a two-layer cathode structure. Ex. 1004 ¶¶ [0349] (Ishigaki providing a density of 2.6 g/cm^3 for active material 1 in a single-layer cathode structure); [0363] (Ishigaki providing a density of 2.6 g/cm^3 for active material 3 in a single-layer cathode structure); [0366] (Ishigaki providing a total density of 2.4 g/cm^3 for a two-layer cathode structure including active material 1 in the first layer and active material 3 in the second layer).

114. As discussed above, Ishigaki's only two-layer cathode structure is Example 2, which Ishigaki describes as including active material 1 "[a]s the active material of the positive electrode for the first layer," and active material 3 "[a]s the active material of the positive electrode for the second layer." Ex. 1004 ¶ [0366]. Ishigaki reports the density of active material 1 in the single-layer cathode structure of Example 1 as being 2.6 g/cm^3 , and reports the density of active material 3 in the single-layer cathode structure of Comparative Example 2 as also being 2.6 g/cm^3 . Ex. 1004 ¶¶ [0349], [0363].

115. While Ishigaki does not provide individual compaction densities for the first and second active materials within the two-layer cathode structure of Example 2, Ishigaki explains that "the slurry 1 [including active material 1] was applied and

dried on one side of aluminum foil” then “the slurry 2 [including active material 3] was applied to one side of the substrate using a doctor blade and dried,” and then “[t]his coating film was made into a test positive electrode using a roll press,” such that the total density was 2.4 g/cm^3 . *Id.* Thus, when compacted together in the two-layer cathode structure, the total density of active material 1 and active material 3 is less than 2.6 g/cm^3 , the density of active material 1 and active material 3 within their respective single-layer cathode structures. In order for the total compaction density to be lower in the two-layer cathode structure than the single-layer cathode structure, at least one of active material 1 or active material 3 must have a lower compaction density in the two-layer cathode structure than in the single-layer cathode structure. Again, Ishigaki’s lack of disclosure regarding the individual compaction density of the first and second layers within the two-layer structure prevents a POSITA from knowing which (if not both) of the first active material or the second active material has a lower compaction density within the two-layer cathode structure, but the POSITA would reasonable conclude that both layers will have different compaction densities in the two-layer cathode structure of Example 2 than when applied to the single-layer cathode structures of Example 1 and Comparative Example 2 due, in part, to the differences in wetting effects (i.e., due to the second layer re-wetting the

first layer and causing the two layers to mix and create a mixture region that behaves differently from the individual layers).

116. Moreover, adding a second layer into the single-layer cathode structure of Kim (e.g., to form a two-layer cathode structure as Ishigaki allegedly attempts to do) would necessarily require modifying other parameters of the battery, such as how thick to make each individual layer of the two-layer cathode structure, how viscous to make each individual slurry from which the individual layers are formed, how to independently determine the best porosity and compositions of each individual layer, and how to make the cathode easily manufacturable and economical (i.e., a battery designer cannot simply pick an arbitrary density or any other material properties like candy bars from a vending machine). Thus, contrary to Dr. Gido's assertion, the press densities of Kim's composite cathode active material are not "compatible with the teachings of Ishigaki," and would not have been applicable to structures other than those described in Kim. *See* Ex. 1010 ¶ 211.

117. Fourth, Kim and Ishigaki are directed to different cathode materials, and the densities provided in Kim are specific to the composite cathode active materials described in Kim. In other words, the densities provided in Kim were tailored to address the problems of Kim and would not have been applicable to other cathode materials.

118. The composite cathode active material of Kim, which is used in a single layer, includes “at least one large-diameter active material” and “at least one small-diameter active material” and “the inclusion of the large-diameter active material and the small-diameter active material in a specific particle diameter ratio and in a specific weight ratio may improve volume density, and thus leading to further increased electrical capacity of a lithium battery.” Ex. 1009 ¶ [0035].

119. As discussed above, Kim states that the “volume density of the composite cathode active material may be too small to obtain a high electrical capacity when the press density of the composite cathode active material is less than 3.31 g/cm³.” Ex. 1009 ¶ [0036]. Thus, according to Kim, the value of the volume density necessarily depends on the value of the press density. *Id.* If volume density is indeed distinct from press density, a POSITA would reasonably consider volume density to refer to the porosity of the materials. The total density ρ of a one-component bulk powder at any stage of compaction depends on the porosity as follows:

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

where porosity ϵ is the volume fraction of void or pores in the material and ρ_{max} is the theoretical maximum compaction density. Taking ρ to be Kim’s press density, and ϵ to be Kim’s volume density, the value of the press density would necessarily

depend on the value of the volume density and vice versa, consistent with Kim's statement regarding the relationship between the volume and press densities. Ex. 1009 ¶ [0036].

120. Kim describes that the volume density of the composite cathode active material "may exceed a conventional density range." Ex. 1009 ¶ [0036]. Kim also describes that "conventional cathode active materials," as used in Kim, refers to any cathode active material that "has at least one different technical feature, for example, in terms of composition, particle diameter, and the like, in comparison with the composite cathode active material." *Id.* ¶ [0042]. Therefore, according to Kim, the purported volume densities, and thus the purported press densities, are only applicable to Kim's composite cathode active material and any changes in composition and/or particle diameter relative to Kim's composite cathode active material will necessarily result in changes to the associated volume/press density. *Id.* ¶¶ [0036], [0042].

121. Kim and Ishigaki are directed to substantially different cathode active materials. Ex. 1009 ¶¶ [0070]-[0090] (providing formulas for Examples 1-10 and Comparative Examples 1-8 of Kim); Ex. 1004 ¶¶ [0346], [0355], [0360], and [0366] (providing formulas for Examples 1-2 and Comparative Examples 1-2 of Ishigaki). A POSITA would understand that even subtle differences in the composition and/or

particle size of the active material are consequential. That is, a POSITA would understand that one cannot randomly and heedlessly swap out one active material for another as Dr. Guido is tacitly suggesting. *See* Ex. 1010 ¶¶ 211-212 (Dr. Guido suggesting that Kim's compaction densities are "compatible with the teachings of Ishigaki" and therefore "there is no need to modify Ishigaki"). Indeed, Kim itself teaches that small changes in active material leads to big changes in electrode performance. Ex. 1009 ¶ [0095] (Table 1).

122. Moreover, as discussed with respect to Ground 1, the '118 Patent clearly establishes that the claimed density range in independent claims 1, 10, and 19 are critical to providing the advantages of the '118 Patent's invention. For example, the '118 Patent explains that its specific electrode compaction densities, including a compaction density value greater than 3.2 g/cc for all active material layers, is required to ensure the energy density of a lithium-ion battery. Ex. 1001, 6:20-27 ("To ensure the energy density of a lithium-ion battery, ***it is required*** that ... ***the compaction density of the all active material layers is greater than 3.2 g/cc.***") (emphasis added).

123. However, like Ishigaki, Kim never mentions such criticality of the claimed compaction density value ranges, nor the advantages of the '118 Patent that such specific compaction density value ranges provide. Rather, if anything, Kim

teaches that, for the particular *composite* cathode active material described in Kim, a press density less than 3.31 g/cc results in a small volume density. Ex. 1009 ¶ [0036] (“volume density of the *composite* cathode active material may be too small to obtain a high electrical capacity when the press density of the *composite* cathode active material is less than 3.31 g/cm³.”).

124. Therefore, Kim’s density values for a composite cathode active material of a single-layer cathode structure are not compatible with Ishigaki’s density values for a two-layer cathode structure, and, consequently, Kim would not motivate a POSITA to pursue compaction densities towards higher values in the range taught by Ishigaki.

2. Petitioner Fails to Show That a POSITA Would have Combined Ishigaki and Kim

125. A POSITA would not have been motivated to combine Ishigaki with Kim as alleged by Dr. Gido. Ex. 1010 ¶¶ 214, 219.

126. First, there is no motivation to combine Kim with Ishigaki because, as described above, Kim and Ishigaki are directed to substantially different active material mixtures and substantially different cathode structures. Ex. 1004 ¶ [0366]; Ex. 1009 ¶¶ [0070], [0079]-[0080]. A POSITA starting with Ishigaki’s two-layer cathode structure would have no reason to look to Kim’s teachings regarding a *composite* cathode active material in a *single-layer* cathode structure. Kim describes

mixing two active materials in a single-layer cathode structure, which would add additional (and significant) complexity to the already complex two-layer structure of Ishigaki, and a POSITA cannot simply cherry-pick Kim's density and use it with Ishigaki. *See* Ex. 1009 ¶ [0006].

127. Second, Kim is not concerned with preventing short circuits due to recesses. Instead, Kim aims to maximize energy density by mixing two different active materials into an otherwise homogenous positive electrode, such that there is only a single layer. Ex. 1009 ¶ [0006]. Thus, Kim's teachings on press densities are not beneficial or applicable to Ishigaki because such teachings rely on the unique microstructures and electrochemical interactions that are only achievable by combining two different active materials.

128. Thus, the density ranges purported in Kim for a composite cathode active material used in a single-layer cathode structure are not compatible with the density ranges purported in Ishigaki for a two-layer cathode structure, and Petitioner/Dr. Guido have not explained why a POSITA would have cherry-picked a density for a composite cathode active material in Kim's single-layer cathode structure and used it with Ishigaki's "conventional" cathode active material in a two-layer cathode structure. Therefore, a POSITA would not be motivated to combine Kim with Ishigaki.

3. The '118 Patent's Claimed Density Ranges are Critical

129. Moreover, even if one were to assume that Dr. Gido's flawed assumptions regarding the densities of Ishigaki are reasonable and justified, and that Ishigaki discloses a range of compaction density values that fall within or overlap the claimed ranges of independent claims 1, 10, and 19, it is my opinion that the '118 Patent establishes that the claimed density range in independent claims 1, 10, and 19 are critical to providing the advantages that the '118 Patent's invention provides, whereas Ishigaki does not.

130. The '118 Patent describes a two-layer electrode structure that improves safety by avoiding internal short circuits of the lithium-ion battery caused by external forces puncturing the battery. *Id.*, 1:45-49. The first layer, closest to the current collector, comprises smaller particles to promote adhesion, but it also tends to have lower compaction density, and consequently a lower capacity of the electrode and hence the energy density of the cell. *Id.*, 3:50-63; 4:55-67; 5:14-18. Therefore, the '118 Patent teaches the use of a second layer that has larger particles and higher compaction density, leading to higher overall energy storage in the cell. *Id.*, 6:4-12; 6:20-27. The '118 Patent states:

To ensure the energy density of a lithium-ion battery, ***it is required*** that the positive electrode has a higher compaction density, the compaction density of the first active material layer is greater than 2.8 g/cc, the

compaction density of the second active material layer is greater than 3.3 g/cc and *the compaction density of the all active material layers is greater than 3.2 g/cc.*”

Ex. 1001, 6:20-27 (emphasis added).

131. Thus, the '118 Patent explains that its specific electrode compaction densities, including a compaction density value greater than 3.2 g/cc for all active material layers in the two-layer electrode structure, is required to ensure the desired energy density of a lithium-ion battery. *Id.*

132. Ishigaki never mentions such criticality of a compaction density value greater than 3.2 g/cc for all active material layers of a two-layer electrode structure, nor the advantages of the '118 Patent that a compaction density greater than 3.2 g/cc for all active material layers provides. Indeed, Dr. Guido never explains that the POSITA would have known of the unexpected benefits discovered by the inventors of the '118 Patent.

133. Moreover, Ishigaki is similarly silent about the criticality of the total compaction density for two-layer electrode structures. For example, the densities for the single-layer cathodes structure and the two-layer cathode structure in Ishigaki's examples are in the narrow range of 2.4-2.6 g/cm³, where the single-layer cathode structures have densities at the upper limit of that range (e.g., 2.6 g/cm³) and the two-layer cathode structure has a density at the lower limit of that range (e.g., 2.4 g/cm³).

Ex. 1004 ¶¶ [0348]-[0349], [0356]-[0357], [0361]-[0363], [0366]. None of the cathode structures described in Ishigaki have a density greater than 2.6 g/cm³ and the only example with multiple layers (Example 2) has a density of only 2.4 g/cm³, the lowest density among all of the examples in Ishigaki. *Id.*

134. The only direct comparison of all four of Ishigaki's cathode structures, which is also Ishigaki's only comparison of a single-layer cathode structure to a two-layer cathode structure, comes in the form of a short circuit test. *Id.* ¶¶ [0376], [0382]-[0383]. This short circuit test showed no distinction in the performance of Example 1 (a single-layer cathode structure) and Example 2 (a two-layer cathode structure). *Id.* ¶ [0382] (Table 6). Rather, the short circuit test showed a distinction in performance between the single-layer cathode structures, all having the same density. *Id.* That is, Comparative Examples 1 and 2 both failed the short circuit test, while Example 1 and Example 2 both passed the short circuit test indicating to the POSITA that single-layer versus two-layer was not critical in determining passage of the test, and also indicating to the POSITA that a density of 2.4 or 2.6 g/cm³ (for either structure) was sufficient to meet Ishigaki's objectives.

135. As illustrated in Tables 2 and 3 of Ishigaki (reproduced below), these four electrodes were prepared to have differing levels of recesses in the surfaces of their current collectors.

[0378]

[Table 2]

Table 2 Depression ratio of current collecting foil

	$\Delta L/L$
Example 1	0%
Example 2	0%
Comparative Example 1	6%
Comparative Example 2	81%

[0379]

[Table 3]

Table 3 Average depth of depressions in current collecting foil

	Average depth
Example 1	0.02 μm
Example 2	0.12 μm
Comparative Example 1	0.54 μm
Comparative Example 2	1.75 μm

Ex. 1004 ¶¶ [0378]-[0379].

Thus, Ishigaki attributes the success of Example 1 and Example 2 in the short circuit test to their “current collector surface structure,” not to their density. Ex. 1004 ¶ [0383].

136. Other than the short circuit test, Ishigaki compared battery characteristics between the single-layer cathode structures, the results of which are illustrated in Table 4 (reproduced below).

[0380]

[Table 4]

Table 4 Battery characteristics per active material weight

	Capacity [Ah]	25°C output [W]	-30°C output [W]
Example 1	1.32	119	6.9
Comparative Example 1	1.30	63	3.8
Comparative Example 2	1.28	118	5.6

Ex. 1004 ¶ [0380].

137. As shown in Table 4 and despite Example 1 having substantially the same density as Comparative Examples 1 and 2, Example 1 has an output at 25°C that is equal to or higher than Comparative Examples 1 and 2 in a cylindrical battery of the same capacity, and the output at −30°C is higher in Example 1 than in Comparative Examples 1 and 2. *Id.* Ishigaki attributes the improved performance of Example 1 relative to Comparative Examples 1 and 2 to Example 1 having “a smaller ratio of recessed portions.” *Id.* ¶ [0383].

138. Thus, Ishigaki’s experiments serve to illustrate how the amount of recesses impact the performance of cathodes, and do not illustrate how cathode compaction density impacts performance. This is consistent with the focus of Ishigaki: to solve problems that result from recesses in the surface of the current collector. Ishigaki’s focus on solving problems related to recesses is made readily apparent by Ishigaki’s claims. Ex. 1004 Claim 1 (“a total length of the recessed portions of the parallel line is ΔL , and a ratio of the recessed portions per unit length

is $\Delta L/L$, where $\Delta L/L$ is 5% or less.”); ¶ [0152] (“by controlling the shape between the mixture and the current collecting foil to have few recesses as specified in the claims of the present application, it is expected the electrode plate of the present invention achieves high safety by generating resistance at the interface between the mixture layer and the current collecting foil.”).

139. The '118 Patent is directed to a completely different problem than Ishigaki (avoiding direct contact between the negative electrode active material layer and the positive electrode current collector due to puncturing) and the claimed density ranges are critical to the solution. Ex. 1001, 3:21-30. Because Ishigaki's disclosure is directed to a completely different problem (too many recesses), Ishigaki's disclosure wouldn't lead a POSITA to the '118 Patent's critical range of density values for a two-layer electrode structure and certainly does not address the criticality of doing so.

140. Thus, it is my opinion that Ishigaki and Kim fail to render obvious at least a two-layer electrode with a compaction density of at least 3.2 g/cc.

C. Ground 3: Wang and Saka do not render obvious claims 1-20

141. It is my understanding that in Ground 3, Petitioner asserts and Dr. Gido opines that Wang and Saka render obvious Claims 1-20 of the '118 Patent. Pet., 35-59; Ex. 1010 ¶¶ 250-401. I disagree. Wang discusses electrodes defining a gradient

of particle sizes or porosity values. Neither Wang nor Saka provides any indication that a POSITA would look to Saka's compaction density values for implementing with Wang's disclosure, instead of simply optimizing the porosity values discussed in Wang—a characteristic that is inversely related with compaction density.

1. Petitioner Fails to Show why a POSITA would have had a “desired density in mind” that is greater than 3.2 g/cc when implementing Wang

142. Wang discloses a gradient, multi-layer cathode with different porosity levels in each layer. Ex. 1005, *Abstract*. Because Wang focuses on implementing specific porosity targets in each layer (*id.* ¶ [0056]), a POSITA would not need to have a “desired density in mind,” because the density values would be redundant characteristics of the cathode. Wang recognizes this, stating that in certain embodiments “at least one of the first porous layer 210 and the second porous layer 220 is exposed to a compression process such as a calendaring process to increase the density of and decrease the porosity of the first porous layer 210 and/or the second porous layer 220.” *Id.* ¶ [0058].

143. Wang's disclosed “compression steps” are described so that the resulting cathode structure satisfies the target porosity values for each cathode layer. *Id.* ¶¶ [0058], [0067], [0073], [0092]. A POSITA reviewing Wang would have understood that these *optional* compression steps are described for two reasons—

neither of which is to “increase the energy density of the cathode.” Ex. 1010 ¶ 255. First, Wang is not limited to a specific cathode deposition method. Wang explains that the cathode active material is deposited on a current collector using “particle application techniques including but not limited to sifting techniques, electrostatic spraying techniques, thermal or flame spraying techniques, fluidized bed coating techniques, roll coating techniques, slit coating, and combinations thereof.” *Id.* ¶¶ [0061]-[0066]. Each of these cathode deposition techniques have some limitations in the achievable porosity values. The subsequent compression process is then used, if needed, to ensure that the deposited cathode material reaches the desired porosity values disclosed in Wang. *Id.* ¶ [0058] (“at least one of the first porous layer 210 and the second porous layer 220 is exposed to a compression process such as a calendaring process to increase the density of and decrease the porosity of the first porous layer 210 and/or the second porous layer 220”); *see also id.* ¶ [0124] (“the compression process may be used to modify the porosity of the as-deposited cathodically active particles to a desired net-density”). For the first layer, those porosity values are between 40%-70%. *Id.* ¶ [0056].

144. Second, the compression steps are used to achieve Wang’s gradient in porosity between multiple layers. *Id.* ¶ [0079] (“as initially deposited, the porosity of the first porous layer 410 and second porous layers 420 a and 420 b are

substantially identical, however, after exposing the second porous layers to the optional compression process described in block 350, the porosity of second porous layers 420 a, 420 b is reduced relative to the porosity of the first porous layer 410”). A POSITA would determine that the same cathode deposition method is used for each of Wang’s cathode layers because Wang does not explain that each layer is deposited using a different method and because Wang states that each layer initially has the same porosity. *Id.* Without separate compression step(s), the resulting cathode layer porosities would be substantially identical according to Wang—as a natural consequence of the porosity values achievable by the deposition method used. *Id.* (“the porosity of the first porous layer 410 and second porous layers 420a and 420b are substantially identical, however, after exposing the second porous layers to the optional compression process described in block 350, the porosity of second porous layers 420a, 420b is reduced relative to the porosity of the first porous layer 410”).¹² Wang explains that a compression step is used after deposition of the

¹² A POSITA would understand that Wang’s layers would be subject to re-wetting and/or other layer-mixing effects not considered by Wang, and achieving multiple layers with “substantially identical” porosity would depend on the layer application method used.

second cathode layer to achieve the desired lower porosity values in the second porous layer (e.g., between 20% and 40% porosity) as compared with the first porous layer (having porosity values between 40%-70%). *Id.* ¶ [0056].

145. Since Wang focuses on achieving porosity targets by using compression steps, Petitioner and Dr. Gido are correct that Wang “does not teach what the desired net density actually is.” Ex. 1010 ¶ 255. However, Dr. Gido misconstrues Wang’s disclosure when stating that Wang “does not explicitly provide the reason a particular net density is more desirable than another.” Ex. 1010 ¶ 276. In fact, Wang provides clear reasoning for porosity targets and by extension, density targets, even if some teachings of Wang are less reliable as described above.

146. Wang states that the cathode composition gradient allows batteries to incorporate thicker cathodes with increased capacity for active materials. Ex. 1005 ¶ [0035]. Specifically, providing a “graded porosity provides for a higher porosity adjacent to the current collector and a lower porosity as the distance from the current collector increases. The higher porosity adjacent to the current collector increases the active surface area of the electrode providing for higher power performance but yielding a lower voltage electrode whereas the lower porosity provides for a higher voltage electrode with slower power performance.” *Id.* ¶ [0036]. Wang therefore teaches that, when the layer adjacent to the current collector is provided with a higher

porosity to achieve higher power performance, layers further way from the current collector are provided with a lower porosity to increase the voltage of the electrode.

Id.

147. Although Wang describes that providing a gradient in which the porosity decreases with subsequent layers “achieve[s] higher power performance,” (*id*) Wang teaches that, for thick electrodes, instead providing the porosity gradient is superior to having uniform porosity. *Id.* ¶¶ [0129]-[0130]. That is, Figures 12A and 12B of Wang illustrate “a 12% improvement in specific energy for a 200 micron thick electrode having graded porosity [in which the porosity of the layer adjacent to the current collector is lower than the porosity of the layer further away from the current collector] in comparison with a 200 micron electrode having uniform porosity.” *Id.* ¶ [0130]. Thus, Wang at least provides reasoning for the disparate porosity targets described in Wang.

148. Of note, my own scientific work, and that of others, arrives at the same teaching as Wang’s later analysis, namely that higher porosity should be employed closer to the separator rather than the current collector in order to maximize ionic transport where it is most needed and thereby allow thicker and higher-energy electrodes. Ex. 2029 and references therein.

149. Given that Dr. Gido overlooks Wang’s explicit reasoning for selecting high porosity values (and consequently, low density values) where there are clear engineering purposes to do so, such as near the current collector, his suggestion that “common sense dictates choosing the highest compaction density that is workable for a given application” (Ex. 1010 ¶ 281) is unsupported and is inconsistent with Wang’s actual teachings.

150. Even more generally, Dr. Gido’s reference to “common sense” dictating a high compaction density, or his suggestion that “a POSA knows that the reason for achieving [Wang’s] ‘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” (*Id.* ¶ 255) is not consistent with the actual knowledge of a POSITA. A POSITA would have understood that there are many reasons for choosing different compaction density values, including reasons why a lower density would be desirable. As an example, in the limit of maximum density, a POSITA would understand that the porosity is necessarily zero, which will lead to zero cell capacity because there is no pathway for ions to travel. Therefore, there is an optimum porosity that would lead to a desired balance between cell energy capacity and the rate at which that capacity must be accessed for a particular application, i.e. cell power. This optimization principle was introduced *supra* in Section IV.B and is

well-established in the battery field. Exs. 2029 and 2017. As another example, Wang describes increasing battery capacity by increasing the *thickness* of electrodes, in part by using a lower density near a current collector and informed by a computer-based optimization procedure. Ex. 1005 ¶¶ [0035], [0128]-[0129]. As yet another example, the '118 Patent explains that using a lower density near the current collector increases the safety of the battery so that it “does not generate a short circuit when pressed by an external force, thereby ensuring the mechanical safety performance of the lithium-ion battery. Ex. 1001, 2:37-43. While the '118 Patent discloses an unexpected combination of design choices leading to beneficial effects, a POSITA nevertheless would have known at the time of Wang’s disclosures the general principle that a battery designer cannot maximize in isolation a desired performance trait such as cell capacity, without tradeoffs with other performance traits and therefore must consider all traits simultaneously.

151. In short, even if a POSITA reviewing Wang had a “desired density in mind,” that density would be driven by Wang’s porosity values, active material selection, particle size selection, binder selection, conductor selection, and other characteristics of the specific cathode materials described in Wang and would not have been driven to select a density for Wang’s cathodes using Dr. Gido’s inaccurate

suggestion that a POSITA “would be motivated to look to another reference, *such as Saka*, for numerical values of a desired cathode density.” Ex. 1010 ¶ 255.

152. Wang discloses a list of available active materials that can be used in a cathode structure constructed according to Wang’s disclosure. Ex. 1005 ¶ [0043]. Each of these active materials has a different theoretical maximum density value (calculated as the density of the material, *without any included pores*). Additionally, Wang states that each cathode layer comprises additives, including conductive additives and binding agents. Ex. 1005 ¶¶ [0052]-[0053]. These additives have density values lower than any of the disclosed active materials. As an illustrative example, the crystalline density of LCO active material is about 5.1 g/cm³, while the crystalline densities of carbon black conductive additive and PVDF binder additive are about 1.8-2.1 g/cm³ and 1.7-1.8 g/cm³, respectively.¹³ Ex. 2034¹⁴ (identifying

¹³ I note that the respective density values for carbon black and PVDF may vary, depending on the manufacturer, but such variation would not cause these densities to exceed that of LCO.

¹⁴ Ex. 2034 (*Lithium-ion Battery Design: Effects of Optimal Compaction Density*, <https://www.neware.net/news/lithium-ion-battery-design-effects-of-optimal-compaction-density/230/83.html> (last visited on May 23, 2025)).

true density and compacted powder density of LCO as 5.1 g/cm^3 and $4.1\text{--}4.3 \text{ g/cm}^3$, respectively), Ex. 2035¹⁵ (“According to the rule of mixture, the volume fraction of pores was estimated to be 60%, given the actual density of the LiCoO_2 – 1 wt% SACNT at 1.94 g cm^{-3} , and the theoretical specific densities of LiCoO_2 and SACNT at 5.1 g cm^{-3} and 1.2 g cm^{-3} , respectively”), Ex. 2036¹⁶ (identifying theoretical density of LCO as 5.1 g/cm^3), Ex. 2037¹⁷ (identifying theoretical density of LCO as $\sim 5.053 \text{ g/cm}^3$), Ex. 2038¹⁸ (identifying density of carbon black as 1.8 to 2.1 g/cm^3),

¹⁵ Ex. 2035 (Shu Lu, et al., *Binder-Free LiCoO_2 /Carbon Nanotube Cathodes for High-Performance Lithium Ion Batteries*, 24 Adv. Mater. 2294(2012)).

¹⁶ Ex. 2036 (Lei-Lei Lu, et al., *Wood-Inspired High-Performance Ultrathick Bulk Battery Electrodes*, Adv. Mater. 1706745 (2018)).

¹⁷ Ex. 2037 (Yasuhiko Takahashi, et al., *Structure and electron density analysis of electrochemically and chemically delithiated LiCoO_2 single crystals*, 180 J. Solid State Chem. 313 (2007) , <https://doi.org/10.1016/j.jssc.2006.10.018>).

¹⁸ Ex. 2038 (*Carbon Black*, <https://pubchem.ncbi.nlm.nih.gov/compound/carbon%20black>, (last visited on May 23, 2025)).

Ex. 2039¹⁹ (identifying the density of carbon black as 1.98 g/cm³ and the density of PVDF as 1.80 g/cm³).

153. Thus, these additives will lower the overall maximum density of the cathode structures disclosed in Wang—and consequently the maximum possible density that a POSITA could “have in mind” when implementing Wang. Neither Petitioner nor Dr. Gido discusses theoretical densities for the active layers of Wang, nor whether a density of 3.2 g/cc would be achievable in a cathode including Wang’s active materials and additives in the relative proportions disclosed in Wang.

154. As mentioned above, Wang focuses on specific porosity values for cathodes that enable use of thicker cathode structures. Ex. 1005 ¶ [0035]. Wang explains that the porosity values for a given cathode layer range between 20%-70%, depending on the chosen embodiment. *Id.* ¶ [0056]. These porosity values are “compared to a solid film formed from the same material.” *Id.* Porosity trades off with electrode density as described above in paragraph 130, so that compression processes to increase the density of a layer necessarily decrease the porosity of the

¹⁹ Ex. 2039 (Sankar Mandal, et al., *The Role of Carbon Black in LiMn₂O₄-Based Composites as Cathodes for Rechargeable Lithium Batteries*. 148 J. Electrochem. Soc. A24 (2001)).

layer. *Id.* ¶ [0058]. As an example, a cathode layer with 20% porosity means that 20% of the volume of the cathode layer is empty void space and by extension, only 80% of the volume of the layer is solids (including the active material, conductive additive, binder, and any other additives). Put another way, a cathode layer having a 20% porosity would have a density value that is 20% *lower* than the theoretical maximum density for the solids included in that layer (ignoring the negligible density of air in the void spaces).

155. Again, neither Petitioner nor Dr. Gido discuss Wang's porosity limitations and how those porosity values impact the maximum possible density values that a POSITA could "have in mind" when implementing the disclosure of Wang. Wang states:

In certain embodiments, the cathode electrodes have a graded porosity such that the porosity varies throughout the structure of the cathode electrode. In certain embodiments, the graded porosity provides for a higher porosity adjacent to the current collector and a lower porosity as the distance from the current collector increases. The higher porosity adjacent to the current collector increases the active surface area of the electrode providing for higher power performance but yielding a lower voltage electrode whereas the lower porosity provides for a higher voltage electrode with slower power performance. In certain embodiments, the graded porosity provides for a lower porosity

adjacent to the current collector and a higher porosity as the distance from the current collector increases.

Ex. 1005 ¶ [0036].

156. Therefore, Dr. Gido's analysis falls short of explaining how a POSITA would have achieved a density value greater than 3.2 g/cc based on Wang's disclosure. In fact, it is my opinion that Dr. Gido could not reach such a conclusion because Dr. Gido does not explain the densities of the active materials discussed in Wang; does not explain the densities of the additives discussed in Wang; and does not explain the maximum densities achievable by a cathode including Wang's active materials and additives, while staying within Wang's desired porosity ranges.

2. Petitioner Fails to Show that a POSITA Would have Combined Wang with Saka

157. In my opinion, a POSITA would not have been motivated to combine Wang and Saka, specifically to cherry-pick Saka's density ranges for use with Wang's cathode structure. Dr. Gido's suggestion to modify Wang based on Saka's disclosure amounts to a mere suggestion that Wang's cathode composition would necessarily have *some* compaction density value. *See* Ex. 1010 ¶ 276 (Wang "teaches the method one would use to achieve any such density"). Neither Petitioner nor Dr. Gido have explained why Saka's density range is relevant to Wang's disclosed porosity values, and specifically why density values greater than 3.2 g/cc

for a two-layer cathode structure would have been relevant for Wang's cathode structure. A POSITA would have recognized that the differences between Wang and Saka's respective cathode compositions would necessitate differences in compaction density between these structures.

158. As discussed above, Wang discloses a list of possible cathode active materials and additive materials, and a range of possible porosity values for cathode structures. Ex. 1005 ¶¶ [0051], [0056]-[0057]. Wang also discloses a range of possible particle sizes for the cathode active material. *Id.* ¶¶ [0081]-[0083]. This combination of characteristics would be sufficient for a POSITA to construct a cathode layer for a lithium ion battery—a POSITA would not need to separately consider a compaction density, as the porosity value ranges dictate the possible density values achievable using Wang's cathode manufacturing method. *See Supra* IV.B.

159. Based on Wang's disclosed cathode materials (e.g., active material, conducting material, and binder) and characteristics (e.g., particle size and porosity), Wang's disclosure limits what compaction densities are achievable by the structure disclosed therein. Petitioner and Dr. Guido do not explain what density values are possible for Wang's disclosure. Instead, Petitioner and Dr. Guido ignore the inherent compaction density limitations imposed by Wang's disclosure, in favor of looking

at Saka (which discloses a different cathode structure with different active materials, different particle size distributions, and different additives) for a “desired” density. Ex. 1010 ¶ 276. A POSITA would not look beyond Wang’s own disclosure when selecting a compaction density for a cathode.

160. Saka, on the other hand, discusses a “first” layer containing a *mixture of* active materials, namely lithium iron phosphate (LFP) and lithium nickel cobalt manganese composite oxide (NCM), and a “second” layer containing NCM.²⁰ Ex. 1006 ¶ [0073]. The “second” layer contains only NCM or NCM mixed with a small amount of LFP. *Id.* ¶ [0079]. Collectively, Saka states that both layers of the positive electrode have a density between 2.5 g/cc to 3.5 g/cc. *Id.* ¶ [0051]. However, Saka does not discuss porosity, and therefore a POSITA would not have understood that these density values—particularly the density values above 3.2 g/cc—would be

²⁰ For the sake of clarity, I note that Saka’s naming convention for the “first” and “second” layers are different from what is disclosed in the ’118 patent and in Wang. Saka states that the “second layer 12b is “formed closer to the positive electrode current collector 11 side than the first layer 12a.” Ex. 1006 ¶ [0053]. By contrast, the ’118 patent and Wang both describe the “first” layer being adjacent to the current collector and the “second” layer being farther away from the current collector.

usable with Wang's disclosed cathode porosity values. Neither Petitioner nor Dr. Gido provides any discussion to demonstrate that Saka's density values would have been compatible with Wang's porosity values.

161. Instead, Dr. Gido attempts to show that Saka suggests that high cathode density values—greater than the claimed 3.2 g/cc—would have been desirable for any lithium ion battery. Ex. 1010 ¶ 281 (“common sense dictates choosing the highest compaction density that is workable for a given application”). But Dr. Gido's rationale is based on *a different reference*—Kim—saying “densities less than 3.31 g/cc ‘may be too small to obtain a high electrical capacity.’” *Id.* (citing Ex. 1009 ¶ [0036]). Kim's disclosure is entirely irrelevant as it provides a density of a cathode active material (and *not* a complete cathode) and because it relates to a single-layer, composite cathode structure comprising a mixture of different cathode active materials, whereas Wang discusses a multi-layer cathode structure with defined porosity targets and Saka discusses multi-layer cathode structures with compaction densities of 3.0 g/cc or less. In fact, *all* of Saka's disclosed examples have “mixture density” values of 3.0 g/cc *or less* demonstrating that any reference to Kim is irrelevant. Ex. 1006, FIGS. 7, 8, 10, 11 (corresponding to Tables 1, 2, 4, and 5, respectively, which show the mixture density value for each of Saka's examples). Saka does not appear to explicitly define the term “mixture density” but in

paragraph 301 of his declaration, Dr. Gido contends that this term is the “[a]verage density of both layers.”). Ex. 1010 ¶ 301.

162. Saka describes that superior battery performance was achieved with a density of 2.8 g/cm³, and that its measured battery performance decreased when density values reached 3.0 g/cm³. Ex. 1006 ¶ [0179]. Saka attributes this decrease in performance of the example high-density batteries (having density values of 3.0 g/cm³) to the collapse of pores during pressing, which resulted in “the pore size of the positive electrode mixture layer [being] small.” *Id.* A POSITA reading Saka would therefore expect even more pore collapse and smaller pore sizes (and worse performance) with density values higher than 3.0 g/cm³.

163. While Kim is not helpful to Petitioner for the point it is cited for in Dr. Gido’s declaration,²¹ Kim does demonstrate that density values are inherently composition and application specific. Ex. 1009 ¶ [0006] (“a mixture of at least two cathode active materials with different particle diameters or a cathode active material with 2 or more peaks in particle size distribution may be used to improve filling

²¹ As discussed *supra* in Section VI.B.1 with respect to Ground 2, Kim only discloses densities for the disclosed composite active materials, not the entire active material layer, which Kim discloses as also including a conductive agent and binder.

density of the cathode active material.”). While Kim states that “density values less than 3.31 g/cc” may not achieve desired electrical capacity goals, (Ex. 1009 ¶ [0036]) Saka and Wang suggest that low density values, or high porosity values, (e.g., less than 3.0 g/cc as demonstrated by Saka’s examples or porosity values as high as 70% as discussed in Wang) achieve desired performance characteristics, depending in part on the content of the cathode composition.

164. A POSITA would have understood that compaction densities (and/or porosities) of electrode materials are not based solely on the densities of the contained active materials and additives. A POSITA would also consider other characteristics of the mixture, such as possible interactions between the various materials in an electrode (e.g., between the multiple active materials discussed in Saka), how the various particles “fit” into the interstices of one another (i.e., how a smaller particle fills the space between adjacent larger particles) and whether the resulting mixture leaves sufficient space for lithium ion movement during charging and discharging processes.

165. In short, workable density values are specific to the materials used in a particular electrode, and a POSITA would not have been motivated to look at density values that are described for use with other electrode structures having different material compositions. Dr. Guido does not discuss how or why a POSITA would have

specifically looked at the density values of Saka to modify Wang, particularly given Saka's disclosure of mixtures of different active materials in each cathode layer, whereas Wang discloses active material layers each containing only one type of active material. Instead, Dr. Gido only states that Wang and Saka disclose similar active materials for inclusion in a cathode structure, but fails to explain how a "mixture" of these active materials, as discussed in Saka, is relevant for determining appropriate density values. Ex. 1010 ¶¶ 253-255.

D. Ground 4: Wang and Li do not render obvious claims 1-20

166. It is my understanding that in Ground 4, Petitioner asserts and Dr. Gido opines that Wang and Li render obvious Claims 1-20 of the '118 Patent. Pet., 59-70; Ex. 1010 ¶¶ 402-528. I disagree. Wang discusses electrodes defining a gradient of particle sizes or porosity values. Neither Wang nor Li provides any indication that a POSITA would look to Li's compaction density values for implementing with Wang's disclosure, instead of simply optimizing the porosity values discussed in Wang—a characteristic that is inversely related with compaction density.

1. Petitioner Fails to Show why a POSITA would have had a "desired density in mind" that is greater than 3.2 g/cc when implementing Wang

167. As discussed in reference to Ground 3, Petitioner's argument that a POSITA would have had a "desired density in mind" (Ex. 1010 ¶ 428) that is greater

than 3.2 g/cc when implementing Wang is unsupported by the disclosure of Wang or the knowledge of a POSITA.

168. Wang discloses a gradient, multi-layer cathode with different porosity levels in each layer. Ex. 1005, *Abstract*. Because Wang focuses on implementing specific porosity targets in each layer (*id.* ¶ [0056]), a POSITA would not need to have a “desired density in mind,” because the density values would be redundant characteristics of the cathode. Wang recognizes this, stating that in certain embodiments “at least one of the first porous layer 210 and the second porous layer 220 is exposed to a compression process such as a calendaring process to increase the density of and decrease the porosity of the first porous layer 210 and/or the second porous layer 220.” *Id.* ¶ [0058].

169. Wang’s disclosed “compression steps” are described so that the resulting cathode structure satisfies the target porosity values for each cathode layer. *Id.* ¶¶ [0058], [0067], [0073], [0092]. A POSITA reviewing Wang would have understood that these *optional* compression steps are described for two reasons—neither of which is “to increase the energy density of the cathode”. Ex. 1010 ¶ 407. First, Wang is not limited to a specific cathode deposition method. Wang explains that the cathode active material is deposited on a current collector using “particle application techniques including but not limited to sifting techniques, electrostatic

spraying techniques, thermal or flame spraying techniques, fluidized bed coating techniques, roll coating techniques, slit coating, and combinations thereof.” *Id.* ¶¶ [0061]-[0066]. Each of these cathode deposition techniques have some limitations in the achievable porosity values. The subsequent compression process is then used, if needed, to ensure that the deposited cathode material reaches the desired porosity values disclosed in Wang. For the first layer, those porosity values are between 40%-70%. *Id.* ¶ [0056].

170. Second, as discussed above with respect to Ground 3, the compression steps are used to achieve Wang’s gradient in porosity between multiple layers. *Id.* ¶ [0079]. A POSITA would determine that the same cathode deposition method is used for each of Wang’s cathode layers because Wang does not explain that each layer is deposited using a different method and because Wang states that each layer initially has the same porosity. *Id.* Without separate compression step(s), the resulting cathode layer porosities would be substantially identical according to Wang—as a natural consequence of the porosity values achievable by the deposition method used. *Id.* So, Wang explains that a compression step is used after deposition of the second cathode layer to achieve the desired lower porosity values in the second porous layer (e.g., between 20% and 40% porosity) as compared with the first porous layer (having porosity values between 40%-70%). *Id.* ¶ [0056].

171. Since Wang focuses on achieving porosity targets by using compression steps, Petitioner and Dr. Gido are correct that Wang “does not teach what the desired net density actually is.” Ex. 1010 ¶ 407. However, Dr. Gido misconstrues Wang’s disclosure when stating that Wang “does not explicitly provide the reason a particular net density is more desirable than another.” Ex. 1010 ¶ 428. Instead, Wang provides that the cathode composition gradient allows batteries to incorporate thicker cathodes with increased capacity for active materials. Ex. 1005 ¶ [0035]. Specifically, Wang states that a “graded porosity provides for a higher porosity adjacent to the current collector and a lower porosity as the distance from the current collector increases. The higher porosity adjacent to the current collector increases the active surface area of the electrode providing for higher power performance but yielding a lower voltage electrode whereas the lower porosity provides for a higher voltage electrode with slower power performance.” *Id.* ¶ [0036]. Consequently, Wang is clear that a higher porosity (and by extension, a lower density) is desirable near a cathode current collector, and a lower porosity (i.e., higher density) is desirable farther away from the current collector.

172. Given that Dr. Gido overlooks Wang’s explicit reasoning for selecting high porosity values (and consequently, low density values), such as near the current collector, his suggestion that “common sense dictates choosing the highest

compaction density that is workable for a given application” (Ex. 1010 ¶ 399) is unsupported and is inconsistent with Wang’s actual teachings.

173. Even more generally, Dr. Gido’s suggestion that “a POSA knows that the reason for achieving [Wang’s] ‘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” (*Id.* ¶ 407) is not consistent with the actual knowledge of a POSITA. A POSITA would have understood that there are many reasons for choosing different compaction density values, including reasons why a lower density might be desirable. For example, in the limit of maximum density, a POSITA would understand that the porosity is necessarily zero, which will lead to zero cell capacity because there is no pathway for ions to travel. Therefore, there is an optimum porosity that would lead to a desired balance between cell energy capacity and the rate at which that capacity must be accessed for a particular application, i.e. cell power. As another example Wang focuses on increasing battery capacity by increasing the *thickness* of electrodes, in part by using a lower density near a current collector. Ex. 1005 ¶ [0035]. As yet another example, the ’118 Patent explains that using a lower density near the current collector increases the safety of the battery so that it “does not generate a short circuit when pressed by an external force, thereby ensuring the mechanical safety performance of the lithium-ion battery. Ex. 1001,

2:37-43. While the '118 Patent discloses an unexpected combination of design choices leading to beneficial effects, a POSITA nevertheless would have known at the time of Wang's disclosures that higher density electrodes pose safety concerns, and so it is desirable to design a battery with a lower electrical capacity so that it satisfies heightened safety concerns.

174. In short, even if a POSITA reviewing Wang had a "desired density in mind," that density would be driven by Wang's porosity values, active material selection, particle size selection, binder selection, conductor selection, and other characteristics of the specific cathode materials described in Wang and would not have been driven to select a density for Wang's cathodes using Dr. Gido's inaccurate suggestion that a POSITA "would be motivated to look to another reference, *such as Li*, for numerical values of a desired cathode density." Ex. 1010 ¶ 407.

2. Petitioner Fails to Show that a POSITA Would have Combined Wang and Li

175. Petitioner has failed to demonstrate that a POSITA would have sought to compact Wang's cathode structure to a compaction density greater than 3.2 g/cc based on Li's disclosure.

176. In my opinion, a POSITA would not have been motivated to combine Wang and Li. Petitioner and Dr. Gido's suggestion to modify Wang to use a density value disclosed in Li, which discusses different cathode compositions, is not

supported by the disclosure of the cited references. Ex. 1010 ¶ 406; Pet., 60. Instead, Dr. Gido's suggestion to modify Wang based on Li's disclosure amounts to a mere suggestion that Wang's cathode composition would necessarily have *some* compaction density value. Ex. 1010 ¶ 434 ("Wang states that is method can be used to achieve any desired net density"). Dr. Gido says that "Li discloses numeric values for the compaction densities that work in a battery like Wang's or like the '118 patent." Ex. 1010 ¶ 408. Dr. Gido bases this conclusion on his finding that "Li's battery structure has a similar layer structure, including a cathode with two active layers, made of the same materials as Wang, and provides detailed information for the compaction density of the cathode active material layers." *Id.* ¶ 406. However, those are not the only cathode characteristics that a POSITA would consider when choosing a compaction density target for a cathode. A POSITA would also consider target porosity values, particle size distributions, cathode thicknesses, and other characteristics of a cathode. Li does not discuss these characteristics, except to the extent necessary to describe Li's new geometry of a cathode with thicker regions and thinner regions that assist in folding an electrode structure into a prismatic battery form. Ex. 1003, *Abstract*. This is evident from Li's explanation of examples, which provide enough detail to convey how the invention works (Ex. 1003 ¶ [0038] explaining that a first layer is coated "by continuous coating" and a second layer

“was coated by gap coating with the gap width of the positive electrode being 2 times as much as the battery thickness...”), but not enough detail to *exactly* reproduce the battery described in the examples (e.g., Li does not explain what cathode particle distribution is used). Li also does not describe how the energy density or discharge performance differs from prior electrode designs. Instead, Li only measures the electrode deformation after charging/discharging cycles—a characteristic that is not contemplated in Wang. Ex. 1003 ¶¶ [0049]-[0055].

177. Therefore, Dr. Gido has not shown that Li does, in fact, disclose compaction density values “that work in a battery like Wang’s” because Li does not convey sufficient information to determine whether Li’s examples are analogous to Wang’s cathode structure. Moreover, nothing in Li indicates that the compaction density used in the examples are desirable to be implemented with Wang’s teachings. Therefore, Dr. Gido has not demonstrated a complete consideration of how or why a POSITA would seek to combine these two references. Specifically, neither Petitioner nor Dr. Gido have explained why Li’s density range is relevant to Wang’s disclosed porosity values, and specifically why density values greater than 3.2 g/cc for a two-layer cathode structure would have been relevant for Wang’s cathode structure.

178. As discussed above, Wang discloses a list of possible cathode active materials and additives, and a range of possible porosity values for cathode structures. Ex. 1005 ¶¶ [0051], [0056]-[0057]. Wang also discloses a range of possible particle sizes for the cathode active material. *Id.* ¶¶ [0081]-[0083]. This combination of characteristics would be sufficient for a POSITA to construct a cathode layer for a lithium ion battery—a POSITA would not need to separately consider or optimize a compaction density, as the porosity value ranges dictate the possible density values achievable using Wang’s cathode manufacturing method. *See Supra* IV.B.

179. Based on Wang’s disclosed cathode materials (e.g., active material, conducting material, and binder) and characteristics (e.g., particle size and porosity), Wang’s disclosure limits what compaction densities are achievable by the structure disclosed therein. Petitioner and Dr. Gido do not explain what density values are possible for Wang’s disclosure, other than providing conclusory statements that Li’s density values “work in a battery like Wang’s.” Ex. 1010 ¶ 408; Pet., 61. Dr. Gido never discusses this fact, never discusses if Li’s density ranges would allow the resulting cathode composition to overlap with Wang’s porosity values, and never discusses why a POSITA would look outside of Wang for a density value that is contradictory with Wang’s own teachings. “Desirable” compaction density values

are inherently specific to the active materials and characteristics of each cathode composition. For example, Kim and Saka have contradictory disclosures about what density values are possible and/or desirable for different lithium ion batteries. Ex. 1009 ¶ [0036] (describing that states that “density values less than 3.31 g/cc” for the composite cathode active material of Kim may not achieve desired electrical capacity goals); Ex. 1006, FIGs. 7-8 (showing that Saka’s examples all have density values of 3.0 g/cc or less). Whereas Kim says that density values less than 3.31 g/cc may be “too small” for some performance metrics, Saka discloses dozens of examples of cathode structures with density values at 3.0 g/cc or less that still meet desired performance characteristics. *See Supra*, VI.B.1. Li explains that compaction densities of 3.8 g/cc may be achieved by compaction (Ex. 1003 ¶¶ [0038], [0044]), but Li does not explain what level of porosity is achieved in the cathode after the disclosed compaction. By contrast, Wang explains that porosity values of up to 70% may be desirable, regardless of the density achieved at that porosity value. Ex. 1005 ¶ [0056]. As these references demonstrate, a POSITA would have understood that the compaction density values from one reference cannot be cherry-picked and used in a battery disclosed by a different reference.

180. Li’s focus is on something entirely unrelated to compaction density—or the overall composition of a cathode at all. Consequently, Li does not

comprehensively describe *any* example cathode compositions in sufficient detail to allow a POSITA to fully replicate the examples. Li focuses on electrode layer geometry, specifically creating electrode layers that have relatively thin regions that align with folded corners of an electrode in a prismatic cell. Ex. 1003 ¶ [0038]. Therefore, Li's examples only provide sufficient detail for a POSITA to replicate the described geometry of a cathode. *Id.* Li repeatedly explains that the composition of the cathode is not important to the invention. *Id.* ¶ [0026] (“There are no special requirements for the positive electrode active material.”). Dr. Guido says that Li “provides the specific numeric densities that result from the compaction steps of a process like Wang’s.” Ex. 1010 ¶ 408. However, Li’s examples—including the portions cited by Dr. Guido—provide compaction density values but they do not provide particle size distributions, quantities of solvent used to provide the described positive electrode slurry, nor quantities of electrolyte mixed with the described positive electrode composition. Ex. 1003 ¶¶ [0038], [0044]. In other words, a POSITA would not have been able to replicate Li’s examples based on the provided disclosure, nor could a POSITA determine whether Li’s density values are usable with Wang’s disclosure, as Dr. Guido argues.

181. Dr. Guido downplays Li’s vagaries, stating “Li explains that there are no special requirements for the active material in the layers.” Ex. 1010 ¶ 433. But as

mentioned above, this is taken out of context. Li only discloses how to “gap coat” a second layer to create thin cathode regions for bending a cathode laminate structure into a prismatic cell. Li explains there are no special requirements for this type of coating because Li is only concerned with how to periodically stop/start the second layer coating process to create a desired cathode *geometry*. Ex. 1003 ¶ [0026]. Nevertheless, a POSITA would have understood that Li’s high-density examples (e.g., higher than 3.8 g/cc) would only be possible with certain specific cathode compositions—with certain cathode materials, additives, and particle size distributions—even though Li does not provide sufficient details to reproduce the exact example discussed. Consequently, a POSITA would have understood that Li’s compaction density ranges are not immediately combinable with Wang’s gradient cathode structure. Li does not explain whether the described density values are achievable with compositions having Wang’s disclosed particle distributions, nor does Li describe any benefits of the example high density values (Li does not discuss how the cathode composition would impact cell performance at all; Li only focuses on the geometry created by the disclosed gap coating method). Therefore, Petitioner and Dr. Guido do not base their opinions that a POSITA would have been motivated to combine these two references based on any teachings contained within the references themselves. Dr. Guido generalizes—again without support in the cited

references—that a POSITA would seek to incorporate the higher density values disclosed in Li when implementing Wang.

182. More generally, a POSITA would have understood that compaction densities (and/or porosities) of electrode materials are not optimized based solely on the densities of the contained active materials and additives. A POSITA would also consider other characteristics of the mixture, such as how the various particles “fit” into the interstices of one another (i.e., how do smaller particles fill the spaces between adjacent larger particles), whether the resulting mixture leaves sufficient space for lithium-ion movement during charging and discharging processes. In short, workable density values are specific to the materials used in a particular electrode, and a POSITA would not have been motivated to look at density values that are described for use with other electrode structures having different material compositions. Dr. Gido does not discuss how or why a POSITA would have specifically looked at the density values of Li to modify Wang, particularly given Li’s focuses exclusively on the disclosed gap coating process and does not provide adequate detail for a POSITA to reproduce Li’s example cathode mixture. Instead, Dr. Gido imprecisely states that Wang and Li disclose cathodes with two active material layers “including the same materials,” (Ex. 1010 ¶ 429) but Dr. Gido fails to recognize that Li does not provide enough information for a POSITA to

conclusively determine if the materials disclosed in Li's examples are, in fact, the "same" as those disclosed in Wang. At least because Dr. Guido overlooks pertinent details of Li's disclosure, Dr. Guido's proposed combination of Wang and Li does not reflect how a POSITA would understand the disclosure of these references, nor how a POSITA would decide whether these references are compatible with one another, as suggested by Petitioner and Dr. Guido.

VII. CONCLUSION

183. In sum, it is my opinion that Grounds 1-4 of the Petition do not render Claims 1-20 of the '118 Patent unpatentable as anticipated or obvious for the reasons I discuss above.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on the information and belief are believed to be true; and further 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 Title 18 of the United States Code.

Executed on August 5, 2025.

A handwritten signature in black ink, appearing to read "Dean R. Wheeler", is positioned above a horizontal line.

Dean R. Wheeler