

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

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2.	10.2: a first layer comprising a first material; and;	140
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I. INTRODUCTION

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

2. I have been asked to provide my independent analysis of the ’118 patent in light of the prior-art publications cited below.

3. I am not, and never have been, an employee of Petitioner. I received no compensation for this Declaration beyond my normal hourly compensation based on my time actually spent analyzing this patent, the prior-art publications cited below, and the issues related thereto, and I will not receive any added compensation based on the outcome of any IPR or other proceeding involving these patents.

II. MY PROFESSIONAL EXPERIENCE AND QUALIFICATIONS

4. A copy of my curriculum vitae (“CV”) is submitted with this Declaration as Exhibit 1011. As my CV shows, I am a professor of polymer science and engineering with a special focus in the compositions and structures of lithium-ion batteries.

5. I have been on the faculty at the University of Massachusetts at Amherst since 1993. I am currently Associate Professor of Polymer Science and

Engineering. I have broad expertise across the fields of polymers (plastics), polymer-nanoparticle composites, fluorinated polymers, polyolefins, porous materials, phase separations, and coating processes. I am an expert in and experienced user of a range of materials characterization techniques including scattering, and spectroscopies, but with a particular emphasis on microscopy, especially electron microscopy. Over the years I have studied materials for a broad range of applications, including: batteries, fuels cells, adhesives, non-stick coatings, elastomers, composites and nanostructures. In addition to academic research, I have done research for, and/or consulted for a range of companies including: W.L. Gore, Boston Scientific, FujiFilm (Japan), Kureha Chemical Industry (Japan), Loctite Corp. (now Henkle), Rexam Graphics, St. Gobain, and Scapa Tape.

6. I studied for my bachelor's degree in Chemical Engineering at Princeton University, and graduated Magna Cum Laude in 1988. While at Princeton I did research at the nearby Textile Research Institute (<https://www.triprinceton.org/what-we-offer>) ("TRI"), where I focused on applying foamed coatings to porous substrates. I completed a bachelor's thesis on this topic; the title of my thesis was: "Foam Flow Through Porous Media: Image Analysis Development & Investigation of Microscopic Flow Mechanism." TRI also

provided my first involvement in using scanning electron microscopy (SEM) to coatings and porous materials.

7. After graduating from Princeton in 1988, I moved on to a doctoral program at the Massachusetts Institute of Technology (MIT). My home department at MIT was Chemical Engineering, but I also was part of the interdisciplinary Program in Polymer Science and Technology (PPST, <http://polymerscience.mit.edu>). I did my research and doctoral thesis under the direction of Prof. Edwin L. Thomas, who was in the Materials Science and Engineering Department at MIT. Prof. Thomas is a world-renowned expert in the study of polymer structure using electron microscopy. Therefore, my training and research at MIT focused on the use of electron microscopy, including SEM and transmission electron microscopy (TEM), to study a range of different topics including plastics, rubbers, copolymers, polymer-ceramic composites, phase behavior, and phase separations.

8. After receiving my Ph.D. in 1993, I moved on to begin my career as an Assistant Professor in the Polymer Science and Engineering Department at the University of Massachusetts at Amherst. Over my academic career I have received millions of dollars of research funding from government (U.S. Army, National Science Foundation, U.S. Department of Education), foundations (Bill and Melinda Gates Foundation, W. M. Keck Foundation), and industry.

9. I have focused on a bottom-up concept of new materials design for advanced applications. In particular, I have worked on development of new molecular structures for the control of nanometer and micrometer length scale structure and morphology, directed toward improving properties such as: mechanical strength, transport (diffusion) of gases, liquids, and ions in porous materials, electrical properties, and adhesion. A large part of this research is on controlling the phase separation behavior (coagulation) of material to form unique, functional structures.

10. I have numerous publications and a U.S. Patent on fluorinated polymers for a range of applications, including in separators and electrodes for batteries and fuel cells. I have done research on materials for batteries and fuel cells, including fluorinated polymers and polymer particle composites, with funding from Kureaha (Japan), and the U.S. Army. In these studies, we developed polymer chemistries, nanometer and micrometer scale composite structures and porous structures, and coating processes to enhance ion conductivity.

11. Additionally, I have worked and continue to work as a consultant for W. L. Gore, a leading company in fluorinated polymers. I have consulted for industry on the topic of coating processes, particularly for Rexam Graphics and Scapa Tape. I was also a co-founder of a startup company, Smart Surfaces LLC, that developed environmentally friendly, non-stick coatings for boats (and other

structures in a marine environment) to prevent fouling with marine organisms.

Smart Surfaces was sold to FujiFilm in 2006, and I continued to consult for the resultant company: FujiFilm Smart Surfaces LLC. These coatings, were silicone based, contained ceramic filler particles, and cured by a coagulation (phase separation) process.

12. I did a research project for Loctite Corporation in which I used electron microscopy to study adhesive polymer layers filled with inorganic reinforcing particles. I also did research for Boston Scientific, which resulted in a U.S. Patent, on polymer coatings for heart stents, using a number of techniques including electron microscopy. These coatings contained filler particles, a particulate drug, and we studied the diffusion of this drug through the coating layer.

13. One of the best ways to really understand a topic is to teach it to someone else. I have taught and continue to teach topics, relevant to this matter, to our advanced graduate students (doctoral candidates) in the Polymer Science and Engineering Department at the University of Massachusetts at Amherst. In past years I have taught PSE 608 Introduction to Polymer Engineering, which includes topics such as mechanical properties, coatings processes, and diffusion of ions in materials. I have also taught in the past and am currently teaching PSE 602 Polymer Characterization Laboratory, in which the students gain practical

laboratory experience with techniques of importance in this matter including SEM, and static laser light scattering (aka laser diffraction) for size determination.

14. I also teach PSE 608 Physical Chemistry of Polymers I and PSE 789 Physical Chemistry of Polymers II. In this sequence of classes, I cover, among other things, phase behavior and phase separations (coagulation), and the theory of laser light scattering. I also teach PSE 721 Polymer Morphology. This class focuses on nanometer and micrometer size structure in polymers and composites, as well as the use of electron microscopy to study materials structure.

15. I also teach a seminar class for freshman, FFYS 191POLY The Polymer Age, which focuses on popular and societal impacts of polymers. In this class, I present a seminar on lithium ion batteries with a particular focus on the materials used in their construction and the safety issues related to separators.

III. LEGAL PRINCIPLES

16. In forming my analysis and conclusions expressed in this Declaration, I have applied the legal principles described in the following paragraphs, which were provided to me by counsel for the Petitioner.

17. I have been informed that prior art is that which was known or used by others in the U.S., or was patented or published anywhere, before the Applicant's invention. I further have been informed that prior art includes that which was patented or published anywhere, or was in public use, on sale, or

offered for sale in this country, more than one year prior to the filing date of the patent application (critical date). I have also been informed that prior art includes that which was described in a U.S. patent granted on an application for a patent (or in a published application for a U.S. patent) that was filed by another in the U.S. before the date of invention for such a claim.

A. Anticipation

18. I understand that a claim is anticipated if all of the limitations of the claim are disclosed in a single prior-art reference. Limitations may be disclosed in the prior art explicitly or inherently.

19. I understand that if the prior art teaches a composition, then the properties of that composition are necessarily present. A prior-art disclosure may therefore *inherently* disclose a claim element reciting the properties of a composition by disclosing that composition. In other words, where a patentee claims a composition, product, or apparatus in terms of a function, property, or characteristic and the composition of the prior art is the same as that of the claim but the function is not explicitly disclosed by the reference, the reference may nonetheless anticipate the claim.

20. For that reason, the discovery of a previously unappreciated property of a prior-art composition, or of a scientific explanation for the prior art's functioning, does not render the old composition patentably new to the discoverer.

B. Obviousness

21. I have been informed that a patent claim is invalid as “obvious” in light of one or more prior-art references if it would have been obvious to a person of ordinary skill in the art at the time of the alleged invention (“POSA”), taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called “secondary considerations” of non-obviousness, which include: (i) “long felt need” for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others.

22. I understand that a patent cannot be properly granted for subject matter that would have been obvious to a POSA at the time of the alleged invention, and that a patent claim directed to such obvious subject matter is invalid under 35 U.S.C. § 103. It is also my understanding that in assessing the obviousness of claimed subject matter one should evaluate obviousness over the prior art from the perspective of a POSA at the time the invention was made (and not from the perspective of either a layman or a genius in that art).

23. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references.

24. A patent can be obvious in light of a single prior-art reference if it would have been obvious to modify that reference to arrive at the patented invention. To be obvious in light of a single prior-art reference or multiple prior-art references, there must be a reason that would have prompted a POSA to modify the single prior art reference, or combine two or more references, in a manner that provides the elements of the claimed invention. This reason may come from a motivation to combine, or may come from the reference(s) themselves, the knowledge and “common sense” of a POSA, or from the nature of the problem to be solved, and this reason may be explicit or implicit from the prior art as a whole. I have been informed that, under the law, the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

25. I understand that a dependent claim contains all of the limitations of the independent claim from which it depends. Thus, to establish unpatentability, every limitation set forth in a dependent claim as well as the independent claim from which it depends must be found in the prior art or be obvious from the prior art.

C. Claim Construction

26. I understand that, for purposes of my analysis in this *inter partes* review proceeding, the terms appearing in the patent claims should be interpreted according to their “ordinary and customary meaning.” In determining the ordinary and customary meaning, the words of a claim are first given their plain meaning that those words would have had to a POSA. I understand that the structure of the claims, the specification, and the file history also may be used to better construe a claim insofar as the plain meaning of the claims cannot be understood. I also understand that a patentee can be his own lexicographer, providing a definition for a term that otherwise does not have an established meaning in the art. Additionally, treatises and dictionaries may be used, albeit under limited circumstances, to determine the meaning attributed by a person of ordinary skill in the art to a claim term at the time of filing. I have followed this approach in my analysis.

IV. MATERIALS CONSIDERED AND BASIS OF OPINIONS

27. My opinions are based on more than 35 years of working with polymers, composites, and materials for a wide range of applications including batteries and fuel cells, as well as my teaching and research experience. My opinions are also based on investigation and study of the relevant materials, including the patent at issue and its file history, and the prior art.

28. In the course of forming my opinions I have reviewed the following exhibits of record:

Exhibit No.	Description
1001	U.S. Patent No. 12,015,118
1002	File History of U.S. Patent No. 12,015,118
1003	Chinese Publication No. 202905885 with Certified English Language Translation (“Li”)
1004	Japanese Publication No. 2013-211096 with Certified English Language Translation (“Ishigaki”)
1005	U.S. Patent Publication No. 2011/0168550 (“Wang”)
1006	U.S. Patent Publication No. 2017/0256776 (“Saka”)
1007	Excel Spreadsheet of Saka Calculations
1008	U.S. Patent Publication No. 2016/0013480 (“Sikha”)
1009	U.S. Patent Publication No. 2013/0302685 (“Kim”)
1011	<i>Curriculum Vitae</i> of Dr. Gido
1012	Certified Translation of the File History of Chinese Patent No. 109004170
1013	“Lithium Ion Battery Nickel Manganese Cobalt Oxide Nmc Cathode Raw Material For Lab Battery Research,” Alibaba, accessed at https://www.alibaba.com/product-detail/Lithium-Ion-Battery-Nickel-Manganese-Cobalt_1600084022147.html
1014	<i>Intentionally Left Blank</i>
1015	File History of U.S. Patent No. 11,664,528
1016	File History of U.S. Patent No. 11,322,774
1017	File History of U.S. Patent No. 10,693,181
1018	ISO 13320-1 standard
1019	<i>Intentionally Left Blank</i>
1020	Kim, J., et al., “Structure Dependent Electrochemical Behaviors of Hard Carbon Anode Materials Derived from Natural Polymers for Next-Generation Sodium Ion Battery” <i>Polymers</i> , 15(22):4373 (Nov. 2023)

Exhibit No.	Description
1021	Malvern Instruments Ltd., “A basic guide to particle characterization,” accessed at https://www.malvernpanalytical.com/en/learn/knowledge-center/whitepapers/wp120620basicguidepartchar
1022	“Battery Capacity,” accessed at https://www.pveducation.org/pvcdrom/battery-characteristics/battery-capacity
1023	“What is the difference between hard carbon black and soft carbon black?,” <i>Dery Chemical</i> , accessed at https://www.dr-carbonblack.com/what-is-the-difference-between-hard-carbon-black-and-soft-carbon-black
1024	“Overview of carbon black industry in China,” Henan Jinhe Industry Co., Ltd., accessed at https://www.jinhetec.com/blog/overview-of-carbon-black-industry-in-china-53773.html
1025	Abanades, A., et al., “Experimental analysis of direct thermal methane cracking,” <i>International Journal of Hydrogen Energy</i> , Vol. 36, pp. 12877-86 (Aug. 2011)
1026	Kim, M., et al., “Preparation of high-crystallinity synthetic graphite from hard carbon-based carbon black,” <i>Applied Physics</i> , Vol. 127:156 (Feb. 2021)
1027	Dick, J.S., et al., “Alternate Instrumental Methods of Measuring Scorch and Cure Characteristics,” <i>Polymer Testing</i> , Vol. 14, pp. 45-84 (April 1994)
1028	Schlögl, R., “Part A: 2.1.10 Carbons,” Department of Inorganic Chemistry, Fritz-Haber-Institute of the MPG (2008)

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

30. I may rely upon these materials and/or additional materials to rebut arguments raised by the Patent Owner. Further, I may also consider additional documents and information in forming any necessary opinions, including documents that may not yet have been provided to me.

31. My analysis of the materials relevant to this proceeding is ongoing and I will continue to review any new material as it is provided. This report presents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

V. DESCRIPTION OF THE RELEVANT FIELD AND A PERSON OF ORDINARY SKILL IN THE RELEVANT FIELD (ART)

32. I have carefully reviewed the '118 patent.

33. Based on my review of these materials, I believe that the relevant field for purposes of the '118 patent is battery construction materials and their properties.

34. In my opinion, “a person of ordinary skill in the relevant field” is a hypothetical person to whom an expert in the relevant field could assign a routine task with reasonable confidence that the task would be successfully carried out. I have been informed that evidence of the level of ordinary skill in the art can be determined based on information about the field including: the types of problems encountered, known solutions, the speed of innovation, sophistication, and the

educational level of active workers. I have considered these types of information along with my own background working with students and other professionals in the field to reach my conclusion.

35. I have been advised that a person of ordinary skill in the “relevant field” (art), (i.e., a “POSA”), must be able to make and use the claimed invention based on the information disclosed in the specification of the patent. Accordingly, where information is required to make and use the claimed invention but has not been expressly disclosed in the specification, the patentee effectively acknowledges that such information should be considered to be within the knowledge of the hypothetical POSA. Whether I use the acronym POSA or not, all of my opinions throughout this Declaration are based on the understanding of a POSA at the time of the effective filing date of the ’118 patent.

36. Based on my analysis of the ’118 patent, it is my opinion that a POSA at the date attributed to the invention would have had at least an undergraduate degree in chemistry, chemical engineering, polymer science and engineering, or materials science and engineering and two years of experience in the field of battery materials and construction. A higher level of education, such as a Master’s Degree in one of these same fields, could substitute for work experience. Based on my educational background and experience, I qualify as at least a POSA at the time of the alleged invention of the patent. And, based on my experience, I have an

understanding of the capabilities of a person of ordinary skill in the relevant field. I have supervised, directed, and instructed many such persons over the course of my career.

VI. THE DATE OF THE PATENT

37. The '118 patent was filed on March 29, 2022 and claims a priority date of February 26, 2018. For purposes of my analysis here, I have been advised by counsel to assume a date of February 26, 2018 as the date governing my analysis. I will note that an earlier or later date by even as much as a year would not impact the relevant analysis in this report.

VII. BACKGROUND OF CONVENTIONAL BATTERY TECHNOLOGY

38. High-capacity electrochemical devices like lithium-ion (“Li-ion”) batteries are used in a growing number of ubiquitous consumer electronics. EX1008, ¶4. Such batteries “typically include an anode electrode, a cathode electrode, a separator positioned between the anode electrode and the cathode electrode, and at least one current collector.” EX1008, ¶5. As the power and safety demands on these batteries increase, there is likewise an increase in the need for higher capacity batteries that are also smaller, lighter, and more resistant to shorting. EX1008, ¶9. One well-known way in which these needs can be met is by manufacturing thicker electrodes containing more active materials. EX1008, ¶8. Doing so increases the battery energy density. *Id.*

39. In other words, to increase battery cell energy density, it is highly desirable to “pack” more materials into each battery cell to increase the electrode loading (mAh/cm²). One method for increasing electrode loading is to increase the amount of active materials per unit electrode area, i.e., make thicker electrodes and/or increase the density of the electrode materials. EX1008, ¶22.

40. To this end, a well-known way of increasing the thickness, active-material content, and energy density of battery electrodes is to form a multi-layer electrode structure. EX1008, ¶10. The typical process for doing so is to deposit a first slurry mixture of an active material on to the conductive substrate of the electrode. That slurry can then be allowed to dry. The process then involves depositing a second slurry mixture of another (or the same) active material to form a second layer over the first layer. The second layer can then be allowed to dry, and the resulting multi-layer structure can be compacted to achieve a desired density or porosity for the electrode. *Id.*, ¶10, FIG. 3.

41. “[T]he layers of the multi-layer electrode may vary relative to the other layers in at least one of the slurry composition used to form each layer, the porosity of each layer, the active material used to form each layer, the particle size of the active material particles, the modal particle size distribution of the particles in each layer, and the tap density of the active materials.” EX1008, ¶23. The

relationships of these properties to the resulting battery performance has long been studied and is generally well-understood.

42. Examples of popular cathode active materials are lithium nickel-manganese-cobalt oxide (called “NMC”) or similar variations of lithium-rich oxides or mixed-metal oxides. Anode materials are typically graphite based. EX1008, ¶21. A wide variety of particle sizes, densities, and thicknesses are known in the art. One of skill in the art would know how to select active materials with the properties for a desired application, balancing the various considerations of capacity, density, weight, cost, safety, ease of manufacturing, and the like.

VIII. THE '118 PATENT

A. Overview of the Claims

43. The claims of the '118 patent are apparatus claims that recite an electronic device (claim 19), a battery (claim 10), and/or an electrode (claim 1). Independent claim 1 recites an electrode comprising a current collector covered in two layers of material. Independent claim 10 recites an electrochemical device (i.e., a battery) comprising an electrode having largely the same features recited in claim 1. Independent claim 19 recites an electronic device comprising an electrochemical device that comprises an electrode having largely the same features recited in claim 1.

44. The layers recited in the independent claims have specified particle sizes and compaction densities. As discussed in detail below, the overall layer

structure of the electrode, as well as the particle sizes and compaction densities of the layers, were known in the art at the time of the '118 patent.

45. The dependent claims narrow the requirements for the thickness of the layers, particle sizes, compaction densities, and materials that compose the layers. Again, and as discussed further below, all of these properties were known in the art, and the prior-art contains examples of lithium-ion batteries that have such electrode structures and are made from the same materials and have the recited properties.

B. Prosecution History

46. The '118 patent issued from U.S. Patent Application No. 17/707,137 ("the '137 application"). EX1001, (21). The '137 application was filed on March 29, 2022 and is a continuation application of U.S. Patent Application No. 16/868,966 ("the '966 application"), filed on May 7, 2020, now U.S. Patent No. 11,322,774 ("the '774 patent"), which is a divisional application of U.S. Patent Application No. 16/000,597 ("the '597 application"), filed on June 5, 2018, now U.S. Patent No. 10,693,181 ("the '181 patent"). Note that in addition to the '137 application, the '966 application has another continuation application, which is U.S. Patent Application No. 17/707,378 ("the '378 application"), filed on March 29, 2023, now U.S. Patent No. 11,664,528 ("the '528 patent"). The prosecution histories of the '378 application and the '528 patent are relevant to the prosecution

of the '137 application in that they were applied as grounds for double-patenting rejections.

47. The '137 application was not subject to any prior-art rejection during its prosecution history. On March 2, 2023, the Office issued a Non-Final Office Action, rejecting the original claims (1-20) based on a double patenting rejection as patentably indistinct from claims 1-20 of the '378 application. EX1002, 0097. On May 31, 2023, the Applicant filed a response to the Non-Final Office Action without making any amendment. EX1002, 0099-102.

48. On October 26, 2023, the Office issued a Final Office Action, in which claims 1-20 are rejected under 35 U.S.C. § 101 based on a statutory double patenting rejection as claiming the same invention as that of claims 1-20 of the '528 patent. EX1002, 0112-13. On December 26, 2023, the Applicant filed a response to the Final Office Action without making any amendment. EX1002, 0118-23.

49. On February 14, 2024, the Office issued a Notice of Allowance, indicating that claims 1-20 are allowed. EX1002, 0139. The Notice of Allowance provides the following Examiner's statement of reasons for allowance:

Claims 1, 10, and 19 recite an electrode comprising a current collector, a first layer, and a second layer wherein the first layer is between the collector and the second layer and on the surface of the

collector. The claim further recites that the total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

Prior art Sikha et al. (US 2016/0013480) teaches a battery with a current collector and two cathode layers wherein the tap densities can vary between 2 and 3 g/cc (par. 67, abstract). Sikha teaches that the first and second layers are the same material but does not specifically teach that the tap density of the cathode material is 3.2 g/cc or more as claimed. (*See Remarks filed 12/12/2023*).

EX1002, 0139.

50. Accordingly, the reason for allowance was that the density disclosed in the cited prior art did not overlap the density recited in the independent claims. There are two shortcomings with that reasoning. First, the examiner appeared to equate numeric tap density and numeric compaction density, which are two different properties and describe two different compositions of material. Second, the examiner did not consider the densities disclosed in the prior art that I cite below, which disclose the compaction-density limitations (and all other limitations) of the claims.

51. The '378 application was not subject to any rejection during its prosecution history. On March 1, 2023, the Office issued a Notice of Allowance, indicating that claims 1-20 are allowed. EX1015, 0103. The Notice of Allowance provides the following examiner's statement of reasons for allowance:

Claims 1, 10, and 19 recite an electrode comprising a current collector, a first layer, and a second layer wherein the first layer is between the collector and the second layer and on the surface of the collector. The claim further recites that the compaction density of the first layer is greater than 2.8 g/cc and the compaction density of the second layer is greater than 3.3 g/cc.

Prior art Sikha et al. (US 2016/0013480) teaches a battery with a current collector and two cathode layers wherein the tap densities can vary between 2 and 3 g/cc (par. 67, abstract). Sikha teaches that the first and second layers are the same material but does not teach that the tap density of the second material is 3.3 g/cc or more.

EX1015, 0103.

52. Accordingly, the reason for allowance given in this application was the same as that for the '528 patent—namely, that the density disclosed in the cited prior art did not overlap the density recited in the independent claims. As I mention above, the examiner did not consider the densities disclosed in the prior art that I cite below.

53. The '966 application (parent application of both the '378 and '137 applications) was not subject to any prior-art rejection during its prosecution history. On October 22, 2021, the Office issued a Non-Final Office Action, in which the original claims 1, 3, 4, 7-10, 12, 13, and 16-19 are rejected based on nonstatutory double patenting rejection over the claims of the '597 application. EX1016, 0066-69. The Non-Final Office Action also indicated that claims 2, 5, 6,

11, 14, 15, and 20 are objected to but include allowable subject matter. EX1016, 0070. On December 8, 2021, the Applicant filed a response to the Non-Final Office Action to amend claims 1, 4, 10, 13, and 19, cancel claims 2, 11, and 20, and add new claims 21-23. EX1016, 0086-95.

54. On January 10, 2022, the Office issued a Notice of Allowance, indicating that claims 1, 3-10, 12-19, and 21-23 are allowed. EX1016, 0117. The Notice of Allowance also provides the following examiner's statement of reasons for allowance:

Claims 1, 10, 19, recite a lithium ion battery comprising a collector, a first active layer, and a second active layer wherein the first layer is between the second layer and the collector. The claims further recite the average particle size of the first active material is less than the average particle size of the second active material.

Prior art Imachi (US 2007 /0026316) teaches a lithium ion battery comprising a collector, a first active layer, and a second active layer wherein the first layer is between the second layer and the collector. Imachi does not teach that the average particle size of the first active material is less than the average particle size of the second active material.

EX1016, 0117.

55. Accordingly, the reason for allowance was that the cited prior art did not disclose the average particle size recited in the claims. The examiner did not consider the prior art that I cite below.

56. The '597 application (the first non-provisional application of the family) was the only application of the family subject to prior-art rejection during its prosecution history. On November 1, 2019, the Office issued a Non-Final Office Action to reject the original claims 1-17 based on the following grounds:

- Imachi (US 2007/026316) in view of Sikha (U.S. Pub. No. 2016/0013480) renders obvious claims 1-7 and 9-16; and
- Imachi in view of Sikha and Ijiri (U.S. Pub. No. 2014/0295284) renders obvious claims 8 and 17.

EX1017, 0127-29.

57. In response to the Non-Final Office Action, the Applicant amended independent claims 1 and 10 to recite “wherein a particle size of 90% accumulative volume of the first active material is less than 40 μm .” EX1017, 0150-52.

58. On February 11, 2020, the Office issued a Notice of Allowance, indicating that claims 1, 2, 4-11, and 13-20 are allowed. EX1017, 0166. The Notice of Allowance also provides the following examiner’s statement of reasons for allowance:

Claims 1 and 10 recite a lithium ion battery comprising a collector, a first active layer, and a second active layer wherein the first layer is between the second layer and the collector. The claims further recite that the particle size ratio between second and first active layer is from 1:1 to 40:1 and that the particle size of 90% accumulative volume of the first active material is less than 40 microns.

Prior art Imachi (US 2007/0026316) teaches recite a lithium ion battery comprising a collector, a first active layer, and a second active layer wherein the first layer is between the second layer and the collector. Imachi does not teach that the particle size ratio between second and first active layer is from 1:1 to 40:1 and that the particle size of 90% accumulative volume of the first active material is less than 40 microns. In addition, there are unexpected results shown in table 1 of the specification which shows that when the particle size of 90% accumulative volume of the first active material is less than 40 microns there can be reduced nail penetration.

EX1017, 0166.

59. Accordingly, the reason for allowance was that the cited prior art did not disclose the Dv90 recited in the claims and did not disclose the particle size ratio of the claims. The examiner gave the recited numeric values patentable weight because the specification showed unexpected results within this range. The examiner did not consider the prior art that I cite below, disclosing embodiments having the Dv90, Dv50, and particle-size ratios recited in the claims.

60. The '137 application also has a corresponding application CN 202110531289 ("the '289 application") filed on February 26, 2018 in The China National Intellectual Property Administration (CNIPA). On October 9, 2022, the CNIPA issued a Final Office Action to reject the claims 1-11 under Article 22.3 of the Chinese Patent Law based on the following ground:

- Claims 1-11 do not involve an inventive step in view of Chinese Patent Application Publication CN 105074967A to Sikha (the Chinese correspondence of U.S. Pub. No. 2016/0013480).

EX1012, 0020-26.

61. On January 18, 2023, the Applicant requested Reexamination of the '289 application. On November 20, 2023, CNIPA issue the decision of Reexamination, affirming the rejection in the Final Office Action. EX1012, 0027-39. While I do not rely on Sikha in my patentability analysis below, I will note that the references on which I rely disclose the same anticipating embodiments as Sikha, and similarly render the claims unpatentable.

IX. OVERVIEW OF PRIOR ART

62. Japanese Patent Application Publication No. JP 2013-211096 A filed by Kenichi Ishigaki et al. ("Ishigaki") was published October 10, 2013. It is prior art under 35 U.S.C. § 102(a)(1). Ishigaki discloses a positive electrode for a lithium-ion battery used in common consumer portable electronic devices. EX1004, ¶4. Two layers of active material are applied to the electrode in order to improve the output and capacity of the battery, without compromising risk of internal short circuits. EX1004, ¶8. Ishigaki teaches electrode active materials containing lithium transition-metal oxides with particle sizes (90% cumulative diameter) of 5 µm or less. Ishigaki also teaches that the key to increasing the capacity of a battery is "packing [the] electrode active material" "as densely as

possible,” which Ishigaki identifies as being preferably at least 2.5 g/cc and up to 3.6 g/cc. EX1004, ¶¶7, 25. Ishigaki’s novel feature includes recesses in the surface of the current collector of the electrode, which Ishigaki claims improves the binding between the active material and the current collector foil. EX1004, Abstract.

63. U.S. Patent Publication No. 20110168550 A1 (“Wang”), published on July 14, 2011, is § 102(a)(1) prior art. Wang discloses methods of manufacture for improving the charging speed and energy capacity for a lithium-ion battery. EX1005, Abstract. Specifically, Wang discloses a process whereby a layer of lithium transition-metal oxide active material is applied to the current collector of an electrode. EX1005, ¶11. The active material is subjected to a compression step, after which a second layer is applied, and compressed again. *Id.* Wang teaches embodiments where the two layers are different active materials, and other embodiments where they are the same. EX1005, ¶14. Wang teaches embodiments in which the first layer has a lower density than the second layer, and vice versa. EX1005, ¶10. Wang describes the density of its layers in terms of porosity, and the effect of the compaction steps on the porosity of the active materials. EX1005, ¶¶56-58.

64. U.S. Patent Publication No. 20170256776 A1 (“Saka”), published on September 7, 2017, is § 102(a)(1) prior art. Saka discloses numerous embodiments

of batteries made by a process very similar to Wang's process. Specifically, Saka's batteries have two layers of lithium transition metal oxide active materials applied to a positive electrode. EX1006, Abstract. Saka details the particle-size distributions, masses, porosities, and densities of the electrode layers across dozens of embodiments. EX1006, FIGs. 7-11. Saka also provides performance test data for the different embodiments, showing how different properties of the active material layers confer different performance characteristics to the resulting battery. *Id.*

Some embodiments of Saka have a first layer containing lithium iron phosphate and a density of 2.9 g/cc, and a second layer containing lithium nickel cobalt manganese oxide and lithium iron phosphate and a density of more than 3.1 g/cc.

65. U.S. Patent Application Publication No. 2013/302685 A1 to Kim et al ("Kim") was published November 14, 2013 and is prior art under § 102(a)(1). Kim discloses a composite cathode active material for a lithium-ion battery, and various desirable attributes for that material. Kim's electrode structure is described in terms of a single active material layer. It teaches the use of lithium cobalt nickel manganese oxide as the active material, and discloses an average particle size (Dv50) from 5 – 50 um. Kim teaches a cathode layer density of 3.31 g/cc or greater, and preferably of 3.4 to 4.0 g/cc. EX1009, ¶36. Kim explains that compaction densities below 3.31 g/cc "may be too small to obtain a high electrical capacity." *Id.*

66. Chinese Publication No. CN 202905885 U to Li et al (“Li”) was published April 24, 2013, and is prior art under § 102(a)(1). Li discloses a lithium-ion battery for modern consumer electronic devices with a winding structure that reduces the deformation rate and increases the energy density of the battery. EX1003, ¶¶1, 2, 27. The structure of the cathode includes a current collector onto which is deposited two material layers. EX1003, ¶¶13, ¶14, ¶38. Li explains that there are no special requirements for the active material in the layers, and suggests Lithium-transition metal composite oxide, lithium-transition metal phosphate, or lithium-transition metal silicate as examples. EX1003, ¶26. Li also suggests graphite and silicon/carbon composites are “obvious” choices for anode active materials. *Id.* Various examples of Li disclose lithium cobalt oxide as a cathode active material and acetylene black as a cathode layer conductive additive. *See, e.g.,* EX1003, ¶38, ¶44. In Li’s examples 2-13, it specifically discloses a method of “coating twice and compaction twice” with a resulting first compaction density of 3.8 g/cm³ for the first layer, and then an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44.

X. CLAIM CONSTRUCTION

67. Independent claims 1, 10, and 19 use the term “**compaction density.**” During prosecution, the Applicant defined “compaction density” as “mass / volume.” EX1002, [0121] (“Moreover, as commonly understood, in the design of

lithium-ion batteries, compaction density = mass / volume.”). While that is a correct definition of “density,” it is confusing and incomplete to the extent it does not account for the “compaction” component of the term.

68. One of skill in the art would understand the plain and ordinary meaning of compaction density to refer to the density of the electrode active material layer (including all components of this layer: active material powder, binder polymer and conductive additive) after it has been subjected to the compression step of the electrode-formation process. In other words, it is the mixture density of the electrode material, or the net density of the compacted particles after the particles are deposited over the conductive substrate and compressed. Structural changes in the layers brought about by compaction (or compression) potentially include deformation of the binder material, rearrangement and change to the packing of the particles, and reduction in void volume, i.e., porosity, of the material. For purposes of my analysis, I have applied this understanding of the term “compaction density.”

69. Claims 3, 4, 12, and 13 use the term **“average particle size.”** This term is ambiguous because there are different mathematical ways to determine averages, and different concepts in physics and chemistry of how to define the size of a particle. The ’118 patent makes clear that by “average particle size” the claim means Dv50. *See* EX1001, 1:60-63. Dv50 is a standard metric in this art (along

with Dv10 and Dv90). Dv50 denotes the maximum particle diameter below which 50% of the sample volume exists. *See, e.g.*, EX1021. Dv50 is also known as the median particle size by volume. *Id.*

70. Accordingly, the PTAB should construe the term “average particle size” as used in the claims to mean Dv50.

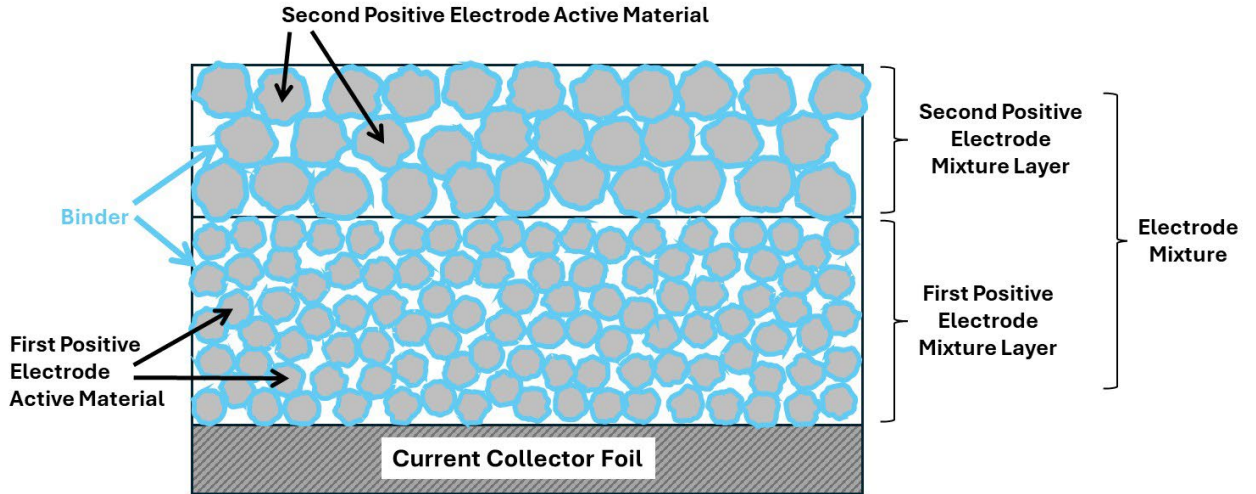
71. For all other terms, I have interpreted them consistently with the ordinary and customary meaning that the words of the claim would have had to a POSA at the relevant time.

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

72. Ishigaki expressly or inherently discloses all of the limitations of claims 1-20, and therefore anticipates the challenged claims.

A. 1.P: An electrode, comprising:

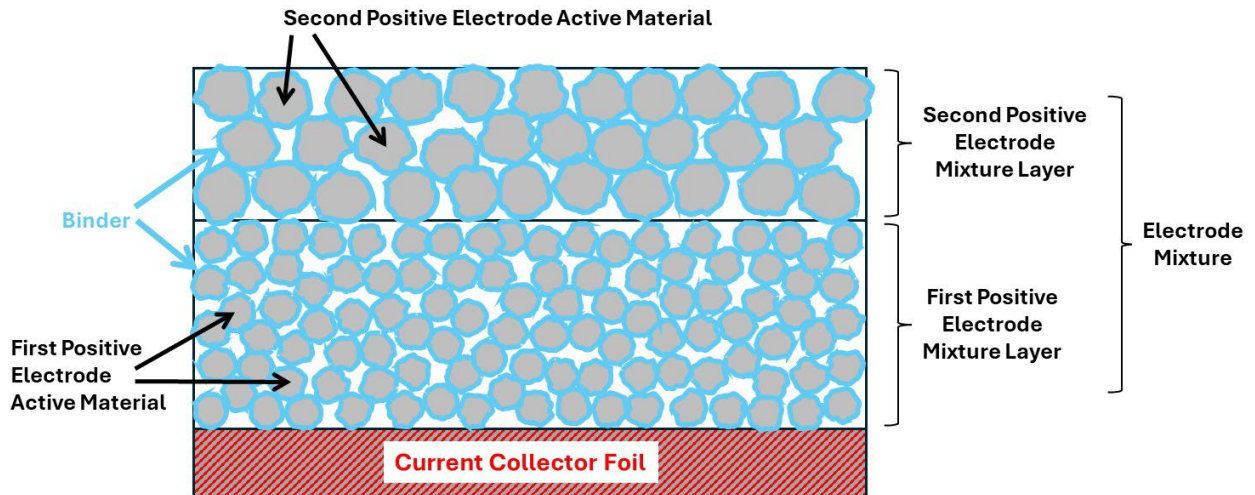
73. Ishigaki discloses an electrode. *See* EX1004, Abstract. Ishigaki further discloses “(1) A positive electrode for a lithium secondary battery comprising, on a current collector foil, an electrode mixture” EX1004, ¶14. As shown below (my illustration), this is the same kind of electrode used in the same context for the same purpose as the ’118 patent.



Gido Demonstrative 1.

1. 1.1: a current collector;

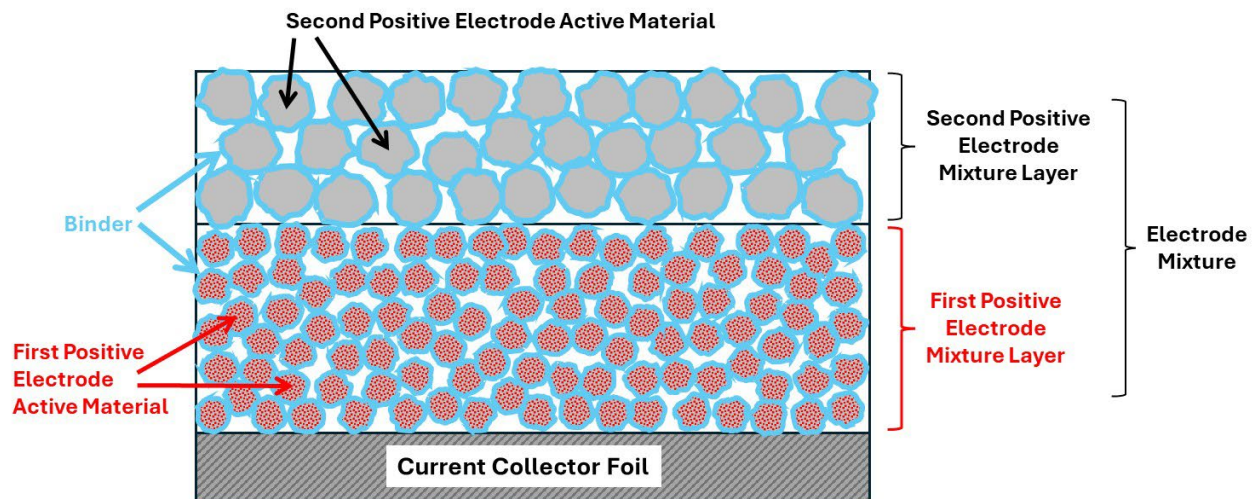
74. Ishigaki discloses that the electrode comprises a current collector foil as ‘a current collector’. *See* EX1004, ¶14. This is the same recited current collector of limitation 1.1.



Gido Demonstrative 2.

2. 1.2: a first layer comprising a first material; and;

75. Ishigaki discloses that the electrode comprises an electrode mixture on a current collector foil. *See* EX1004, ¶14 (“A positive electrode for a lithium secondary battery comprising, on a current collector foil, an electrode mixture comprising a positive electrode active material . . .”). The electrode mixture comprises a first positive electrode mixture layer, which is the first layer of claim 1.2. EX1004, ¶¶153, 347, 348. The first positive electrode mixture layer, in turn, comprises a first positive electrode active material, which is the first material of claim 1.2. EX1004, ¶153 (disclosing a first positive electrode mixture layer containing a first positive electrode active material on the current collector).

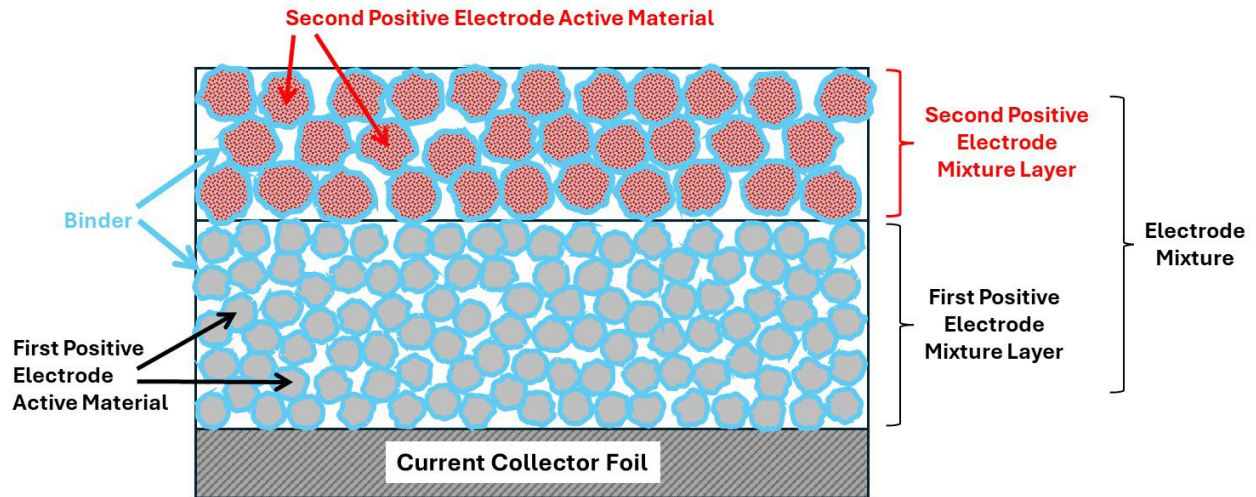


Gido Demonstrative 3.

3. 1.3: a second layer comprising a second material;

76. Ishigaki discloses that the electrode mixture comprises a second positive electrode mixture layer. EX1004, ¶153. This is the second layer of claim

1.3. Ishigaki further discloses “a second positive electrode mixture layer containing a second positive electrode active material.” EX1004, ¶14. This is the second material in the second layer of claim 1.3.

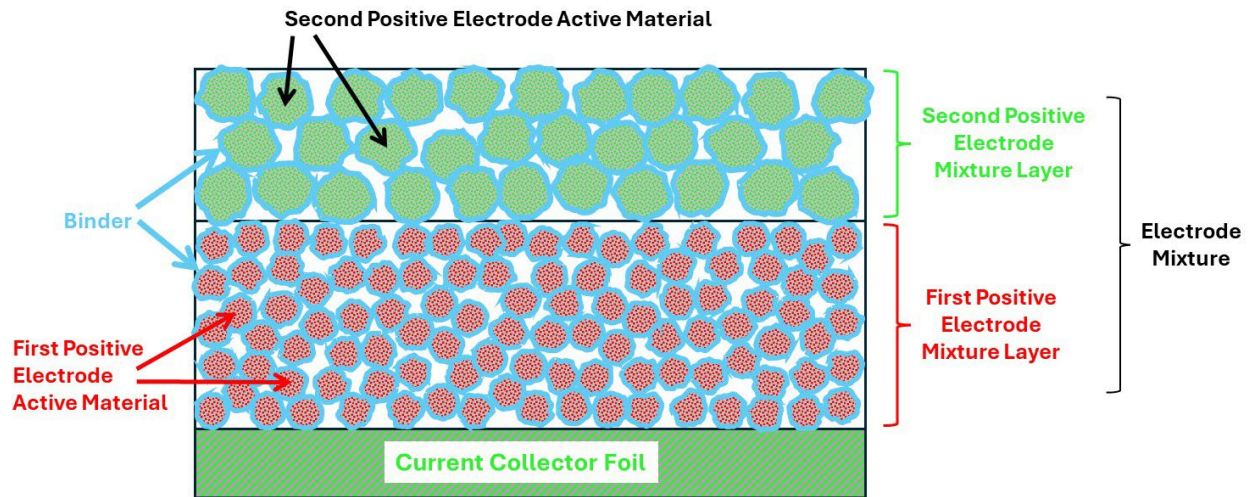


Gido Demonstrative 4.

4. 1.4.1: wherein the first layer is arranged between the current collector and the second layer,

77. Ishigaki discloses that the first and second positive electrode mixture layers are sequentially laminated on the current collector foil. EX1004, ¶153; *see also* EX1004, ¶14 (“[A] second positive electrode mixture layer containing a second positive electrode active material having a particle diameter larger than that of the first positive electrode active material are sequentially laminated and formed on the current collector.”); *see also* EX1004, ¶366 (describing the first layer in between the current collector and second layer). Therefore, the Ishigaki discloses

that the first layer is arranged between the current collector and the second layer.



Gido Demonstrative 5.

78. Additionally, Ishigaki explains that “[a]ctive material 1 was used as the active material of the positive electrode for the first layer. . . . Active material 3 was used as the active material of the positive electrode for the second layer. . . .” EX1004, ¶366. “Next, slurry 1 was coated on one side and dried on an aluminum foil (thickness: 15 μm) as a collector foil with a doctor blade. Then the slurry 2 was applied on one side with a doctor blade and dried.” *Id.* This order of operations confirms that the resulting layer configuration is for the first layer to be arranged between the current collector and the second layer.

5. 1.4.2: the first layer is formed on a surface of the current collector,

79. Ishigaki discloses that the first positive electrode mixture layer is formed by applying a slurry of the first positive electrode active material on a

surface of the current collector foil. EX1004, ¶366. Therefore, Ishigaki discloses that the first layer is formed on a surface of the current collector.

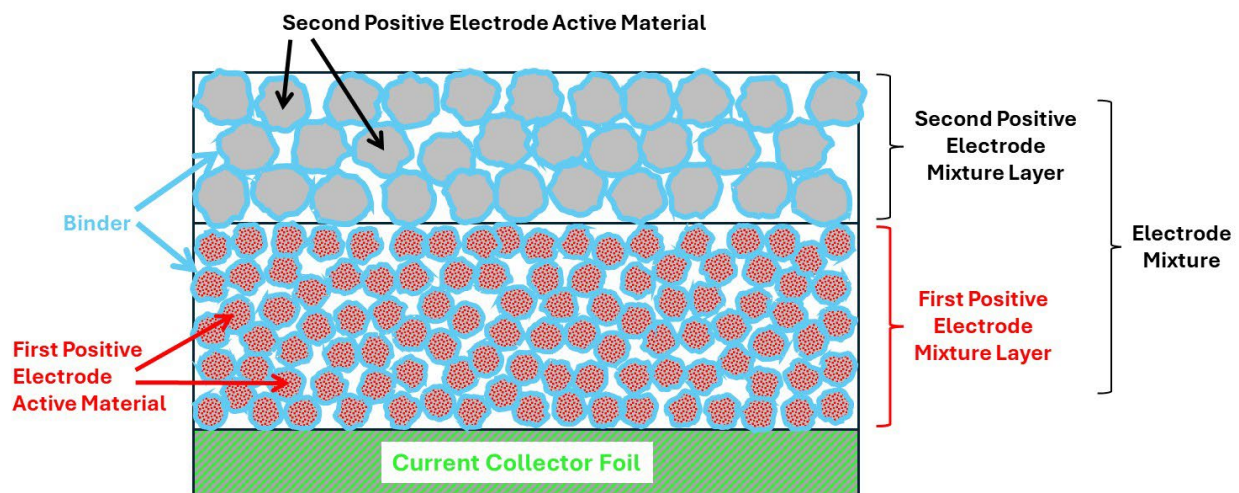
80. More specifically, Ishigaki explains:

As the active material of the positive electrode for the first layer, (active material 1) was used...

The active material, conductive material (HS100 made by Denki Kagaku Kogyo), and binder PVdF (Kureha Corporation: KF Polymer L#1120) were weighed and mixed in a weight ratio of 87:8 (as solid content):5, and N-methylpyrrolidone (NMP) was further added so that the solid content ratio was 45% by mass, and a uniform slurry 1 was prepared using a planetary centrifugal mixer...

Next, the slurry 1 was applied and dried on one side of aluminum foil (thickness 15 μm) of the current collecting foil using a doctor blade.

EX1004, ¶366.



Gido Demonstrative 6.

6. 1.4.3: and a particle size of 90% accumulative volume of the first active material is less than 40 μm ,

81. A particle size of 90% accumulative volume is a standard metric in the art also known as Dv90. 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 .

82. More specifically, Ishigaki discloses that “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, 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.” EX1004, ¶38.

83. Ishigaki’s statement “cumulative diameter (D90)” may be alleged to be, by itself, insufficient to establish that the parameter Ishigaki is teaching

corresponds to Dv90. There are multiple ways of “accumulating” the particle size distribution to obtain an average diameter. This could be done on a number basis, counting all particles, no matter how large or small equally), or it could be done on a mass basis (counting heavier particles more according to their weight). Dv90 is an accumulation based on the volume of the particles. These different accumulation averages do not necessarily yield the same number values.

84. Ishigaki teaches 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.” 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. Other sections of Ishigaki describe particle sizes of $Dv90 \leq 5$ microns. *See, e.g.*, EX1004, ¶¶14, 40, 346. These are all disclosures of a particle size of 90% accumulative volume of the first active material that is less than 40 μm .

7. 1.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

85. The maximum density of the Ishigaki cathode layers is constrained by the densities of its components—active material, conductive additive, and binder—resulting in a theoretical upper limit of 4.4 g/cm³ when porosity is zero. This density is derived from the weight ratios of these components in Ishigaki's

Example 2. The density of the active material is 4.8 g/cm^3 , and the densities of both the conductive carbon and the binder are 1.8 g/cm^3 . The presence of porosity lowers the overall density, with Ishigaki teaching a range of 2.0 to 4.2 g/cm^3 . The calculations and graphs provided throughout the discussion below demonstrate that combinations of the two layers can achieve densities greater than 3.2 g/cm^3 , with the red areas highlighting the higher density ranges Ishigaki emphasizes for maximizing energy density. These ranges are consistent with and anticipate “a total compaction density of the first layer and the second layer is greater than 3.2 g/cc .”

86. Ishigaki discloses treating the electrode mixture by pressure to increase the packing density of the positive electrode materials. This is “compaction density” because the entire layer, including active material particles, conductive additive and polymer binder, is compacted by mechanical pressing, typically applied by a metal roller or a pair of metal rollers. EX1004, ¶24 (“In order to increase the packing density of the positive electrode active material, the positive electrode active material layer obtained by coating and drying is preferably consolidated by a hand press, a roller press, or the like.”). The density that results from this treatment is compaction density.

87. Ishigaki also discloses that the electrode mixture can have a compaction density (density after pressing of the positive electrode) between 2.0 g/cm^3 and 3.6 g/cm^3 . EX1004, ¶25. Specifically, Ishigaki discloses “[t]he electrode

density of the positive electrode after pressing has a lower limit of normally 2.0 g/cm³ or more, preferably 2.4 g/cm³ or more, and particularly preferably 2.6 g/cm³ or more, and an upper limit of normally 4.2 g/cm³ or less, preferably 4.0 g/cm³ or less, and particularly preferably 3.8 g/cm³ or less.” EX1004 ¶151. This numeric range overlaps the numeric range of the claims, and therefore anticipates it.

88. Ishigaki also explains “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.” EX1004, ¶25. All of these disclosures describe individual preferred embodiments of Ishigaki in which the compaction density is greater than 3.2 g/cc, namely preferred embodiments with compaction densities of 3.4 g/cc, 3.5 g/cc, and 3.6 g/cc. These disclosures also anticipate the claim limitation.

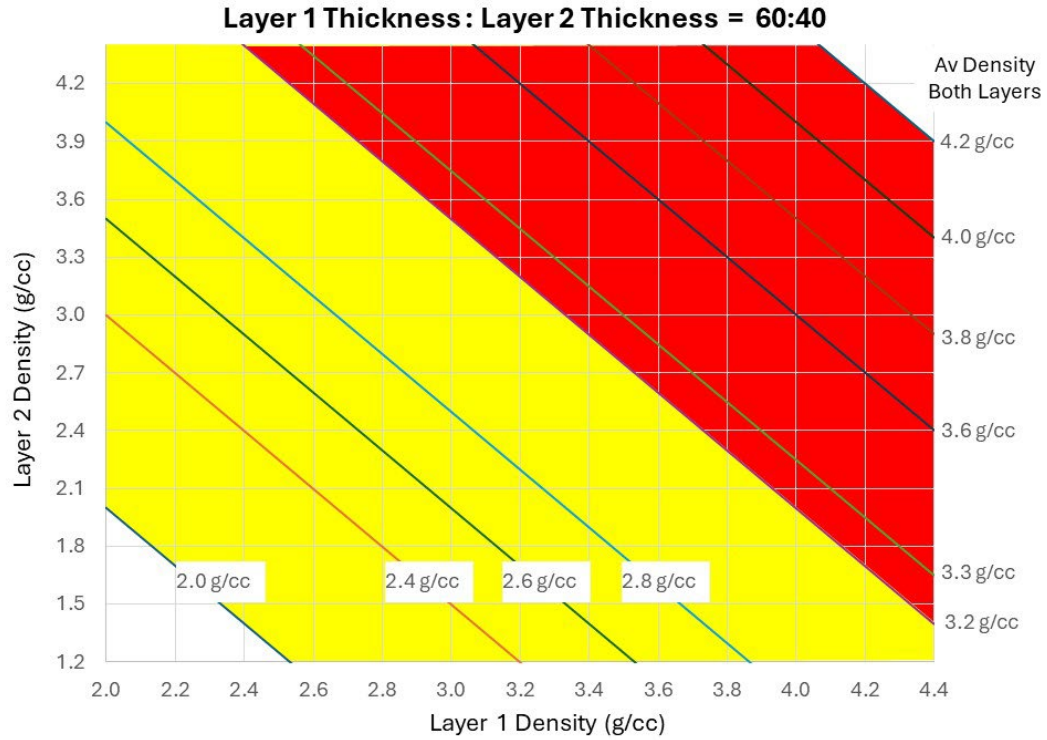
89. I note that there is a physical constraint on the upper possible limit of the density of the Ishigaki cathode layers of 4.4 g/cm³. This is based on the densities of the components (active particles, conductive additive, and polymer binder) in the layer, in the amounts taught by Ishigaki, when the porosity of the layers is zero. Lower densities than this maximum, such as the 2.0 g/cm³ to 4.2 g/cm³ range taught by Ishigaki, are due to the presence of porosity, which adds empty space into the layers.

90. I calculated the maximum density value based on composition ranges for the conductive material, *see* EX1004, ¶¶14, 139, the binder, *see* EX1004, ¶144, and the active material powder, *see* EX1004, ¶150, given by Ishigaki. In particular, I used the compositions of the two layers given in Ishigaki's Example 2, EX1004, ¶366: First Layer ("The active material, conductive material (HS100 made by Denki Kagaku Kogyo), and binder PVdF (Kureha Corporation: KF Polymer L#1120) were weighed and mixed in a weight ratio of 87:8 (as solid content):5"), Second Layer ("This active material: L#1120 of HS100:KF polymer was weighed and mixed so that the weight ratio was 85:10 (as solid content):5"). The density of the active material (lithium nickel manganese cobalt oxide) is 4.8 g/cm³. The densities of the conductive carbon additive is 1.8 g/cm³ and the density of the PVdF binder is also 1.8 g/cm³. The maximum possible density of the first layer of Ishigaki's Example 2 is the composition weighted average of the densities of the component materials: Layer 1 Max Density = $0.87 \times 4.8 + 0.08 \times 1.8 + 0.05 \times 1.8 = 4.4 \text{ g/cm}^3$. The analogous calculation for Ishigaki Example 2, Layer two also gives a maximum density of 4.4 g/cm³, to within the precision specified by Ishigaki.

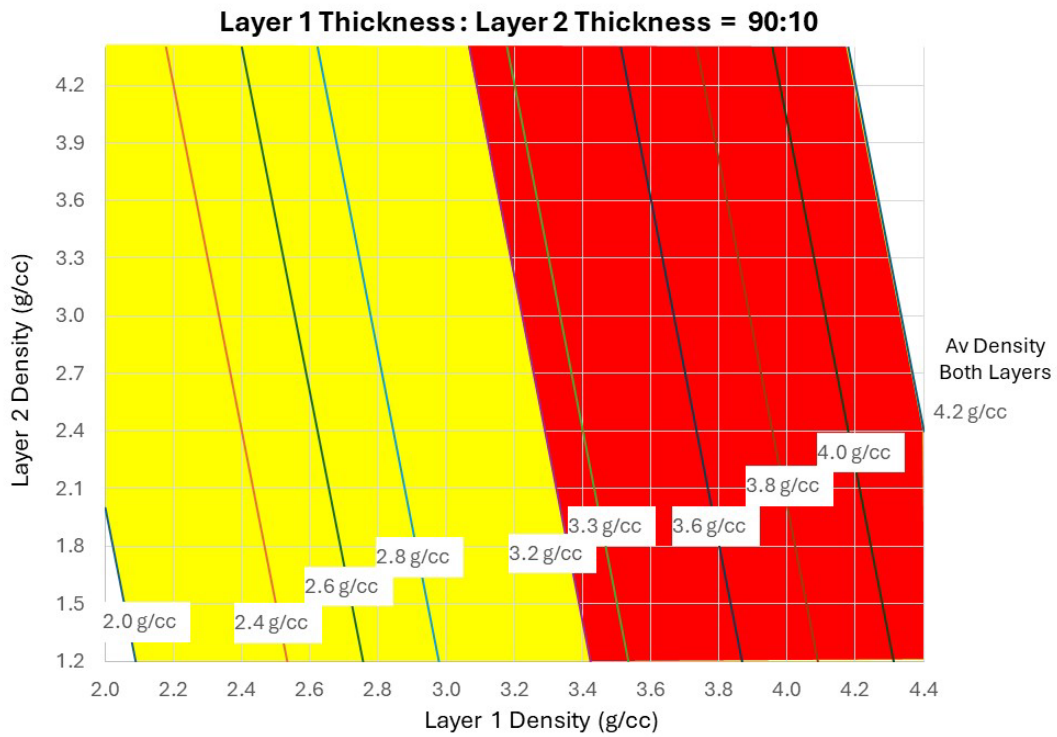
91. This maximum active material layer density is significant because it imposes constraints on the possible densities of the two layers that can combine to produce the Ishigaki's average cathode active material density, for comparison to claim element 1.5 of the '118 patent. The following graphs illustrate combinations

of the two Ishigaki layer densities that yield particular overall cathode average densities, while making sure that no density can be greater than the maximum of 4.4 g/cc.

92. The diagonal lines are made up of combinations of layer 1 density and layer 2 density that combine to give the average density listed for each diagonal line. The first graph is for a case where the thickness ratio of the first layer to the second layer is 60:10, and the second graph is for the case where the thickness ratio of the first layer to the second layer is 90:10. These two thickness ratios bracket the range taught by Ishigaki. EX1004, ¶216. In these graphs, the total colored area (yellow plus red) represents combinations of the first and second layer that satisfy the teaching of Ishigaki regarding overall cathode density. The red area represents combinations of layer densities that are taught by Ishigaki and which also satisfy the constraint of '118 claim 1.5, that the average density is greater than 3.2 g/cc. The red areas of these graphs represent embodiments disclosed by Ishigaki that anticipate the '118 claim element 1.5.



Gido Demonstrative 7.



Gido Demonstrative 8.

93. Although Ishigaki teaches a range of densities, it also directs a POSA to consider the higher density (red) portions of the graphs above by citing the “viewpoint of increasing capacitance density”¹ with higher layer densities. EX1004, ¶25. A POSA would therefore understand that it is advantageous from the perspective of maximizing the energy density of the electrode to work in the higher density ranges taught by Ishigaki, i.e., the red portions of the graphs which anticipate ’118 claim element 1.5.

94. Even if one were to interpret the “electrode density” described in Ishigaki to refer to the total density of the entire electrode including both the current collector and the layers containing the active materials (instead of that of just the active materials layers containing the active materials), Ishigaki at least teaches that the total density of the entire electrode can be 3.2 g/cc and greater. Given the known density of the aluminum foil used as the current collector is 2.7 g/cc, which is less than the 3.2 g/cc. Therefore, for the total average density of the

¹ The use of the word “capacitance” here is an obvious clerical error, likely resulting from the translator’s unfamiliarity with technical terms. A POSA would immediately recognize that Ishigaki is not referring to capacitance, which is a separate electrical property not discussed in Ishigaki. “Capicitanace density” is nonsense. Ishigaki is referring to battery *capacity*, or increasing energy density.

entire electrode structure to be at least 3.2 g/cc, the other layers (layers containing active material) of the electrode must have a greater density than 3.2 g/cc.

Consequently, if the current collector is included in the “electrode density,”

Ishigaki’s teaching indicates that the density of the active material containing layers on the current collector must be greater than 3.2 g/cc to compensate for the less dense current collector.

8. Claim 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.

95. Ishigaki discloses that the combined thickness of the first and second layers is between 10 and 200 microns. EX1004, ¶25 (“The thickness of the positive electrode active material layer is usually about 10 to 200 um.”).

96. Ishigaki also teaches how this total cathode layer thickness is to be divided between the first and second active material layers. EX1004, ¶216 (“The thickness ratio of the first positive electrode active material layer and the second positive electrode active material layer is normally 60:40, and because the second positive electrode active material has a higher bulk density than the first active material, in order to obtain a high energy density, the thickness ratio is preferably 70:30, more preferably 80:20, and particularly preferably 90:10.”)

97. Therefore, Ishigaki teaches that at a minimum the thickness of the first active material layer is 60% of the total active material thickness, which is 60% of 10 to 200 μm , or 6 to 120 μm .

98. Ishigaki teaches that it is “particularly preferabl[e]” for 90% of the total active material thickness to reside in the first active material layer. Ishigaki teaches that this is done “in order to obtain a high energy density.” Therefore, Ishigaki’s preferred embodiment has a first layer thickness, which is 90% of 10 to 200 μm , or 9 to 180 μm .

99. Ishigaki also teaches that “a volume ratio of the positive electrode active material having a particle diameter of 5 μm or more is 10 vol% or less,” [0014] which is the same as teaching that Dv90 of the active material particles is 5 μm .

100. Thus, Ishigaki teaches that Dv90 of the active material particles is smaller than the smallest possible first layer thickness (6 μm), and smaller than the most preferable smallest first layer thickness (9 μm).

101. Therefore, Ishigaki teaches that Dv90 of the active material particles is smaller than the first layer thickness, satisfying the limitations of claim 1. Ishigaki therefore anticipates claim 2.

9. Claim 3. The electrode according to claim 1, 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.

102. Claim 3 of the '118 patent refers to an “average particle size.” The '118 patent specification makes it clear that the claim means Dv50 when it says average particle size. *See* EX1001, 1:60-63 (“The average particle size (Dv50) refers to a particle size that reaches a volume accumulation of 50% from the small particle size side in a volume-based granularity distribution.”).

103. Ishigaki uses the term “median diameter” rather than average, when describing the general size of its particles. *See* EX1004, Claim 8, ¶14.

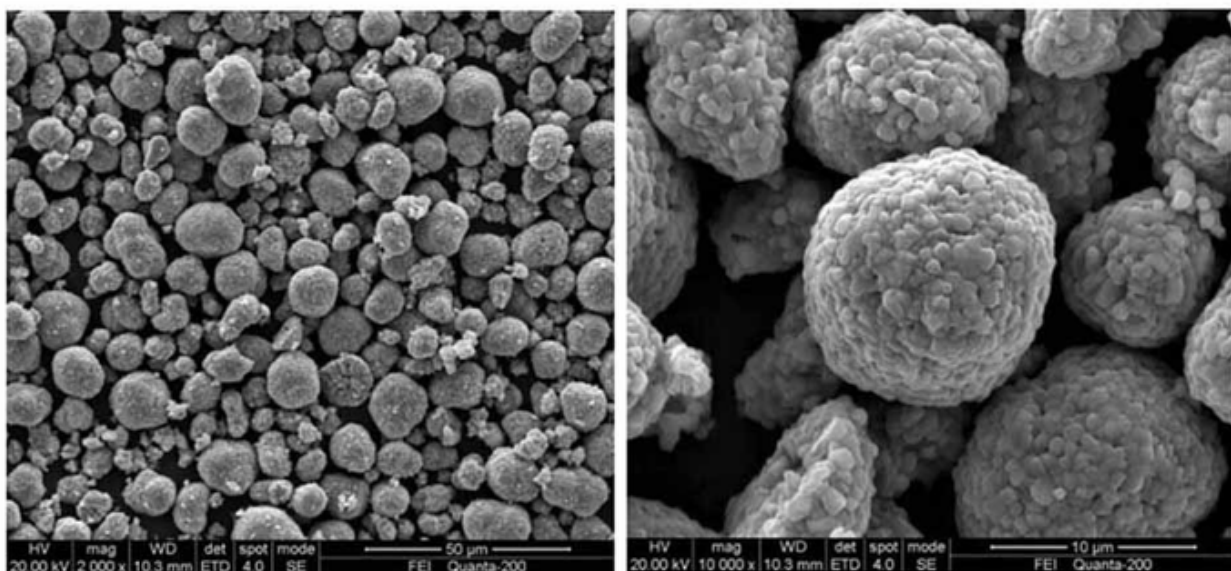
104. A POSA would equate “median” with the middle value of a distribution, but would need to know whether that distribution was weighted by number, volume, or mass.

105. Ishigaki states 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.” EX1004, ¶¶39, 184, 342. The laser diffraction technique for measuring particle sizes is sensitive to the volume of the particles, and it therefore gives volume based cumulative averages such as Dv50 and Dv90.

106. A POSA understands that a median diameter measured by laser diffraction is the same thing as Dv50.

107. Ishigaki also refers to an “average diameter” of primary particles, using a technique of measuring a number of individual particles seen in electron microscope (SEM) images. EX1004, ¶¶41, 185.

108. To help understand how the average particle size might describe different properties at different scales, it is helpful to visualize what the active material looks like at the micron level. Below are scanning electron microscope (SEM) images of lithium nickel manganese cobalt oxide powder of the type used by both Ishigaki and the '118 patent:



EX1013.

109. The image on the left is at 2000x magnification, and the image on the right is a higher magnification (10,000x) of a small part of the image on the left. In the higher magnification image, it is clear that the larger (secondary) particles are made up of aggregates of much smaller, primary particles. The SEM images

include scale bars that give sizes in micrometers. By comparison to the scale bars, it can be seen that in this particular active material powder the secondary (aggregate) particles are about 10 μm in size, while the primary particles are smaller by a factor of about 20. This image is provided as a general illustration of the meaning of primary and secondary particles. It does not correspond to any specific material claimed or used by Ishigaki or the '118 patent.

110. The laser diffraction technique, taught by Ishigaki, for measuring particle size only detects and measures the larger secondary (aggregate) particles. These measurements of the secondary particles give cumulative average values Dv50 and Dv90 that correspond to the values claimed in the '118 patent.

111. A POSA would readily understand that secondary particles are the aggregates of the primary particles, and are the relevant comparison to the particle size recited in the '118 patent.

112. Ishigaki teaches the use of laser-light scattering to get the secondary particle median diameter and Dv90. EX1004, ¶39.

113. Comparatively, the '118 patent teaches the use of cumulative volume averages to obtain Dv50 and Dv90.

114. A POSA knows that the way to measure these volume-related parameters is to use laser light scattering, which inherently gives sizes on a volume-weighted basis, and which inherently treats an aggregate of primary

particles as a single object: a secondary particle. Therefore, Ishigaki's analysis of primary particles using SEM is not relevant to the '118 patent claims.

115. The parameters disclosed in Ishigaki thus reveal sufficient information for a POSA to determine the volume-based Dv50 and Dv90 for the secondary particles. These numbers are comparable to the Dv50 and Dv90 recited in the '118 patent (with Dv50 being the "average particle size" recited in claim 3). From these numbers, a POSA could easily determine the claimed ratio.

116. Accordingly, Ishigaki discloses an electrode according to claim 1, and further recites the average particle size ratio in claim 3. For instance, Ishigaki claim 3 recites that the median diameter of the positive electrode active material is 0.1 – 5 μm . EX1004, ¶¶14, 37. Ishigaki claim 7 recites that the first positive electrode mixture layer comprises the positive electrode active material, and has a smaller particle diameter than the second active material in the second layer. *See* EX1004, Claim 7 ("a second positive electrode mixture layer comprising a second positive electrode active material having a larger particle diameter than the first positive electrode active material"). Ishigaki goes on to recite, in claim 8, that the median particle diameter of the second positive electrode active material is between 6 and 20 μm . *See* EX1004, ¶¶14, 182. The ratios of the second material to the first material are therefore 6:5 (or 1.2:1) to 20:0.1 (or 200:1).

117. Taking as an example Ishigaki's most-preferred ranges, i.e., 1.2 μm to 2.5 μm (first material) and 9 μm to 15 μm (second material), EX1004, ¶¶37, 182 Ishigaki discloses a ratio of the average particle size of the second material to the average particle size of the first material that ranges from a maximum of 12.5:1 (15 μm , the upper end of Ishigaki's most-preferred range for the second material's median particle diameter, divided by 1.2 μm , the lower end of Ishigaki's most-preferred range for the first material's median particle diameter, to a minimum of 3.6:1 (9 μm , the lower end of Ishigaki's most-preferred range for the second material's median particle diameter, divided by 2.5 μm , the upper end of Ishigaki's most-preferred range for the first material's median particle diameter), both of which fall within the claimed range of 1:1 to 40:1. Ishigaki's numeric range overlaps the claimed range (indeed, it almost entirely subsumes the claimed range) and therefore anticipates it.

10. Claim 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 .

118. Ishigaki discloses a median diameter of the first active material (Dv50) of 0.1 to 5 μm . Ishigaki. *See* EX1004, ¶¶14, 37; *see also* Section XI.A.7 (analysis of Ishigaki's disclosure of median particle size for claim 3). I have already established *supra* that Ishigaki's median particle size is Dv50, and the "average particle size" in the '118 patent claims is also Dv50.

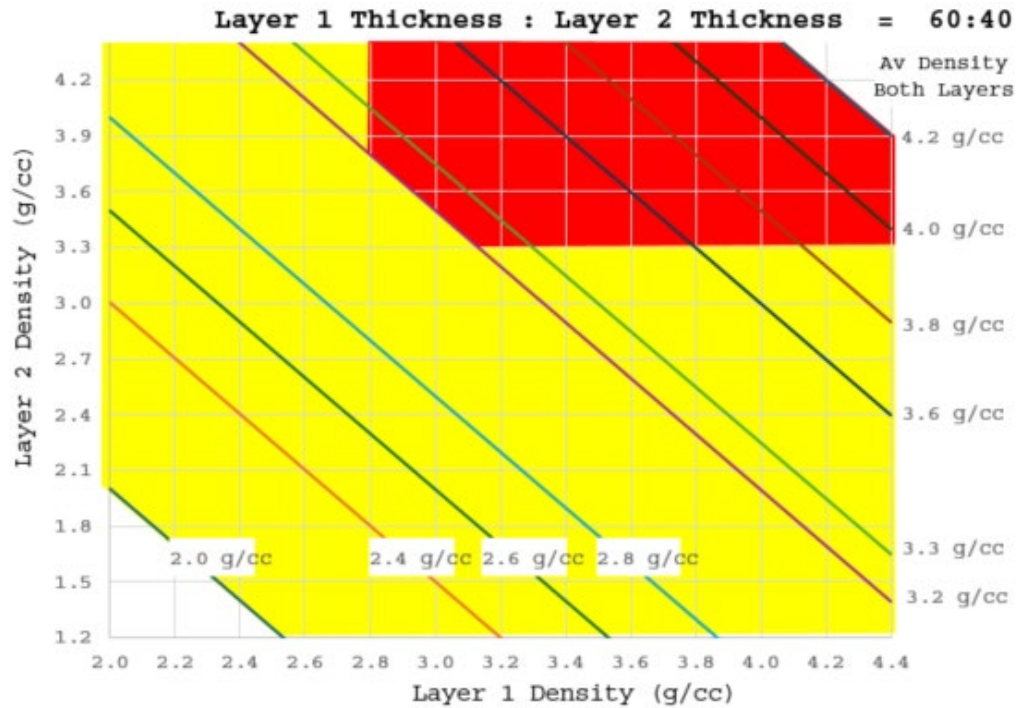
119. At least some of Ishigaki's compositions with Dv50 of 0.1 to 5 μm will necessarily have an average particle size in a range of 0.2 μm to 15 μm . For example, an Ishigaki composition with a first active material "median diameter" (Dv50) of 2 μm corresponds to the '118 patent first material "average particle size" (also Dv50) of 2 μm , and will necessarily have an average particle size in a range of 0.2 μm to 15 μm .

120. Ishigaki therefore inherently anticipates claim 4.

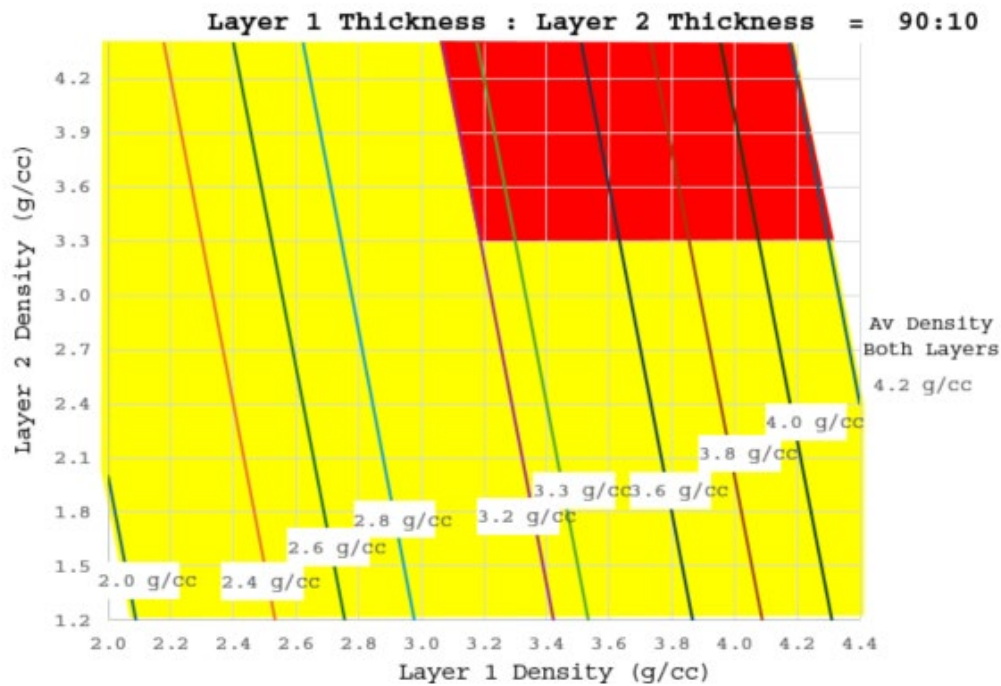
11. Claim 5. The electrode according to claim 1, wherein a compaction density of the first layer is greater than 2.8 g/cc, and a compaction density of the second layer is greater than 3.3 g/cc.

121. Ishigaki also discloses that the electrode mixture can have a compaction density (density after pressing of the positive electrode) between 2.0 g/cm³ and 4.2 g/cm³. EX1004, ¶¶25, 151. As discussed *supra* (Section XI.A.7), this leads to a range of combinations for the individual densities of layers 1 and 2, which are represented graphically below for Ishigaki's cases where the thickness ratio of the first and the second layer are 60:40 and 90:10. As discussed above, the total colored area (yellow plus red) represents combinations of the two layer densities that follow the teachings of Ishigaki, in that they yield average combined densities ranging from 2.0 to 4.2 g/cc. The red regions in these graphs represent combinations of the two layer densities, which are taught by Ishigaki, and which anticipate '118 claim 5 because the first layer density is greater than 2.8 g/cc and

the second layer density is greater than 3.3 g/cc (and also satisfy the limitations of '118 claim 10.5 in that they have an average density greater than 3.2 g/cc).



Gido Demonstrative 9.



Gido Demonstrative 10.

122. Although Ishigaki teaches a range of densities, it also directs a POSA to consider the higher density (red) portions of the graphs above by citing the “viewpoint of increasing capacitance density”² with higher layer densities. EX1004, ¶25.

123. A POSA would therefore understand that it is advantageous from the perspective of maximizing the energy density of the electrode to work in the higher density ranges taught by Ishigaki, i.e., the red portions of the graphs which anticipate ’118 claim 5 because the density of layer 1 is greater than 2.8 g/cc and the density of layer 2 is greater than 3.3 g/cc.

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

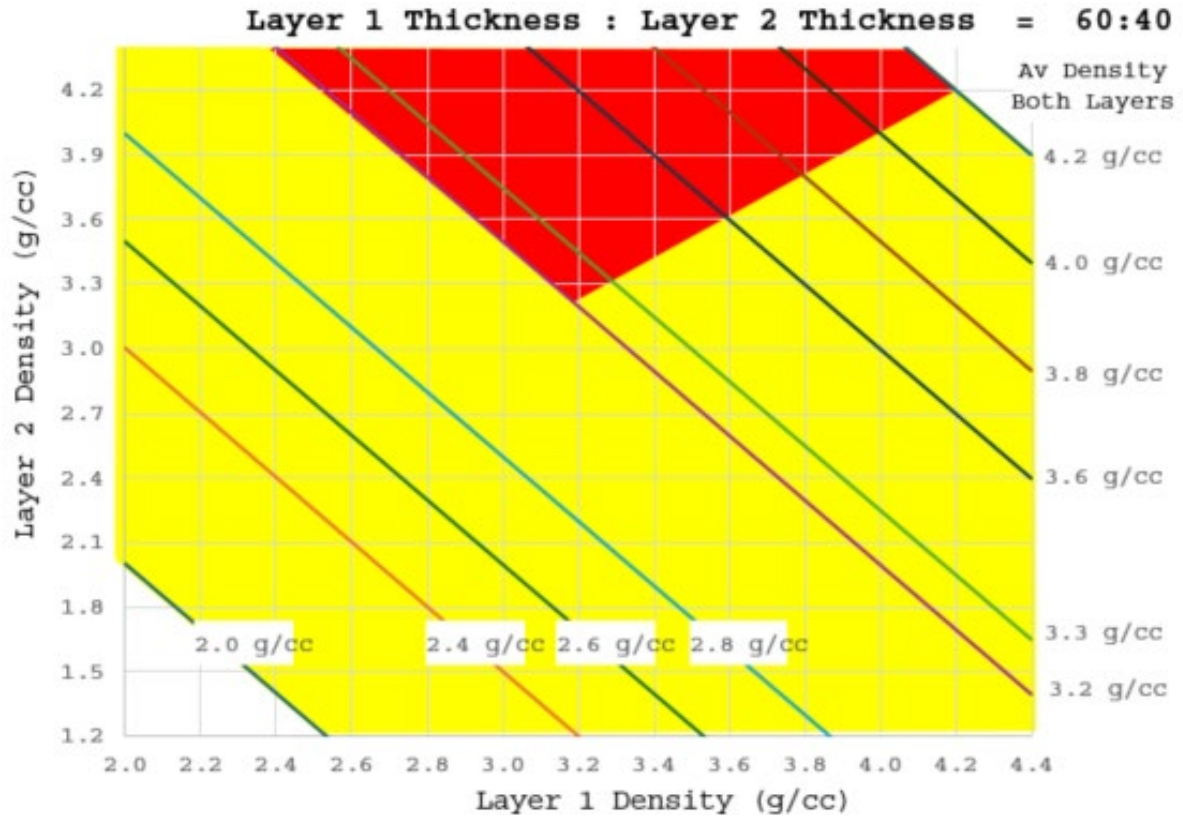
124. Ishigaki discloses that “[t]he thickness ratio of the first positive electrode active material layer and the second positive electrode active material layer is normally 60:40, and because the second positive electrode active material has a higher bulk density than the first active material, in order to obtain a high energy density, the thickness ratio is preferably 70:30, more preferably 80:20, and particularly preferably 90:10.” EX1004, ¶216 (emphasis added). In the context of this statement about adjusting layer thicknesses to control energy density, it would be clear to a POSA that the “bulk density” of “first active

² See n.1, *supra*.

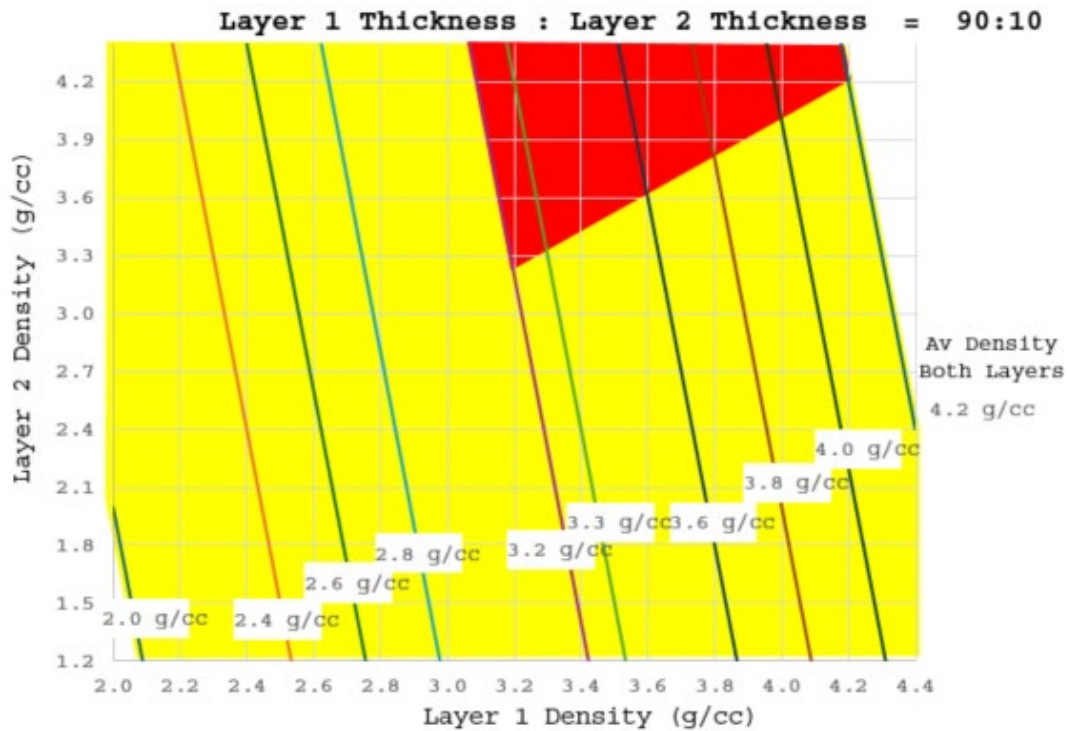
material” and “second active material” in this statement is a proxy for the compaction densities of the first and second layers, including all the components in those layers, not just the lithium containing active material powders. That is because the bulk density ratios are disclosed as a means for obtaining a high energy density in the final product, and Ishigaki’s teaching that the second layer has a higher compaction density than the first layer is part of the effort to achieve a high energy density. Therefore, Ishigaki teaches that the first layer has a lower bulk density than the second layer.

125. In the graphs below the colored regions (yellow and red) illustrate combinations of first and second layer densities that follow the teachings of Ishigaki regarding the range of average (over both layers) densities from 2.0 g/cc to 4.2 g/cc. The red region of the graph are combinations of layer densities that follow the additional teaching of Ishigaki, EX1004, ¶216, that the second layer density is greater than the first (and also satisfy the limitations of ’118 claim 5 in that they have an average density greater than 3.2 g/cc), which anticipates ’118 claim 6.

126. Ishigaki therefore inherently anticipates claim 6.



Gido Demonstrative 11.



Gido Demonstrative 12.

- 13. Claim 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.**

127. Ishigaki discloses that the first material in the first layer is lithium nickel cobalt manganese oxide (LiNiMnCoO_2). EX1004, ¶27; *see also* EX1004, Claims 5, 9.

128. Ishigaki therefore discloses a composition selected from the recited group, which anticipates the Markush group.

- 14. Claim 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.**

129. Ishigaki discloses that the second material in the second layer is also lithium nickel cobalt manganese oxide (LiNiMnCoO_2). EX1004, Claim 9, ¶27; *see also* EX1004, claim 5.

130. Ishigaki therefore discloses a composition selected from the recited group, which anticipates the Markush group.

- 15. Claim 9. The electrode according to claim 1, 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.**

131. Ishigaki discloses a first material comprising natural graphite or artificial graphite, soft carbon and hard carbon. *See* EX1004, Claim 6, ¶110 (“[S]pecific examples include... graphite (graphite) such as natural graphite and artificial graphite, carbon black such as acetylene black”). Ishigaki therefore anticipates claim 9. Note that soft carbon and hard carbon, as recited in the claim, are different grades of carbon black. *See generally* EX1025; EX1026; EX1027; EX1028. Acetylene black, as taught by Ishigaki, is a particular form of hard carbon, carbon black. *See* EX1020.

132. Ishigaki therefore anticipates claim 9.

- B. 10.P. An electrochemical device, comprising an electrode, wherein the electrode comprises:**

133. Ishigaki discloses an electrochemical device (namely, a Li-ion battery) that comprises an electrode. *See* EX1004, Abstract. Ishigaki further discloses “(1) A positive electrode for a lithium secondary battery comprising, on a current collector foil, an electrode mixture” EX1004, ¶14. This is the same kind of electrochemical device used in the same context for the same purpose as the ’118 patent.

1. 10.1: a current collector;

134. Ishigaki discloses that the electrode comprises a current collector foil as ‘a current collector.’ *See* EX1004, ¶14. This is the same recited current collector of limitation 10.1.

2. 10.2: a first layer comprising a first material; and;

135. Ishigaki discloses that the electrode comprises an electrode mixture on a current collector foil. *See* EX1004, ¶14 (“A positive electrode for a lithium secondary battery comprising, on a current collector foil, an electrode mixture comprising a positive electrode active material . . .”). The electrode mixture comprises a first positive electrode mixture layer, which is the first layer of claim 1.2. EX1004, ¶¶153, 347, 348. The first positive electrode mixture layer, in turn, comprises a first positive electrode active material, which is the first material of claim 10.2. EX1004, ¶153 (disclosing a first positive electrode mixture layer containing a first positive electrode active material on the current collector).

3. 10.3: a second layer comprising a second material;

136. Ishigaki discloses that the electrode mixture comprises a second positive electrode mixture layer. EX1004, ¶153. This is the second layer of claim 1.3. Ishigaki further discloses “a second positive electrode mixture layer containing a second positive electrode active material.” EX1004, ¶14. This is the second material in the second layer of claim 10.3.

4. 10.4.1: wherein the first layer is arranged between the current collector and the second layer,

137. Ishigaki discloses that the first and second positive electrode mixture layers are sequentially laminated on the current collector foil. EX1004, ¶153; *see also* EX1004, ¶14 (“[A] second positive electrode mixture layer containing a second positive electrode active material having a particle diameter larger than that of the first positive electrode active material are sequentially laminated and formed on the current collector.”); *see also* EX1004, ¶366 (describing the first layer in between the current collector and second layer). Therefore, the Ishigaki discloses that the first layer is arranged between the current collector and the second layer.

138. Additionally, Ishigaki explains that “[a]ctive material 1 was used as the active material of the positive electrode for the first layer. . . . Active material 3 was used as the active material of the positive electrode for the second layer. . . .” EX1004, ¶366. “Next, slurry 1 was coated on one side and dried on an aluminum foil (thickness: 15 μ m) as a collector foil with a doctor blade. Then the slurry 2 was applied on one side with a doctor blade and dried.” *Id.* This order of operations confirms that the resulting layer configuration is for the first layer to be arranged between the current collector and the second layer.

5. 10.4.2: the first layer is formed on a surface of the current collector,

139. Ishigaki discloses that the first positive electrode mixture layer is formed by applying a slurry of the first positive electrode active material on a

surface of the current collector foil. EX1004, ¶366. Therefore, Ishigaki discloses that the first layer is formed on a surface of the current collector.

140. More specifically, Ishigaki explains:

As the active material of the positive electrode for the first layer, (active material 1) was used

The active material, conductive material (HS100 made by Denki Kagaku Kogyo), and binder PVdF (Kureha Corporation: KF Polymer L#1120) were weighed and mixed in a weight ratio of 87:8 (as solid content):5, and N-methylpyrrolidone (NMP) was further added so that the solid content ratio was 45% by mass, and a uniform slurry 1 was prepared using a planetary centrifugal mixer...

Next, the slurry 1 was applied and dried on one side of aluminum foil (thickness 15 μm) of the current collecting foil using a doctor blade.”

EX1004, ¶366.

6. 10.4.3: and a particle size of 90% accumulative volume of the first active material is less than 40 μm ,

141. 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); 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 .

142. More specifically, Ishigaki discloses that “[a] 90% cumulative diameter (D_{90}) of the secondary particles of the lithium transition metal compound powder of the present invention is usually 10 μm or less, preferably 8 μm or less, more preferably 6 μm or less, and most preferably 5 μm or less, usually 0.5 μm or more, preferably 0.8 μm or more, more preferably 1 μm , and most preferably 1.5 μm or more.” EX1004, ¶38.

143. Ishigaki’s statement “cumulative diameter (D_{90})” may be alleged to be, by itself, insufficient to establish that the parameter Ishigaki is teaching corresponds to D_v90 . There are multiple ways of “accumulating” the particle size distribution to obtain an average diameter. This could be done on a number basis (counting all particles, no matter how large or small equally), or it could be done on a mass basis (counting heavier particles more according to their weight). D_v90 is an accumulation based on the volume of the particles. These different accumulation averages do not necessarily yield the same number values.

144. Ishigaki teaches that “the median diameter, as the average particle diameter, and the 90% cumulative diameter (D_{90}) are measured by a well-known laser diffraction/scattering particle size distribution measuring device.” 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 $Dv90$.

145. Other sections of Ishigaki describe particle sizes of D_{90} (i.e., $Dv90$) $\leq$ 5 microns. *See, e.g.*, EX1004, ¶¶14, 40, 346. These are all disclosures of a particle size of 90% accumulative volume of the first active material that is less than 40 μm .

7. 10.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

146. The maximum density of the Ishigaki cathode layers is constrained by the densities of its components—active material, conductive additive, and binder—resulting in a theoretical upper limit of 4.4 g/cm³ when porosity is zero. This density is derived from the weight ratios of these components in Ishigaki's Example 2. The density of the active material is 4.8 g/cm³, and the densities of both the conductive carbon and the binder are 1.8 g/cm³. The presence of porosity lowers the overall density, with Ishigaki teaching a range of 2.0 to 4.2 g/cm³. The calculations and graphs provided below demonstrate that combinations of the two layers can achieve densities greater than 3.2 g/cm³, with the red areas highlighting the higher density ranges Ishigaki emphasizes for maximizing energy density. These ranges are consistent with and anticipate “a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.”

147. Ishigaki discloses treating the electrode mixture by pressure to increase the packing density of the positive electrode materials. EX1004, ¶24 (“In order to increase the packing density of the positive electrode active material, the positive electrode active material layer obtained by coating and drying is preferably consolidated by a hand press, a roller press, or the like.”). The density that results from this treatment is compaction density.

148. Ishigaki also discloses that the electrode mixture can have a compaction density (density after pressing of the positive electrode) between 2.0 g/cm³ and 3.6 g/cm³. EX1004, ¶25. Specifically, Ishigaki discloses “[t]he electrode density of the positive electrode after pressing has a lower limit of normally 2.0 g/cm³ or more, preferably 2.4 g/cm³ or more, and particularly preferably 2.6 g/cm³ or more, and an upper limit of normally 4.2 g/cm³ or less, preferably 4.0 g/cm³ or less, and particularly preferably 3.8 g/cm³ or less.” EX1004, ¶151. This numeric range overlaps the numeric range of the claims, and therefore anticipates it.

149. Ishigaki also explains “[t]he 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.” EX1004, ¶25. All of these disclosures describe individual preferred embodiments of Ishigaki in which the compaction density is greater than 3.2 g/cc,

namely preferred embodiments with compaction densities of 3.4 g/cc, 3.5 g/cc, and 3.6 g/cc. These disclosures also anticipate the claim limitation.

150. I note that there is a physical constraint on the upper possible limit of the density of the Ishigaki cathode layers of 4.4 g/cm³. This is based on the densities of the components (active particles, conductive additive, and polymer binder) in the layer, in the amounts taught by Ishigaki, when the porosity of the layers is zero. Lower densities than this maximum, such as the 2.0 g/cm³ to 4.2 g/cm³ range taught by Ishigaki, are due to the presence of porosity, which adds empty space into the layers.

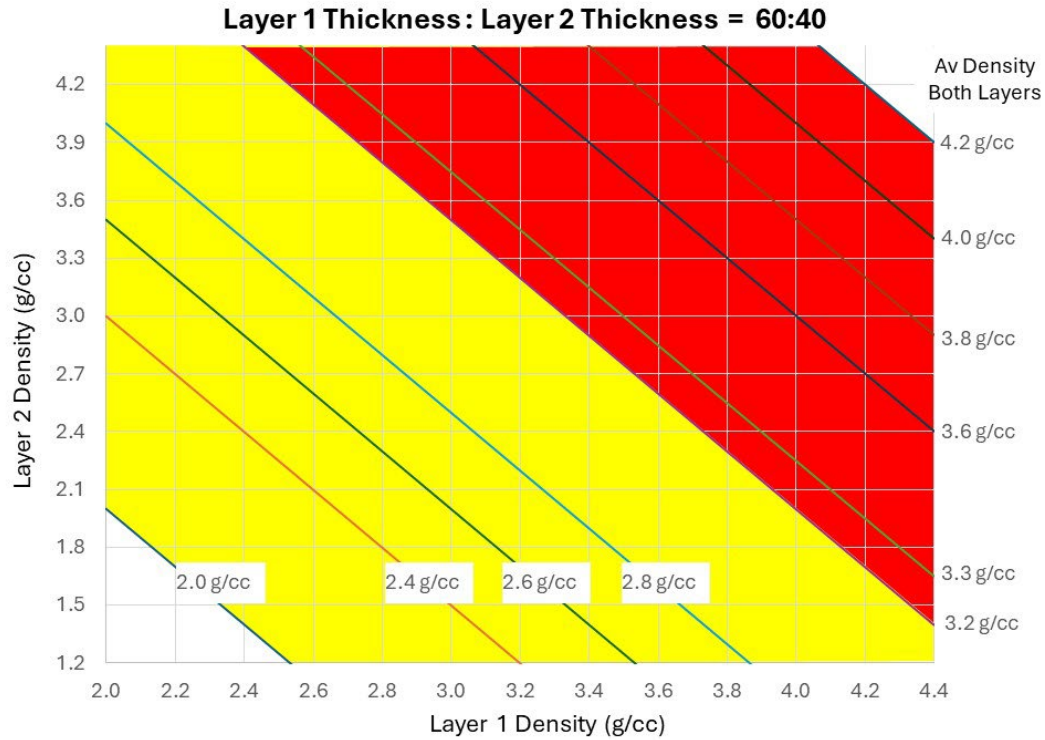
151. I calculated the maximum density value based on composition ranges for the conductive material, EX1004, ¶¶14, 139, the binder, EX1004, ¶144, and the active material powder, EX1004, ¶150, given by Ishigaki. In particular, I used the compositions of the two layers given in Ishigaki's Example 2, EX1004, ¶366: First Layer ("The active material, conductive material (HS100 made by Denki Kagaku Kogyo), and binder PVdF (Kureha Corporation: KF Polymer L#1120) were weighed and mixed in a weight ratio of 87:8 (as solid content):5"), Second Layer ("This active material: L#1120 of HS100:KF polymer was weighed and mixed so that the weight ratio was 85:10 (as solid content):5"). The density of the active material (lithium nickel manganese cobalt oxide) is 4.8 g/cm³. The densities of the conductive carbon additive is 1.8 g/cm³ and the density of the PVdF binder is also

1.8 g/cm³. The maximum possible density of the first layer of Ishigaki's Example 2 is the composition weighted average of the densities of the component materials:

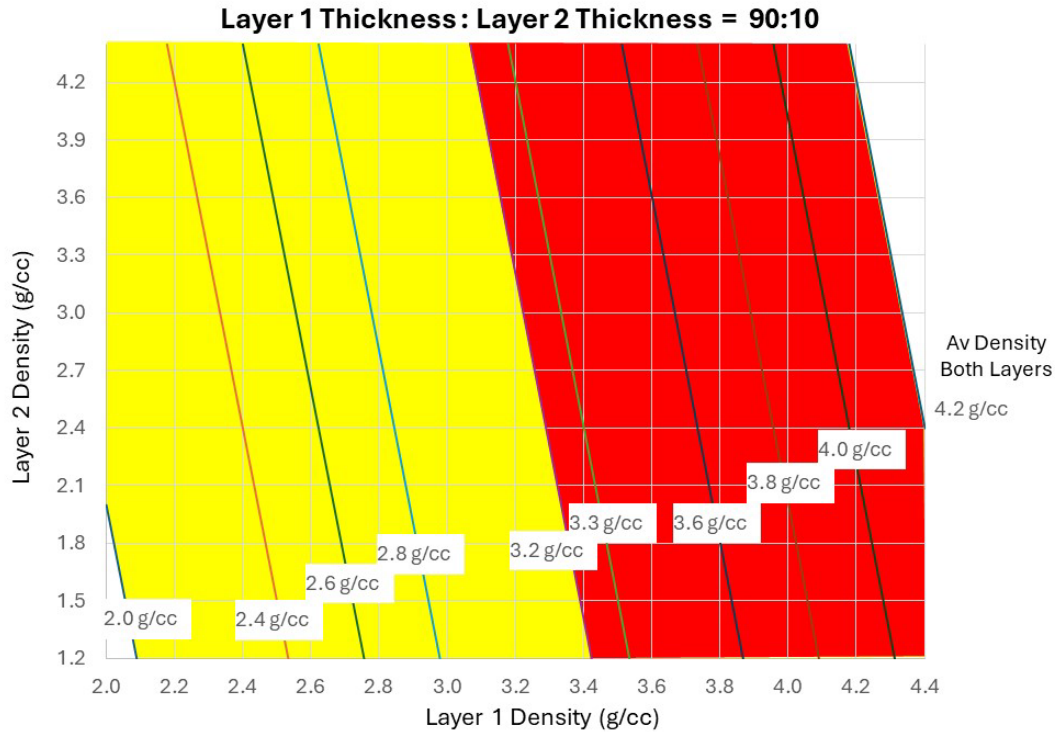
Layer 1 Max Density = $0.87 \times 4.8 + 0.08 \times 1.8 + 0.05 \times 1.8 = 4.4$ g/cm³. The analogous calculation for Ishigaki Example 2, Layer two also gives a maximum density of 4.4 g/cm³, to within the precision specified by Ishigaki.

152. This maximum active material layer density is significant because it imposes constraints on the possible densities of the two layers that can combine to produce the Ishigaki average cathode active material density, for comparison to claim element 10.5 of the '118 patent. The following graphs illustrate combinations of the two Ishigaki layer densities that yield particular overall cathode average densities, while making sure that no density can be greater than the maximum of 4.4 g/cc. The diagonal lines are made up of combinations of layer 1 density and layer 2 density that combine to give the average density listed for each diagonal line. The first graph is for a case where the thickness ratio of the first layer to the second layer is 60:10, and the second graph is for the case where the thickness ratio of the first layer to the second layer is 90:10. These two thickness ratios bracket the range taught by Ishigaki. EX1004, ¶216. In these graphs, the total colored area (yellow plus red) represents combinations of the first and second layer that satisfy the teaching of Ishigaki regarding overall cathode density. The red area represents combinations of layer densities that are taught by Ishigaki and which

also satisfy the constraint of '118 claim element 10.5, that the average density is greater than 3.2 g/cc. The red areas of these graphs represent disclosures by Ishigaki that anticipate the '118 claim element 10.5.



Gido Demonstrative 13.



153. Although Ishigaki teaches a range of densities, it also directs a POSA to consider the higher density (red) portions of the graphs above by citing the “viewpoint of increasing capacitance density”³ with higher layer densities. EX1004, ¶25. A POSA would therefore understand that it is advantageous from the perspective of maximizing the energy density of the electrode to work in the higher density ranges taught by Ishigaki, i.e., the red portions of the graphs which anticipate ’118 claim element 10.5.

154. Even if one were to interpret the “electrode density” described in Ishigaki to refer to the total density of the entire electrode including both the

³ See n.1, *supra*.

current collector and the layers containing the active materials (instead of that of just the layers containing the active materials), Ishigaki at least teaches that the total density of the entire electrode can be 3.2 g/cc and greater. The known density of the aluminum foil used as the current collector is 2.7 g/cc, which is less than the 3.2 g/cc. Therefore, for the total average density of the entire electrode structure to be at least 3.2 g/cc, the other layers (layers containing active material) of the electrode must have a greater density than 3.2 g/cc.

155. Consequently, if the current collector is included in the “electrode density,” Ishigaki’s teaching indicates that the density of the active material containing layers on the current collector must be greater than 3.2 g/cc to compensate for the less dense current collector.

8. Claim 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.

156. Ishigaki discloses that the combined thickness of the first and second layers is between 10 and 200 microns. EX1004, ¶25 (“The thickness of the positive electrode active material layer is usually about 10 to 200 um.”). Ishigaki also teaches how this total cathode layer thickness is to be divided between the first and second active material layers. EX1004, ¶216 (“The thickness ratio of the first positive electrode active material layer and the second positive electrode active material layer is normally 60:40, and because the second positive electrode active

material has a higher bulk density than the first active material, in order to obtain a high energy density, the thickness ratio is preferably 70:30, more preferably 80:20, and particularly preferably 90:10.”).

157. Therefore, Ishigaki teaches that at a minimum the thickness of the first active material layer is 60% of the total active material thickness, which is 60% of 10 to 200 μm , or 6 to 120 μm . Ishigaki teaches that it is “particularly preferabl[e]” for 90% of the total active material thickness to reside in the first active material layer. Ishigaki teaches that this is done “in order to obtain a high energy density.”

158. Therefore, Ishigaki’s preferred embodiment has a first layer thickness, which is 90% of 10 to 200 μm , or 9 to 180 μm .

159. Ishigaki also teaches that “a volume ratio of the positive electrode active material having a particle diameter of 5 μm or more is 10 vol% or less,” [0014] which is the same as teaching that Dv90 of the active material particles is 5 μm .

160. Thus Ishigaki teaches that Dv90 of the active material particles is smaller than the smallest possible first layer thickness (6 μm), and smaller than the most preferable smallest first layer thickness (9 μm).

161. Therefore, Ishigaki teaches that Dv90 of the active material particles is smaller than the first layer thickness, satisfying the limitations of claim 11.

162. Ishigaki therefore anticipates claim 11.

9. **Claim 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.**

163. The claims of Ishigaki recite an electrochemical device according to claim 10, and further recite the average particle size ratio claimed. *see also* Section X1.A.7 (analysis of Ishigaki's disclosure of median particle size for claim 3). Ishigaki claim 3 recites that the median diameter of the positive electrode active material is 0.1 to 5 μm .

164. Ishigaki claim 3 recites that the median diameter of the positive electrode active material is 0.1 – 5 μm . EX1004, ¶¶14, 37. Ishigaki claim 7 recites that the first positive electrode mixture layer comprises the positive electrode active material, and has a smaller particle diameter than the second active material in the second layer. *See* EX1004, Claim 7 (“a second positive electrode mixture layer comprising a second positive electrode active material having a larger particle diameter than the first positive electrode active material”). Ishigaki goes on to recite, in claim 8, that the median particle diameter of the second positive electrode active material is between 6 and 20 μm . The ratios of the second material to the first material are therefore 6:5 (or 1.2:1) to 20:0.1 (or 200:1).

165. Taking as an example Ishigaki's most-preferred ranges, i.e., 1.2 μm to 2.5 μm (first material) and 9 μm to 15 μm (second material), Ishigaki discloses a ratio of the average particle size of the second material to the average particle size

of the first material that ranges from a maximum of 12.5:1 (15 μm , the upper end of Ishigaki's most-preferred range for the second material's median particle diameter, divided by 1.2 μm , the lower end of Ishigaki's most-preferred range for the first material's median particle diameter) to a minimum of 3.6:1 (9 μm , the lower end of Ishigaki's most-preferred range for the second material's median particle diameter, divided by 2.5 μm , the upper end of Ishigaki's most-preferred range for the first material's median particle diameter), both of which fall within the claimed range of 1:1 to 40:1. This numeric range overlaps the claimed range (indeed, it almost entirely subsumes the claimed range) and therefore anticipates it.

10. Claim 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 .

166. Ishigaki discloses a median diameter of the first active material (Dv50) of 0.1 to 5 μm . EX1004, ¶¶14, 37; *see also* Section X1.A.7 (analysis of Ishigaki's disclosure of median particle size for claim 3). I have already established *supra* that Ishigaki's median particle size is Dv50, and the "average particle size" in the '118 patent claim is also Dv50.

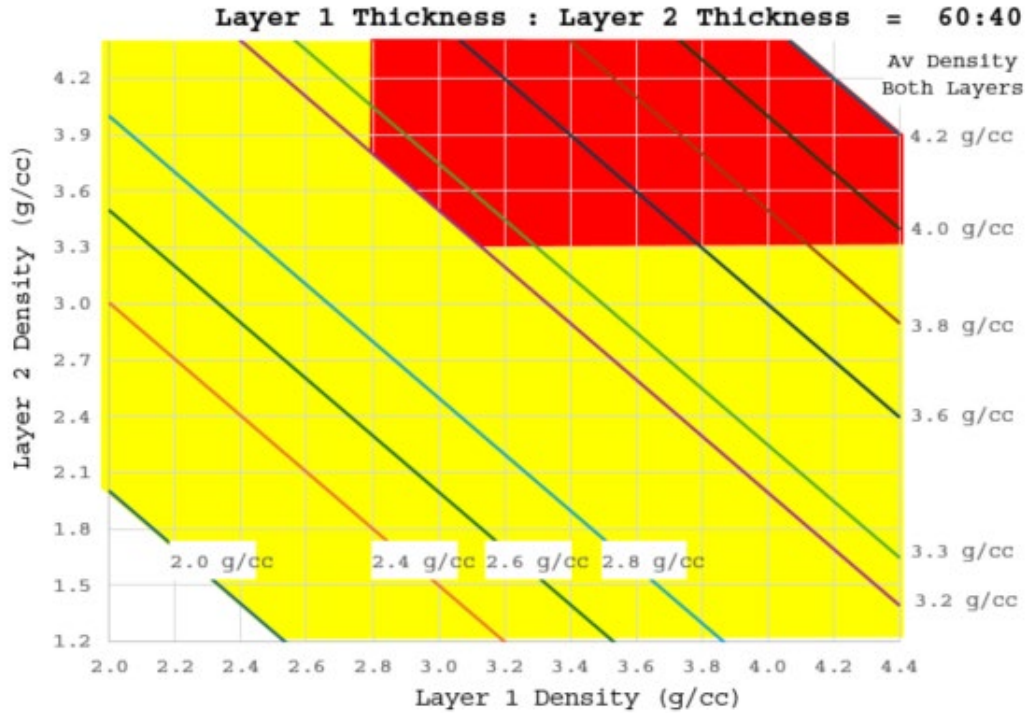
167. At least some of Ishigaki's compositions with Dv50 of 0.1 to 5 μm will necessarily have an average particle size in a range of 0.2 μm to 15 μm . For example, an Ishigaki composition with a first active material "median diameter" (Dv50) of 2 μm corresponds to a '118 patent first material "average particle size"

(also Dv50) of 2 μm , and will necessarily have an average particle size in a range of 0.2 μm to 15 μm .

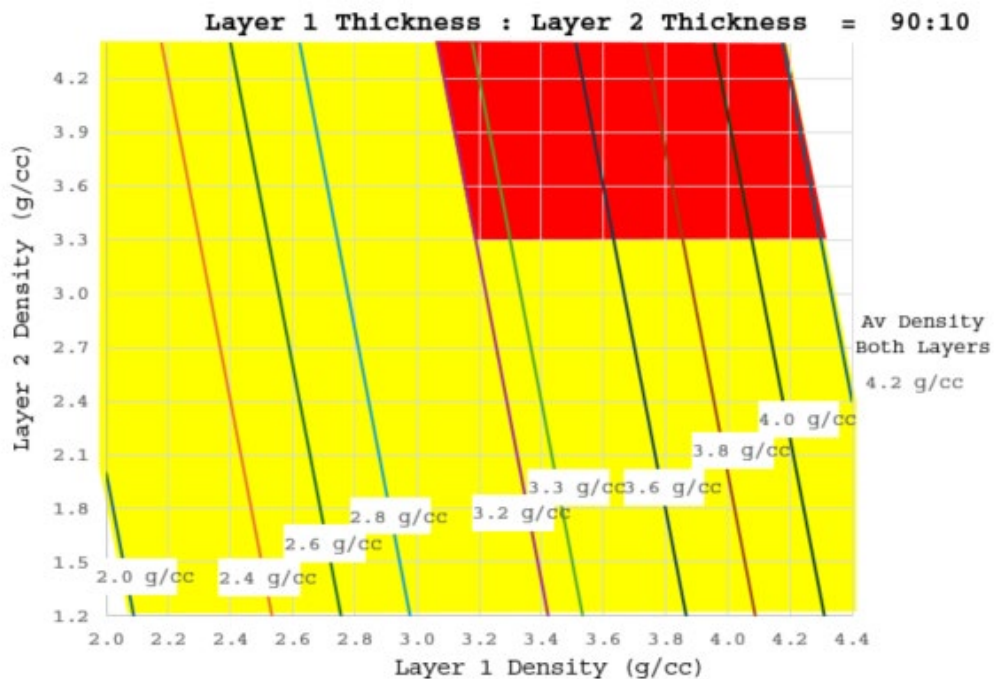
168. Ishigaki therefore inherently anticipates claim 13.

11. Claim 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.

169. Ishigaki also discloses that the electrode mixture can have a compaction density (density after pressing of the positive electrode) between 2.0 g/cm³ and 4.2 g/cm³. EX1004, ¶¶25, 151. As discussed *supra* (Section XI.A.7), this leads to a range of combinations for the individual densities of layers 1 and 2, which are represented graphically below for Ishigaki's cases where the thickness ratio of the first and the second layer are 60:40 and 90:10. As above, the total colored area (yellow plus red) represents combinations of the two layer densities that follow the teachings of Ishigaki, in that they yield average combined densities ranging from 2.0 to 4.2 g/cc. The red regions in these graphs represent combinations of the two layer densities, which are taught by Ishigaki, and which anticipate '118 claim 5 because the first layer density is greater than 2.8 g/cc and the second layer density is greater than 3.3 g/cc (and also satisfy the limitations of '118 claim 10.5 in that they have an average density greater than 3.2 g/cc).



Gido Demonstrative 15.



Gido Demonstrative 16.

170. Although Ishigaki teaches a range of densities, it also directs a POSA to consider the higher density (red) portions of the graphs above by citing the

“viewpoint of increasing capacitance density”⁴ with higher layer densities.

EX1004, ¶25. A POSA would therefore understand that it is advantageous from the perspective of maximizing the energy density of the electrode to work in the higher density ranges taught by Ishigaki, i.e., the red portions of the graphs which anticipate ’118 claim 14 because the density of layer 1 is greater than 2.8 g/cc and the density of layer 2 is greater than 3.3 g/cc.

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

171. Ishigaki discloses that “[t]he thickness ratio of the first positive electrode active material layer and the second positive electrode active material layer is normally 60:40, and because the second positive electrode active material has a higher bulk density than the first active material, in order to obtain a high energy density, the thickness ratio is preferably 70:30, more preferably 80:20, and particularly preferably 90:10.” EX1004, ¶216.⁵

172. In the context of this statement about adjusting layer thicknesses to control energy density, it would be clear to a POSA that the “bulk density” of “first active material” and “second active material” in this statement is a proxy for the compaction densities of the first and second layers, including all the components in

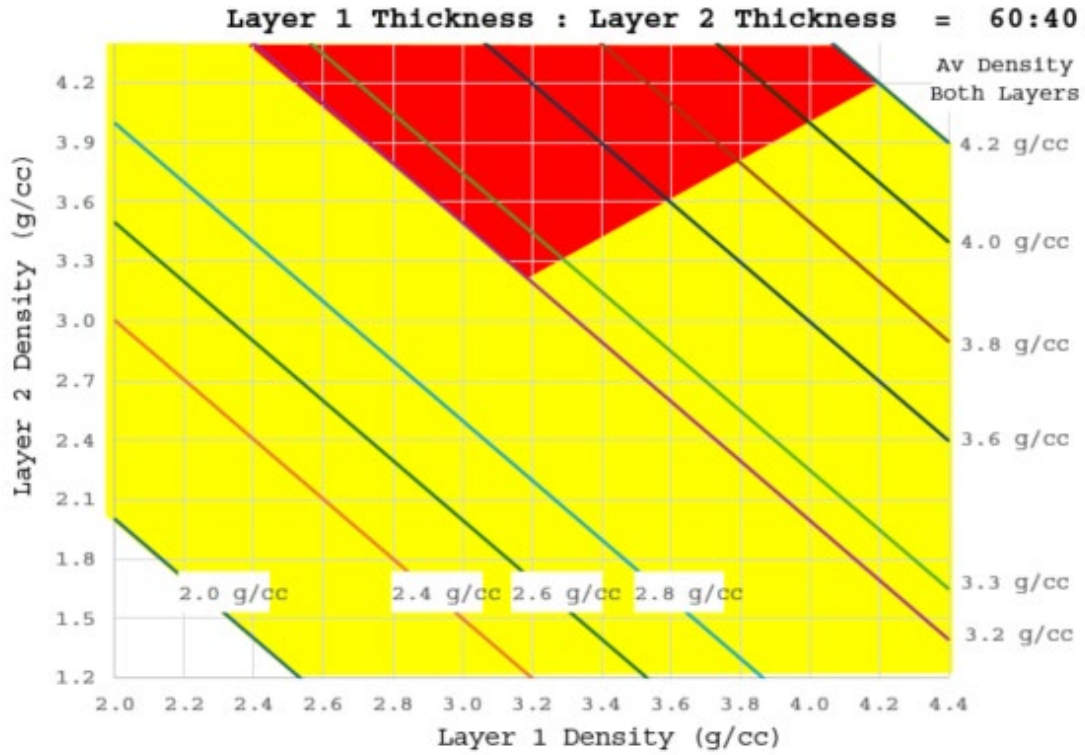
⁴ See n.1, *supra*.

⁵ Emphasis added unless otherwise noted.

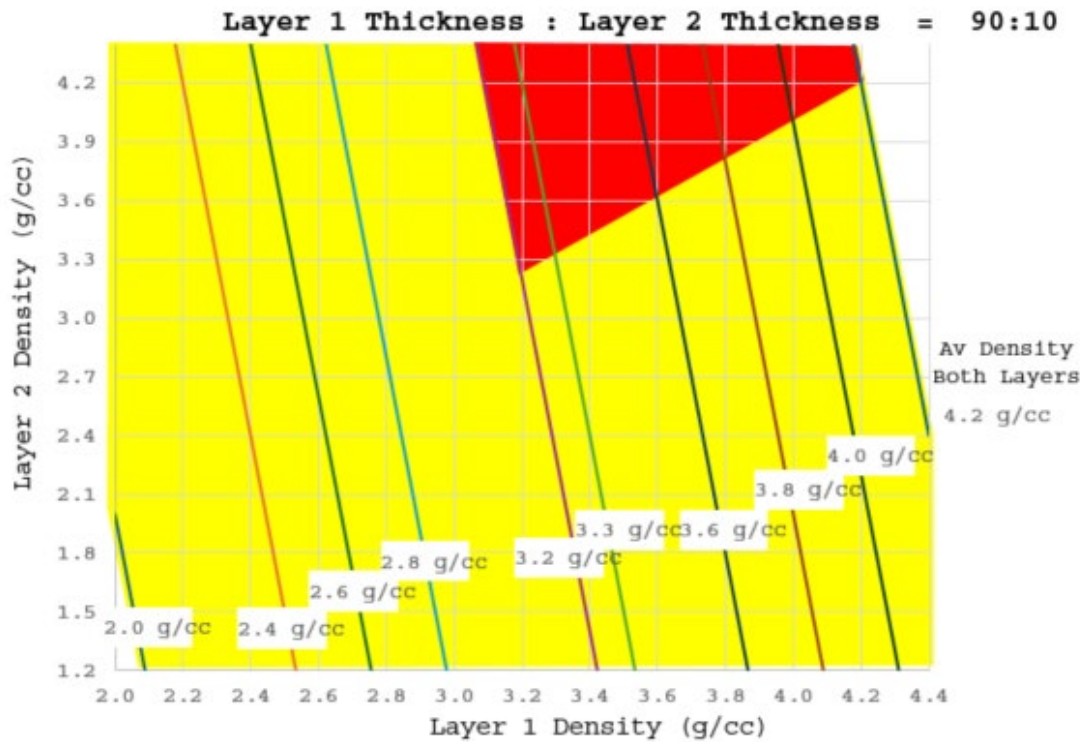
those layers, not just the lithium containing active material powders. That is because the bulk density ratios are disclosed as a means for obtaining a high energy density in the final product, and Ishigaki's teaching that the second layer has a higher compaction density than the first layer is part of the effort to achieve a high energy density. Therefore, Ishigaki teaches that the first layer has a lower bulk density than the second layer.

173. In the graphs below the colored regions (yellow and red) illustrate combinations of first and second layer densities that follow the teachings of Ishigaki regarding the range of average (over both layers) densities from 2.0 g/cc to 4.2 g/cc. The red region of the graph are combinations of layer densities that follow the additional teaching of Ishigaki, EX1004, ¶216, that the second layer density is greater than the first (and also satisfy the limitations of '118 claim 10.5 in that they have an average density greater than 3.2 g/cc), which anticipates '118 patent claim 15.

174. Ishigaki therefore inherently anticipates claim 15.



Gido Demonstrative 17.



Gido Demonstrative 18.

- 13. Claim 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.**

175. Ishigaki discloses that the first material in the first layer is lithium nickel cobalt manganese oxide (LiNiMnCoO_2). EX1004, ¶27; *see also* EX1004, Claims 5, 9.

176. Ishigaki therefore discloses a composition selected from the recited group, which anticipates the Markush group.

- 14. Claim 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.**

177. Ishigaki discloses that the second material in the second layer is also lithium nickel cobalt manganese oxide (LiNiMnCoO_2). EX1004, Claim 9, ¶27; *see also* EX1004, Claim 5.

178. Ishigaki therefore discloses a composition selected from the recited group, which anticipates the Markush group.

- 15. Claim 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.**

179. Ishigaki discloses a first material comprising natural graphite or artificial graphite, soft carbon and hard carbon. *See* EX1004, Claim 6, ¶110 (“[S]pecific examples include . . . graphite (graphite) such as natural graphite and artificial graphite, carbon black such as acetylene black”). Ishigaki therefore anticipates claim 9. Note that soft carbon and hard carbon, as recited in the claim, are different grades of carbon black. *See generally* EX1025; EX1026; EX1027; EX1028. Acetylene black, as taught by Ishigaki, is a particular form of hard carbon, carbon black. EX1020.

180. Ishigaki therefore anticipates claim 18.

- C. 19.P. An electronic device, comprising an electrochemical device, the electrochemical device comprising an electrode, wherein the electrode comprises:**

181. Ishigaki discloses “electronic devices,” and “lithium rechargeable batteries for use in these devices.” EX1004, ¶2. Ishigaki gives examples of electronic devices being “notebook computers, mobile phones, and handheld video cameras, as well as hybrid electric vehicles.” EX1004, ¶4. Ishigaki further discloses “(1) A positive electrode for a lithium secondary battery comprising, on a current collector foil, an electrode mixture” EX1004, ¶14. This is the same

kind of electronic device, electrochemical device, and electrode used in the same context for the same purpose as the '118 patent.

1. 19.1: a current collector;

182. Ishigaki discloses that the electrode comprises a current collector foil as ‘a current collector’. *See* EX1004, ¶14. This is the same recited current collector of limitation 19.1.

2. 19.2: a first layer comprising a first material; and;

183. Ishigaki discloses that the electrode comprises an electrode mixture on a current collector foil. *See* EX1004, ¶14 (“A positive electrode for a lithium secondary battery comprising, on a current collector foil, an electrode mixture comprising a positive electrode active material . . .”). The electrode mixture comprises a first positive electrode mixture layer, which is the first layer of claim 1.2. EX1004, ¶¶153, 347, 348. The first positive electrode mixture layer, in turn, comprises a first positive electrode active material, which is the first material of claim 19.2. EX1004, ¶153 (disclosing a first positive electrode mixture layer containing a first positive electrode active material on the current collector).

3. 19.3: a second layer comprising a second material;

184. Ishigaki discloses that the electrode mixture comprises a second positive electrode mixture layer. EX1004, ¶153. This is the second layer of claim 19.3. Ishigaki further discloses “a second positive electrode mixture layer

containing a second positive electrode active material.” Ishigaki, [0014]. This is the second material in the second layer of claim 19.3.

4. 19.4.1: wherein the first layer is arranged between the current collector and the second layer,

185. Ishigaki discloses that the first and second positive electrode mixture layers are sequentially laminated on the current collector foil. EX1004, ¶153; *see also* EX1004, ¶14 (“[A] second positive electrode mixture layer containing a second positive electrode active material having a particle diameter larger than that of the first positive electrode active material are sequentially laminated and formed on the current collector.”) ; *see also* EX1004, ¶366 (describing the first layer in between the current collector and second layer). Therefore, the Ishigaki discloses that the first layer is arranged between the current collector and the second layer.

186. Additionally, Ishigaki explains that “[a]ctive material 1 was used as the active material of the positive electrode for the first layer. . . . Active material 3 was used as the active material of the positive electrode for the second layer. . . .” EX1004, ¶366. “Next, slurry 1 was coated on one side and dried on an aluminum foil (thickness: 15 μ m) as a collector foil with a doctor blade. Then the slurry 2 was applied on one side with a doctor blade and dried.” *Id.* This order of operations confirms that the resulting layer configuration is for the first layer to be arranged between the current collector and the second layer.

5. 19.4.2: the first layer is formed on a surface of the current collector,

187. Ishigaki discloses that the first positive electrode mixture layer is formed by applying a slurry of the first positive electrode active material on a surface of the current collector foil. EX1004, ¶366. Therefore, Ishigaki discloses that the first layer is formed on a surface of the current collector.

188. More specifically, Ishigaki explains:

As the active material of the positive electrode for the first layer, (active material 1) was used...

The active material, conductive material (HS100 made by Denki Kagaku Kogyo), and binder PVdF (Kureha Corporation: KF Polymer L#1120) were weighed and mixed in a weight ratio of 87:8 (as solid content):5, and N-methylpyrrolidone (NMP) was further added so that the solid content ratio was 45% by mass, and a uniform slurry 1 was prepared using a planetary centrifugal mixer...

Next, the slurry 1 was applied and dried on one side of aluminum foil (thickness 15 μm) of the current collecting foil using a doctor blade.

EX1004, ¶366.

6. 19.4.3: and a particle size of 90% accumulative volume of the first active material is less than 40 μm ,

189. 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); 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 .

190. More specifically, Ishigaki discloses that “[a] 90% cumulative diameter (D90) of the secondary particles of the lithium transition metal-based 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, normally 0.5 μm or more, preferably 0.8 μm or more, more preferably 1 μm , and most preferably 1.5 μm or more.” EX1004, ¶38.

191. Ishigaki’s statement “cumulative diameter (D90)” may be alleged to be, by itself, insufficient to establish that the parameter Ishigaki is teaching corresponds to Dv90. There are multiple ways of “accumulating” the particle size distribution to obtain an average diameter. This could be done on a number basis (sampling counting all particles, no matter how large or small equally), or it could be done on a mass basis (counting heavier particles more according to their weight). Dv90 is an accumulation based on the volume of the particles. These different accumulation averages do not necessarily yield the same number values.

192. Ishigaki also teaches 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.” 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. EX1018 (ISO 13320-1 standard explaining that laser diffraction is a volume-based measurement).

193. Other sections of Ishigaki describe particle sizes of D_{90} (i.e., Dv90) $\leq$ 5 microns. *See, e.g.*, EX1004, ¶¶14, 40, 346. These are all disclosures of a particle size of 90% accumulative volume of the first active material that is less than 40 μm .

7. 19.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

194. The maximum density of the Ishigaki cathode layers is constrained by the densities of its components—active material, conductive additive, and binder—resulting in a theoretical upper limit of 4.4 g/cm³ when porosity is zero. This density is derived from the weight ratios of these components in Ishigaki's Example 2. The density of the active material is 4.8 g/cm³, and the densities of both the conductive carbon and the binder are 1.8 g/cm³. The presence of porosity lowers the overall density, with Ishigaki teaching a range of 2.0 to 4.2 g/cm³. The

calculations and graphs provided below demonstrate that combinations of the two layers can achieve densities greater than 3.2 g/cm³, with the red areas highlighting the higher density ranges Ishigaki emphasizes for maximizing energy density. These ranges are consistent with and anticipate “a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.”

195. Ishigaki discloses treating the electrode mixture by pressure to increase the packing density of the positive electrode materials. This is called “compaction density” because the entire layer, including active material particles, conductive additive and polymer binder, is compacted by mechanical pressing, typically applied by a metal roller or a pair of metal rollers. EX1004, ¶24 (“In order to increase the packing density of the positive electrode active material, the positive electrode active material layer obtained by coating and drying is preferably consolidated by a hand press, a roller press, or the like.”). The density that results from this treatment is compaction density.

196. Ishigaki also discloses that the electrode mixture can have a compaction density (density after pressing of the positive electrode) between 2.0 g/cm³ and 3.6 g/cm³. EX1004, ¶25. Specifically, Ishigaki discloses “[t]he electrode density of the positive electrode after pressing has a lower limit of normally 2.0 g/cm³ or more, preferably 2.4 g/cm³ or more, and particularly preferably 2.6 g/cm³ or more, and an upper limit of normally 4.2 g/cm³ or less, preferably 4.0 g/cm³ or

less, and particularly preferably 3.8 g/cm^3 or less.” EX1004, ¶151. This numeric range overlaps the numeric range of the claims, and therefore anticipates it.

197. Ishigaki also explains “[t]he 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/cm^3 or less, more preferably 3.5 g/cm^3 or less, and particularly preferably 3.4 g/cm^3 or less.” EX1004, ¶25. All of these disclosures describe individual preferred embodiments of Ishigaki in which the compaction density is greater than 3.2 g/cc , namely preferred embodiments with compaction densities of 3.4 g/cc , 3.5 g/cc , and 3.6 g/cc . These disclosures also anticipate the claim limitation.

198. I note that there is a physical constraint on the upper possible limit of the density of the Ishigaki cathode layers of 4.4 g/cm^3 . This is based on the densities of the components (active particles, conductive additive, and polymer binder) in the layer, in the amounts taught by Ishigaki, when the porosity of the layers is zero. Lower densities than this maximum, such as the 2.0 g/cm^3 to 4.2 g/cm^3 range taught by Ishigaki, are due to the presence of porosity, which adds empty space into the layers.

199. I calculated the maximum density value based on composition ranges for the conductive material, EX1004, ¶¶14, 139, the binder, EX1004, ¶144, and the active material powder, EX1004, ¶150 given by Ishigaki. In particular, I used the

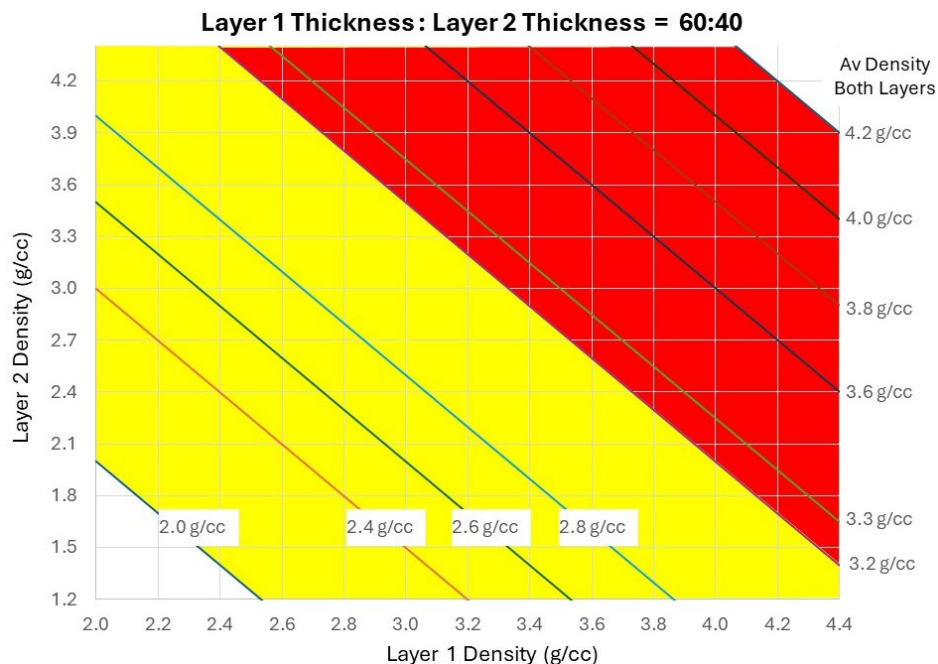
compositions of the two layers given in Ishigaki's Example 2, EX1004, ¶366: First Layer ("The active material, conductive material (HS100 made by Denki Kagaku Kogyo), and binder PVdF (Kureha Corporation: KF Polymer L#1120) were weighed and mixed in a weight ratio of 87:8 (as solid content):5"), Second Layer ("This active material: L#1120 of HS100:KF polymer was weighed and mixed so that the weight ratio was 85:10 (as solid content):5").

200. The density of the active material (lithium nickel manganese cobalt oxide) is 4.8 g/cm^3 . The densities of the conductive carbon additive is 1.8 g/cm^3 and the density of the PVdF binder is also 1.8 g/cm^3 . The maximum possible density of the first layer of Ishigaki's Example 2 is the composition weighted average of the densities of the component materials: Layer 1 Max Density = $0.87 \times 4.8 + 0.08 \times 1.8 + 0.05 \times 1.8 = 4.4 \text{ g/cm}^3$. The analogous calculation for Ishigaki Example 2, Layer two also gives a maximum density of 4.4 g/cm^3 , to within the precision specified by Ishigaki.

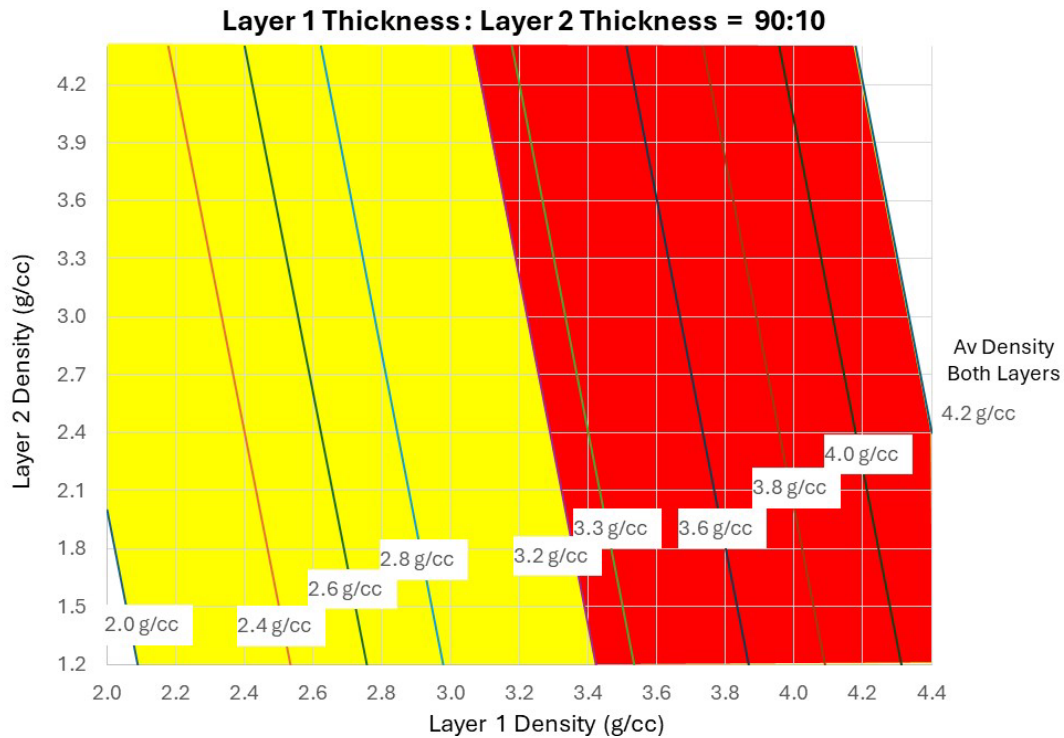
201. This maximum active material layer density is significant because it imposes constraints on the possible densities of the two layers that can combine to produce the Ishigaki average cathode active material density, for comparison to claim 19.5 of the '118 patent.

202. The following graphs illustrate combinations of the two Ishigaki layer densities that yield particular overall cathode average densities, while making sure

that no density can be greater than the maximum of 4.4 g/cc. The diagonal lines are made up of combinations of layer 1 density and layer 2 density that combine to give the average density listed for each diagonal line. The first graph is for a case where the thickness ratio of the first layer to the second layer is 60:10, and the second graph is for the case where the thickness ratio of the first layer to the second layer is 90:10. These two thickness ratios bracket the range taught by Ishigaki. EX1004, ¶216. In these graphs, the total colored area (yellow plus red) represent combinations of the first and second layer that satisfy the teaching of Ishigaki regarding overall cathode density. The red area represents combinations of layer densities that are taught by Ishigaki and which also satisfy the constraint of '118 claim 19.5, that the average density is greater than 3.2 g/cc. The red areas of these graphs represent disclosures by Ishigaki that anticipate the '118 claim 19.5.



Gido Demonstrative 19.



203. Although Ishigaki teaches a range of densities, it also directs a POSA to consider the higher density (red) portions of the graphs above by citing the “viewpoint of increasing capacitance density”⁶ with higher layer densities. EX1004, ¶25. A POSA would therefore understand that it is advantageous from the perspective of maximizing the energy density of the electrode to work in the higher density ranges taught by Ishigaki, i.e., the red portions of the graphs which anticipate ’118 claim 19.5.

204. Even if one were to interpret the “electrode density” described in Ishigaki to refer to the total density of the entire electrode including both the

⁶ See n.1, *supra*.

current collector and the layers containing the active materials (instead of that of just the layers containing the active materials), Ishigaki at least teaches that the total density of the entire electrode can be 3.2 g/cc and greater. The known density of the aluminum foil used as the current collector is 2.7 g/cc, which is less than the 3.2 g/cc. Therefore, for the total average density of the entire electrode structure to be at least 3.2 g/cc, the other layers (layers containing active material) of the electrode must have a greater density than 3.2 g/cc. Consequently, if the current collector is included in the “electrode density,” Ishigaki’s teaching indicates that the density of the active material containing layers on the current collector must be greater than 3.2 g/cc to compensate for the less dense current collector.

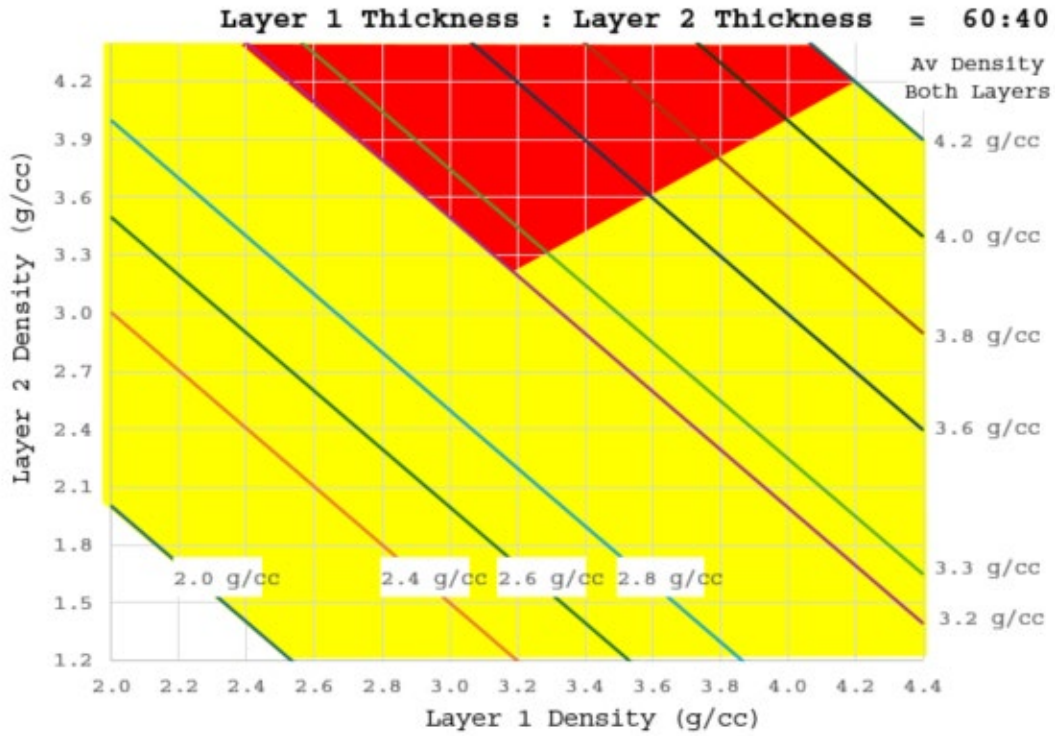
8. Claim 20. The electronic device according to claim 19, wherein the first layer has a lower compaction density than the second layer.

205. Ishigaki discloses that “[t]he thickness ratio of the first positive electrode active material layer and the second positive electrode active material layer is normally 60:40, and because the second positive electrode active material has a higher bulk density than the first active material, in order to obtain a high energy density, the thickness ratio is preferably 70:30, more preferably 80:20, and particularly preferably 90:10”. EX1004, ¶216. In the context of this statement about adjusting layer thicknesses to control energy density, it would be clear to a POSA that the “bulk density” of “first active material” and

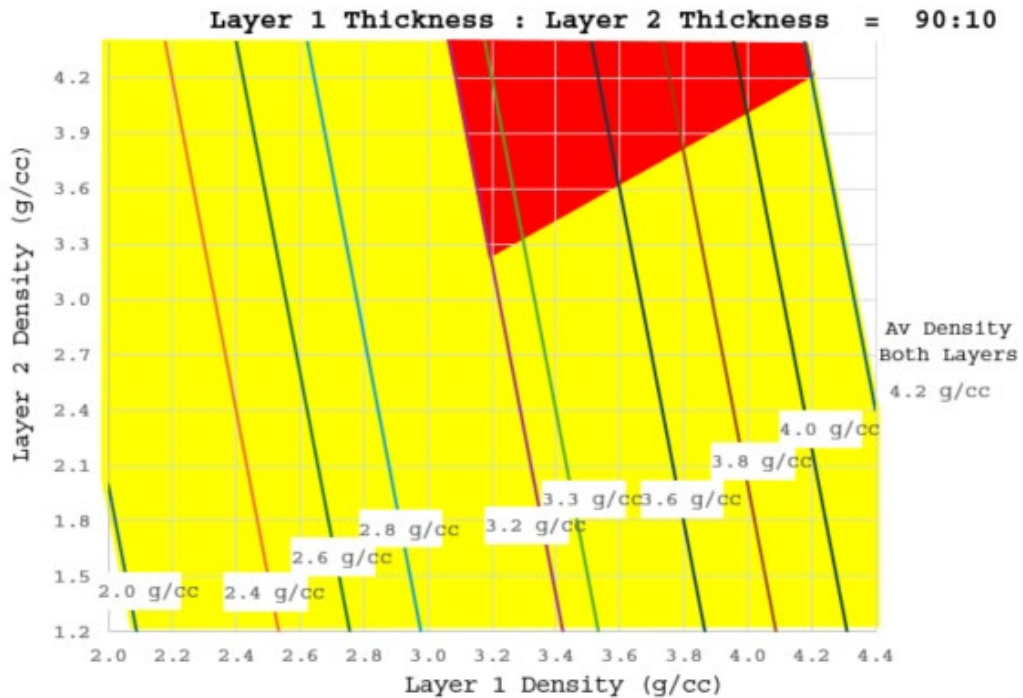
“second active material” in this statement is a proxy for the compaction densities of the first and second layers, including all the components in those layers, not just the lithium containing active material powders. That is because the bulk density ratios are disclosed as a means for obtaining a high energy density in the final product, and Ishigaki’s teaching that the second layer has a higher compaction density than the first layer is part of the effort to achieve a high energy density. Therefore, Ishigaki teaches that the first layer has a lower bulk density than the second layer.

206. In the graphs below the colored regions (yellow and red) illustrate combinations of first and second layer densities that follow the teachings of Ishigaki regarding the range of average (over both layers) densities from 2.0 g/cc to 4.2 g/cc. The red region of the graph are combinations of layer densities that follow the additional teaching of Ishigaki, EX1004, ¶216, that the second layer density is greater than the first (and also satisfy the limitations of ’118 claim 19.5 in that they have an average density greater than 3.2 g/cc), which anticipates ’118 patent claim 20.

207. Ishigaki therefore inherently anticipates claim 20.



Gido Demonstrative 21.



Gido Demonstrative 22.

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

208. Like Ishigaki and the '118 patent, Kim discloses a “composite cathode active material” for a lithium-ion battery, and various desirable attributes for that material. EX1009, Abstract. Also like Ishigaki, 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 . Kim’s materials and material attributes are therefore compatible with Ishigaki’s electrode and applications.

209. As discussed above in Ground 1, Ishigaki discloses all of the limitations of the '118 patent claims and therefore anticipates claims 1-20. For the compaction density limitation, however, Ishigaki discloses a numeric range (>2 g/cc) that subsumes the claimed range (>3.2 g/cc total or 2.8 g/cc first layer and 3.3 g/cc second layer). Ishigaki teaches that the upper limit of mixture densities for preferred embodiments is 3.6 g/cc, more preferably 3.5 g/cc, and most preferably 3.4 g/cc. EX1004, ¶25.

210. To the extent Patent Owner argues that there is a criticality to the claimed range—despite no such criticality being supported in the specification—Patent Owner may contend that Ishigaki does not explicitly teach a POSA of any criticality for the claimed numeric range specifically. In the event that Patent Owner attempts to distinguish Ishigaki based on an alleged criticality of the claimed numeric range, Kim discloses that range and criticality.

211. Specifically, Kim teaches a cathode layer density of 3.31 g/cc or greater, and of 3.4 to 4.0 g/cc. EX1009, ¶36. Kim explains that compaction densities below 3.31 g/cc “may be too small to obtain a high electrical capacity.” EX1009, ¶36. Ishigaki discloses the pursuit of high electrical capacity, which it calls “high energy density,” EX1004, ¶216, and “high capacity,” EX1004, Abstract, ¶¶7, 13, 14, 16, 18, 109, as one of its objectives. High energy density is also an objective of the ’118 patent, EX1001, 1:36-41, 4:18-24, 6:7-12, 6:20-27, and a near-universal objective in the art. Kim’s compaction density ranges are therefore compatible with the teachings of Ishigaki, and encourage a POSA to pursue compaction densities towards the higher values of the range taught by Ishigaki.

212. Accordingly, there is no need to modify Ishigaki, as Ishigaki teaches compaction densities greater than 2 g/cc and further specifies mixture densities of 2.5 to 3.4g/cc. EX1004, ¶25 (“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.”).

213. Ishigaki’s quoted reason for using compaction densities above a lower limit is “increasing capacitance density.” EX1004, ¶25. Capacitance is another property of some electrical devices, particularly capacitors, but that is not what Ishigaki means here. *See* n.1, *supra*. This is likely a result from the translation from the original Japanese. What Ishigaki means here is “high capacity,” or “high electrical capacity,” or “high energy density,” which are all referring to a common property.

214. Ishigaki even teaches a POSA to pack the electrode active material “as densely as possible” in order to maximize the energy capacity of the battery. EX1004, ¶7. A POSA would therefore already be motivated to choose densities at the higher end of the range disclosed in Ishigaki, and would thus look to the density range disclosed in Kim to improve the battery’s electrical capacity within his practicing the teachings of Ishigaki.

- A. 1.P: An electrode, comprising: 1.1: a current collector; 1.2: a first layer comprising a first material; and; 1.3: a second layer comprising a second material; 1.4.1: wherein the first layer is arranged between the current collector and the second layer, 1.4.2: the first layer is formed on a surface of the current collector, 1.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,**

215. Ishigaki teaches limitations 1.P – 1.4.3 as discussed in Ground 1 above.

- 1. 1.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.**

216. Ishigaki, as above. To the extent Ishigaki does not explicitly teach the criticality of the total compaction density being at least 3.2 g/cc, Kim teaches this feature.

217. Kim teaches the density of the electrode active material layer (including all components of this layer: active material powder, binder polymer and conductive additive) after it has been subjected to the compression step of the electrode formation process. And Kim discloses structural changes in the layers brought about by compaction (or compression) potentially include deformation of the binder material, rearrangement and change to the packing of the particles, and reduction in void volume, i.e., porosity, of the material.

218. Kim discloses a cathode layer density of 3.31 g/cc or greater, and of 3.4 to 4.0 g/cc. EX1009, ¶36. Kim explains that compaction densities below 3.31 g/cc “may be too small to obtain a high electrical capacity.” EX1009, ¶36. These

ranges are compatible with the teachings of Ishigaki, and encourage a POSA to pursue compaction densities towards the higher values of the range taught by Ishigaki. EX1004, ¶25.

219. Furthermore, Ishigaki teaches that the key to increasing the capacity of a battery is “packing [the] electrode active material . . . as densely as possible,” which Ishigaki identifies as being preferably at least 2.5 g/cc and up to 3.6 g/cc. EX1004, ¶7. A POSA reading Ishigaki would therefore already be motivated to choose compaction densities as high as possible, and would be further motivated by Kim to choose a compaction density over 3.2 g/cc in order to avoid a compaction density that is too small to obtain the desired high electrical capacity.

220. Accordingly, a POSA reading Ishigaki would be motivated to select a compaction density that packs the electrode material “as densely as possible,” which Ishigaki suggests is around 3.4 – 3.6 g/cc (the upper limit of Ishigaki’s densities). Ishigaki would look to Kim for additional information regarding what densities are possible and why one should choose certain densities over others. Kim’s express teaching that compaction densities lower than 3.31 g/cc may be too small to obtain high energy capacity would motivate a POSA to choose only densities of 3.31 g/cc or higher in practicing Ishigaki because achieving high energy capacity is a primary objective of Ishigaki. A POSA would expect compaction densities of 3.31 or higher to be successful in the battery described in

Ishigaki because Ishigaki expressly embraces densities of 3.4 g/cc, 3.5 g/cc and 3.6 g/cc.

2. **Claim 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.**

221. Ishigaki teaches the additional limitations of claim 2 as discussed in Ground 1 above.

3. **Claim 3. The electrode according to claim 1, 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.**

222. Ishigaki teaches the additional limitations of claim 3 as discussed in Ground 1 above.

4. **Claim 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 .**

223. Ishigaki teaches the additional limitations of claim 4 as discussed in Ground 1 above.

5. **Claim 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.**

224. Ishigaki, as above. To the extent Ishigaki does not explicitly teach the criticality of the compaction density being greater than 2.8 g/cc for the first layer and greater than 3.2 g/cc for the second layer, Kim teaches this feature.

225. Kim teaches a cathode layer density of 3.31 g/cc or greater, and of 3.4 to 4.0 g/cc. EX1009, ¶36. Kim explains that compaction densities below 3.31 g/cc “may be too small to obtain a high electrical capacity.” EX1009, ¶36. These ranges are compatible with the teachings of Ishigaki, and encourage a POSA to pursue compaction densities towards higher values in the range taught by Ishigaki, which also has a stated goal of achieving high energy density, i.e., high electrical capacity. EX1004, ¶25.

226. Specifically, A POSA using Kim’s teaching to inform the compaction densities of Ishigaki’s two-layer structure, where the first layer has a lower compaction density than the second layer as taught in Ishikgaki, EX1004, ¶216, would be motivated to select a compaction density of 3.31 g/cc or greater for the first layer, and a compaction density of 3.4 to 4.0 g/cc for the second layer. This is consistent with the teachings of both Ishigaki and Kim, as discussed above, and is the natural result of their combination.

227. Furthermore, it would be well known to a POSA that higher compaction densities were commonplace in the art and that common sense dictates choosing the highest workable compaction density for a given application. *See, e.g.,* EX1004, ¶7 (teaching a POSA to pack the electrode active material “as densely as possible” in order to maximize the energy capacity of the battery). A POSA would have a greater expectation of success using the compaction densities

in the higher end of the range taught by Ishigaki as compared to the densities in the lower end of that range. EX1003, ¶44. A POSA would be especially motivated to choose Ishigaki's highest densities for both layers in view of Kim's teaching that densities less than 3.31 g/cc "may be too small to obtain a high electrical capacity." EX1009, ¶36.

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

228. Ishigaki teaches the additional limitations of claim 6 as discussed in Ground 1 above.

7. **Claim 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.**

229. Ishigaki teaches the additional limitations of claim 7 as discussed in Ground 1 above.

8. **Claim 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.**

230. Ishigaki teaches the additional limitations of claim 8 as discussed in Ground 1 above.

- 9. Claim 9. The electrode according to claim 1, 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.**

231. Ishigaki teaches the additional limitations of claim 9 as discussed in Ground 1 above.

- B. Claim 10.P. An electrochemical device, comprising an electrode, wherein the electrode comprises: 10.1: a current collector; 10.2: a first layer comprising a first material; and; 10.3: a second layer comprising a second material; 10.4.1: wherein the first layer is arranged between the current collector and the second layer, 10.4.2: the first layer is formed on a surface of the current collector, 10.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,**

232. Ishigaki teaches limitations 10.P – 10.4.3 as discussed in Ground 1 above.

- 1. 10.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.**

233. Ishigaki, as above. To the extent Ishigaki does not teach the criticality of the compaction density being at least 3.2 g/cc, Kim teaches this feature.

234. Kim teaches a cathode layer density of 3.31 g/cc or greater, and preferably of 3.4 to 4.0 g/cc. EX1009, ¶36. Kim explains that compaction densities below 3.31 g/cc “may be too small to obtain a high electrical capacity.” EX1009, ¶36. These ranges are compatible with the teachings of Ishigaki, and encourage a POSA to pursue compaction densities towards higher values in the range taught by Ishigaki. EX1004, ¶25. Specifically, Ishigaki teaches that the key to increasing the

capacity of a battery is “packing [the] electrode active material . . . as densely as possible,” which Ishigaki identifies as being preferably at least 2.5 g/cc and up to 3.6 g/cc. EX1004, ¶7. A POSA reading Ishigaki would therefore already be motivated to choose compaction densities as high as possible, and would be motivated by Kim to choose a compaction density over 3.2 g/cc in order to avoid a compaction density that is too small to obtain the desired high electrical capacity.

2. **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.**

235. Ishigaki, as above.

3. **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.**

236. Ishigaki, as above.

4. **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 .**

237. Ishigaki, as above.

- 5. 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.**

238. Ishigaki, as above. To the extent Ishigaki does not teach the criticality of the compaction density being greater than 2.8 g/cc for the first layer and greater than 3.2 g/cc, for the second layer, Kim teaches this feature.

239. Kim teaches a cathode layer density of 3.31 g/cc or greater, and of 3.4 to 4.0 g/cc. EX1009, ¶36. Kim explains that compaction densities below 3.31 g/cc “may be too small to obtain a high electrical capacity.” EX1009, ¶36. These ranges are compatible with the teachings of Ishigaki, and encourage a POSA to pursue compaction densities towards higher values in the range taught by Ishigaki. EX1004, ¶25.

240. Specifically, A POSA using Kim’s teaching to inform the compaction densities of Ishigaki’s two-layer structure, where the first layer has a lower compaction density than the second layer as taught in Ishikgaki, would be motivated to select a compaction density of 3.31 g/cc or greater for the first layer, and a compaction density of 3.4 to 4.0 g/cc for the second layer. This is consistent with the teachings of both references, as discussed above, and is the natural result of their combination.

241. Furthermore, it would be well known to a POSA that higher compaction densities were commonplace in the art and that common sense dictates

choosing the highest compaction density available for a given application. *See*, e.g., EX1004, ¶7 (teaching a POSA to pack the electrode active material “as densely as possible” in order to maximize the energy capacity of the battery). A POSA would have a greater expectation of success using the compaction densities in the higher end of the range taught by Ishigaki (consistent with Li) as compared to the densities in the lower end of that range. EX1003, ¶44. A POSA would be especially motivated to choose Ishigaki’s highest densities for both layers in view of Kim’s teaching that densities less than 3.31 g/cc “may be too small to obtain a high electrical capacity.” EX1009, ¶36.

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

242. Ishigaki teaches the additional limitations of claim 15 as discussed in Ground 1 above.

- 7. 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.**

243. Ishigaki teaches the additional limitations of claim 16 as discussed in Ground 1 above.

8. **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.**

244. Ishigaki teaches the additional limitations of claim 17 as discussed in Ground 1 above.

9. **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.**

245. Ishigaki teaches the additional limitations of claim 18 as discussed in Ground 1 above.

- C. **19.P. An electronic device, comprising an electrochemical device, the electrochemical device comprising an electrode, wherein the electrode comprises: 19.1: a current collector; 19.2: a first layer comprising a first material; and; 19.3: a second layer comprising a second material; 19.4.1: wherein the first layer is arranged between the current collector and the second layer, 19.4.2: the first layer is formed on a surface of the current collector, 19.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,**

246. Ishigaki teaches limitations 19.P – 19.4.3 as discussed in Ground 1 above.

1. 19.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

247. Ishigaki, as above. To the extent Ishigaki does not teach the criticality of the compaction density being at least 3.2 g/cc, Kim teaches this feature.

248. Kim teaches a cathode layer density of 3.31 g/cc or greater, and preferably of 3.4 to 4.0 g/cc. EX1009, ¶36. Kim explains that compaction densities below 3.31 g/cc “may be too small to obtain a high electrical capacity.” EX1009, ¶36. These ranges are compatible with the teachings of Ishigaki, and encourage a POSA to consider the higher values in the range taught by Ishigaki. EX1004, ¶25. Specifically, Ishigaki teaches that the key to increasing the capacity of a battery is “packing [the] electrode active material . . . as densely as possible,” which Ishigaki identifies as being preferably at least 2.5 g/cc and up to 3.6 g/cc. EX1004, ¶7. A POSA reading Ishigaki would therefore already be motivated to choose compaction densities as high as possible, and would be motivated by Kim to choose a compaction density over 3.2 g/cc in order to avoid a compaction density that is too small to obtain the desired high electrical capacity.

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

249. Ishigaki teaches the additional limitations of claim 20 as discussed in Ground 1 above.

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

250. Wang discloses all of the limitations of claims 1-20 with the exception of the compaction densities of the layers. For that, a POSA would look to Saka, which discloses the compaction densities recited in the claims.

251. Wang discloses a lithium-ion battery for an electronic device, the battery having an electrode with virtually all of the structural and material features of the '118 patent claims.

252. Saka also discloses a lithium-ion battery having a very similar structure to Wang and the '118 patent, including an electrode with virtually all of the structural and material features of the '118 patent claims.

253. More specifically, Wang and Saka both disclose cathode structures with two positive electrode mixture layers for increasing the energy density of lithium-ion batteries. Wang generally discloses the same structures and materials recited in the '118 patent claims, including the same layer materials having the same particle sizes. While Wang teaches compression steps to increase the density of its layers, Wang does not provide explicit information regarding the compaction density that results from that compression. *See, e.g.*, EX1005, ¶58 (“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”); ¶86. A POSA would understand, however, that the device disclosed in Wang is consistent with and would accommodate the compaction density of the electrode recited in the ’118 patent claims. A POSA could confirm that understanding by looking to the electrode disclosed in Saka.

254. Saka’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. Accordingly, a POSA practicing the disclosure of Wang, who was unsure of the compaction density that would be appropriate for his application of Wang’s technology, would look to Saka for that information, and incorporate Saka’s compaction density into the layers of Wang.

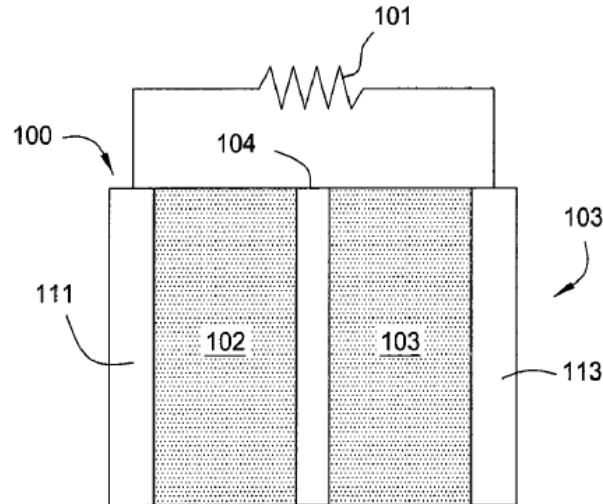
255. Wang repeatedly teaches a POSA to use compaction to achieve a “desired net density.” EX1005, ¶¶67, 73, 89, 92, 106, 109. Based on their knowledge and experience in the art, a POSA knows that the reason for achieving this “desired net density” is to increase the energy density of the cathode and therefore to increase the energy density, and the capacity, of the lithium-ion battery. “*Battery capacity*’ is a measure (typically in Amp-hr) of the charge stored by the battery, and is determined by the mass of active material contained in the battery. The battery capacity represents the maximum amount of energy that can be extracted from the battery” EX1022, 0002. Since Wang does not teach what

the desired net density actually is, a POSA would be motivated to look to another reference, such as Saka, for numerical values of a desired cathode density.

256. An express goal of Saka is to maintain enough mixture density to maintain a good battery capacity. EX1006, ¶7 (“[I]n order to maintain the battery capacity, it is necessary to improve the filling factor, that is, the mixture density of a positive electrode mixture layer . . .”). Saka’s teaching of the connection between layer density and battery capacity would therefore motivate a POSA to apply Wang’s battery construction methods to achieve Saka’s disclosed densities to arrive at a battery with high energy capacity—a stated goal of Wang, Saka, and the ’118 patent. Therefore, a POSA would look to Saka for numerical values of “desired net density” needed to practice Wang’s invention.

A. 1.P: An electrode, comprising:

257. Wang’s cathode structure 103 is an electrode. *See* EX1005, ¶¶10, 11, 35. In particular, Wang teaches, “[t]he primary functional components of Li-ion battery 100 include an anode structure 102, **a cathode structure 103**, [and] a separator layer 104” EX1005, ¶41. The cathode structure 103 is an electrode of the Li-ion battery 100. *See* EX1005, FIG. 1A.

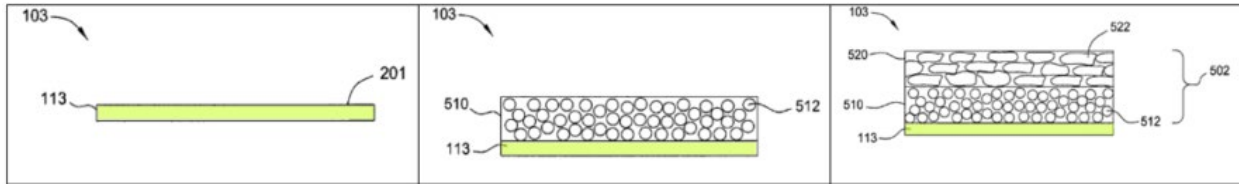


EX1005, FIG. 1A.

258. Wang teaches the limitation.

1. 1.1: a current collector;

259. Wang's current collector 113 is the claimed current collector. Wang teaches that the electrode comprises a current collector. *See* EX1005, ¶42; *see also* EX1005, ¶¶10, 11 ("The graded cathode structure comprises a conductive substrate"). A POSA will understand that "conductive substrate" is referring to a current collector. Wang teaches that "FIGS. 5A-5C are schematic cross-sectional views of one embodiment of a **graded cathode electrode structure 103** having a particle size gradient formed according to embodiments described herein." EX1005, ¶80. Wang also teaches that "[i]n FIG. 5A, **current collector 113** is schematically illustrated prior to the deposition of the graded particle structure 502 on the current collector 113." EX1005, ¶80.

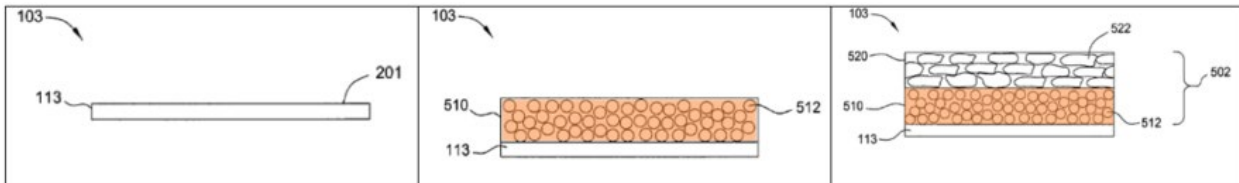


EX1005, FIGs. 5A-5C, left to right (annotated).

260. Wang teaches this element.

2. 1.2: a first layer comprising a first material; and;

261. Wang teaches that the electrode comprises a first layer, which comprises a first material. *See* EX1005, ¶¶10, 11. Wang’s first layer 510 is the claimed first layer. Wang’s first cathodically active particles 512 are the claimed first material. In particular, Wang teaches that “**a first layer 510 having first cathodically active particles 512** having a first diameter is formed over a surface 201 of the current collector 113.” EX1005, ¶81; *see also* EX1005, FIGs. 5A-5C.



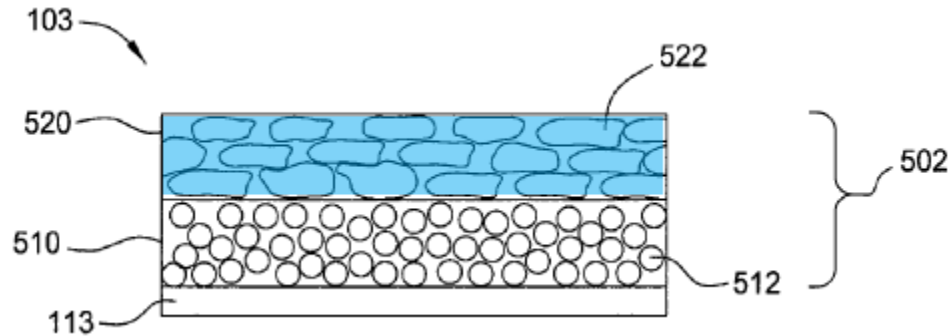
EX1005, FIGs. 5A-5C, left to right (annotated).

262. Wang teaches this element.

3. 1.3: a second layer comprising a second material;

263. Wang teaches that the electrode comprises a second layer, which comprises a second material. *See* EX1005, ¶¶10, 11. Wang’s second layer 520 is the second layer. Wang’s second cathodically active particles 522 is the second material. In particular, Wang teaches that “**a second layer 520 having second**

cathodically active particles 522 having a second diameter is formed over the first layer 510.” EX1005, ¶83; *see also* EX1005, FIG. 5C.

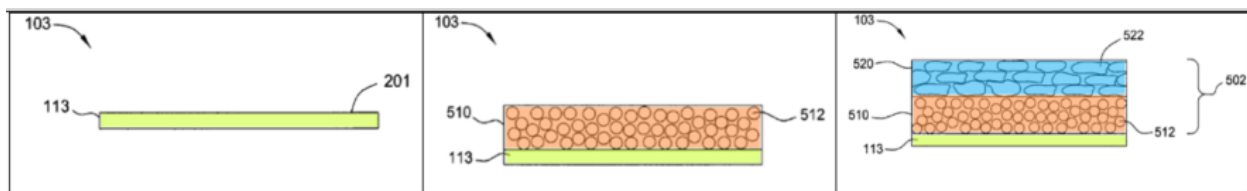


EX1005, FIG. 5C (annotated).

264. Wang teaches this element.

4. 1.4.1: wherein the first layer is arranged between the current collector and the second layer,

265. Wang teaches that the first layer is arranged between the current collector and the second layer. *See* EX1005, ¶¶10, 11, 38. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of the current collector 113**” and “a second layer 520 . . . **is formed over the first layer 510.**” EX1005, ¶¶81, 83; *see also* EX1005, FIGs. 5A-5C.

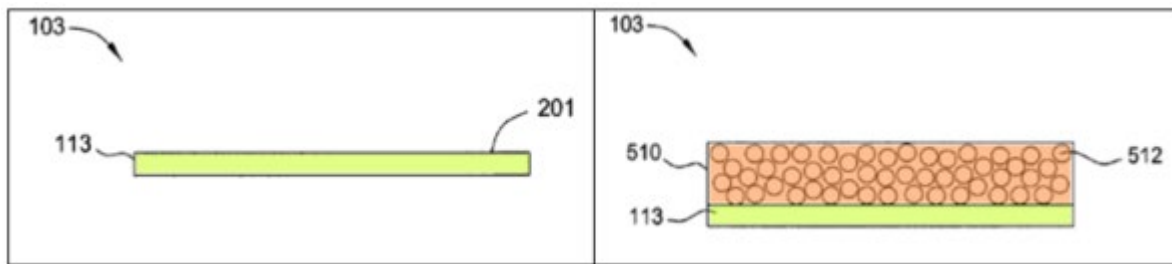


EX1005, FIGs. 5A-5C, left to right (annotated).

266. Wang teaches this element.

5. 1.4.2: the first layer is formed on a surface of the current collector,

267. Wang teaches that the first layer is formed on a surface of the current collector. *See* EX1005, ¶¶10, 11. In particular, Wang teaches that “a first layer 510 . . . is formed over a surface 201 of the current collector 113.” EX1005, ¶81; *see also* EX1005, FIGs. 5A, 5B.



EX1005, FIGs. 5A, 5B, left to right (annotated).

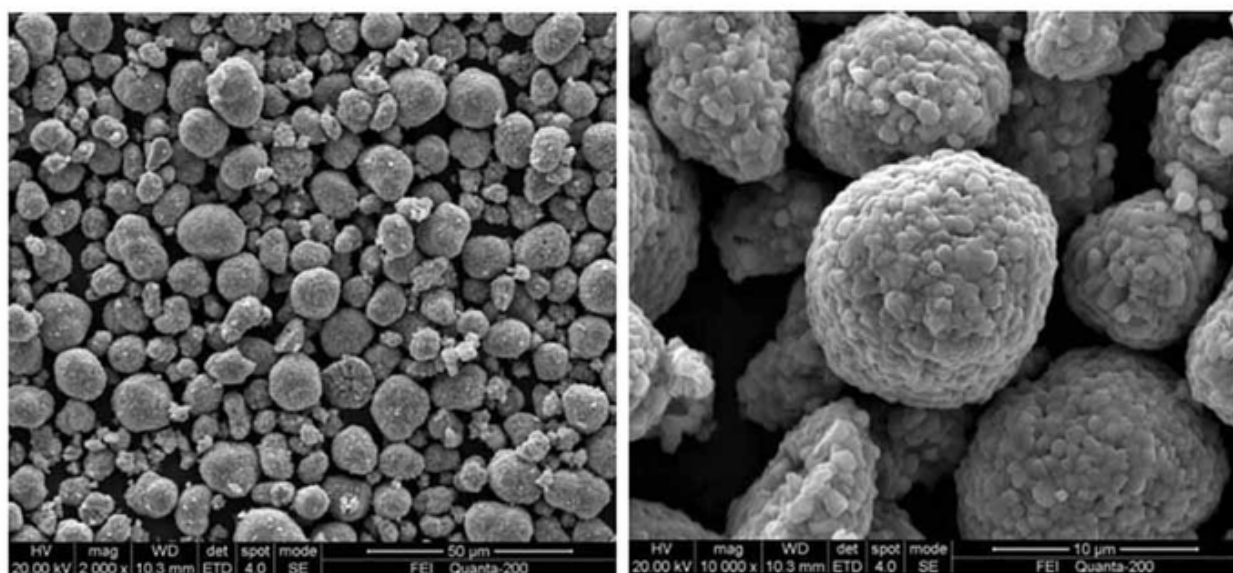
268. Wang teaches this element.

6. 1.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,

269. Wang teaches that a particle size of 90% accumulative volume of the first material is less than 40 μm . EX1005, ¶81. Wang teaches in one embodiment that the first cathodically active particles 512 “are nano-scale particles.” EX1005, ¶81 (“In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one

embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . The Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than 40 μm .

270. To help understand why prior art like Wang references two particle sizes, one nano-scale and one micro-scale, it is helpful to visualize what the active material looks like at these scales. Below are scanning electron microscope (SEM) images of lithium nickel manganese cobalt oxide powder of the type used by both Wang (¶ 51) and the '118 patent.



EX1013.

271. The image on the left is at 2000x magnification, and the image on the right is a higher magnification (10,000x) of a small part of the image on the left. In the higher magnification image, it is clear that the larger, “micro-scale particles”

are made up of aggregates of much smaller, “nano-scale particles.” This image is provided as a general illustration of the meaning of nano-scale and micro-scale particles, as taught by Wang. It does not correspond to any specific material claimed or used by Wang or the ’118 patent. It is clear that the nano-scale particles taught by Wang (¶ 81), ranging in size from 1 nm (0.001 μm) to 100 nm (0.1 μm), meet the claim limitation that **a particle size of 90% accumulative volume of the first material is less than 40 μm .**

272. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than 40 μm . Thus, Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm .

7. 1.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

273. Wang in view of Saka teaches that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

274. Wang teaches that, in the method for producing a cathode, following the deposition of “cathodically active particles over the vertically oriented flexible conductive substrate,” the cathode is further processed using “a compression chamber . . . configured to expose the vertically oriented flexible conductive substrate to a calendaring process to compress the deposited particles to a desired net-density.” EX1005, ¶¶15, 58 (“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.”).

275. Wang further describes that there can be one or two compression steps, depending on the desired compaction density of the layers. EX1005, ¶92 (“After the particles are deposited over the conductive substrate, the particles may be compressed using compression techniques, for example, a calendaring process, to achieve a desired net density of compacted particles while planarizing the surface of the second layer. In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of

the first layer.”). Wang thus teaches the processes and techniques required for achieving the desired compaction density of the layers, in order to achieve a high packing density of active material in the cathode layers and thus a high energy density for the battery.

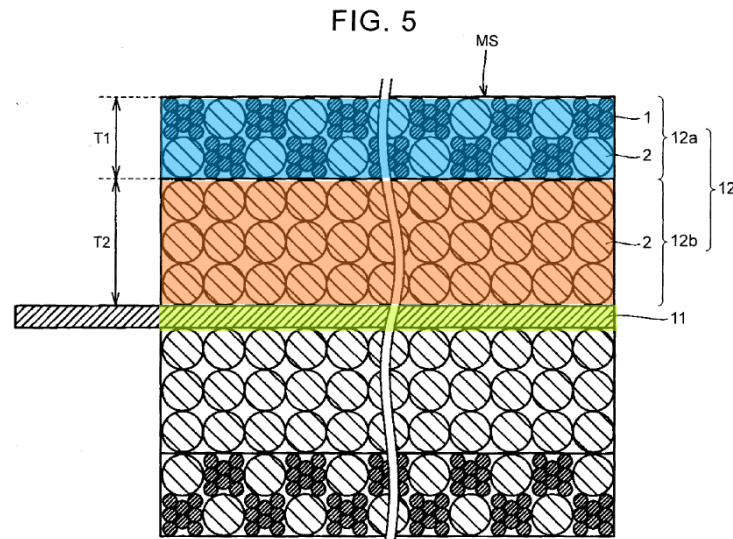
276. The only aspect of limitation 1.5 Wang does not explicitly teach is the numeric value for the desired compaction density. Indeed, while Wang devotes much of its focus to achieving a desired density, it does not explicitly provide the reason a particular net density is more desirable than another. Wang assumes the reader already has a desired density in mind, and teaches the method one would use to achieve any such density. A reader that does not have a desired density in mind would therefore be motivated to look to a reference such as Saka, which discusses in great detail the reasons and rationales for achieving particular densities. As such, while Wang may not expressly teach that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc, the range of desired compaction densities, including the density recited in limitation 1.5, is explicitly taught in Saka.

277. Saka teaches an electrode having a positive electrode mixture 12 on a current collector 11, where positive electrode mixture 12 includes a first layer 12a and a second layer 12b. *See* EX1006, FIG. 5. In addition, Saka teaches that “the dried positive electrode mixture layer 12 **may be pressed using a rolling mill or**

the like to adjust the thickness and the mixture density thereof.” EX1006, ¶51.

Thus, after the treatment of being pressed, the density of mixture layer 12 is a compaction density. Saka further teaches that “[t]he mixture density of the positive electrode mixture layer 12 is, for example, 2.5 g/cm³ to 3.5 g/cm³.” EX1006, ¶51.

Therefore, Saka teaches that the compaction density of the positive electrode mixture layer 12 (including both first and second layers 12a and 12b) can be greater than 3.2 g/cc.



EX1006, FIG. 5 (annotated).

278. The combination teaches this element.

279. It would have been obvious to a POSA to combine Wang and Saka.

To start, Wang and Saka are analogous to each other and to the problem in the '118 patent. In particular, like the '118 patent, Wang and Saka are both directed towards battery electrodes, particularly cathodes, having a current collector and a bilayer structure of active materials on the current collector. Wang describes first layer 510

on a current collector 113 and a second layer 520 on first layer 510, with the first and second layers 510 and 520 having particles of different sizes. EX1005, FIG. 5C. Saka describes a second layer 12b on a current collector 11 and a first layer 12a on the second layer 12b, with the first and second layers 12a and 12b having different compositions. EX1006, FIG. 5.

280. More specifically, both Wang and Saka teach compression treatments to the bilayer structure of active materials to consolidate the bilayer structure of active materials and increase its density. EX1006, ¶7 (“in order to maintain the battery capacity, it is necessary to improve the filling factor, that is, the mixture density of a positive electrode mixture layer”). Although Wang does not explicitly provide values or ranges of values of the compaction density (density of the bilayer structure of active materials after the compression treatment), a POSA reading Wang would reasonably understand the purpose and the outcome of the compression treatment to the bilayer structure of active material, and would reasonably be motivated to review additional teachings about quantitative values or ranges of the compaction density, of which Saka teaches.

281. Furthermore, it would be well known to a POSA the range of compaction densities that were commonplace in the art and that common sense dictates choosing the highest compaction density that is workable for a given application. *See, e.g.*, EX1004, ¶7 (teaching a POSA to pack the electrode active

material “as densely as possible” in order to maximize the energy capacity of the battery); EX1009, ¶36 (teaching that densities less than 3.31 g/cc “may be too small to obtain a high electrical capacity”).

282. Having reviewed Saka, a POSA would have been motivated to modify Wang’s teaching by combining Saka’s range of the compaction density with the properties of the active material in Wang’s cathode structure. The resulting combination of teachings would have provided more detailed characteristics of Wang’s structure of the electrode, and a POSA would have had a reasonable expectation of success that the active material as taught by Wang could reach the quantitative range of the compaction density, and thus battery energy densities, as taught by Saka after the compression treatment.

8. Claim 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.

283. Wang discloses that the thickness of the first layer is not less than the Dv90 of the first material. EX1005, ¶81. Specifically, Wang discloses that the first layer 510 has a thickness between about 10 μm to about 150 μm , or between about 50 μm to about 100 μm . EX1005, ¶81.

284. Wang teaches particle sizes that are smaller than this layer thickness. EX1005, ¶81 (“**In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.**”). A POSA knows that a diameter range

of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than any possible layer thicknesses taught by Wang.

285. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than most of the first layer thicknesses in Wang’s broadest disclosed range of 10 to 150 μm , and is demonstrably less than the minimum thickness, 50 μm , of Wang’s other quoted layer thickness range of 50 to 100 μm .

286. Thus, Wang teaches that 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.

9. Claim 3. The electrode according to claim 1, 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.

287. Wang discloses the claimed ratio between the particle sizes of the layers. EX1005, ¶83. Specifically, Wang discloses a second layer 520 having second cathodically active particles 522 having a second diameter is formed over the first layer 510. EX1005, ¶83. In one embodiment, “the second cathodically active particles 522 have a second diameter greater than five times the particle size of the particles of the first layer.” EX1005, ¶83. In other words, the ratio of the average particle size of the second material to the first material is at least 5:1. A ratio of 5:1, and a range of greater ratios implied by Wang, is within the claimed numeric range of 1:1 to 40:1. *See also* EX1005, ¶84 (“In certain embodiments where the particles are micrometer sized particles . . . the second cathodically active particles have a particle diameter greater than five times the particle size of the particles of the first layer.”).

288. Wang therefore discloses the claimed ratio of particle sizes between layers.

10. Claim 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 .

289. Wang discloses a first material with an average particle size within this range. EX1005, ¶81. Wang teaches an embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . In this embodiment, “average particle size” of Wang’s first cathodically active layer, which the ’118 patent uses to denote Dv50, falls within this size range between 2 and 15 μm , i.e., the average or median size cannot be outside of the range for which is it describing the average or median.

290. Thus, the average particle size taught by this Wang embodiment falls within the claimed range of 0.2 μm to 15 μm .

- 11. Claim 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.**

291. Wang in view of Saka teaches that 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 3.2 g/cc. As discussed above, Saka teaches that “[t]he mixture density of the positive electrode mixture layer 12 is, for example, 2.5 g/cm³ to 3.5 g/cm³.” EX1006, ¶51. Accordingly, Saka teaches densities as high as 3.5 g/cc, which is greater than 2.8 g/cc and greater than 3.3 g/cc.

292. A POSA would be motivated to combine Saka with Wang for the purpose of learning specific compaction densities for the layers as discussed above. For instance, as discussed for limitation 1.5, Wang describes that one or both layers can be exposed to a compression process, such as a calendaring process, to increase the packing density of the particles and achieve a desired net density. EX1005, ¶¶15, 58 (“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.”).

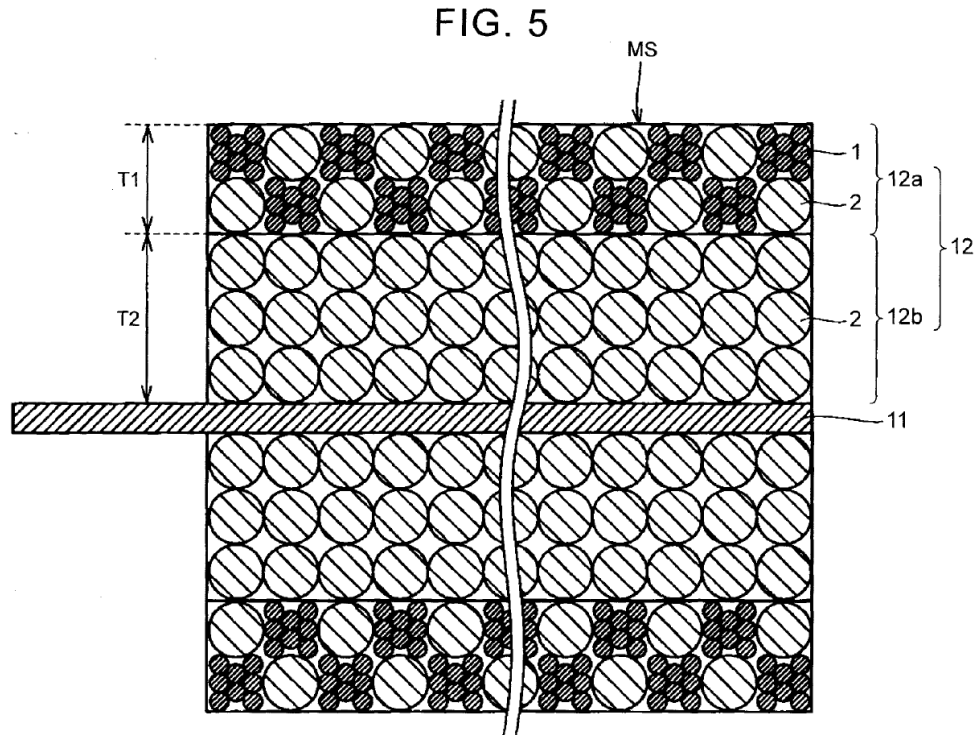
293. Wang specifically describes embodiments where the layers have different densities, which is accomplished by subjecting both layers to separate compression processes. EX1005, FIG. 3 (illustrating a process for applying a first

layer, compressing it, applying a second layer, and compressing the resulting layered structure again), ¶¶73, 92 (“In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the net density of the second porous layer relative to the first porous layer.”).

294. Wang does not explicitly teach the numeric values of the compaction densities for the two layers. Saka does. Saka teaches a similar layering process with compression steps, comparable to the process disclosed in Wang. Saka goes on to disclose the numeric compaction densities of the layers for several embodiments. While Saka does not disclose the relative compaction densities for the individual layers, Saka discloses other information from which a POSA could easily calculate that information without the need to rely on assumptions or outside information.

295. I have calculated the compaction densities for all of Saka’s examples in Exhibit 1007 (excel spreadsheet).

296. The structure of the cathodes taught by Saka is illustrated below.



EX1006, FIG. 5.

297. Saka's layers are labeled opposite to the convention used in the '118 patent and in the other prior art I discuss, introducing a minor bookkeeping complication to analyzing and discussing this prior art. Saka's layer one is the outer (top) layer of the structure, which is called layer 2 or the second layer in both Wang and the '118 patent. Saka's layer two is the inner (bottom) layer, or the layer sitting directly on the current collector, which is called layer 1 or the first layer in both Wang and the '118 patent. Two types of active material particles are used in Saka's cathode layers. Lithium nickel cobalt manganese oxide (NCM) is present in both of Saka's layers 1 and 2. Lithium iron phosphate (LFP) is only present in the outer layer, i.e., Saka's layer 1.

298. Saka's layers, like the layers in the '118 patent and in Wang, include active material particles, a conductive additive, and a polymer binder. The relative amounts of these components in each of the two layers of Saka's examples and comparative examples are given by Saka. EX1006, ¶¶107 ("Powder of a positive electrode active material (NCM), powder of a conductive material (AB), and powder of a binder (PVdF) . . . for forming the second layer . . . a mixing ratio (positive electrode active material : conductive material : binder; mass ratio) of the positive electrode mixture (solid content) was 90:7:3."), 108 ("Powder of a positive electrode active material (LFP and NCM), powder of a conductive material (AB), and powder of a binder (PVDF) . . . for forming the first layer . . . a mixing ratio (positive electrode active material : conductive material : binder; mass ratio) of the positive electrode mixture was 86:10:4, and a ratio of the mass of LFP to the total mass of LFP and NCM was 13.3 mass %."). These compositions of the first and second layer remain the same throughout Saka's examples and comparative examples except that the relative amounts of LFP and NCM in the first layer changes between examples.

299. The following table summarizes the composition values for Saka's examples and the notation I will use in my calculation:

	Layer 1	Layer 2
mass fraction of particles	$m_{p1} = 0.86$	$m_{p2} = 0.90$
mass fraction of NCM	$m_{NCM1} = \text{varies among examples}$	$m_{NCM2} = 0.90$
mass fraction of LFP	$m_{LFP} = \text{varies among examples}$	0
mass fraction conductive additive	$m_{c1} = 0.10$	$m_{c2} = 0.07$
mass fraction PVdF binder	$m_{v1} = 0.04$	$m_{v2} = 0.03$

300. Saka has tables (Figure 7/Table 1 and Figure 10/Table 4) that list characteristics of example batteries (A1 through A15) and comparative example batteries (B1 through B14). Batteries B1-B5 have single layer cathodes and were not considered.

301. For each example or comparative example, the Saka tables list the following parameters, to which I will assign a letter variable or other mathematical expression as detailed below:

Name in Saka Tables	Variable in Calculation
Thickness of Layer 1	T1
Thickness of Layer 2	T2
Volume of Layer 1	V1
Volume of Layer 2	V2
Volume Ratio of First Layer	$\frac{V_1}{V_1 + V_2} = \frac{T_1}{T_1 + T_2}$
Ratio of mass of LFP to mass of positive electrode active material in first layer	$R1 = \frac{m_{LFP}}{m_{LFP} + m_{NCM1}}$
Ratio of mass of LFP to total mass of positive electrode active material (in both layers)	$R2 = \frac{m_{LFP}}{m_{p1} + m_{p2}} = \frac{m_{LFP}}{m_{LFP} + m_{NCM1} + m_{NCM2}}$
Mixture Density (Average density of both layers)	D_{av}

302. Saka's Tables 1 (Figure 7) and 4 (Figure 10), along with the compositions given for the Saka examples, provide all the necessary information to calculate the separate densities of Saka's two cathode layers. No assumptions or outside information are necessary. Saka's Table 1 is shown below.

FIG. 7

TABLE 1

BATTERY	POSITIVE ELECTRODE MIXTURE LAYER					
	LAYER CONFIGURATION		VOLUME RATIO OF FIRST LAYER T1/(T1+T2)	RATIO OF MASS OF LFP TO MASS OF POSITIVE ELECTRODE ACTIVE MATERIAL IN FIRST LAYER	RATIO OF MASS OF LFP TO TOTAL MASS OF POSITIVE ELECTRODE ACTIVE MATERIAL	MIXTURE DENSITY
	FIRST LAYER (UPPER LAYER)	SECOND LAYER (LOWER LAYER)				
			Vol%	mass%	mass%	g/cm ³
B1	NCM SINGLE LAYER		-	-	0	2.7
B2	NCM SINGLE LAYER		-	-	0	3.0
B3	(LFP+NCM) SINGLE LAYER		-	-	10	3.0
B4	(LFP+NCM) SINGLE LAYER		-	-	20	3.0
B5	(LFP+NCM) SINGLE LAYER		-	-	50	2.7
B6	LFP+NCM	NCM	75	6.7	5	3.0
A1	LFP+NCM	NCM	75	13.3	10	3.0
A2	LFP+NCM	NCM	75	26.6	20	3.0
B7	LFP+NCM	NCM	75	33.3	25	3.0
B8	LFP+NCM	NCM	50	10	5	3.0
A3	LFP+NCM	NCM	50	15	7.5	3.0
A4	LFP+NCM	NCM	50	30	15	3.0
A5	LFP+NCM	NCM	50	40	20	3.0
B9	LFP+NCM	NCM	50	50	25	3.0
A6	LFP+NCM	NCM	25	40	10	3.0
A7	LFP+NCM	NCM	25	80	20	3.0
B10	LFP+NCM	NCM	20	25	5	3.0
A8	LFP+NCM	NCM	20	50	10	3.0
A9	LFP+NCM	NCM	20	80	16	3.0
B11	LFP	NCM	20	100	20	2.9
B12	LFP+NCM	NCM	15	66.6	10	3.0
B13	LFP+NCM	NCM	12.5	80	10	3.0
B14	LFP	NCM	10	100	10	3.0

EX1006, FIG. 7 (Table 1).

303. What Saka calls the volume ratio of the first layer is actually the volume ratio of the first layer to the total volume of both layers. They express this in terms of layer thicknesses, rather than volumes, because the volume of each layer is the thickness multiplied by the area of each layer. Since the layers occupy the same area on the cathode surface, this common area divides out of the ratio and we are left with an equivalent ratio in terms of layer thicknesses.

304. Saka gives relative amounts of the components in each layer, but does not specify actual amounts, for instance in grams. For the purpose of calculation, a POSA knows that one can pick a convenient amount of material, called a “basis,” on which to do the calculation. I am choosing a basis of 100g of total cathode active layer material. At the beginning of the calculation, we do not know how this 100g is divided between the first and second layer. We do know, however, that:

$$M_T = M_1 + M_2 = 100g \quad \text{Equation 1}$$

where M_T is the total mass of both layers, M_1 is the mass of first layer and M_2 is the mass of second layer. Information specified by Saka, including layer compositions and the ratios of LFP to total active material in the first layer and in the total of both layers, allows a POSA to calculate the separate masses of the two layers, as well as the separate layer densities.

305. The following calculation is for Saka's example battery A1. The other calculations are analogous. For example A1, Saka's Table 1 specifies that:

$$R_1 = \frac{m_{LFP}}{m_{LFP} + m_{NCM1}} = 0.133$$
$$R_2 = \frac{m_{LFP}}{m_{LFP} + m_{NCM1} + m_{NCM2}} = 0.10 \quad \text{Equation 2}$$

306. We know that from Saka's paragraphs 107 and 108 that:

$$m_{p1} = \frac{m_{LFP} + m_{NCM1}}{m_{LFP} + m_{NCM1} + m_{c1} + m_{V1}} = 0.86$$
$$m_{p2} = \frac{m_{NCM2}}{m_{NCM2} + m_{c2} + m_{V2}} = 0.90$$

307. We can calculate from what Saka has specified for layer 1 that:

$$\text{Mass of LFP in Layer 1} = m_{p1}R_1M_1 = M_{LFP} = 0.86 \times 0.133 \times M_1$$

$$\begin{aligned} \text{Mass of NCM in Layer 1} &= m_{p1}(1 - R_1)M_1 = M_{NCM1} \\ &= 0.86 \times (1 - 0.133) \times M_1 \end{aligned}$$

$$\text{Mass of Conductive additive in layer 1} = m_{c1}M_1 = M_{c1} = 0.1 \times M_1$$

$$\text{Mass of PVdF in layer 1} = m_{V1}M_1 = M_{V1} = 0.04 \times M_1$$

308. We can calculate from what Saka has specified for layer 2 that:

$$\text{Mass of NCM in Layer 2} = m_{p2}M_2 = M_{NCM2} = 0.9 \times M_2$$

$$\text{Mass of Conductive additive in layer 2} = m_{c2}M_2 = M_{c2} = 0.07 \times M_2$$

$$\text{Mass of PVdF in layer 2} = m_{V2}M_2 = M_{V2} = 0.04 \times M_2$$

309. Substituting the above values into Equation 2, I obtain:

$$\begin{aligned}
 R_2 &= \frac{m_{LFP}}{m_{LFP} + m_{NCM1} + m_{NCM2}} \\
 &= \frac{(100 \text{ g})m_{LFP}}{100 \text{ g} (m_{LFP} + m_{NCM1} + m_{NCM2})} \\
 &= \frac{M_{LFP}}{M_{LFP} + M_{NCM1} + M_{NCM2}} \\
 &= \frac{0.86 \times 0.133 \times M_1}{0.86 \times 0.133 \times M_1 + 0.86 \times (1 - 0.133) \times M_1 + 0.9 \times M_2} = 0.10
 \end{aligned}$$

Equation 3

310. Equations 1 and 3 are two equations with two unknowns, M_1 and M_2 , which can be solved algebraically to yield the masses (relative to a 100 g basis) of the two cathode layers in Saka's example battery A1. These values are: M_1 (A1) = 76.03 g, and M_2 (A1) = 23.97 g.

311. In order to calculate the separate densities of Saka's two layers, we need to divide the masses of the individual layers by the volumes of the individual layers, V_1 and V_2 . The volumes of the individual layers are calculated from the information provided in Saka's Table 1 as follows:

$$\frac{V_1}{V_1 + V_2} = \frac{T_1}{T_1 + T_2} = 0.75 \quad \text{Equation 4}$$

$$D_{av} = \frac{M_T}{V_1 + V_2} = \frac{100 \text{ g}}{V_1 + V_2} = 3.0 \text{ g/cm}^3 \quad \text{Equation 5}$$

312. Equations 4 and 5 are two equations in the two unknowns V_1 and V_2 which can be solved algebraically. For Saka's example battery A1, these layer volumes are: $V_1 = 25.0 \text{ cm}^3$, and $V_2 = 8.33 \text{ cm}^3$. The individual layer densities, D_1 and D_2 , are calculated by dividing the mass of each layer by the volume of each layer:

$$D_1 = \frac{M_1}{V_1} = \frac{76.03 \text{ g}}{25.0 \text{ cm}^3} = 3.04 \text{ g/cm}^3$$

$$D_2 = \frac{M_2}{V_2} = \frac{23.97 \text{ g}}{8.33 \text{ cm}^3} = 2.88 \text{ g/cm}^3$$

313. These individual layer densities are all that is required to compare Saka to claim 5 of the '118 patent. However, it is also possible to calculate the separate porosities of the two layers, P_1 and P_2 , in each of Saka's examples. This is done by first calculating the "occupied volume" of each layer, V_{O1} and V_{O2} . This is the space (volume) that each component (active material particles, conductive additive, and polymer binder) occupies based on the mass present in the layer and on the known density of each component. The reciprocal of these densities are the volumes occupied by each gram of each of these ingredients. Then, the porosities are calculated as follows: $P_1 = (V_1 - V_{O1})/V_1$, and $P_2 = (V_2 - V_{O2})/V_2$. For Saka's battery example A1, the porosity of layer 1 is 19% and the porosity of layer 2 is 30%. The reasonableness of these porosity values reinforces the validity of my

density calculations, and provides insight into why the density of layer 2 is less than that of layer 1.

314. The examples of Saka for which the compaction densities of the first layers falls within the scope of claim 5 are as follows:

Example	Compaction Density (g/cc) First Layer	Compaction Density (g/cc) Second Layer
A1	2.88	3.04
A2	2.88	3.04
B7	2.89	3.04
B8	2.93	3.07
A3	2.93	3.07
A4	2.93	3.07
A5	2.93	3.07
B9	2.93	3.07
A6	2.97	3.10
A7	2.97	3.10
B10	2.97	3.11
A8	2.97	3.11
A9	2.97	3.11
B11	2.87	3.01
B12	2.98	3.12
B13	2.98	3.12
B14	2.99	3.13
A15	2.93	3.07

315. In this table, the layers are labeled using the nomenclature of the '118 patent and of Wang, to facilitate comparison to the '118 claim. This is reversed from the Saka's layer labeling used in the calculations above. While the second layers in these examples fall short of the 3.3 g/cc requirement for the second layer, they are very close, and they are greater than the compaction densities for the first layers. Saka's overarching teaching that the compaction density can be as high as

3.5 g/cc, in view of these examples, thus suggests to one of skill in the art that the density of the first layer is greater than 2.8 g/cc and the density of the second layer is greater than 3.3 g/cc.

316. The combination of Wang and Saka therefore teaches an electrode wherein a compaction density of the first layer is greater than 2.8 g/cc, and a compaction density of the second layer is greater than 3.3 g/cc. And they would have been obvious to combine, and once combined, there would be an expectation of success of their combination.

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

317. Wang teaches that “it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.” EX1005, ¶92. This implies that the particles of the first layer have a lower compaction density than the second layer.

318. Saka also teaches that the first layer has a lower compaction density than the second layer, as all of the examples in the chart above for claim 5 list a compaction density for the first layer that is less than that for the second layer. *See* EX1007. One of skill in the art would be motivated to combine Wang and Saka’s teachings in this regard for the reasons stated above with respect to claim 1, and for

the additional reason that the teachings of the two references are consistent and reinforce one another in the context of the first layer having a lower compaction density than the second layer.

- 13. Claim 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.**

319. Wang teaches that the first “cathodically active material 212 is selected from the group comprising: lithium cobalt dioxide (LiCoO_2), lithium manganese dioxide (LiMnO_2), titanium disulfide (TiS_2), $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$, LiMn_2O_4 , LiFePO_4 , $\text{LiFe}_{1-x}\text{MgPO}_4$, LiMoPO_4 , LiCoPO_4 , $\text{Li}_3\text{V}_2(\text{PO}_4)_3$, LiVOPO_4 , LiMP_2O_7 , $\text{LiFe}_{1.5}\text{P}_2\text{O}_7$, LiVPO_4F , LiAlPO_4F , $\text{Li}_5\text{V}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_5\text{Cr}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_2\text{CoPO}_4\text{F}$, $\text{Li}_2\text{NiPO}_4\text{F}$, $\text{Na}_5\text{V}_2(\text{PO}_4)_2\text{F}_3$, $\text{Li}_2\text{FeSiO}_4$, $\text{Li}_2\text{MnSiO}_4$, $\text{Li}_2\text{VOSiO}_4$, LiNiO_2 , and combinations thereof.” EX1005, ¶51.

320. Wang therefore teaches most items in the Markush group of claim 7.

321. To fully appreciate the correspondence between the ’118 patent’s claim 7 and Wang’s paragraph 51, it should be noted that: lithium cobalt dioxide (LiCoO_2) is lithium cobaltate, $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$ is lithium nickel cobalt manganese oxide, LiMn_2O_4 is lithium manganate, LiFePO_4 is lithium iron phosphate, $\text{LiFe}_{1-x}\text{MgPO}_4$ is lithium iron manganese phosphate, $\text{Li}_3\text{V}_2(\text{PO}_4)_3$ is lithium

vanadium phosphate, LiVOPO_4 is lithium vanadyl phosphate, and LiNiO_2 is lithium nickelate. The only items in the Markush group of claim 7 that are not in Wang's paragraph 51 are lithium nickel cobalt aluminate and lithium titanate.

322. Additionally, Saka teaches that the particles of its first (inner) layer are lithium nickel cobalt manganese oxide ($\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$). EX1006, ¶10. Saka therefore also teaches an item within the Markush group that is common to Wang.

323. Accordingly, a POSA combining Wang's teachings with Saka's particle densities would know that Saka's lithium-nickel-cobalt-manganese-oxide particles are compatible with Wang's device and that the compaction density for Saka's particles can be readily incorporated into Wang's device.

324. The combination therefore teaches claim 7, at least to the extent that it teaches lithium nickel cobalt manganese oxide ($\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$).

14. Claim 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.

325. Wang teaches that the second "cathodically active material 222 is selected from the group comprising: lithium cobalt dioxide (LiCoO_2), lithium manganese dioxide (LiMnO_2), titanium disulfide (TiS_2), $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$, LiMn_2O_4 , LiFePO_4 , $\text{LiFe}_{1-x}\text{MgPO}_4$, LiMoPO_4 , LiCoPO_4 , $\text{Li}_3\text{V}_2(\text{PO}_4)_3$, LiVOPO_4 , LiMP_2O_4 , $\text{LiFe}_{1.5}\text{P}_2\text{O}_7$, LiVPO_4F , LiAlPO_4F , $\text{Li}_5\text{V}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_5\text{Cr}(\text{PO}_4)_2\text{F}_2$,

$\text{Li}_2\text{CoPO}_4\text{F}$, $\text{Li}_2\text{NiPO}_4\text{F}$, $\text{Na}_5\text{V}_2(\text{PO}_4)_2\text{F}_3$, $\text{Li}_2\text{FeSiO}_4$, $\text{Li}_2\text{MnSiO}_4$, $\text{Li}_2\text{VOSiO}_4$, LiNiO_2 , and combinations thereof.” EX1005, ¶55. Wang therefore teaches almost all items in the Markush group of claim 8.

326. To fully appreciate the correspondence between the '118 patent's claim 8 and Wang's paragraph 55, it should be noted that: lithium cobalt dioxide (LiCoO_2) is lithium cobaltate, $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$ is lithium nickel cobalt manganese oxide, LiMn_2O_4 and $\text{LiFe}_{1-x}\text{MgPO}_4$ are lithium-rich manganese-based materials, and LiFePO_4 is lithium iron phosphate. The only item in the Markush group of claim 8 that is not in Wang's paragraph 55 is lithium nickel cobalt aluminium oxide.

327. Additionally, Saka teaches that the second material is lithium iron phosphate (LFP) and lithium nickel cobalt manganese oxide (NCM). EX1006, ¶10. Saka therefore teaches two items within the Markush group of claim 8 that are also common to Wang.

328. Accordingly, a POSA combining Wang's teachings with Saka's cathode-layer densities would know that both Saka's LFP and NCM particles are compatible with Wang's device and that the compaction density for Saka's layers can be readily incorporated into Wang's device. The combination therefore teaches claim 8, at least to the extent that it teaches lithium iron phosphate and lithium nickel cobalt manganese oxide.

- 15. Claim 9. The electrode according to claim 1, 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.***

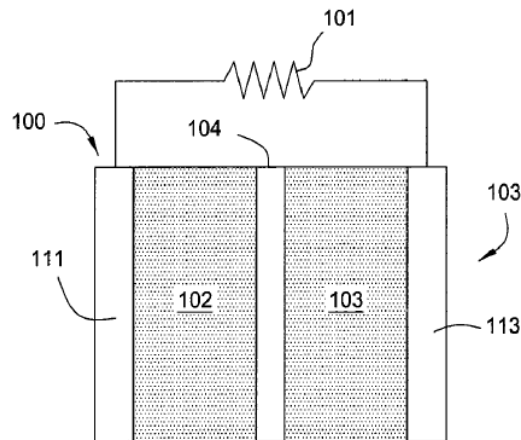
329. Wang teaches that the first material can be graphite, soft carbon, hard carbon, silicon, silicon carbide, and lithium titanate. EX1005, ¶52. Wang therefore teaches several of the items in the Markush group of claim 9. “Soft carbon” and “hard carbon” as recited in claim 9 are different grades of carbon black. *See generally* EX1025; EX1026; EX1027; EX1028. Wang teaches the use of “carbon black,” EX1005, ¶52, and thus teaches a form of soft carbon and hard carbon. EX1023 (discussing hard carbon black and soft carbon black); EX1024 (“Carbon black is divided into hard carbon black and soft carbon black according to its function; The particle size of hard carbon black is less than 40nm and that of soft carbon black is more than 40nm.”).

330. Additionally, Saka teaches that there can be a conductive material in the first (inner) layer, which is compatible with Wang’s listing of materials. EX1006, ¶22. Saka also mentions acetylene black (a form of hard carbon black) as a material for the first (inner) layer, and uses this form of hard carbon in its examples. EX1006, ¶75; EX1020 (characterizing acetylene black as a form of hard carbon black).

331. Accordingly, a POSA looking to combine Wang and Saka would understand that the various forms of carbon and silicon listed in this Markush group are compatible with the combined teachings of Wang and Saka, including the compaction densities disclosed in Saka.

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

332. Wang teaches a battery, which is an electrochemical device. *See* EX1005, ¶¶10, 11, 35. Wang’s battery includes Wang’s cathode structure 103, which is an electrode. In particular, Wang teaches, “The primary functional components of Li-ion battery 100 include an anode structure 102, **a cathode structure 103**, [and] a separator layer 104” EX1005, ¶41. The cathode structure 103 is an electrode of Li-ion battery 100. *See* EX1005, FIG. 1A.

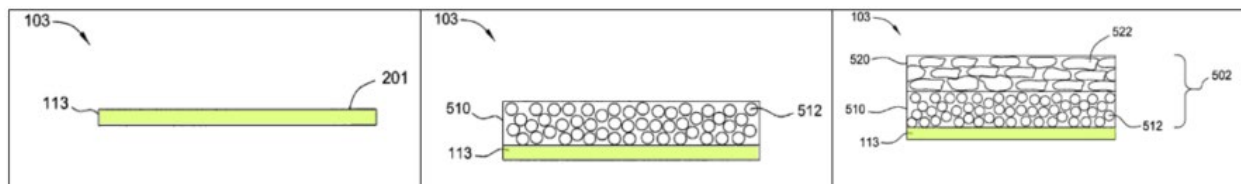


EX1005, FIG. 1A.

333. Wang teaches the limitation.

1. 10.1: a current collector;

334. Wang's current collector 113 is the claimed current collector. *See* EX1005, ¶¶10, 11. Wang teaches that the electrode comprises a current collector. EX1005, ¶42; *see also* EX1005, ¶¶10, 11 (“The graded cathode structure comprises a conductive substrate . . .”). A POSA will understand that “conductive substrate” is referring to a current collector. Wang teaches that “FIGS. 5A-5C are schematic cross-sectional views of one embodiment of a **graded cathode electrode structure 103** having a particle size gradient formed according to embodiments described herein.” EX1005, ¶80. Wang also teaches that “[i]n FIG. 5A, **current collector 113** is schematically illustrated prior to the deposition of the graded particle structure 502 on the current collector 113.” EX1005, ¶80.



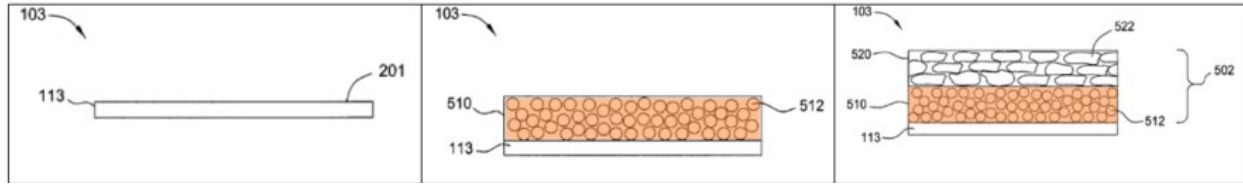
EX1005, FIGs. 5A-5C, left to right (annotated).

335. Wang teaches this element.

2. 10.2: a first layer comprising a first material; and;

336. Wang teaches that the electrode comprises a first layer, which comprises a first material. *See* EX1005, ¶¶10, 11. Wang's first layer 510 is the claimed first layer. Wang's first cathodically active particles 512 are the claimed first material. In particular, Wang teaches that “**a first layer 510 having first**

cathodically active particles 512 having a first diameter is formed over a surface 201 of the current collector 113.” EX1005, ¶81; *see also* EX1005, FIGs. 5A-5C.

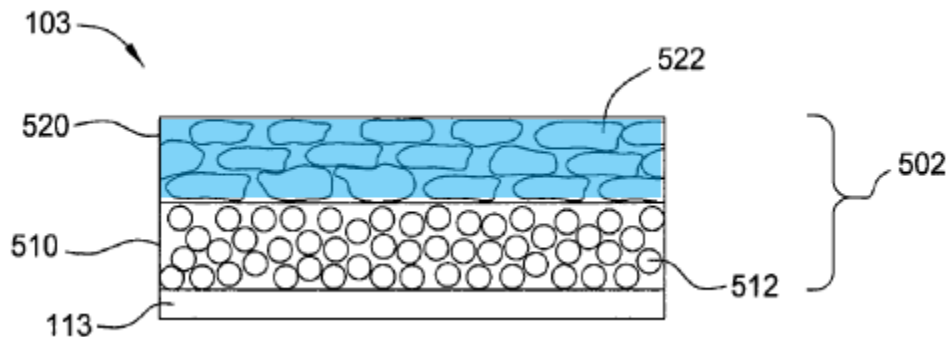


EX1005, FIGs. 5A-5C, left to right (annotated).

337. Wang teaches this element.

3. 10.3: a second layer comprising a second material;

338. Wang teaches that the electrode comprises a second layer, which comprises a second material. *See* EX1005, ¶¶10, 11. Wang’s second layer 520 is the second layer. Wang’s second cathodically active particles 522 are the second material. In particular, Wang teaches that “**a second layer 520 having second cathodically active particles 522** having a second diameter is formed over the first layer 510.” EX1005, ¶83; *see also* EX1005, FIG. 5C.

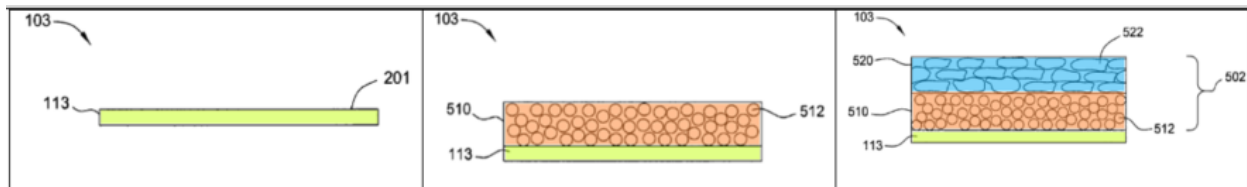


EX1005, FIG. 5C (annotated).

339. Wang teaches this element.

4. **10.4.1: wherein the first layer is arranged between the current collector and the second layer,**

340. Wang teaches that the first layer is arranged between the current collector and the second layer. *See* EX1005, ¶¶10, 11. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of** the current collector 113” and “a second layer 520 . . . **is formed over** the first layer 510.” EX1005, ¶¶81, 83; *see also* EX1005, FIGs. 5A-5C.

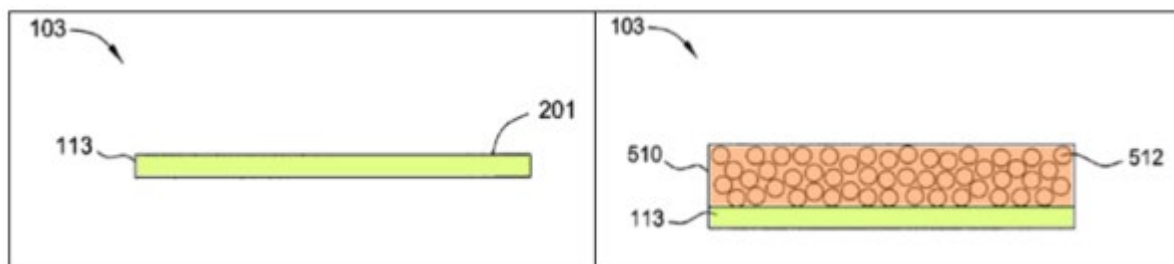


EX1005, FIGs. 5A-5C, left to right (annotated).

341. Wang teaches this element.

5. **10.4.2: the first layer is formed on a surface of the current collector,**

342. Wang teaches that the first layer is formed on a surface of the current collector. *See* EX1005, ¶¶10, 11, 38. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of** the current collector 113.” EX1005, ¶81; *see also* EX1005, FIGs. 5A, 5B.



EX1005, FIGs. 5A, 5B, left to right (annotated).

343. Wang teaches this element.

6. 10.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,

344. Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm . EX1005, ¶81. Wang teaches in one embodiment that the first cathodically active particles 512 “are nano-scale particles.” EX1005, ¶81 (“**In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.**”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . (*See, e.g.*, discussion of nanoscale particles and SEM images for claim 1.4.3, above). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . The Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than 40 μm .

345. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“**In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .**”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments.

Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than 40 μm . Thus, Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm .

7. 10.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

346. Wang in view of Saka teaches that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

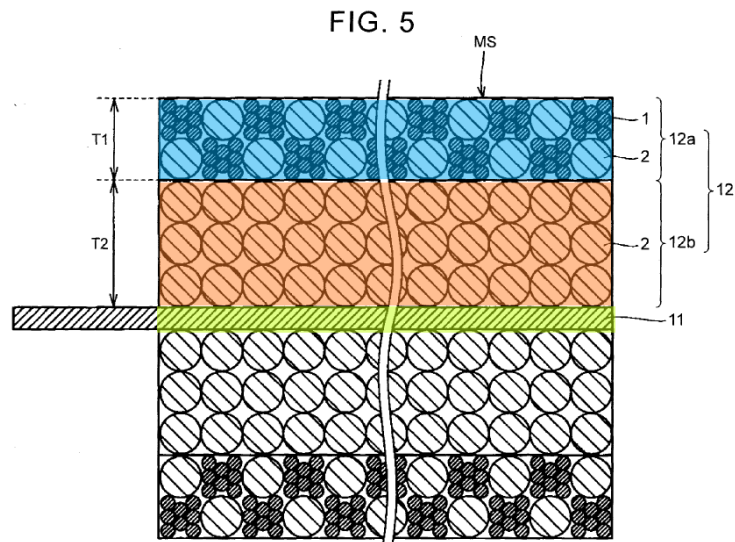
347. Wang teaches that, in the method for producing a cathode, following the deposition of “cathodically active particles over the vertically oriented flexible conductive substrate,” the cathode is further processed using “a compression chamber . . . configured to expose the vertically oriented flexible conductive substrate to a calendaring process to compress the deposited particles to a desired net-density.” EX1005, ¶¶15, 58 (“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.”).

348. Wang further describes that there can be one or two compression steps, depending on the desired compaction density of the layers. EX1005, ¶92

(“After the particles are deposited over the conductive substrate, the particles may be compressed using compression techniques, for example, a calendaring process, to achieve a desired net density of compacted particles while planarizing the surface of the second layer. In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.”). Wang thus teaches the processes and techniques required for achieving the desired compaction density of the layers in order to achieve a high packing density of active material in the cathode layers and thus a high energy density for the battery.

349. The only aspect of limitation 1.5 Wang does not explicitly teach is the numeric value for the desired compaction density. Indeed, despite Wang’s focus on teaching methods of achieving desired densities, Wang does not give a reason to desire any particular density. Wang assumes the reader has a desired density in mind. To the extent the reader does not, one of skill in the art would be motivated to look to a reference like Saka, which provides numerous specific densities and discusses their relative desirability. Wang therefore does not expressly teach that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc. But the range of desired compaction densities, including the density recited in limitation 1.5, is explicitly taught in Saka.

350. Saka teaches an electrode having a positive electrode mixture 12 on a current collector 11, where positive electrode mixture 12 includes a first layer 12a and a second layer 12b. *See* EX1006, FIG. 5. In addition, Saka teaches that “the dried positive electrode mixture layer 12 **may be pressed using a rolling mill or the like to adjust the thickness and the mixture density thereof.**” EX1006, ¶51. Thus, after the treatment of being pressed, the density of mixture layer 12 is a compaction density. Saka further teaches that “[t]he mixture density of the positive electrode mixture layer 12 is, for example, 2.5 g/cm³ to 3.5 g/cm³.” EX1006, ¶51. Therefore, Saka teaches that the compaction density of the positive electrode mixture layer 12 (including both first and second layers 12a and 12b) can be greater than 3.2 g/cc.



EX1006, FIG. 5 (annotated).

351. The combination teaches this element.

352. It would have been obvious to a POSA to combine Wang and Saka.

To start, Wang and Saka are analogous to each other and to the problem in the '118 patent. In particular, like the '118 patent, Wang and Saka are both directed towards battery electrodes, particularly cathodes, having a current collector and a bilayer structure of active materials on the current collector. Wang describes first layer 510 on a current collector 113 and a second layer 520 on first layer 510, with the first and second layers 510 and 520 having particles of different sizes. EX1005, FIG. 5C. Saka describes a second layer 12b on a current collector 11 and a first layer 12a on the second layer 12b, with the first and second layers 12a and 12b having different compositions. EX1006, FIG. 5.

353. More specifically, both Wang and Saka teach compression treatments to the bilayer structure of active materials to consolidate the bilayer structure of active materials and increase its density. EX1006, ¶7 (“in order to maintain the battery capacity, it is necessary to improve the filling factor, that is, the mixture density of a positive electrode mixture layer”). Although Wang does not explicitly provide values or ranges of values of the compaction density (density of the bilayer structure of active materials after the compression treatment), a POSA reading Wang would reasonably understand the purpose and the outcome of the compression treatment to the bilayer structure of active material, and would

reasonably be motivated to review additional teachings about quantitative values or ranges of the compaction density, of which Saka teaches.

354. Furthermore, it would be well known to a POSA what compaction densities were commonplace in the art and that common sense dictates choosing the highest compaction density available for a given application. *See, e.g.*, EX1004, ¶7 (teaching a POSA to pack the electrode active material “as densely as possible” in order to maximize the energy capacity of the battery); *see also* EX1009, ¶36 (teaching that densities less than 3.31 g/cc “may be too small to obtain a high electrical capacity”).

355. Having reviewed Saka, a POSA would have been motivated to modify Wang’s teaching by combining Saka’s range of the compaction density with the properties of the active material in Wang’s cathode structure. The resulting combination of teachings would have provided more detailed characteristics of Wang’s structure of the electrode, and a POSA would have had a reasonable expectation of success that the active material as taught by Wang could reach the quantitative range of the compaction density, and thus battery energy densities, as taught by Saka after the compression treatment.

8. **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.**

356. Wang discloses that the thickness of the first layer is not less than the Dv90 of the first material. EX1005, ¶81. Specifically, Wang discloses that the first layer 510 has a thickness between about 10 μm to about 150 μm , or between about 50 μm to about 100 μm . EX1005, ¶81. Wang teaches particle sizes that are smaller than this layer thickness. EX1005, ¶81 (“**In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.**”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than any possible layer thicknesses taught by Wang.

357. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“**In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .**”). The plain language of this statement indicates that it is not referring to a range of

possible average sizes of particles across all different possible embodiments.

Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than most of the first layer thicknesses in Wang’s broadest disclosed range of 10 to 150 μm , and is demonstrably less than the minimum thickness, 50 μm , of Wang’s other quoted layer thickness range of 50 to 100 μm . Thus, Wang teaches that 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.

9. 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.

358. Wang discloses the claimed ratio between the particle sizes of the layers. EX1005, ¶83. Specifically, Wang discloses a second layer 520 having second cathodically active particles 522 having a second diameter is formed over the first layer 510. *Id.* In one embodiment, “the second cathodically active particles 522 have a second diameter greater than five times the particle size of the particles of the first layer.” EX1005, ¶83. In other words, the ratio of the average particle size of the second material to the first material is at least 5:1. A ratio of 5:1, and a range of greater ratios implied by Wang, are within the claimed numeric range of

1:1 to 40:1. *See also* EX1005, ¶84 (“In certain embodiments where the particles are micrometer sized particles . . . the second cathodically active particles have a particle diameter greater than five times the particle size of the particles of the first layer.”). Wang therefore discloses the claimed ratio of particle sizes between layers.

10. 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 .

359. Wang discloses a first material with an average particle size within this range. EX1005, ¶81. Wang teaches an embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . In this embodiment, “average particle size” of Wang’s first cathodically active layer, which the ’118 patent uses to denote Dv50, must necessarily fall within this size range between 2 and 15 μm , i.e., the average or median size cannot be outside of the range for which is it

describing the average or median. Thus, the average particle size taught by this

Wang embodiment must fall within the claimed range of 0.2 μm to 15 μm .

11. 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.

360. Wang in view of Saka teaches that 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 3.2 g/cc. As discussed above, Wang does not teach the numeric values of the compaction densities for the two layers. Saka does. Saka teaches that “[t]he mixture density of the positive electrode mixture layer 12 is, for example, 2.5 g/cm³ to 3.5 g/cm³.” EX1006, ¶51. Accordingly, Saka teaches densities as high as 3.5 g/cc, which is greater than 2.8 g/cc and greater than 3.3 g/cc.

361. Saka teaches a similar layering process with compression steps, comparable to the process disclosed in Wang. Saka goes on to disclose the numeric compaction densities of the layers for several embodiments. While Saka does not disclose the relative compaction densities for the individual layers, Saka discloses other information from which a POSA could easily calculate that information without the need to rely on assumptions or outside information.

362. I have calculated the compaction densities for all of Saka’s examples in Exhibit 1007. I have also explained the basis for the calculations a POSA would

use and walked through the equations above in claim 5. *See* Section VIII.A.11.,
supra.

363. I will note that Saka numbers its layers in the reverse of the '118 patent. In other words, Saka calls the inner layer the second layer and the outer layer the first layer. Despite that difference in arbitrary enumeration, the substance of Saka's teaching about the layers, how they are formed, and their material properties is the same. A POSA would readily understand that there is no significance attached to which layer is designated the "first" layer or "second layer" and a POSA would readily understand which of Saka's layers corresponds to which of the '118 patent's layers.

364. The examples of Saka for which the compaction densities of the layers falls within the scope of claim 14 are as follows:

Example	Compaction Density (g/cc) First Layer	Compaction Density (g/cc) Second Layer
A1	2.88	3.04
A2	2.88	3.04
B7	2.89	3.04
B8	2.93	3.07
A3	2.93	3.07
A4	2.93	3.07
A5	2.93	3.07
B9	2.93	3.07
A6	2.97	3.10
A7	2.97	3.10
B10	2.97	3.11
A8	2.97	3.11
A9	2.97	3.11
B11	2.87	3.01

Example	Compaction Density (g/cc) First Layer	Compaction Density (g/cc) Second Layer
B12	2.98	3.12
B13	2.98	3.12
B14	2.99	3.13
A15	2.93	3.07

365. Note that the terms “first layer” and “second layer” in the chart above use the enumeration of the ’118 patent, rather than Saka (which reverses the layer enumerations). While the second layers in these examples fall short of the 3.3 g/cc requirement for the second layer, they are very close, and they are greater than the compaction densities for the first layers. Saka’s overarching teaching that the compaction density can be as high as 3.5 g/cc, in view of these examples, thus suggests to one of skill in the art that the density of the first layer is greater than 2.8 g/cc and the density of the second layer is greater than 3.3 g/cc.

366. A POSA would be motivated to combine Saka with Wang for the purpose of learning specific compaction densities for the layers as discussed above. For instance, as discussed for limitation 1.5, Wang describes that one or both layers can be exposed to a compression process such as a calendaring process to increase the packing density of the particles and achieve a desired net density. EX1005, ¶¶15, 58 (“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”).

367. Wang specifically describes embodiments where the layers have different densities, which is accomplished by subjecting both layers to separate compression processes. EX1005, FIG. 3 (illustrating a process for applying a first layer, compressing it, applying a second layer, and compressing the resulting layered structure again), ¶¶73, 92 (“In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the net density of the second porous layer relative to the first porous layer”). The combination of Wang and Saka therefore teaches an electrode wherein a compaction density of the first layer is greater than 2.8 g/cc, and a compaction density of the second layer is greater than 3.3 g/cc.

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

368. Wang teaches that “it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.” EX1005, ¶92. This implies that the particles of the first layer have a lower compaction density than the second layer. Saka also teaches that the first layer has a lower compaction density than the second layer, as all of the examples in the chart above for claim 14 list a compaction density for the first layer that is less than that for the second layer. *See* EX1007.

13. **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.**

369. Wang teaches that the first “cathodically active material 212 is selected from the group comprising: lithium cobalt dioxide (LiCoO_2), lithium manganese dioxide (LiMnO_2), titanium disulfide (TiS_2), $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$, LiMn_2O_4 , LiFePO_4 , $\text{LiFe}_{1-x}\text{MgPO}_4$, LiMoPO_4 , LiCoPO_4 , $\text{Li}_3\text{V}_2(\text{PO}_4)_3$, LiVOPO_4 , LiMP_2O_7 , $\text{LiFe}_{1.5}\text{P}_2\text{O}_7$, LiVPO_4F , LiAlPO_4F , $\text{Li}_5\text{V}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_5\text{Cr}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_2\text{CoPO}_4\text{F}$, $\text{Li}_2\text{NiPO}_4\text{F}$, $\text{Na}_5\text{V}_2(\text{PO}_4)_2\text{F}_3$, $\text{Li}_2\text{FeSiO}_4$, $\text{Li}_2\text{MnSiO}_4$, $\text{Li}_2\text{VOSiO}_4$, LiNiO_2 , and combinations thereof.”. EX1005, ¶51. Wang therefore teaches most items in the Markush group of claim 16.

370. To fully appreciate the correspondence between the ’118 patent’s claim 7 and Wang’s paragraph 51, it should be noted that: lithium cobalt dioxide (LiCoO_2) is lithium cobaltate, $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$ is lithium nickel cobalt manganese oxide, LiMn_2O_4 is lithium manganate, LiFePO_4 is lithium iron phosphate, $\text{LiFe}_{1-x}\text{MgPO}_4$ is lithium iron manganese phosphate, $\text{Li}_3\text{V}_2(\text{PO}_4)_3$ is lithium vanadium phosphate, LiVOPO_4 is lithium vanadyl phosphate, and LiNiO_2 is

lithium nickelate. The only items in the Markush group of claim 7 that are not in Wang's paragraph 51 are lithium nickel cobalt aluminate and lithium titanate.

371. Additionally, Saka teaches that the particles of its first (inner) layer are lithium nickel cobalt manganese oxide ($\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$). EX1006, ¶10. Saka therefore also teaches an item within the Markush group that is common to Wang. Accordingly, a POSA combining Wang's teachings with Saka's cathode-layer densities would know that Saka's lithium-nickel-cobalt-manganese-oxide particles are compatible with Wang's device and that the compaction density for Saka's layers can be readily incorporated into Wang's device. The combination therefore teaches claim 16, at least to the extent that it teaches lithium nickel cobalt manganese oxide ($\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$).

- 14. 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.**

372. Wang teaches that the second "cathodically active material 222 is selected from the group comprising: lithium cobalt dioxide (LiCoO_2), lithium manganese dioxide (LiMnO_2), titanium disulfide (TiS_2), $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$, LiMn_2O_4 , LiFePO_4 , $\text{LiFe}_{1-x}\text{MgPO}_4$, LiMoPO_4 , LiCoPO_4 , $\text{Li}_3\text{V}_2(\text{PO}_4)_3$, LiVOPO_4 , LiMP_2O_4 , $\text{LiFe}_{1.5}\text{P}_2\text{O}_7$, LiVPO_4F , LiAlPO_4F , $\text{Li}_5\text{V}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_5\text{Cr}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_2\text{CoPO}_4\text{F}$, $\text{Li}_2\text{NiPO}_4\text{F}$, $\text{Na}_5\text{V}_2(\text{PO}_4)_2\text{F}_3$, $\text{Li}_2\text{FeSiO}_4$, $\text{Li}_2\text{MnSiO}_4$, $\text{Li}_2\text{VOSiO}_4$,

LiNiO₂, and combinations thereof.” EX1005, ¶55. Wang therefore teaches almost all items in the Markush group of claim 17.

373. To fully appreciate the correspondence between the '118 patent's claim 7 and Wang's paragraph 55, it should be noted that: lithium cobalt dioxide (LiCoO₂) is lithium cobaltate, LiNi_xCo_{1-2x}MnO₂ is lithium nickel cobalt manganese oxide, LiMn₂O₄ and LiFe_{1-x}MgPO₄ are lithium-rich manganese-based materials, and LiFePO₄ is lithium iron phosphate. The only item in the Markush group of claim 7 that is not in Wang's paragraph 55 is lithium nickel cobalt aluminium oxide.

374. Additionally, Saka teaches that the second material can be lithium iron phosphate (LFP) and lithium nickel cobalt manganese oxide (NCM). EX1006, ¶10. Saka therefore teaches two items within the Markush group of claim 8 that are also common to Wang. Accordingly, a POSA combining Wang's teachings with Saka's cathode-layer densities would know that both Saka's LFP and NCM particles are compatible with Wang's device and that the compaction density for Saka's layers can be readily incorporated into Wang's device. The combination therefore teaches claim 17, at least to the extent that it teaches lithium iron phosphate and lithium nickel cobalt manganese oxide.

- 15. 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.**

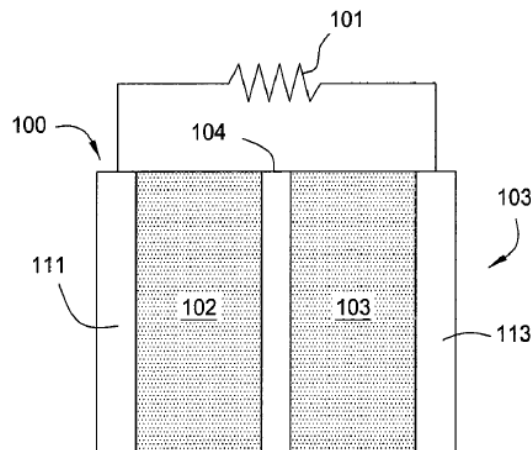
375. Wang teaches that the first material can be graphite, soft carbon, hard carbon, silicon, silicon carbide, and lithium titanate. EX1005, ¶52. Wang therefore teaches several of the items in the Markush group of claim 18. “Soft carbon” and “hard carbon” as recited in claim 18 are different grades of carbon black. *See generally* EX1025; EX1026; EX1027; EX1028. Wang teaches the use of “carbon black,” EX1005, ¶52, and thus teaches a form of soft carbon and hard carbon. EX1023 (discussing hard carbon black and soft carbon black); EX1024 (“Carbon black is divided into hard carbon black and soft carbon black according to its function; The particle size of hard carbon black is less than 40nm and that of soft carbon black is more than 40nm.”).

376. Additionally, Saka teaches that there can be a conductive material in the first (inner) layer, which is compatible with Wang’s listing of materials. EX1006, ¶22. Saka also mentions acetylene black (a form of hard carbon black) as a material for the first (inner) layer and uses this form of hard carbon in its examples. EX1006, ¶75; EX1020. Accordingly, a POSA looking to combine Wang and Saka would understand that the various forms of carbon and silicon listed in

this Markush group are compatible with the combined teachings of Wang and Saka, including the compaction densities disclosed in Saka.

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

377. Wang teaches a battery, which is an electrochemical device, and teaches that its battery is appropriate for use in electronic devices. EX1005, ¶¶10, 11, 35. Wang’s cathode structure 103 is an electrode. In particular, Wang teaches, “The primary functional components of Li-ion battery 100 include an anode structure 102, **a cathode structure 103**, a separator layer 104” EX1005, ¶41. The cathode structure 103 is an electrode of the Li-ion battery 100. *See* EX1005, FIG. 1A.



EX1005, FIG. 1A.

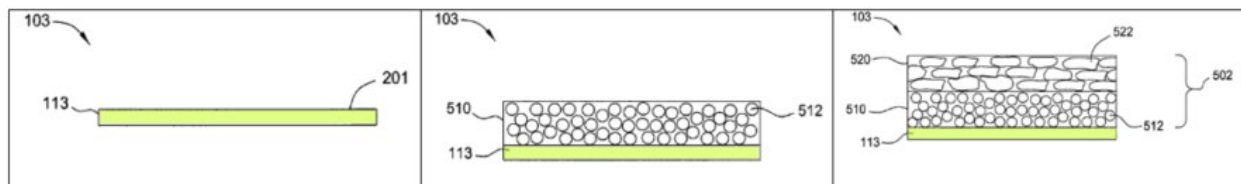
378. Wang teaches this element.

1. 19.1: a current collector;

379. Wang's current collector 113 is the claimed current collector.

EX1005, ¶¶10, 11. Wang teaches that the electrode comprises a current collector.

EX1005, ¶42, *see also* ¶¶10, 11 (“The graded cathode structure comprises a conductive substrate . . .”). A POSA will understand that “conductive substrate” is referring to a current collector. Wang teaches that “FIGS. 5A-5C are schematic cross-sectional views of one embodiment of a **graded cathode electrode structure 103** having a particle size gradient formed according to embodiments described herein.” EX1005, ¶80. Wang also teaches that “[i]n FIG. 5A, **current collector 113** is schematically illustrated prior to the deposition of the graded particle structure 502 on the current collector 113.” EX1005, ¶80.



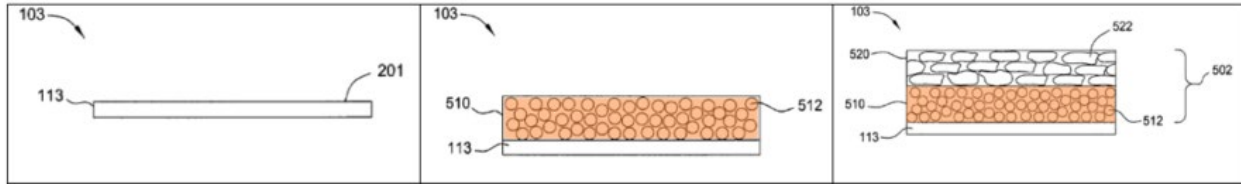
EX1005, FIGs. 5A-5C, left to right (annotated).

380. Wang teaches this element.

2. 19.2: a first layer comprising a first material; and;

381. Wang teaches that the electrode comprises a first layer, which comprises a first material. EX1005, ¶¶10, 11. Wang's first layer 510 is the claimed first layer. Wang's first cathodically active particles 512 are the claimed first material. In particular, Wang teaches that “a **first layer 510** having **first**

cathodically active particles 512 having a first diameter is formed over a surface 201 of the current collector 113.” EX1005, ¶81, *see also* FIGs. 5A-5C.

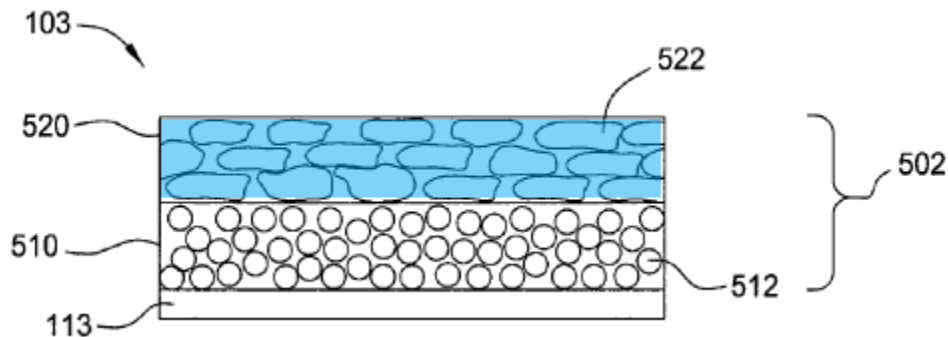


EX1005, FIGs. 5A-5C, left to right (annotated).

382. Wang teaches this element.

3. 19.3: a second layer comprising a second material;

383. Wang teaches that the electrode comprises a second layer, which comprises a second material. EX1005, ¶¶10, 11. Wang’s second layer 520 is the second layer. Wang’s second cathodically active particles 522 are the second material. In particular, Wang teaches that “**a second layer 520 having second cathodically active particles 522** having a second diameter is formed over the first layer 510.” EX1005, ¶83, *see also* FIG. 5C.

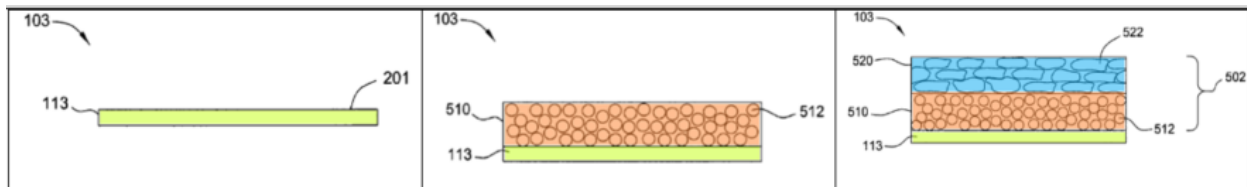


EX1005, FIG. 5C (annotated).

384. Wang teaches this element.

4. **19.4.1: wherein the first layer is arranged between the current collector and the second layer,**

385. Wang teaches that the first layer is arranged between the current collector and the second layer. EX1005, ¶¶10, 11, 38. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of the current collector 113**” and “a second layer 520 . . . **is formed over the first layer 510.**” EX1005, ¶¶81, 83; *see also* EX1005, FIGs. 5A-5C.

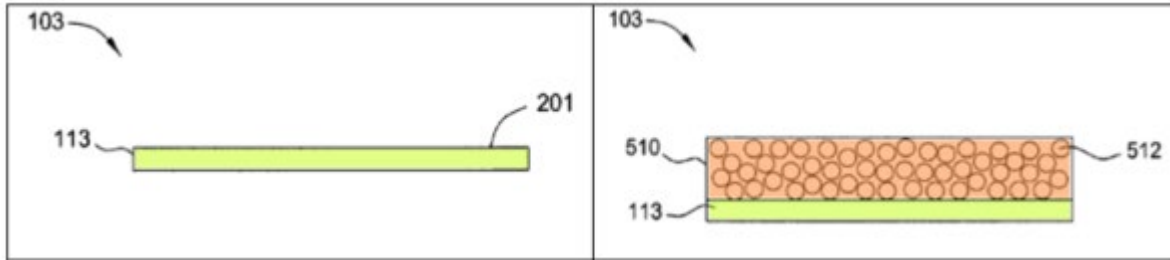


EX1005, FIGs. 5A-5C, left to right (annotated).

386. Wang teaches this element.

5. **19.4.2: the first layer is formed on a surface of the current collector,**

387. Wang teaches that the first layer is formed on a surface of the current collector. EX1005, ¶¶10, 11. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of the current collector 113.**” EX1005, ¶81; *see also* EX1005, FIGs. 5A, 5B.



EX1005, FIGs. 5A, 5B, left to right (annotated).

388. Wang teaches this element.

6. 19.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,

389. Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm . EX1005, ¶81. Wang teaches in one embodiment that the first cathodically active particles 512 “are nano-scale particles.” EX1005, ¶81 (“**In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.**”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . (*See, e.g.,* discussion of nanoscale particles and SEM images for claim 1.4.3, above). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . The Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than 40 μm .

390. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than 40 μm . Thus, Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm .

7. 19.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

391. Wang in view of Saka teaches that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

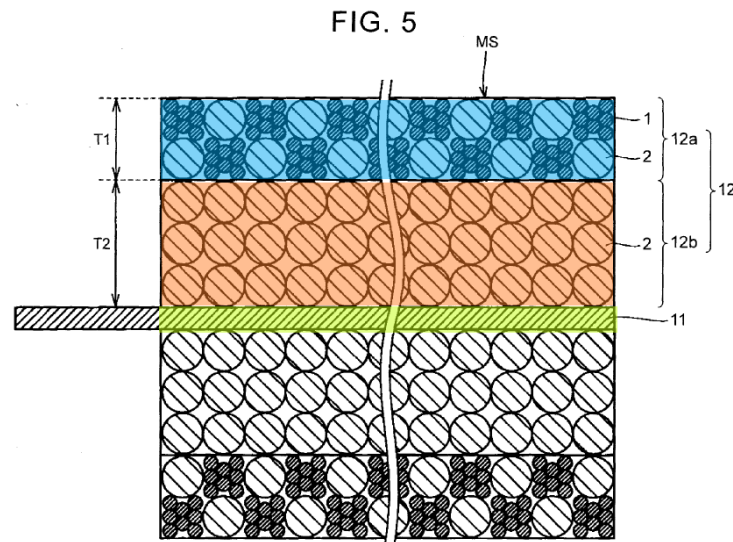
392. Wang teaches that, in the method for producing a cathode, following the deposition of “cathodically active particles over the vertically oriented flexible conductive substrate,” the cathode is further processed using “a compression chamber... configured to expose the vertically oriented flexible conductive substrate to a calendaring process to compress the deposited particles to a desired net-density.” EX1005, ¶¶15, 58 (“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.”).

393. Wang further describes that there can be one or two compression steps, depending on the desired compaction density of the layers. EX1005, ¶92 (“After the particles are deposited over the conductive substrate, the particles may be compressed using compression techniques, for example, a calendaring process, to achieve a desired net density of compacted particles while planarizing the surface of the second layer. In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.”). Wang thus teaches the processes and techniques required for achieving the desired compaction density of the layers in order to achieve a high packing density of active material in the cathode layers and thus a high energy density for the battery.

394. The only aspect of limitation 19.5 Wang does not explicitly teach is the numeric value for the desired compaction density. Wang therefore does not expressly teach that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc. The range of desired compaction densities, including the density recited in limitation 19.5, is explicitly taught in Saka.

395. Saka teaches an electrode having a positive electrode mixture 12 on a current collector 11, where positive electrode mixture 12 includes a first layer 12a and a second layer 12b. *See* EX1006, FIG. 5. In addition, Saka teaches that “the dried positive electrode mixture layer 12 **may be pressed using a rolling mill or the like to adjust the thickness and the mixture density thereof.**” EX1006, ¶51. Thus, after the treatment of being pressed, the density of mixture layer 12 is a compaction density. Saka further teaches that “[t]he mixture density of the positive electrode mixture layer 12 is, for example, 2.5 g/cm³ to 3.5 g/cm³.” EX1006, ¶51. Therefore, Saka teaches that the compaction density of the positive electrode mixture layer 12 (including both first and second layers 12a and 12b) can be greater than 3.2 g/cc.



EX1006, FIG. 5 (annotated).

396. The combination teaches this element.

397. It would have been obvious to a POSA to combine Wang and Saka.

To start, Wang and Saka are analogous to each other and to the problem in the '118 patent. In particular, like the '118 patent, Wang and Saka are both directed towards battery electrodes, particularly cathodes, having a current collector and a bilayer structure of active materials on the current collector. Wang describes a first layer 510 on a current collector 113 and a second layer 520 on the first layer 510, with the first and second layers 510 and 520 having particles of different sizes. EX1005, FIG. 5C. Saka describes a second layer 12b on a current collector 11 and a first layer 12a on the second layer 12b, with the first and second layers 12a and 12b having different compositions. EX1006, FIG. 5.

398. More specifically, both Wang and Saka teach compression treatments to the bilayer structure of active materials to consolidate the bilayer structure of active materials and increase its density. EX1006, ¶7 (“in order to maintain the battery capacity, it is necessary to improve the filling factor, that is, the mixture density of a positive electrode mixture layer”). Although Wang does not explicitly provide values or ranges of values of the compaction density (density of the bilayer structure of active materials after the compression treatment), a POSA reading Wang would reasonably understand the purpose and the outcome of the compression treatment to the bilayer structure of active material, and would

reasonably be motivated to review additional teachings about quantitative values or ranges of the compaction density, of which Saka teaches.

399. Furthermore, it would be well known to a POSA what compaction densities were commonplace in the art and that common sense dictates choosing the highest compaction density available for a given application. *See, e.g.*, EX1004, ¶7 (teaching a POSA to pack the electrode active material “as densely as possible” in order to maximize the energy capacity of the battery); EX1009, ¶36 (teaching that densities less than 3.31 g/cc “may be too small to obtain a high electrical capacity”).

400. Having reviewed Saka, a POSA would have been motivated to modify Wang’s teaching by combining Saka’s range of the compaction density with the properties of the active material in Wang’s cathode structure. The resulting combination of teachings would have provided more detailed characteristics of Wang’s structure of the electrode, and a POSA would have had a reasonable expectation of success that the active material as taught by Wang could reach the quantitative range of the compaction density, and thus battery energy density, as taught by Saka after the compression treatment.

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

401. Wang teaches that “it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.”

EX1005, ¶92. This implies that the particles of the first layer have a lower compaction density than the second layer. Saka also teaches that the first layer has a lower compaction density than the second layer, as all of the examples in the chart above for claim 5 list a compaction density for the first layer that is less than that for the second layer. *See* EX1007.

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

402. Wang discloses all of the limitations of claims 1-20 with the exception of the numeric values for the compaction densities of the layers. For that, a POSA would look to Li, which discloses compaction densities within the ranges recited in the claims.

403. Wang discloses a lithium-ion battery for an electronic device, the battery having an electrode with virtually all of the structural and material features of the ’118 patent claims.

404. Li also discloses a lithium-ion battery having a very similar structure as Wang and the '118 patent, including an electrode with similar structural and material features of the '118 patent claims.

405. More specifically, Wang and Li both disclose cathode structures with two positive electrode mixture layers for increasing the energy density of lithium-ion batteries. Wang generally discloses the same structures and materials recited in the '118 patent claims, including the same layer materials having the same particle sizes. While Wang teaches compression steps to increase the density of its layers, Wang does not provide explicit information regarding the compaction density that results from that compression. *See, e.g.*, EX1005, ¶58 (“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”); ¶86. A POSA would understand, however, that the device disclosed in Wang is consistent with and would accommodate the compaction density of the electrode recited in the '118 patent claims. A POSA could confirm that understanding by looking to the electrode disclosed in Li.

406. 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.

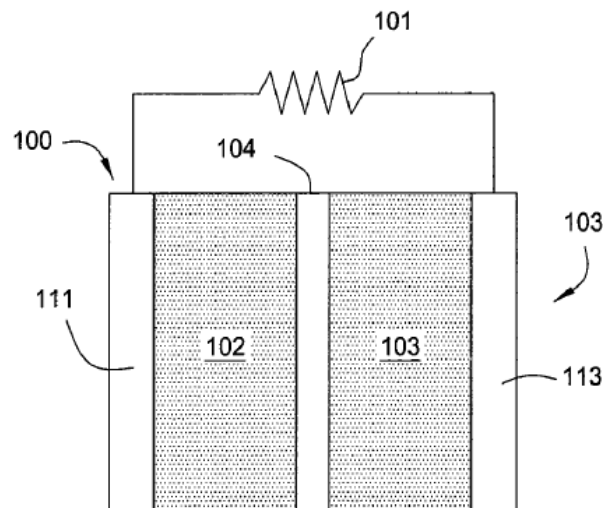
Accordingly, a POSA practicing the disclosure of Wang, who was unsure of the compaction density that would be appropriate for his application of Wang's technology, would look to Li for that information, and incorporate Li's compaction density into the layers of Wang.

407. Wang repeatedly teaches a POSA to use compaction to achieve a "desired net density." EX1005, ¶¶67, 73, 89, 92, 106, 109. Based on their knowledge and experience in the art, a POSA knows that the reason for achieving this "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. "*Battery capacity*" is a measure (typically in Amp-hr) of the charge stored by the battery, and is determined by the mass of active material contained in the battery. The battery capacity represents the maximum amount of energy that can be extracted from the battery" EX1022, 0002. Since Wang does not teach what the desired net density actually is, a POSA would be motivated to look to another reference, such as Li, for numerical values of a desired cathode density.

408. Li discloses numeric values for the compaction densities that work in a battery like Wang's or like the '118 patent. EX1003, ¶44. Li therefore teaches the numerical values of "desired net density" needed to practice Wang's invention. EX1005, ¶¶67, 73, 89, 92, 106, 109. A POSA would have an expectation of success by using Li's compaction densities in practicing Wang's battery-

construction method because Wang specifically discloses that its method can be used to achieve any desired density, and Li teaches a density that works in a battery made by a process similar to Wang's method. 1.P: An electrode, comprising:

409. Wang's cathode structure 103 is an electrode. *See* EX1005, ¶¶10, 11, 35. In particular, Wang teaches, "[t]he primary functional components of Li-ion battery 100 include an anode structure 102, **a cathode structure 103**, [and] a separator layer 104" EX1005, ¶41. The cathode structure 103 is an electrode of the Li-ion battery 100. *See* EX1005, FIG. 1A.



EX1005, FIG. 1A.

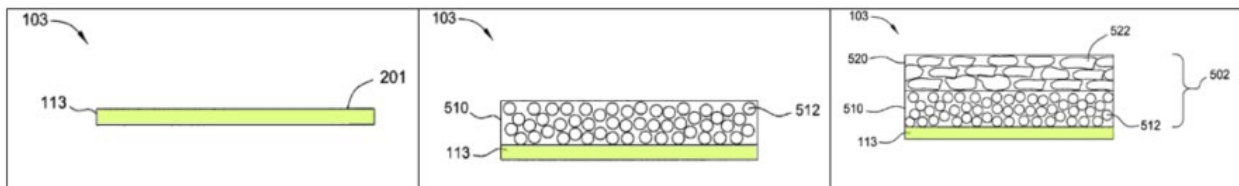
410. Wang teaches the limitation.

1. 1.1: a current collector;

411. Wang's current collector 113 is the claimed current collector. Wang teaches that the electrode comprises a current collector. *See* EX1005, ¶42; *see also*

EX1005, ¶¶10, 11 (“The graded cathode structure comprises a conductive substrate”). A POSA will understand that “conductive substrate” is referring to a current collector. Wang teaches that “FIGS. 5A-5C are schematic cross-sectional views of one embodiment of a **graded cathode electrode structure 103** having a particle size gradient formed according to embodiments described herein.”

EX1005, ¶80. Wang also teaches that “[i]n FIG. 5A, **current collector 113** is schematically illustrated prior to the deposition of the graded particle structure 502 on the current collector 113.” EX1005, ¶80.

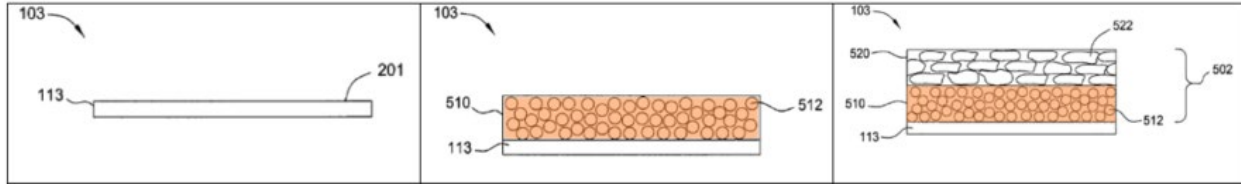


EX1005, FIGs. 5A-5C, left to right (annotated).

412. Wang teaches this element.

2. 1.2: a first layer comprising a first material; and;

413. Wang teaches that the electrode comprises a first layer, which comprises a first material. *See* EX1005, ¶¶10, 11. Wang’s first layer 510 is the claimed first layer. Wang’s first cathodically active particles 512 are the claimed first material. In particular, Wang teaches that “**a first layer 510 having first cathodically active particles 512** having a first diameter is formed over a surface 201 of the current collector 113.” EX1005, ¶81; *see also* EX1005, FIGs. 5A-5C.

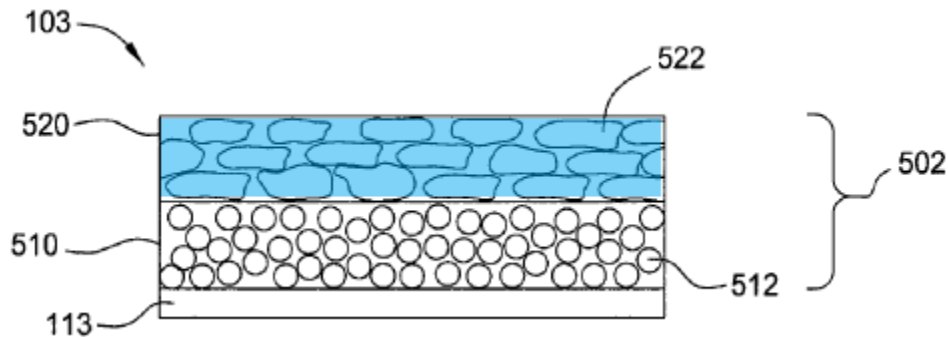


EX1005, FIGs. 5A-5C, left to right (annotated).

414. Wang teaches this element.

3. 1.3: a second layer comprising a second material;

415. Wang teaches that the electrode comprises a second layer, which comprises a second material. *See* EX1005, ¶¶10, 11. Wang's second layer 520 is the second layer. Wang's second cathodically active particles 522 is the second material. In particular, Wang teaches that "**a second layer 520 having second cathodically active particles 522** having a second diameter is formed over the first layer 510." EX1005, ¶83; *see also* EX1005, FIG. 5C.

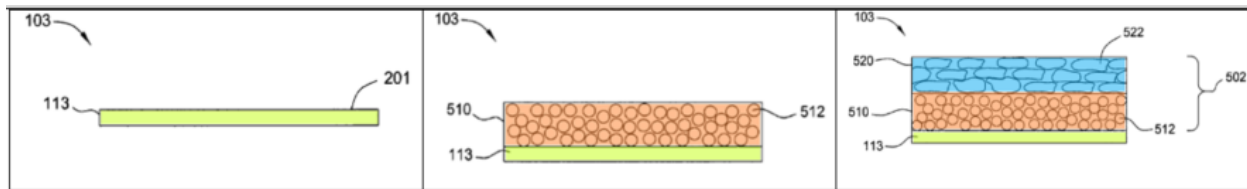


EX1005, FIG. 5C (annotated).

416. Wang teaches this element.

4. **1.4.1: wherein the first layer is arranged between the current collector and the second layer,**

417. Wang teaches that the first layer is arranged between the current collector and the second layer. *See* EX1005, ¶¶10, 11, 38. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of the current collector 113**” and “a second layer 520 . . . **is formed over the first layer 510.**” EX1005, ¶¶81, 83; *see also* EX1005, FIGs. 5A-5C.

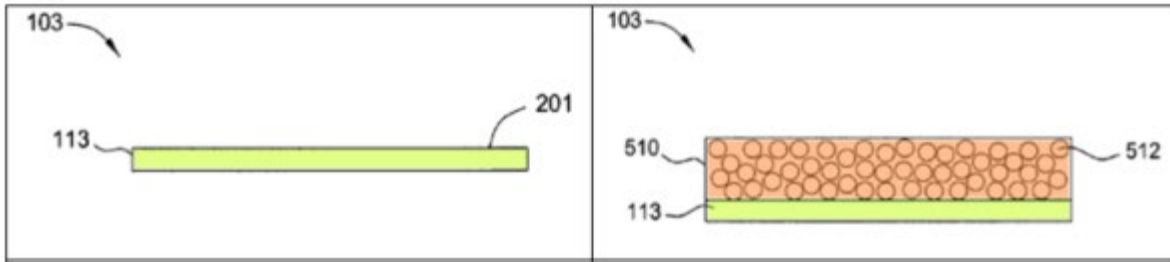


EX1005, FIGs. 5A-5C, left to right (annotated).

418. Wang teaches this element.

5. **1.4.2: the first layer is formed on a surface of the current collector,**

419. Wang teaches that the first layer is formed on a surface of the current collector. *See* EX1005, ¶¶10, 11. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of the current collector 113.**” EX1005, ¶81; *see also* EX1005, FIGs. 5A, 5B.



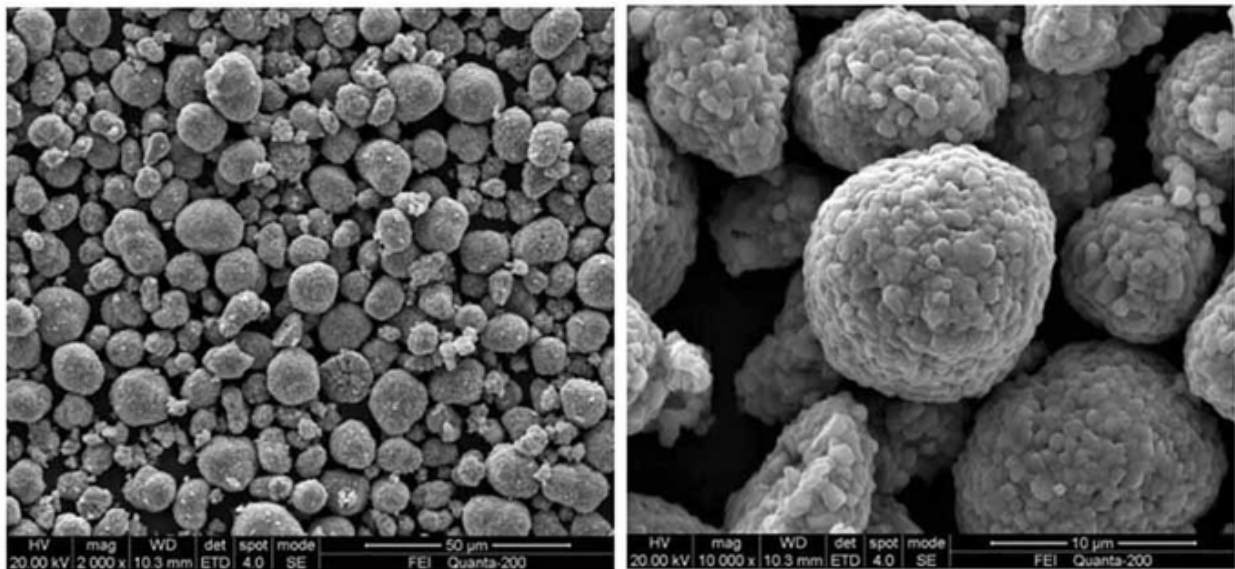
EX1005, FIGs. 5A, 5B, left to right (annotated).

420. Wang teaches this element.

6. 1.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,

421. Wang teaches that a particle size of 90% accumulative volume of the first material is less than 40 μm . EX1005, ¶81. Wang teaches in one embodiment that the first cathodically active particles 512 “are nano-scale particles.” EX1005, ¶81 (“In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . The Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than 40 μm .

422. To help understand why prior art like Wang references two particle sizes, one nano-scale and one micro-scale, it is helpful to visualize what the active material looks like at these scales. Below are scanning electron microscope (SEM) images of lithium nickel manganese cobalt oxide powder of the type used by both Wang (¶ 51) and the '118 patent.



EX1013.

423. The image on the left is at 2000x magnification, and the image on the right is a higher magnification (10,000x) of a small part of the image on the left. In the higher magnification image, it is clear that the larger, “micro-scale particles” are made up of aggregates of much smaller, “nano-scale particles.” This image is provided as a general illustration of the meaning of nano-scale and micro-scale particles, as taught by Wang. It does not correspond to any specific material claimed or used by Wang or the '118 patent. It is clear that the nano-scale particles

taught by Wang (¶ 81), ranging in size from 1 nm (0.001 μm) to 100 nm (0.1 μm), meet the claim limitation that **a particle size of 90% accumulative volume of the first material is less than 40 μm .**

424. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than 40 μm . Thus, Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm .

7. 1.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

425. Wang in view of Li teaches that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

426. Wang teaches that, in the method for producing a cathode, following the deposition of “cathodically active particles over the vertically oriented flexible conductive substrate,” the cathode is further processed using “a compression

chamber . . . configured to expose the vertically oriented flexible conductive substrate to a calendaring process to compress the deposited particles to a desired net-density.” EX1005, ¶¶15, 58 (“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.”).

427. Wang further describes that there can be one or two compression steps, depending on the desired compaction density of the layers. EX1005, ¶92 (“After the particles are deposited over the conductive substrate, the particles may be compressed using compression techniques, for example, a calendaring process, to achieve a desired net density of compacted particles while planarizing the surface of the second layer. In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.”). Wang thus teaches the processes and techniques required for achieving the desired compaction density of the layers, in order to achieve a high packing density of active material in the cathode layers and thus a high energy density for the battery.

428. The only aspect of limitation 1.5 Wang does not explicitly teach is the numeric value for the desired compaction density. Indeed, while Wang devotes

much of its focus to achieving a desired density, it does not explicitly provide the reason a particular net density is more desirable than another. Wang assumes the reader already has a desired density in mind, and teaches the method one would use to achieve any such density. A reader that does not have a desired density in mind would therefore be motivated to look to a reference such as Li, which provides the specific numeric densities that result from the compaction steps of a process like Wang's. As such, while Wang may not expressly teach that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc, the range of desired compaction densities, including the density recited in limitation 1.5, is explicitly taught in Li.

429. For instance, Li discloses a lithium-ion battery for similar applications as Wang, and the '118 patent. EX1003, ¶¶1-2, 27. The structure of Li's cathode includes a current collector onto which is deposited two active material layers including the same materials disclosed in Wang and the '118 patent. EX1003, ¶¶8, 26. Li specifically discloses a compaction density of 3.8 g/cm³ for the first layer, and an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44.

430. Accordingly, the total compaction density of the first layer and the second layer is greater than 3.2 g/cc, because 4.1 g/cc > 3.2 g/cc. Li therefore

teaches element 1.5, and the Wang-Li combination teaches all of the limitations of claim 1.

431. It would have been obvious to a POSA to combine Wang and Li. To start, Wang and Li are analogous to each other and to the problem in the '118 patent. In particular, like the '118 patent, Wang and Li are both directed towards battery electrodes, particularly cathodes, having a current collector and a bilayer structure of active materials on the current collector. Wang describes first layer 510 on a current collector 113 and a second layer 520 on first layer 510, with the first and second layers 510 and 520 having particles of different sizes. EX1005, FIG. 5C. Li describes the same overall structure, and provides the compaction densities that are missing from Wang.

432. More specifically, both Wang and Li teach compression treatments to the bilayer structure of active materials to consolidate the bilayer structure of active materials and increase its density. EX1005, ¶11 (discussing the use of compression steps applied to two-layer material applied to a cathode current collector); EX1003, ¶44 (discussing a method of coating twice and compaction twice to achieve the disclosed density). Although Wang does not explicitly provide values or ranges of values of the compaction density (density of the bilayer structure of active materials after the compression treatment), a POSA reading Wang would reasonably understand the purpose and the outcome of the

compression treatment to the bilayer structure of active material, and would reasonably be motivated to review additional teachings about quantitative values or ranges of the compaction density, of which Li teaches.

433. Li explains that there are no special requirements for the active material in the layers, and suggests Lithium-transition metal composite oxide, lithium-transition metal phosphate, or lithium-transition metal silicate as examples. EX1003, ¶26. This teaching is compatible with Wang. Li also suggests graphite and silicon/carbon composites are “obvious” choices for anode active materials. *Id.* Various examples of Li disclose lithium cobalt oxide as a cathode active material and acetylene black as a cathode layer conductive additive. *See, e.g.*, EX1003, ¶38, ¶44. This teaching is also compatible with Wang.

434. In Li’s examples 2-13, it specifically discloses a method of “coating twice and compaction twice” with a resulting first compaction density of 3.8 g/cm³ for the first layer, and then an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44. This method is similar to Wang’s method. While Wang states that its method can be used to achieve any desired net density, Li expressly teaches particular densities that work in the battery that results from this process.

435. Having reviewed Li, a POSA would have been motivated to modify Wang’s teaching by combining Li’s range of the compaction density with the

properties of the active material in Wang's cathode structure. The resulting combination of teachings would have provided more detailed characteristics of Wang's structure of the electrode, and a POSA would have had a reasonable expectation of success that the active material as taught by Wang could reach the quantitative range of the compaction density, and thus battery energy densities, as taught by Li after the compression treatments.

8. Claim 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.

436. Wang discloses that the thickness of the first layer is not less than the Dv90 of the first material. EX1005, ¶81. Specifically, Wang discloses that the first layer 510 has a thickness between about 10 μm to about 150 μm , or between about 50 μm to about 100 μm . EX1005, ¶81.

437. Wang teaches particle sizes that are smaller than this layer thickness. EX1005, ¶81 (“**In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.**”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm .

Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than any possible layer thicknesses taught by Wang.

438. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than most of the first layer thicknesses in Wang’s broadest disclosed range of 10 to 150 μm , and is demonstrably less than the minimum thickness, 50 μm , of Wang’s other quoted layer thickness range of 50 to 100 μm .

439. Thus, Wang teaches that 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.

9. Claim 3. The electrode according to claim 1, 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.

440. Wang discloses the claimed ratio between the particle sizes of the layers. EX1005, ¶83. Specifically, Wang discloses a second layer 520 having second cathodically active particles 522 having a second diameter is formed over the first layer 510. EX1005, ¶83. In one embodiment, “the second cathodically active particles 522 have a second diameter greater than five times the particle size of the particles of the first layer.” EX1005, ¶83. In other words, the ratio of the average particle size of the second material to the first material is at least 5:1. A ratio of 5:1, and a range of greater ratios implied by Wang, is within the claimed numeric range of 1:1 to 40:1. *See also* EX1005, ¶84 (“In certain embodiments where the particles are micrometer sized particles . . . the second cathodically active particles have a particle diameter greater than five times the particle size of the particles of the first layer.”).

441. Wang therefore discloses the claimed ratio of particle sizes between layers.

10. Claim 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 .

442. Wang discloses a first material with an average particle size within this range. EX1005, ¶81. Wang teaches an embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one

embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . In this embodiment, “average particle size” of Wang’s first cathodically active layer, which the ’118 patent uses to denote Dv_{50} , falls within this size range between 2 and 15 μm , i.e., the average or median size cannot be outside of the range for which is it describing the average or median.

443. Thus, the average particle size taught by this Wang embodiment falls within the claimed range of 0.2 μm to 15 μm .

11. Claim 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.

444. Wang in view of Li teaches that 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 3.2 g/cc. As discussed above, Li specifically discloses a compaction density of 3.8 g/cm³ for the first layer, and an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44. Accordingly, Li teaches a density for the first layer of at least 3.8 g/cc, which is greater than 2.8

g/cc. It is possible that the second compaction process will compact the first layer even further, and possible that it will not. Either way, the compaction density of the first layer will be at least 3.8 g/cc, which satisfies the first-layer density element of claim 5.

445. While Li's teaching does not provide a numeric value for the density of the second layer, a POSA would immediately recognize that if the first layer has a compaction density of 3.8 g/cm³ and the average density across the two layers is 4.1 g/cm³, then the density of the second layer is necessarily greater than 3.8 g/cm³, and is most likely greater than 4.1 g/cm³. Either way, the compaction density of the second layer is necessarily greater than 3.3 g/cc. As such, Li discloses the second-layer density limitation.

446. A POSA would be motivated to combine Li with Wang for the purpose of learning specific compaction densities for the layers as discussed above. For instance, as discussed for limitation 1.5, Wang describes that one or both layers can be exposed to a compression process, such as a calendaring process, to increase the packing density of the particles and achieve a desired net density. EX1005, ¶¶15, 58 ("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.").

447. Wang specifically describes embodiments where the layers have different densities, which is accomplished by subjecting both layers to separate compression processes. EX1005, FIG. 3 (illustrating a process for applying a first layer, compressing it, applying a second layer, and compressing the resulting layered structure again), ¶¶73, 92 (“In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the net density of the second porous layer relative to the first porous layer.”).

448. Wang does not explicitly teach the numeric values of the compaction densities for the two layers. Li does. Li teaches a similar layering process with compression steps, comparable to the process disclosed in Wang. Li goes on to disclose the numeric compaction densities of the layers. The combination of Wang and Li therefore teaches an electrode wherein a compaction density of the first layer is greater than 2.8 g/cc, and a compaction density of the second layer is greater than 3.3 g/cc. These references would have been obvious to combine, and once combined, there would be an expectation of success of their combination.

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

449. Wang teaches that “it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density

of the particles of the second layer relative to the particles of the first layer.”

EX1005, ¶92. This implies that the particles of the first layer have a lower compaction density than the second layer.

450. Li also teaches that the first layer has a lower compaction density than the second layer. Li specifically discloses a compaction density of 3.8 g/cm^3 for the first layer, and an average compaction density of 4.1 g/cm^3 across the two-layer structure following the second compaction. EX1003, ¶44. Accordingly, the total compaction density of the first layer and the second layer is greater than 3.2 g/cc , because $4.1 \text{ g/cc} > 3.2 \text{ g/cc}$. Li therefore teaches element 1.5, and the Wang-Li combination teaches all of the limitations of claim 1. While Li’s teaching does not provide a numeric value for the density of the second layer, a POSA would immediately recognize that if the first layer has a compaction density of 3.8 g/cm^3 and the average density across the two layers is 4.1 g/cm^3 , then the density of the second layer is necessarily greater than 4.1 g/cm^3 . A POSA would also recognize that the compaction density of the second layer is necessarily greater than the compaction density of the first layer, because the average density across the two layers is greater than the density of the first layer alone.

451. One of skill in the art would be motivated to combine Wang and Li’s teachings in this regard for the reasons stated above with respect to claim 1, and for the additional reason that the teachings of the two references are consistent and

reinforce one another in the context of the first layer having a lower compaction density than the second layer.

- 13. Claim 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.**

452. Wang teaches that the first “cathodically active material 212 is selected from the group comprising: lithium cobalt dioxide (LiCoO_2), lithium manganese dioxide (LiMnO_2), titanium disulfide (TiS_2), $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$, LiMn_2O_4 , LiFePO_4 , $\text{LiFe}_{1-x}\text{MgPO}_4$, LiMoPO_4 , LiCoPO_4 , $\text{Li}_3\text{V}_2(\text{PO}_4)_3$, LiVOPO_4 , LiMP_2O_7 , $\text{LiFe}_{1.5}\text{P}_2\text{O}_7$, LiVPO_4F , LiAlPO_4F , $\text{Li}_5\text{V}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_5\text{Cr}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_2\text{CoPO}_4\text{F}$, $\text{Li}_2\text{NiPO}_4\text{F}$, $\text{Na}_5\text{V}_2(\text{PO}_4)_2\text{F}_3$, $\text{Li}_2\text{FeSiO}_4$, $\text{Li}_2\text{MnSiO}_4$, $\text{Li}_2\text{VOSiO}_4$, LiNiO_2 , and combinations thereof.” EX1005, ¶51.

453. Wang therefore teaches most items in the Markush group of claim 7.

454. To fully appreciate the correspondence between the ’118 patent’s claim 7 and Wang’s paragraph 51, it should be noted that: lithium cobalt dioxide (LiCoO_2) is lithium cobaltate, $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$ is lithium nickel cobalt manganese oxide, LiMn_2O_4 is lithium manganate, LiFePO_4 is lithium iron phosphate, $\text{LiFe}_{1-x}\text{MgPO}_4$ is lithium iron manganese phosphate, $\text{Li}_3\text{V}_2(\text{PO}_4)_3$ is lithium vanadium phosphate, LiVOPO_4 is lithium vanadyl phosphate, and LiNiO_2 is

lithium nickelate. The only items in the Markush group of claim 7 that are not in Wang's paragraph 51 are lithium nickel cobalt aluminate and lithium titanate.

455. Additionally, Li teaches the positive electrode slurry comprises at least one of lithium cobalt oxide, lithium manganese oxide, nickel-cobalt-manganese, or lithium iron phosphate. EX1012, ¶17. Li therefore teaches items in the Markush group that are common with Wang. The combination therefore teaches claim 7.

- 14. Claim 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.**

456. Wang teaches that the second “cathodically active material 222 is selected from the group comprising: lithium cobalt dioxide (LiCoO_2), lithium manganese dioxide (LiMnO_2), titanium disulfide (TiS_2), $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$, LiMn_2O_4 , LiFePO_4 , $\text{LiFe}_{1-x}\text{MgPO}_4$, LiMoPO_4 , LiCoPO_4 , $\text{Li}_3\text{V}_2(\text{PO}_4)_3$, LiVOPO_4 , LiMP_2O_4 , $\text{LiFe}_{1.5}\text{P}_2\text{O}_7$, LiVPO_4F , LiAlPO_4F , $\text{Li}_5\text{V}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_5\text{Cr}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_2\text{CoPO}_4\text{F}$, $\text{Li}_2\text{NiPO}_4\text{F}$, $\text{Na}_5\text{V}_2(\text{PO}_4)_2\text{F}_3$, $\text{Li}_2\text{FeSiO}_4$, $\text{Li}_2\text{MnSiO}_4$, $\text{Li}_2\text{VOSiO}_4$, LiNiO_2 , and combinations thereof.” EX1005, ¶55. Wang therefore teaches almost all items in the Markush group of claim 8.

457. Additionally, Li teaches the positive electrode slurry comprises at least one of lithium cobalt oxide, lithium manganese oxide, nickel-cobalt-

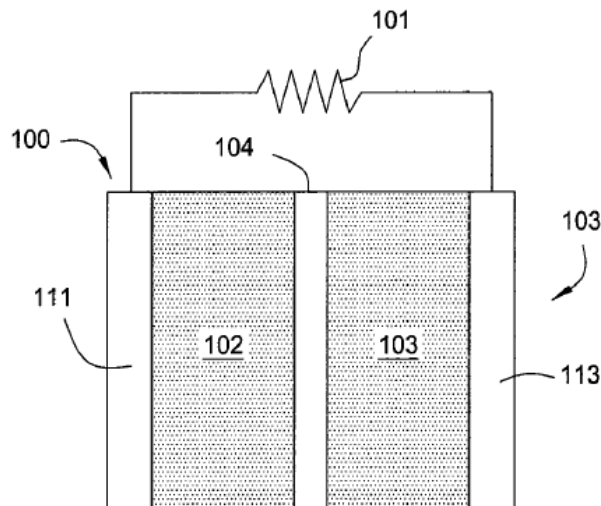
manganese, or lithium iron phosphate. EX1012, ¶17. Li therefore teaches items in the Markush group that are common with Wang. The combination therefore teaches claim 8.

15. Claim 9. The electrode according to claim 1, 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.*

458. Wang teaches that the first material can be graphite, soft carbon, hard carbon, silicon, silicon carbide, and lithium titanate. EX1005, ¶52. Wang therefore teaches several of the items in the Markush group of claim 9. “Soft carbon” and “hard carbon” as recited in claim 9 are different grades of carbon black. *See generally* EX1025; EX1026; EX1027; EX1028. Wang teaches the use of “carbon black,” EX1005, ¶52, and thus teaches a form of soft carbon and hard carbon. EX1023 (discussing hard carbon black and soft carbon black); EX1024 (“Carbon black is divided into hard carbon black and soft carbon black according to its function; The particle size of hard carbon black is less than 40nm and that of soft carbon black is more than 40nm.”). Examples of Li disclose acetylene black as a cathode layer conductive additive. *See, e.g.,* EX1003, ¶38, ¶44. Li also teaches electrode material comprising at least one of natural graphite, artificial graphite, and silicon negative electrode material, soft carbon, or hard carbon. EX1012, ¶20. Li therefore teaches items in the Markush group that are common with Wang.

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

459. Wang teaches a battery, which is an electrochemical device. *See* EX1005, ¶¶10, 11, 35. Wang’s battery includes Wang’s cathode structure 103, which is an electrode. In particular, Wang teaches, “The primary functional components of Li-ion battery 100 include an anode structure 102, **a cathode structure 103**, [and] a separator layer 104” EX1005, ¶41. The cathode structure 103 is an electrode of Li-ion battery 100. *See* EX1005, FIG. 1A.



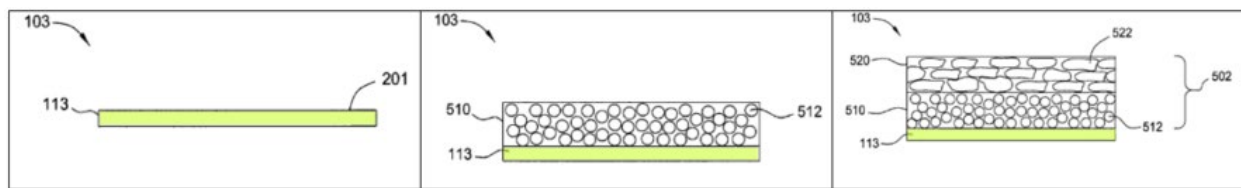
EX1005, FIG. 1A.

460. Wang teaches the limitation.

1. 10.1: a current collector;

461. Wang’s current collector 113 is the claimed current collector. *See* EX1005, ¶¶10, 11. Wang teaches that the electrode comprises a current collector. EX1005, ¶42; *see also* EX1005, ¶¶10, 11 (“The graded cathode structure comprises a conductive substrate”). A POSA will understand that “conductive

substrate” is referring to a current collector. Wang teaches that “FIGS. 5A-5C are schematic cross-sectional views of one embodiment of a **graded cathode electrode structure 103** having a particle size gradient formed according to embodiments described herein.” EX1005, ¶80. Wang also teaches that “[i]n FIG. 5A, **current collector 113** is schematically illustrated prior to the deposition of the graded particle structure 502 on the current collector 113.” EX1005, ¶80.

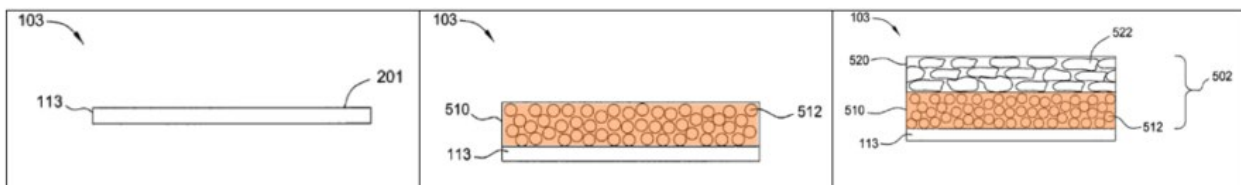


EX1005, FIGs. 5A-5C, left to right (annotated).

462. Wang teaches this element.

2. 10.2: a first layer comprising a first material; and;

463. Wang teaches that the electrode comprises a first layer, which comprises a first material. *See* EX1005, ¶¶10, 11. Wang’s first layer 510 is the claimed first layer. Wang’s first cathodically active particles 512 are the claimed first material. In particular, Wang teaches that “**a first layer 510 having first cathodically active particles 512** having a first diameter is formed over a surface 201 of the current collector 113.” EX1005, ¶81; *see also* EX1005, FIGs. 5A-5C.

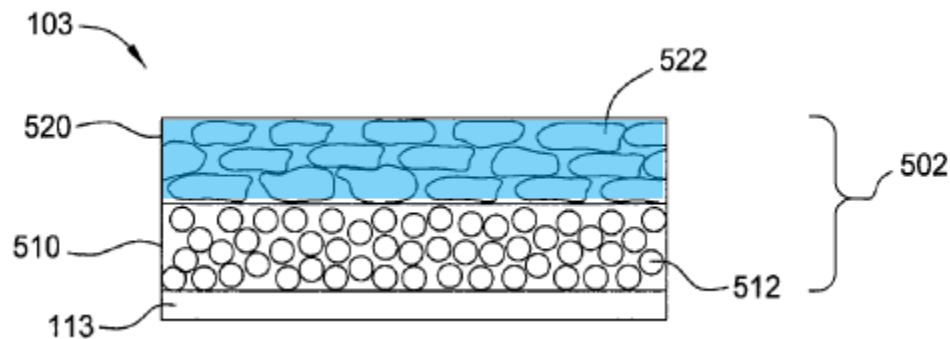


EX1005, FIGs. 5A-5C, left to right (annotated).

464. Wang teaches this element.

3. 10.3: a second layer comprising a second material;

465. Wang teaches that the electrode comprises a second layer, which comprises a second material. *See* EX1005, ¶¶10, 11. Wang's second layer 520 is the second layer. Wang's second cathodically active particles 522 are the second material. In particular, Wang teaches that **"a second layer 520 having second cathodically active particles 522 having a second diameter is formed over the first layer 510."** EX1005, ¶83; *see also* EX1005, FIG. 5C.



EX1005, FIG. 5C (annotated).

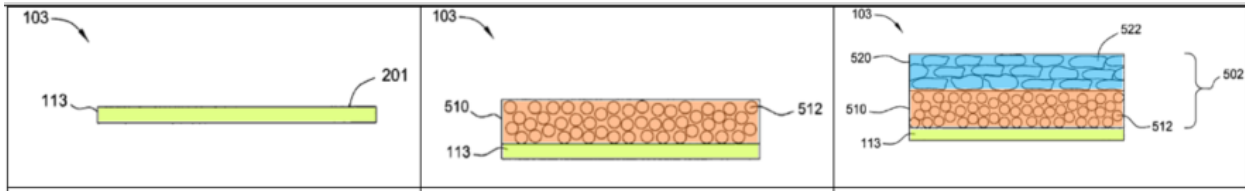
466. Wang teaches this element.

4. 10.4.1: wherein the first layer is arranged between the current collector and the second layer,

467. Wang teaches that the first layer is arranged between the current collector and the second layer. *See* EX1005, ¶¶10, 11. In particular, Wang teaches that **"a first layer 510 . . . is formed over a surface 201 of the current collector**

113” and “a second layer 520 . . . **is formed over** the first layer 510.” EX1005,

¶¶81, 83; *see also* EX1005, FIGs. 5A-5C.

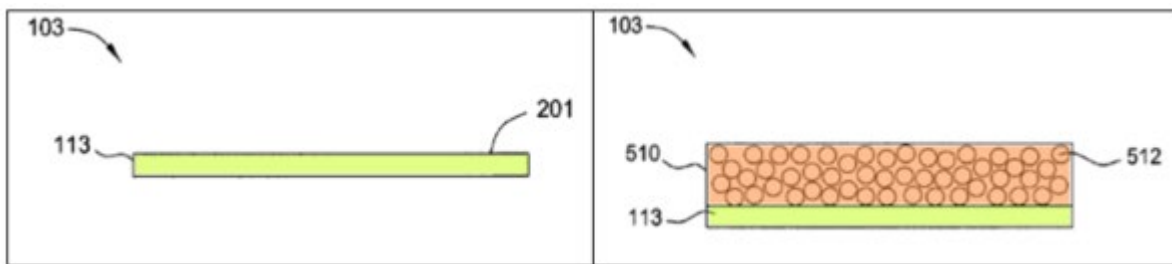


EX1005, FIGs. 5A-5C, left to right (annotated).

468. Wang teaches this element.

5. 10.4.2: the first layer is formed on a surface of the current collector,

469. Wang teaches that the first layer is formed on a surface of the current collector. *See* EX1005, ¶¶10, 11, 38. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201** of the current collector 113.” EX1005, ¶81; *see also* EX1005, FIGs. 5A, 5B.



EX1005, FIGs. 5A, 5B, left to right (annotated).

470. Wang teaches this element.

6. 10.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,

471. Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm . EX1005, ¶81. Wang teaches in one embodiment that the first cathodically active particles 512 “are nano-scale particles.” EX1005, ¶81 (“**In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.**”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . (*See, e.g.*, discussion of nanoscale particles and SEM images for claim 1.4.3, above). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . The Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than 40 μm .

472. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“**In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .**”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the

individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than 40 μm . Thus, Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm .

7. 10.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

473. Wang in view of Li teaches that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

474. Wang teaches that, in the method for producing a cathode, following the deposition of “cathodically active particles over the vertically oriented flexible conductive substrate,” the cathode is further processed using “a compression chamber . . . configured to expose the vertically oriented flexible conductive substrate to a calendaring process to compress the deposited particles to a desired net-density.” EX1005, ¶¶15, 58 (“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.”).

475. Wang further describes that there can be one or two compression steps, depending on the desired compaction density of the layers. EX1005, ¶92 (“After the particles are deposited over the conductive substrate, the particles may

be compressed using compression techniques, for example, a calendaring process, to achieve a desired net density of compacted particles while planarizing the surface of the second layer. In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.”). Wang thus teaches the processes and techniques required for achieving the desired compaction density of the layers, in order to achieve a high packing density of active material in the cathode layers and thus a high energy density for the battery.

476. The only aspect of limitation 10.5 Wang does not explicitly teach is the numeric value for the desired compaction density. Indeed, while Wang devotes much of its focus to achieving a desired density, it does not explicitly provide the reason a particular net density is more desirable than another. Wang assumes the reader already has a desired density in mind, and teaches the method one would use to achieve any such density. A reader that does not have a desired density in mind would therefore be motivated to look to a reference such as Li, which provides the specific numeric densities that result from the compaction steps of a process like Wang’s. As such, while Wang may not expressly teach that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc,

the range of desired compaction densities, including the density recited in limitation 10.5, is explicitly taught in Li.

477. For instance, Li discloses a lithium-ion battery for similar applications as Wang, and the '118 patent. EX1003, ¶¶1-2, 27. The structure of Li's cathode includes a current collector onto which is deposited two active material layers including the same materials disclosed in Wang and the '118 patent. EX1003, ¶¶8, 26. Li specifically discloses a compaction density of 3.8 g/cm³ for the first layer, and an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44.

478. Accordingly, the total compaction density of the first layer and the second layer is greater than 3.2 g/cc, because 4.1 g/cc > 3.2 g/cc. Li therefore teaches element 10.5, and the Wang-Li combination teaches all of the limitations of claim 1.

479. It would have been obvious to a POSA to combine Wang and Li. To start, Wang and Li are analogous to each other and to the problem in the '118 patent. In particular, like the '118 patent, Wang and Li are both directed towards battery electrodes, particularly cathodes, having a current collector and a bilayer structure of active materials on the current collector. Wang describes first layer 510 on a current collector 113 and a second layer 520 on first layer 510, with the first and second layers 510 and 520 having particles of different sizes. EX1005, FIG.

5C. Li describes the same overall structure, and provides the compaction densities that are missing from Wang.

480. More specifically, both Wang and Li teach compression treatments to the bilayer structure of active materials to consolidate the bilayer structure of active materials and increase its density. EX1005, ¶11 (discussing the use of compression steps applied to two-layer material applied to a cathode current collector); EX1003, ¶44 (discussing a method of coating twice and compaction twice to achieve the disclosed density). Although Wang does not explicitly provide values or ranges of values of the compaction density (density of the bilayer structure of active materials after the compression treatment), a POSA reading Wang would reasonably understand the purpose and the outcome of the compression treatment to the bilayer structure of active material, and would reasonably be motivated to review additional teachings about quantitative values or ranges of the compaction density, of which Li teaches.

481. Li explains that there are no special requirements for the active material in the layers, and suggests Lithium-transition metal composite oxide, lithium-transition metal phosphate, or lithium-transition metal silicate as examples. EX1003, ¶26. This teaching is compatible with Wang. Li also suggests graphite and silicon/carbon composites are “obvious” choices for anode active materials. *Id.* Various examples of Li disclose lithium cobalt oxide as a cathode active material

and acetylene black as a cathode layer conductive additive. *See, e.g.*, EX1003, ¶38, ¶44. This teaching is also compatible with Wang.

482. In Li's examples 2-13, it specifically discloses a method of "coating twice and compaction twice" with a resulting first compaction density of 3.8 g/cm³ for the first layer, and then an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44. This method is similar to Wang's method. While Wang states that its method can be used to achieve any desired net density, Li expressly teaches particular densities that work in the battery that results from this process.

483. Having reviewed Li, a POSA would have been motivated to modify Wang's teaching by combining Li's range of the compaction density with the properties of the active material in Wang's cathode structure. The resulting combination of teachings would have provided more detailed characteristics of Wang's structure of the electrode, and a POSA would have had a reasonable expectation of success that the active material as taught by Wang could reach the quantitative range of the compaction density, and thus battery energy densities, as taught by Li after the compression treatments.

8. **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.**

484. Wang discloses that the thickness of the first layer is not less than the Dv90 of the first material. EX1005, ¶81. Specifically, Wang discloses that the first layer 510 has a thickness between about 10 μm to about 150 μm , or between about 50 μm to about 100 μm . EX1005, ¶81. Wang teaches particle sizes that are smaller than this layer thickness. EX1005, ¶81 (“**In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.**”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than any possible layer thicknesses taught by Wang.

485. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“**In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .**”). The plain language of this statement indicates that it is not referring to a range of

possible average sizes of particles across all different possible embodiments.

Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than most of the first layer thicknesses in Wang’s broadest disclosed range of 10 to 150 μm , and is demonstrably less than the minimum thickness, 50 μm , of Wang’s other quoted layer thickness range of 50 to 100 μm . Thus, Wang teaches that 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.

9. 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.

486. Wang discloses the claimed ratio between the particle sizes of the layers. EX1005, ¶83. Specifically, Wang discloses a second layer 520 having second cathodically active particles 522 having a second diameter is formed over the first layer 510. *Id.* In one embodiment, “the second cathodically active particles 522 have a second diameter greater than five times the particle size of the particles of the first layer.” EX1005, ¶83. In other words, the ratio of the average particle size of the second material to the first material is at least 5:1. A ratio of 5:1, and a range of greater ratios implied by Wang, are within the claimed numeric range of

1:1 to 40:1. *See also* EX1005, ¶84 (“In certain embodiments where the particles are micrometer sized particles . . . the second cathodically active particles have a particle diameter greater than five times the particle size of the particles of the first layer.”). Wang therefore discloses the claimed ratio of particle sizes between layers.

10. 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 .

487. Wang discloses a first material with an average particle size within this range. EX1005, ¶81. Wang teaches an embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . In this embodiment, “average particle size” of Wang’s first cathodically active layer, which the ’118 patent uses to denote Dv50, must necessarily fall within this size range between 2 and 15 μm , i.e., the average or median size cannot be outside of the range for which is it

describing the average or median. Thus, the average particle size taught by this

Wang embodiment must fall within the claimed range of 0.2 μm to 15 μm .

11. 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.

488. Wang in view of Li teaches that 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 3.2 g/cc. As discussed above, Li specifically discloses a compaction density of 3.8 g/cm³ for the first layer, and an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44. Accordingly, Li teaches a density for the first layer of at least 3.8 g/cc, which is greater than 2.8 g/cc. It is possible that the second compaction process will compact the first layer even further, and possible that it will not. Either way, the compaction density of the first layer will be at least 3.8 g/cc, which satisfies the first-layer density element of claim 5.

489. While Li's teaching does not provide a numeric value for the density of the second layer, a POSA would immediately recognize that if the first layer has a compaction density of 3.8 g/cm³ and the average density across the two layers is 4.1 g/cm³, then the density of the second layer is necessarily greater than 3.8 g/cm³, and is most likely greater than 4.1 g/cm³. Either way, the compaction density of the

second layer is necessarily greater than 3.3 g/cc. As such, Li discloses the second-layer density limitation.

490. A POSA would be motivated to combine Li with Wang for the purpose of learning specific compaction densities for the layers as discussed above. For instance, as discussed for limitation 1.5, Wang describes that one or both layers can be exposed to a compression process, such as a calendaring process, to increase the packing density of the particles and achieve a desired net density. EX1005, ¶¶15, 58 (“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.”).

491. Wang specifically describes embodiments where the layers have different densities, which is accomplished by subjecting both layers to separate compression processes. EX1005, FIG. 3 (illustrating a process for applying a first layer, compressing it, applying a second layer, and compressing the resulting layered structure again), ¶¶73, 92 (“In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the net density of the second porous layer relative to the first porous layer.”).

492. Wang does not explicitly teach the numeric values of the compaction densities for the two layers. Li does. Li teaches a similar layering process with compression steps, comparable to the process disclosed in Wang. Li goes on to disclose the numeric compaction densities of the layers. The combination of Wang and Li therefore teaches an electrode wherein a compaction density of the first layer is greater than 2.8 g/cc, and a compaction density of the second layer is greater than 3.3 g/cc. These references would have been obvious to combine, and once combined, there would be an expectation of success of their combination.

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

493. Wang teaches that “it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.” EX1005, ¶92. This implies that the particles of the first layer have a lower compaction density than the second layer.

494. Li also teaches that the first layer has a lower compaction density than the second layer. Li specifically discloses a compaction density of 3.8 g/cm³ for the first layer, and an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44. Accordingly, the total compaction density of the first layer and the second layer is greater than 3.2 g/cc,

because $4.1 \text{ g/cc} > 3.2 \text{ g/cc}$. Li therefore teaches element 10.5, and the Wang-Li combination teaches all of the limitations of claim 10. While Li's teaching does not provide a numeric value for the density of the second layer, a POSA would immediately recognize that if the first layer has a compaction density of 3.8 g/cm^3 and the average density across the two layers is 4.1 g/cm^3 , then the density of the second layer is necessarily greater than 4.1 g/cm^3 . A POSA would also recognize that the compaction density of the second layer is necessarily greater than the compaction density of the first layer, because the average density across the two layers is greater than the density of the first layer alone.

495. One of skill in the art would be motivated to combine Wang and Li's teachings in this regard for the reasons stated above with respect to claim 1, and for the additional reason that the teachings of the two references are consistent and reinforce one another in the context of the first layer having a lower compaction density than the second layer.

- 13. 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.**

496. Wang teaches that the first “cathodically active material 212 is selected from the group comprising: lithium cobalt dioxide (LiCoO_2), lithium manganese dioxide (LiMnO_2), titanium disulfide (TiS_2), $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$, LiMn_2O_4 , LiFePO_4 , $\text{LiFe}_{1-x}\text{MgPO}_4$, LiMoPO_4 , LiCoPO_4 , $\text{Li}_3\text{V}_2(\text{PO}_4)_3$, LiVOPO_4 , LiMP_2O_7 , $\text{LiFe}_{1.5}\text{P}_2\text{O}_7$, LiVPO_4F , LiAlPO_4F , $\text{Li}_5\text{V}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_5\text{Cr}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_2\text{CoPO}_4\text{F}$, $\text{Li}_2\text{NiPO}_4\text{F}$, $\text{Na}_5\text{V}_2(\text{PO}_4)_2\text{F}_3$, $\text{Li}_2\text{FeSiO}_4$, $\text{Li}_2\text{MnSiO}_4$, $\text{Li}_2\text{VOSiO}_4$, LiNiO_2 , and combinations thereof.” EX1005, ¶51. Wang therefore teaches most items in the Markush group of claim 16. To fully appreciate the correspondence between the ’118 patent’s claim 7 and Wang’s paragraph 51, it should be noted that: lithium cobalt dioxide (LiCoO_2) is lithium cobaltate, $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$ is lithium nickel cobalt manganese oxide, LiMn_2O_4 is lithium manganate, LiFePO_4 is lithium iron phosphate, $\text{LiFe}_{1-x}\text{MgPO}_4$ is lithium iron manganese phosphate, $\text{Li}_3\text{V}_2(\text{PO}_4)_3$ is lithium vanadium phosphate, LiVOPO_4 is lithium vanadyl phosphate, and LiNiO_2 is lithium nickelate. The only items in the Markush group

of claim 7 that are not in Wang's paragraph 51 are lithium nickel cobalt aluminate and lithium titanate.

497. Additionally, Li teaches the positive electrode slurry comprises at least one of lithium cobalt oxide, lithium manganese oxide, nickel-cobalt-manganese, or lithium iron phosphate. EX1012, ¶17. Li therefore teaches items in the Markush group that are common with Wang.

- 14. 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.**

498. Wang teaches that the second “cathodically active material 222 is selected from the group comprising: lithium cobalt dioxide (LiCoO_2), lithium manganese dioxide (LiMnO_2), titanium disulfide (TiS_2), $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$, LiMn_2O_4 , LiFePO_4 , $\text{LiFe}_{1-x}\text{MgPO}_4$, LiMoPO_4 , LiCoPO_4 , $\text{Li}_3\text{V}_2(\text{PO}_4)_3$, LiVOPO_4 , LiMP_2O_4 , $\text{LiFe}_{1.5}\text{P}_2\text{O}_7$, LiVPO_4F , LiAlPO_4F , $\text{Li}_5\text{V}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_5\text{Cr}(\text{PO}_4)_2\text{F}_2$, $\text{Li}_2\text{CoPO}_4\text{F}$, $\text{Li}_2\text{NiPO}_4\text{F}$, $\text{Na}_5\text{V}_2(\text{PO}_4)_2\text{F}_3$, $\text{Li}_2\text{FeSiO}_4$, $\text{Li}_2\text{MnSiO}_4$, $\text{Li}_2\text{VOSiO}_4$, LiNiO_2 , and combinations thereof.” EX1005, ¶55. Wang therefore teaches almost all items in the Markush group of claim 17. To fully appreciate the correspondence between the '118 patent's claim 7 and Wang's paragraph 55, it should be noted that: lithium cobalt dioxide (LiCoO_2) is lithium cobaltate, $\text{LiNi}_x\text{Co}_{1-2x}\text{MnO}_2$ is lithium nickel cobalt manganese oxide, LiMn_2O_4 and $\text{LiFe}_{1-x}\text{MgPO}_4$ are lithium-

rich manganese-based materials, and LiFePO_4 is lithium iron phosphate. The only item in the Markush group of claim 7 that is not in Wang's paragraph 55 is lithium nickel cobalt aluminium oxide.

499. Li teaches the positive electrode slurry comprises at least one of lithium cobalt oxide, lithium manganese oxide, nickel-cobalt-manganese, or lithium iron phosphate. EX1012, ¶17. Li therefore teaches items in the Markush group that are common with Wang.

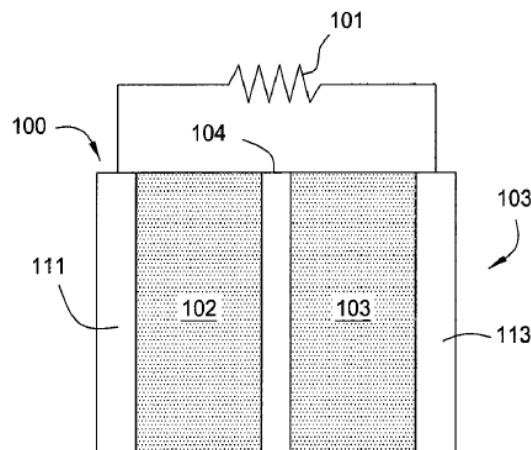
15. 18. The electrochemical device according to claim 10, wherein the first material comprises one selected from the group consisting of artificial graphite, natural graphite, mesocarbon microbeads, soft carbon, hard carbon, silicon, silicon carbide, lithium titanate, and combinations thereof.

500. Wang teaches that the first material can be graphite, soft carbon, hard carbon, silicon, silicon carbide, and lithium titanate. EX1005, ¶52. Wang therefore teaches several of the items in the Markush group of claim 18. "Soft carbon" and "hard carbon" as recited in claim 18 are different grades of carbon black. *See generally* EX1025; EX1026; EX1027; EX1028. Wang teaches the use of "carbon black," EX1005, ¶52, and thus teaches a form of soft carbon and hard carbon. EX1023 (discussing hard carbon black and soft carbon black); EX1024 ("Carbon black is divided into hard carbon black and soft carbon black according to its function; The particle size of hard carbon black is less than 40nm and that of soft carbon black is more than 40nm."). Examples of Li disclose acetylene black as a

cathode layer conductive additive. *See, e.g.*, EX1003, ¶38, ¶44. Li also teaches electrode material comprising at least one of natural graphite, artificial graphite, silicon negative electrode material, soft carbon, or hard carbon. EX1012, ¶20. Li therefore teaches items in the Markush group that are common with Wang.

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

501. Wang teaches a battery, which is an electrochemical device, and teaches that its battery is appropriate for use in electronic devices. EX1005, ¶¶10, 11, 35. Wang’s cathode structure 103 is an electrode. In particular, Wang teaches, “The primary functional components of Li-ion battery 100 include an anode structure 102, **a cathode structure 103**, a separator layer 104” EX1005, ¶41. The cathode structure 103 is an electrode of the Li-ion battery 100. *See* EX1005, FIG. 1A.



EX1005, FIG. 1A.

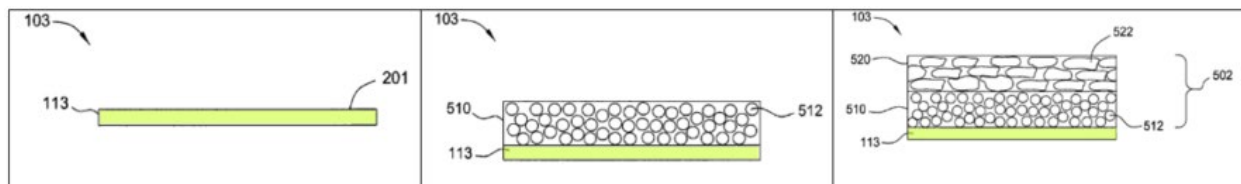
502. Wang teaches this element.

1. **19.1: a current collector;**

503. Wang's current collector 113 is the claimed current collector.

EX1005, ¶¶10, 11. Wang teaches that the electrode comprises a current collector.

EX1005, ¶42, *see also* ¶¶10, 11 (“The graded cathode structure comprises a conductive substrate . . .”). A POSA will understand that “conductive substrate” is referring to a current collector. Wang teaches that “FIGS. 5A-5C are schematic cross-sectional views of one embodiment of a **graded cathode electrode structure 103** having a particle size gradient formed according to embodiments described herein.” EX1005, ¶80. Wang also teaches that “[i]n FIG. 5A, **current collector 113** is schematically illustrated prior to the deposition of the graded particle structure 502 on the current collector 113.” EX1005, ¶80.



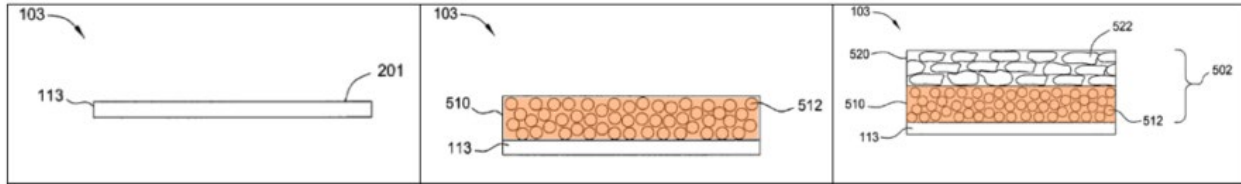
EX1005, FIGs. 5A-5C, left to right (annotated).

504. Wang teaches this element.

2. **19.2: a first layer comprising a first material; and;**

505. Wang teaches that the electrode comprises a first layer, which comprises a first material. EX1005, ¶¶10, 11. Wang's first layer 510 is the claimed first layer. Wang's first cathodically active particles 512 are the claimed first material. In particular, Wang teaches that “a **first layer 510** having **first**

cathodically active particles 512 having a first diameter is formed over a surface 201 of the current collector 113.” EX1005, ¶81, *see also* FIGs. 5A-5C.

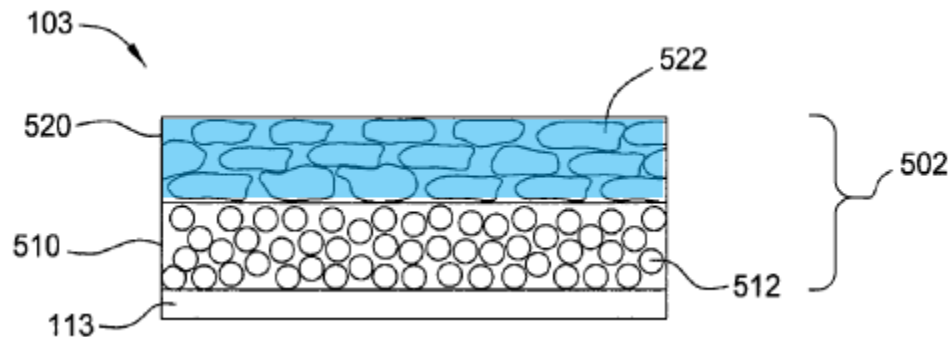


EX1005, FIGs. 5A-5C, left to right (annotated).

506. Wang teaches this element.

3. 19.3: a second layer comprising a second material;

507. Wang teaches that the electrode comprises a second layer, which comprises a second material. EX1005, ¶¶10, 11. Wang’s second layer 520 is the second layer. Wang’s second cathodically active particles 522 are the second material. In particular, Wang teaches that “**a second layer 520 having second cathodically active particles 522** having a second diameter is formed over the first layer 510.” EX1005, ¶83, *see also* FIG. 5C.

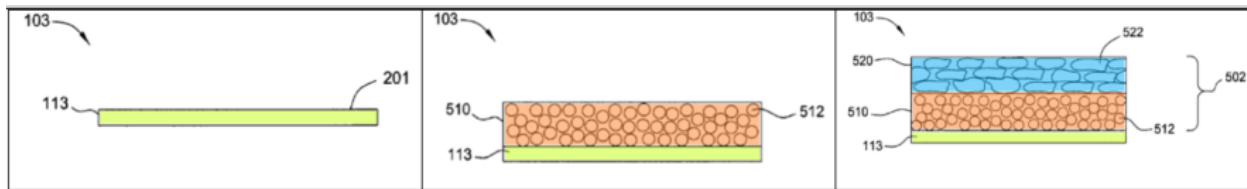


EX1005, FIG. 5C (annotated).

508. Wang teaches this element.

4. **19.4.1: wherein the first layer is arranged between the current collector and the second layer,**

509. Wang teaches that the first layer is arranged between the current collector and the second layer. EX1005, ¶¶10, 11, 38. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of the current collector 113**” and “a second layer 520 . . . **is formed over the first layer 510.**” EX1005, ¶¶81, 83; *see also* EX1005, FIGs. 5A-5C.

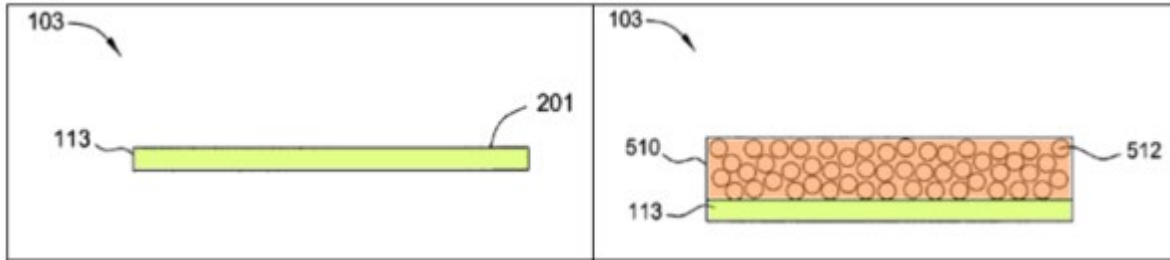


EX1005, FIGs. 5A-5C, left to right (annotated).

510. Wang teaches this element.

5. **19.4.2: the first layer is formed on a surface of the current collector,**

511. Wang teaches that the first layer is formed on a surface of the current collector. EX1005, ¶¶10, 11. In particular, Wang teaches that “a first layer 510 . . . **is formed over a surface 201 of the current collector 113.**” EX1005, ¶81; *see also* EX1005, FIGs. 5A, 5B.



EX1005, FIGs. 5A, 5B, left to right (annotated).

512. Wang teaches this element.

6. 19.4.3: and a particle size of 90% accumulative volume of the first material is less than 40 μm ,

513. Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm . EX1005, ¶81. Wang teaches in one embodiment that the first cathodically active particles 512 “are nano-scale particles.” EX1005, ¶81 (“**In one embodiment, the nano-scale particles have a diameter between about 1 nm and about 100 nm.**”). A POSA knows that a diameter range of 1 nm to 100 nm is the same as 0.001 μm to 0.1 μm . (*See, e.g.*, discussion of nanoscale particles and SEM images for claim 1.4.3, above). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 0.001 μm and 0.1 μm . The Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 0.1 μm , which is less than 40 μm .

514. Wang teaches another embodiment of the first cathodically active particles 512 are “micro-scale particles.” EX1005, ¶81 (“In one embodiment, the micro-scale particles have a diameter between about 2 μm and about 15 μm .”). The plain language of this statement indicates that it is not referring to a range of possible average sizes of particles across all different possible embodiments. Rather, it is referring to “one embodiment” in which the full distribution of all the individual sizes of first cathodically active particles 512 fall in the range between 2 μm and 15 μm . Dv90 of this particle size distribution must necessarily be less than the upper end of this range, 15 μm , which is less than 40 μm . Thus, Wang teaches that a particle size of 90% accumulative volume of the first active material is less than 40 μm .

7. 19.5: wherein a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

515. Wang in view of Li teaches that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc.

516. Wang teaches that, in the method for producing a cathode, following the deposition of “cathodically active particles over the vertically oriented flexible conductive substrate,” the cathode is further processed using “a compression chamber . . . configured to expose the vertically oriented flexible conductive substrate to a calendaring process to compress the deposited particles to a desired net-density.” EX1005, ¶¶15, 58 (“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.”).

517. Wang further describes that there can be one or two compression steps, depending on the desired compaction density of the layers. EX1005, ¶92 (“After the particles are deposited over the conductive substrate, the particles may be compressed using compression techniques, for example, a calendaring process, to achieve a desired net density of compacted particles while planarizing the surface of the second layer. In certain embodiments, it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.”). Wang thus teaches the processes and techniques required for achieving the desired compaction density of the layers, in order to achieve a high packing density of active material in the cathode layers and thus a high energy density for the battery.

518. The only aspect of limitation 19.5 Wang does not explicitly teach is the numeric value for the desired compaction density. Indeed, while Wang devotes much of its focus to achieving a desired density, it does not explicitly provide the reason a particular net density is more desirable than another. Wang assumes the reader already has a desired density in mind, and teaches the method one would

use to achieve any such density. A reader that does not have a desired density in mind would therefore be motivated to look to a reference such as Li, which provides the specific numeric densities that result from the compaction steps of a process like Wang's. As such, while Wang may not expressly teach that a total compaction density of the first layer and the second layer is greater than 3.2 g/cc, the range of desired compaction densities, including the density recited in limitation 19.5, is explicitly taught in Li.

519. For instance, Li discloses a lithium-ion battery for similar applications as Wang, and the '118 patent. EX1003, ¶¶1-2, 27. The structure of Li's cathode includes a current collector onto which is deposited two active material layers including the same materials disclosed in Wang and the '118 patent. EX1003, ¶¶8, 26. Li specifically discloses a compaction density of 3.8 g/cm³ for the first layer, and an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44.

520. Accordingly, the total compaction density of the first layer and the second layer is greater than 3.2 g/cc, because 4.1 g/cc > 3.2 g/cc. Li therefore teaches element 19.5, and the Wang-Li combination teaches all of the limitations of claim 1.

521. It would have been obvious to a POSA to combine Wang and Li. To start, Wang and Li are analogous to each other and to the problem in the '118

patent. In particular, like the '118 patent, Wang and Li are both directed towards battery electrodes, particularly cathodes, having a current collector and a bilayer structure of active materials on the current collector. Wang describes first layer 510 on a current collector 113 and a second layer 520 on first layer 510, with the first and second layers 510 and 520 having particles of different sizes. EX1005, FIG. 5C. Li describes the same overall structure, and provides the compaction densities that are missing from Wang.

522. More specifically, both Wang and Li teach compression treatments to the bilayer structure of active materials to consolidate the bilayer structure of active materials and increase its density. EX1005, ¶11 (discussing the use of compression steps applied to two-layer material applied to a cathode current collector); EX1003, ¶44 (discussing a method of coating twice and compaction twice to achieve the disclosed density). Although Wang does not explicitly provide values or ranges of values of the compaction density (density of the bilayer structure of active materials after the compression treatment), a POSA reading Wang would reasonably understand the purpose and the outcome of the compression treatment to the bilayer structure of active material, and would reasonably be motivated to review additional teachings about quantitative values or ranges of the compaction density, of which Li teaches.

523. Li explains that there are no special requirements for the active material in the layers, and suggests Lithium-transition metal composite oxide, lithium-transition metal phosphate, or lithium-transition metal silicate as examples. EX1003, ¶26. This teaching is compatible with Wang. Li also suggests graphite and silicon/carbon composites are “obvious” choices for anode active materials. *Id.* Various examples of Li disclose lithium cobalt oxide as a cathode active material and acetylene black as a cathode layer conductive additive. *See, e.g.*, EX1003, ¶38, ¶44. This teaching is also compatible with Wang.

524. In Li’s examples 2-13, it specifically discloses a method of “coating twice and compaction twice” with a resulting first compaction density of 3.8 g/cm³ for the first layer, and then an average compaction density of 4.1 g/cm³ across the two-layer structure following the second compaction. EX1003, ¶44. This method is similar to Wang’s method. While Wang states that its method can be used to achieve any desired net density, Li expressly teaches particular densities that work in the battery that results from this process.

525. Having reviewed Li, a POSA would have been motivated to modify Wang’s teaching by combining Li’s range of the compaction density with the properties of the active material in Wang’s cathode structure. The resulting combination of teachings would have provided more detailed characteristics of Wang’s structure of the electrode, and a POSA would have had a reasonable

expectation of success that the active material as taught by Wang could reach the quantitative range of the compaction density, and thus battery energy densities, as taught by Li after the compression treatments.

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

526. Wang teaches that “it is desirable to perform a calendaring process after deposition of the second porous layer in order to increase the packing density of the particles of the second layer relative to the particles of the first layer.”

EX1005, ¶92. This implies that the particles of the first layer have a lower compaction density than the second layer.

527. Li also teaches that the first layer has a lower compaction density than the second layer. Li specifically discloses a compaction density of 3.8 g/cm^3 for the first layer, and an average compaction density of 4.1 g/cm^3 across the two-layer structure following the second compaction. EX1003, ¶44. Accordingly, the total compaction density of the first layer and the second layer is greater than 3.2 g/cc , because $4.1 \text{ g/cc} > 3.2 \text{ g/cc}$. Li therefore teaches element 1.5, and the Wang-Li combination teaches all of the limitations of claim 1. While Li’s teaching does not provide a numeric value for the density of the second layer, a POSA would immediately recognize that if the first layer has a compaction density of 3.8 g/cm^3 and the average density across the two layers is 4.1 g/cm^3 , then the density of the

second layer is necessarily greater than 4.1 g/cm^3 . A POSA would also recognize that the compaction density of the second layer is necessarily greater than the compaction density of the first layer, because the average density across the two layers is greater than the density of the first layer alone.

528. One of skill in the art would be motivated to combine Wang and Li's teachings in this regard for the reasons stated above with respect to claim 1, and for the additional reason that the teachings of the two references are consistent and reinforce one another in the context of the first layer having a lower compaction density than the second layer.

XV. CONCLUSION

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

Executed on this 31st day of March in Amherst, Massachusetts.



Samuel P. Guido, Ph.D.