

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHUHAI COSMX BATTERY CO., LTD.,
Petitioner

v.

NINGDE AMPEREX TECHNOLOGY LTD.,
Patent Owner

IPR2023-00587
Patent 10,964,987

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

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	BASIS FOR OPINIONS	2
	A. Qualifications	2
	B. Materials Considered.....	5
III.	LEGAL STANDARDS	6
	A. Claim Construction.....	6
	B. Prior Art Status	7
	C. Anticipation	8
	D. Obviousness.....	9
IV.	Technology Overview	11
	A. Separators in Lithium-Ion Batteries	11
	1. General Overview	11
	2. Materials and Manufacturing Steps	12
	B. The '987 Patent	15
V.	CLAIM CONSTRUCTION	17
	A. Dv90	17
VI.	LEVEL OF ORDINARY SKILL IN THE ART	18
VII.	THE BOARD SHOULD NOT INSTITUTE INTER PARTES REVIEW	19
	A. Grounds 1 and 2: Nishikawa Does Not Anticipate Claims 1-2 and 4-9, and Does Not Render Obvious Claims 10-16.....	19

1.	Petitioner Fails to Show That Nishikawa Anticipates the Dv90 Value of Claims 1 and 10.....	22
2.	Petitioner Fails to Show that Nishikawa Anticipates or Renders Obvious the Porous Layer Thickness of Claim 1	32
3.	Petitioner Fails to Show that Nishikawa Renders Obvious the Method Steps of Claim 10	55
4.	Claims 2, 4-9 and 11-17 Are Not Unpatentable	61
B.	Ground 4: Iwai Does Not Anticipate Claims 1-2 and 4-9.....	61
1.	Petitioner Fails to Show That Iwai Anticipates Claim 1	62
2.	Claims 2 and 4-9 Are Not Unpatentable.....	73

I. INTRODUCTION

1. I have been retained by Ningde Amperex Technology Ltd. (“ATL” or “Patent Owner”) as an independent technical expert in this proceeding before the United States Patent and Trademark Office (“PTO”) Patent Trial and Appeal Board (“PTAB”) regarding U.S. Patent No. 10,964,987 (the “’987 Patent”).

2. I understand that Zhuhai CosMX Battery Co., Ltd. (“Petitioner”) filed a petition for Inter Partes Review of the ’987 Patent (“Petition”), in which Petitioner asserts that:

- Claims 1-2 and 4-9 are anticipated by U.S. Patent No. 7,976,987 (“Nishikawa” or “Ex. 1005”) (Ground 1);
- Claims 10-16 are obvious over Nishikawa (Ground 2);
- Claim 17 is obvious over Nishikawa and U.S. Patent App. Pub. No. 2015/0263325 (“Honda” or “Ex. 1007”) (Ground 3);
- Claims 1-2 and 4-9 are anticipated U.S. Patent App. Pub. No. 2014/0248525 (“Iwai” or “Ex. 1006”) (Ground 4); and
- Claim 3 is obvious over Iwai (Ground 5)

3. I have been asked, for purposes of Patent Owner’s Preliminary Response, to analyze and respond to Petitioner’s assertion that claim 1 is anticipated by Nishikawa (Ground 1), that claim 10 is rendered obvious by Nishikawa (Ground

2), and that claim 1 is anticipated by Iwai (Ground 4). I reserve the right to analyze and respond to other alleged patentability challenges if this proceeding is instituted.

4. As explained below, in my opinion, the Petition fails to show that claim 1 of the '987 Patent is anticipated, and that claim 10 of the '987 Patent is rendered obvious.

5. I am being compensated at my customary consulting rate of \$300 per hour. My compensation is in no way contingent on the nature of my opinions or the outcome of this or any other proceeding. I have no other interest in this proceeding.

II. BASIS FOR OPINIONS

A. Qualifications

6. My qualifications and professional experience are described in my curriculum vitae, a copy of which is provided with this Declaration as Ex. 2002. The following is a brief summary of my qualifications and professional experience.

7. I am a university professor and consultant with 26 years of experience in the fields of electrochemical engineering, materials science, and manufacturing of battery materials. I received a B.S. in Chemical Engineering from Brigham Young University in 1996, and a Ph.D. in Chemical Engineering from the University of California, Berkeley, in 2002. My Ph.D. advisor was Professor John Newman, arguably the world's foremost leader in understanding porous battery

materials through computer simulations. Under his direction I acquired a deep understanding of the physics and chemistry of battery materials.

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

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

10. I have also authored or co-authored 62 peer-reviewed scientific publications. My most influential paper, “Quantifying tortuosity in porous Li-ion battery materials,” published in the Journal of Power Sources in 2009, has been cited more than 500 times, and describes the movement of ions through various types of battery materials, including separator and electrode materials. I have also published papers on the subject of poor uniformity in electrode and separator thin layers, how defects in thin layers such as variations in layer thickness or pinholes can lead to failure of the entire battery cell, and how practitioners must identify and

avoid heterogeneity so that batteries will have long lifetime and not have catastrophic failures.¹

11. I have received more than \$6 million in government research grants to study batteries and related materials. My student assistants and I regularly fabricate and analyze porous battery materials in the laboratory, using techniques comparable to those described in the '987 Patent, Nishikawa, and Iwai. In particular, we routinely mix polymers (such as the binders described in the '987 Patent), powdered solids (such as the inorganic filler particles described in the '987 Patent), and solvents (such as the "first solvent" described in the '987 Patent) to produce coating slurries which are then coated onto substrates, dried, and further processed to produce functional battery materials, such as the porous layer described in the '987 Patent. We also routinely measure the properties of battery materials and develop new diagnostic tools for making such measurements. Such training in my laboratory has allowed the students graduating from my program to go on to employment at numerous battery manufacturers and battery-related startup companies across the United States.

¹ See, e.g., Exs. 2004-2006.

12. In 2016, I led the Gordon Research Conference on Batteries,² as conference chair, having been nominated and voted into that position at a previous conference. This biennial international conference is attended by around two hundred of the world's thought leaders in the field of batteries. Furthermore, on three occasions I was selected to be a member of the technical review team for the ongoing \$13-25 million/year "Battery Hub" program funded by the U.S. Department of Energy.³ I believe my experience in such positions of leadership and responsibility, among others, reflects the stature with which I am viewed by my peers in the academic, industrial, and government battery research communities.

B. Materials Considered

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

² See Ex. 2007.

³ See Ex. 2008; Ex. 2009.

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

III. LEGAL STANDARDS

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

A. Claim Construction

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

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

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

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

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

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

B. Prior Art Status

21. I understand that the “priority date” of a patent is the date on which it is filed, or the date on which an earlier-filed patent application is filed if the patentee claims the benefit of priority to that earlier-filed patent application. I

understand that a particular claim is entitled to claim the priority date of an earlier-filed application if the earlier-filed application provides written description of the subject matter of that particular claim.

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

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

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

C. Anticipation

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

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

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

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

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

D. Obviousness

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

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

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

33. I understand that in order to show obviousness based on a single reference or a combination of references, a particular motivation to modify the reference or combine the teachings in the references, and a reasonable expectation of success must be shown.

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

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

36. I understand that in order to rely on a reference for obviousness, the reference must be analogous art. I also understand that to be analogous art, the

reference must be either (1) from the same field of endeavor as the claimed subject matter, regardless of the problem addressed, or (2) if not in the same field of endeavor, reasonably pertinent to the particular problem with which the inventor is involved. I am also familiar with the premise that for a reference to be reasonably pertinent, it must have logically commended itself to an inventor's attention at the time of invention.

IV. TECHNOLOGY OVERVIEW

A. Separators in Lithium-Ion Batteries

1. General Overview

37. The primary function of a lithium-ion battery separator is to provide a permeable barrier between the two electrodes of a battery to prevent electrical short circuits while allowing the flow of ions but not the flow of electrons between the electrodes. This requires that separators have a solid framework with sufficient mechanical rigidity to prevent the two electrodes from touching each other. It also requires that separators have interconnected pores that are filled with ion-containing liquid electrolyte, which allow ions to flow from one side of the separator to the other, that is, between the two electrodes.

38. A common problem with separators is the lack of a sufficiently rigid mechanical framework to maintain separation of electrodes and support the pores within it, as the separator materials can heat up, swell, and compress the separator

pores when the battery is in use, and separator materials can lose strength at high temperatures. The thickness of the separator, as well as the separator materials, are among some factors that affect the mechanical rigidity of the separator. Another challenge with separators is producing pores of a suitable density and size that can allow facile movement of ions for desired charge/discharge rates or other performance and energy storage characteristics. Naturally, the density and size of pores must be balanced with the need for a sufficiently rigid mechanical framework to support the pore network. Inadequacy of separators to fulfill these functions has led to catastrophic failures of commercial lithium-ion batteries.

39. Furthermore, in many commercially produced lithium-ion batteries such as cylindrical lithium-ion batteries, the separator layer is tightly held between the two electrode layers for efficiency and performance purposes. In such batteries, continued charging and discharging of the battery causes volume changes in the electrodes which can then create a gap between the electrode and the separator, resulting in a reduction of the cycle capacity and safety of the lithium-ion battery. As such, achieving good adhesiveness between the separator and its adjacent electrodes is an important objective in such lithium-ion batteries.

2. Materials and Manufacturing Steps

40. One way to address the above challenges and objectives is to provide a separator comprising multiple layers, each having different mechanical properties

and materials, so that taken as a whole, the separator can satisfy various objectives, design challenges, and design criteria.

41. However, using multiple separator layers necessarily introduces complexity in design and manufacturing as there are many possible choices in separator layer materials, geometry, and fabrication steps. There are also tradeoffs where improvement in one aspect of a separator's function can degrade another function. For instance, a separator might be improved to be more rigid, but as a result, might degrade or reduce the mobility of ions through the separator.

42. In such multi-layer separators, many factors influence the stability, performance, lifespan, safety, and manufacturability of the separator itself and the battery as a whole. Such factors include, for example, the materials used to build the various separator layers, pore size, pore density, and thickness of each layer of the separator, and fabrication steps and ingredients for manufacturing the separator, including the binder material, inorganic filler material, and solvent used to dissolve the binder.

43. In addition, a key problem in the manufacturing of battery materials is poor uniformity of electrode and separator layers. A lithium-ion battery is constructed as a "cell sandwich" in which there are two electrodes and a separator, each of which can itself be comprised of multiple thin layers, on the order of 10-100 μm (for comparison, the thickness of a human hair is about 100 μm). On the

other hand, each “cell sandwich” layer has a large lateral area, in some cases more than a square meter in a single cell, that is rolled or folded to fit into a compact space. If there are defects in these thin layers, such as variations in layer thickness or pinholes, they can lead to failure of the entire cell even if such defects are relatively uncommon across the large lateral area. In fact, a lithium-ion battery can be thought of as a chain in which the “weakest link” in each such layer can induce failure of the entire device. *See, e.g.*, Exs. 2004-2006.

44. Furthermore, “pore density” or equivalently “porosity” is the volume fraction of pores present in a composite material containing solid material interspersed with pores. This property is one of several properties, including pore size, known to affect the performance of the separator layers but that can be difficult to control directly during manufacturing. That is, many such properties must be controlled indirectly by choice of layer materials and method of combining and applying those layers.

45. As described above, there are many non-obvious tradeoffs between the various factors discussed above, and it can be very challenging to identify the optimal parameters for such factors to manufacture multi-layer separators that meet desired technical objectives and design criteria.

B. The '987 Patent

46. The '987 Patent discloses multilayer separators, energy storage devices including such separators, and methods of manufacturing such separators. Ex. 1001, Abstract, 1:38-3:3. In particular, the '987 Patent discloses an improved separator that addresses, among other things, safety issues from the gapping that occurs between the separator and adjacent electrodes from poor or inadequate adhesion between the separator and electrodes, rate performance (how fast the battery can be charged or discharged), and cycle performance (how long the battery can function upon repeated charges and discharges). *Id.* 1:27-31, 2:59-3:3, 4:5-27, 5:26-35, 15:26-36.

47. The '987 Patent addresses such issues and objectives by providing a multi-layer separator comprising a porous substrate and a porous layer attached to the porous substrate, wherein the porous layer comprises inorganic particles and a binder, and where the ratio of Dv90 of the inorganic particles to the thickness of the porous layer is in a particular range that provides technical advantages in performance, adhesion and safety. *Id.* Table 1, Table 2, 1:38-3:3, 15:26-36. In particular, the '987 Patent describes that the ratio of the Dv90 of the inorganic particles to the porous layer ("Dv90/thickness"), is critical to achieving the advantages of the invention. *Id.* Table 1, Table 2, 15:26-36.

48. The '987 Patent teaches that a Dv90/thickness ratio that is within a particular range improves rate or cycle performance of the battery. *Id.* Table 1, Table 2, 1:38-46, 15:26-59. Specifically, the '987 Patent teaches that:

- If the Dv90/thickness ratio is too high, the pores are not uniform and the porous layer will not attach to the porous substrate with sufficient strength. *Id.* 5:50-54, 15:36-49. The POSA would have understood from this that the issues with attachment could be a result of large particles protruding above the surface of the porous layer to reduce adhesion and uniformity of the porous layer to the porous substrate.
- If the Dv90/thickness ratio is too low, then pores may become plugged with small particles. *Id.* 5:54-61, 15:49-59. In addition, if the Dv90/thickness ratio is too low, the mechanical strength of the porous layer is sacrificed, which results in the porous layer's pores closing under mechanical compression.

Id.

49. In view of these disclosures, a person of ordinary skill would have understood that the '987 Patent indicates that there is a tradeoff between the Dv90 of the inorganic particles and thickness of the porous layer.

50. The '987 patent also discloses a method for preparing a separator involving mixing inorganic particles with a binder to generate a mixture, adding a first solvent into the mixture, stirring the mixture with the first solvent to obtain a

uniform coating solution, coating the uniform coating solution onto a surface of a porous substrate to form a wet film, immersing the wet film into a coagulating solution for phase transformation, and drying the phase-transformed wet film to obtain the separator. *Id.* 2:19-29, 5:62-6:67.

V. CLAIM CONSTRUCTION

A. Dv90

51. Dv90 is recited in claims 1 and 10 of the '987 Patent. I understand that Petitioner has not proposed a construction for the term “Dv90” in this proceeding. However, I further understand that the parties have agreed that the term Dv90 should be construed to mean “a particle size which reaches 90% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis” in the co-pending district court case between the parties. Ex. 2010 (Patent Rule 4-3 Joint Claim Construction Chart and Prehearing Statement dated May 23, 2023 filed in *Ningde Amperex Tech. Ltd. v. Zhuhai CosMX Battery Co., Ltd.*, Civ. No. 2:22-cv-00232-JRG (E.D. Tex.)) at 2.

52. It is my opinion that the construction agreed on between the parties is consistent with plain and ordinary meaning of the term. Moreover, the agreed upon construction is consistent with the '987 Patent, which states: “[t]he Dv90 of the inorganic particles refers to a particle size which reaches 90% the cumulative volume from the side of small particle size in the granularity distribution on a

volume basis.” Ex. 1001, 3:63-66; see also 1:53-56. As a result, I adopt the agreed upon construction of the term Dv90 for the purposes of my analysis.

VI. LEVEL OF ORDINARY SKILL IN THE ART

53. Each of the arguments below should be considered from the standpoint of a POSA in the field of the '987 Patent.

54. I understand that Petitioner provides the following definition of a POSA:

A person of ordinary skill in the art (“POSA”) at the time of the alleged invention in 2018 would have had at least a bachelor’s degree or equivalent degree from an accredited institution in chemistry, chemical engineering, materials science, or a similar discipline covering relevant principles of organic and inorganic chemistry, polymer processing, ceramic materials, and ceramic processing, as well as three or more years of experience in electrochemical energy storage devices, lithium-ion battery technology, separators, characterizations and analyses of particle size, film thickness, and/or materials compositions, battery performance characterization, or other applications of polymer chemistry, ceramic chemistry, and ceramic processing. Gido, ¶14. More education could substitute for less experience, and vice versa. *Id.*

Pet. at 17.

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

VII. THE BOARD SHOULD NOT INSTITUTE INTER PARTES REVIEW

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

A. Grounds 1 and 2: Nishikawa Does Not Anticipate Claims 1-2 and 4-9, and Does Not Render Obvious Claims 10-16

57. Petitioner contends that Nishikawa anticipates claims 1-2 and 4-9, and renders obvious claims 10-16 of '987 Patent. These claims recite:

1. A separator, comprising: a porous substrate; and
a porous layer arranged on a surface of the porous substrate, wherein the porous layer comprises inorganic particles and a binder, and a ratio of Dv90 of the inorganic particles to the thickness of the porous layer is in a range from 0.3 to 3.0.
2. The separator according to claim 1, wherein the porous layer has a thickness of 0.2 μm to 10 μm .

4. The separator according to claim 1, wherein a volume ratio of the inorganic particles to the binder is in a range from 0.2 to 3.0.
5. The separator according to claim 1, wherein the porous layer has a porosity of 20% to 90%.
6. The separator according to claim 1, wherein the inorganic particles are one or more selected from the group consisting of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, zirconia, cerium dioxide, nickel oxide, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.
7. The separator according to claim 1, wherein the binder is one or more selected from the group consisting of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylates, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.
8. An energy storage device, comprising the separator according to claim 1.
9. The energy storage device according to claim 8, wherein the energy storage device is a lithium-ion battery.
10. A method for preparing the separator of claim 1, wherein the method comprises steps of:
 - mixing inorganic particles with a binder to generate a mixture;
 - adding a first solvent into the mixture;

stirring the mixture with the first solvent to obtain a uniform coating solution;

coating the uniform coating solution onto a surface of a porous substrate to form a wet film;

the coating solution is in a range from 7% to 25%;
and

wherein a ratio of Dv90 of the inorganic particles to the thickness of the porous layer is in a range from 0.3 to 3.0.

11. The method according to claim 10, wherein the solid content in the coating solution is in a range from 7% to 25%.

12. The method according to claim 10, wherein the coagulating solution comprises a second solvent and a third solvent, and the second solvent has a mass percentage of 20% to 60%.

13. The method according to claim 10, wherein the first solvent is one or more independently selected from the group consisting of N-methylpyrrolidone, dimethylacetamide and dimethylformamide.

14. The method according to claim 10, wherein the porous substrate comprises a polymer film, a multilayer polymer film, or a non-woven fabric formed by any one or more of the following polymers: polyethylene, polypropylene, polyethylene terephthalate, polyphthaloyl diamine, polybutylene terephthalate, polyester, polyacetal, polyamide, polyimide, polyetheretherketone, polyaryletherketone, polyetherimide, polyamide imide, polybenzimidazole, polyethersulfone, polyphenylene oxide, cycloolefin copolymer, polyphenylene sulfide, and polyethylene naphthalene.

15. The method according to claim 14, wherein the polyethylene is at least one selected from the group

consisting of high density polyethylene, low density polyethylene, and ultrahigh molecular weight polyethylene.

16. The method according to claim 12, wherein the second solvent is one or more independently selected from the group consisting of N-methylpyrrolidone, dimethylacetamide and dimethylformamide, and the third solvent is one or more selected from the group consisting of deionized water, ethanol, propanol, acetone, dimethyl carbonate and diethyl carbonate.

1. Petitioner Fails to Show That Nishikawa Anticipates the Dv90 Value of Claims 1 and 10

58. As described above, the plain and ordinary meaning of Dv90 is “a particle size which reaches 90% the cumulative volume from the side of small particle size in the granularity distribution *on a volume basis*.” Ex. 2010 at 2.

59. I understand that Petitioner acknowledges that Nishikawa “defines its D90 with reference to a *cumulative weight distribution*” but asserts that “a POSA would have recognized that where, as in Nishkawa’s Examples 4 and 5, the inorganic filler is of a single material... a cumulative volume distribution and a cumulative weight distribution will have the same D90 value because volume is directly proportional to weight.” Pet. at 22. Dr. Guido also confirms that Nishikawa discloses a cumulative weight distribution and not a cumulative volume distribution. Ex. 1003, ¶ 99. Petitioner then points to Nishikawa’s “d90” values of 1.05 µm and 1.07 µm for Examples 4 and 5, respectively, in Table 2, as shown in

Nishikawa's reproduced Table 2 below, and asserts that such d90 values would result in claimed Dv90/thickness ratio. Pet. at 10-11, 22.

TABLE 2						
	d10	d50	d90	α	Sliding property	Coating property
Example 4	0.38	0.75	1.05	0.89	good	good
Example 5	0.50	1.02	1.07	0.56	good	good
Example 6	1.50	8.0	22.0	2.56	good	poor
Example 7	5.10	23.0	58.0	2.30	good	poor

Ex. 1005, Table 2.

60. It is my opinion that Petitioner's assumption and arguments fail for numerous reasons.

**a. Volume-Based Dv90 Must Be Experimentally
Obtained, Not Derived From Weight-Based D90**

61. I understand that Petitioner and Dr. Gido admitted that "*Nishikawa* actually defines its D90 with reference to a cumulative weight distribution." Pet. at 22; Ex. 1003, ¶ 99. I further understand that Petitioner has asserted that "a cumulative volume distribution and a cumulative weight distribution will have the same D90 value because volume is directly proportional to weight." Pet. at 22. Petitioner and Dr. Gido's arguments fail in my opinion because the person of ordinary skill in the art would have understood that the claimed Dv90 must be determined from an experimentally obtained volume particle size distribution, not derived from a weight-based distribution value. Ex. 1003, ¶¶ 98-102. In fact,

material suppliers generally provide particle size distribution values such as Dv90, such values are based on experimentally obtained particle size distributions.

62. Particle size distribution is an experimentally determined statistical distribution analysis method to approximate the particle size at which the particles of a material reach a certain volume or weight threshold or other characteristic property. There are various methods for measuring and determining particle size distribution experimentally, such as sieving, sedimentation, laser diffraction, Coulter counter (electrozone), dynamic light scattering, gas adsorption, light obscuration (photozone), and image analysis (including optical and electron microscopies). *See* Ex. 2012 at 2-12.

63. Each of these techniques for determining particle size distribution is sensitive to some property or combination of properties of individual particles that changes with particle size, thereby enabling the method to determine particle size. For instance, one method might determine size based on how particles interact with light while another method might use hydrodynamic forces. Once a particle distribution is obtained, it can be used to obtain the D10, D50, and D90 values, corresponding to different effective diameters in the cumulative distribution.

64. A POSA would not convert a particle size distribution determined from one type of measurement to a particle size distribution that would be determined by another type of measurement. This is due to various assumptions

that must be made for such a conversion to provide an accurate reflection of the measurement that would have been made, which may not be true.

65. Equivalence between volume-based and weight-based particle size distributions can only be assumed if the respective distributions were in fact determined by experimental apparatuses with the same sensitivity to all relevant particle properties and such relevant particle properties of the powder sample are absolutely uniform with respect to particle size. Even when a powder comprises only one material, rather than a mixture, a direct correlation between a weight particle size distribution and a volume particle size distribution cannot be assumed unless it can be assumed that all the particles of the powder have perfectly uniform shapes, perfectly uniform densities, perfectly uniform porosities, and perfectly uniform surface properties, and further that the respective weight-based and volume-based instruments can with nearly equal accuracy detect the particles present in the powder sample.

66. In practice a perfect scenario is rarely, if ever, the case due to inherent irregularities and non-uniformities that are present in powders. For example, the particles of a powder can vary with respect to surface v. interior composition, crystallinity v. amorphous character, and internal porosity. If any of these characteristics of the particles has a dependence on particle size, a conversion between a volume particle size distribution value and a weight particle size

distribution value cannot be conducted reliably. For instance, larger particles can be more porous than smaller particles due to the larger particles being aggregates of smaller particles, in which case the volume particle size distribution will not align with the weight particle size distribution.

67. A person of ordinary skill in the art would have understood that particles *of the same material* can have irregular particle shapes, densities, and porosities, that can result in volume particle size distributions that differ significantly from weight particle size distributions.

68. For example, two spherical particles of the same material may seemingly have the same external shape, but different internal structures – one may be fully solid on the inside, while the other may be hollow. Such particles would be measured by a volume particle size distribution technique as having the same volume even if they have different internal structures, but different weights when measured by a weight particle size distribution technique. This effect could be present, for example, when larger aggregate particles of smaller particles are not full and complete aggregates and thus contain internal air gaps or pores. Such air gaps or pores would not be detected by a volume particle size distribution method and would result in volume particle size distribution and weight particle size distribution profiles that do not match each other.

69. In addition, densities of single materials can change with crystal structure, including a lack of long-range structure leading to so-called amorphous or glassy materials. In amorphous alumina, for example, the density at room temperature can range from 2.66 to 3.4 g/cm³. Ex. 2013 at 6. In crystalline alumina derived from the mineral corundum, the specific gravity (an equivalent term for density) can range from 3.9 to 4.1 g/cm³. Ex. 2014 at 39. These varying densities indicate that there can be a wide range of densities possible even for the same material, which could be dependent on particle size depending on raw materials and manufacturing conditions.

70. Importantly, when particles have irregular material densities, their volumes may appear to be the same when measured through a volume particle size distribution method, but their weights would be different when measured through a weight particle size distribution method. A POSA would have understood that because density equals mass over volume, and weight and mass have a direct relationship, therefore irregular densities will result in irregular weights that differ from weights expected based on the volumes of the particles.

71. In addition, certain particle size distribution measurement techniques, such as the laser diffraction technique typically used for obtaining volume-based particle size distributions, rely on the assumption that the powder particles have smooth spherical shapes. When the particles being examined do not have such

shapes, obtaining a volume particle size distribution value using a volume measurement, and converting to a weight particle size distribution value, or *vice versa*, would result in inconsistencies due to erroneous assumptions regarding the particle shapes that carry over through the conversions.

72. Due to the fundamental difference between weight particle size distributions and volume particle size distributions, a POSA would have understood that weight particle size distributions and volume particle size distributions are measured using completely different techniques.

73. Because volume and weight particle size distributions are measured by different methods, a volume particle size distribution cannot be assumed to be an accurate representation of a weight particle size distribution, even of the same material. In fact, because the two measure different properties of the powder that can vary depending on various factors, they can only be expected to result in different particle size distribution graphs even for the same material sample.

74. For the above reasons, it is my opinion that the claimed volume particle size distribution Dv90 value must be determined from an experimentally obtained volume particle size distribution, rather than derived from Nishikawa's weight particle size distribution d90.

b. Deriving Dv90 From D90 Would Be Reasonable Only, if Ever, When All Particles Have Perfectly Uniform Shapes, Densities and Porosities

75. Dr. Gido makes a generalized assumption that when the inorganic filler is of a single material, a volume particle size distribution and weight particle size distribution will have the same D90 value simply based on the mathematical direct relationship between volume and weight:

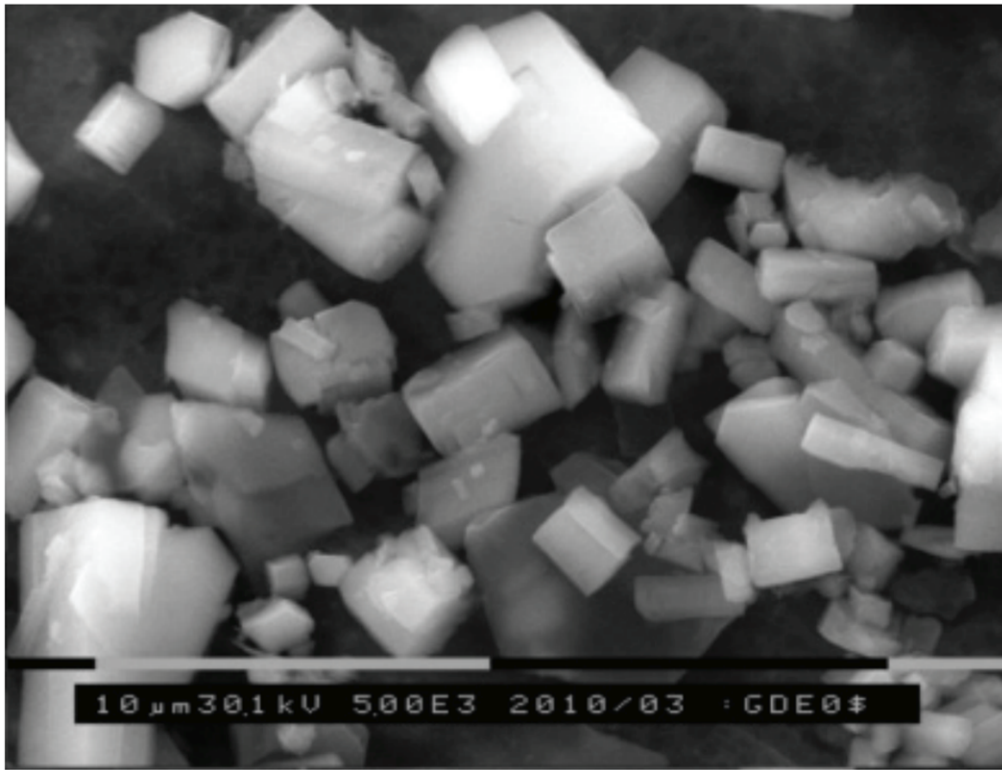
[A] POSA would have recognized that where, as in *Nishikawa*'s Examples 4 and 5, the inorganic filler is of a single material (here, aluminum hydroxide, *see Nishikawa*, 22:26-35, 22:46-51), a cumulative volume distribution and a cumulative weight distribution will have the same D90 value. This is because, as a POSA would have known, volume is directly proportional to weight—in particular, mass is equivalent to volume multiplied with density. Where the inorganic filler is of a single material, the density relating each particle's mass to each particle's volume will be the same, such that Dm90 and Dv90 will have the same value. *Compare also Nishikawa*, 3:52-55 (defining "D90" as "an average particle diameter (μm) of weight accumulation of 90% by weight calculated from a smaller particle side in a particle size distribution") *with* '987 patent, 1:53-56 (defining "Dv90" as "a particle size which reaches 90%

the cumulative volume from the side of small particle size in the granularity distribution on a volume basis.”).

Ex. 1003, ¶ 99.

76. Dr. Guido’s assumption is based on the incorrect premise that Dv90 is a value that can be simply converted from a weight particle size distribution value, without determining Dv90 from an experimentally obtained volume particle size distribution. But even assuming that it were reasonable to derive a volume particle size distribution Dv90 value based on Nishikawa’s weight particle size distribution d90 value as Dr. Guido asserts, such a conversion would only be scientifically sound in a theoretical, ideal world where all of Nishikawa’s inorganic filler particles, even if made from the same material, have perfectly or near-perfectly uniform shapes, densities, and porosities, and as a result, identical particle size distribution profiles.

77. In fact, the aluminum hydroxide filler particles of Nishikawa’s Examples 4 and 5 are crystalline, non-spherical particles, as shown in the exemplary image below showing a characteristic distribution of aluminum hydroxide particle sizes and shapes, taken with a scanning electron microscope.



Ex. 2015, 020042-1.

78. As the image above shows, aluminum hydroxide particles are not spherical and have sharp edges that can result in anomalies even in a volume particle size distribution measurement, such as a laser diffraction measurement (in this case the sharp surface angles cause the diffraction pattern to generate non-existing or ghost particles). Simply converting a weight particle size distribution value to a volume particle size distribution based on the mathematical relationship between volume and weight, as Petitioner and Dr. Gido propose, would not account for these anomalies.

79. As such, a person of ordinary skill would have understood that particles, even of the same material, can have significant variations in particle shapes, porosities, and densities, and, as such, would not have derived a volume particle size distribution Dv90 value from a weight particle size distribution d90 value, for example, from a simple mathematical relationship between volume and weight as Petitioner does. A person of ordinary skill would have understood that a volume particle size distribution value would need to be experimentally obtained using a volume particle size distribution method. For the above reasons and in view of Petitioner and Dr. Gido's admissions that Nishikawa only discloses weight particle size distribution, Petitioner's argument that Nishikawa's weight particle size distribution d90 value is equal to a volume particle size distribution Dv90 value fails.

2. Petitioner Fails to Show that Nishikawa Anticipates or Renders Obvious the Porous Layer Thickness of Claim 1

80. In asserting that Nishikawa teaches the claimed Dv90/thickness range, Petitioner points to Examples 4 and 5 of Nishikawa and states "[i]n each of Nishikawa's Example 4 and Example 5 separators, the heat resistant porous layer has a thickness of 3.15 μ m on each side of the microporous membrane (both sides totaling 6.3 μ m)." Pet. at 23. I understand Petitioner's expert relies on an alleged thickness of the heat resistant porous layer of Example 1 as the thickness for

Examples 4 and 5 as well. Ex. 1003, ¶ 100. Yet neither the Petition nor Dr. Gido provide any explanation or basis for why the total porous layer thicknesses of Examples 4 and 5 are assumed to be equivalent to the total porous layer thickness of Example 1, or why each porous layer thickness on each side of the substrate in Examples 1, 4 and 5 is assumed to be equal to exactly one half of the total porous layer thickness of 6.3 μm in Example 1—Dr. Gido only states that “Example 1 ([] is, in this aspect, the same as Examples 4 and 5).” *Id.* Petitioner’s assumptions and arguments fail for several reasons, as explained below.

a. The Porous Layer Thicknesses of Examples 4 and 5 Are Not Equal to the Porous Layer Thickness of Example 1

81. Petitioner and Dr. Gido appear to rely on Example 1 of Nishikawa as noted in footnote 1 of Dr. Gido’s declaration:

Nishikawa’s Example 4 separator is “produced in the same manner as in Example 1, except that” the coating slurry is modified. *Nishikawa*, 22:37-40. *Nishikawa*’s Example 5 separator is “produced in the same manner as in Example 4 except that the inorganic filler was changed” from H-43M to H-42M, where H-42M and H-43M are both commercially available aluminum hydroxide organic fillers having different particle size distribution as shown in Table 2. *Nishikawa*, 22:26-33, 22:46-51. Accordingly, throughout my declaration,

citations to discussions of Example 1 are provided where they apply equally to Example 4 and Example 5.

Ex. 1003, n. 1; *see also* Pet., n. 3.

82. But it is my opinion that the porous layer thicknesses of Examples 4 and 5 are not equal to the porous layer thickness of Example 1.

(i) **“Produced In The Same Manner” Does Not Mean Having the Same Porous Layer Thickness**

83. With respect to Example 4, Nishikawa states that “[a] separator for a nonaqueous secondary battery of the invention was *produced in the same manner* as in Example 1 *except that the aforementioned coating slurry was used.*” Ex. 1005, 22:37-40 (emphasis added). With respect to Example 5, Nishikawa states that “[a] separator for a nonaqueous secondary battery of the invention was *produced in the same manner* as in Example 4 *except that the inorganic filler was changed to aluminum hydroxide (H-42M, produced by Showa Denko K.K.) having a particle size distribution of d90 of 1.07, d50 of 1.02 and d10 of 0.50 by laser diffraction.*” *Id.* 22:46-51 (emphasis added). A POSA would have understood that using different coating slurries having different resin and inorganic fillers materials to produce the porous layers of Examples 1, 4 and 5 would result in porous layers having different properties and thicknesses.

84. First, it is my opinion that the phrase “produced in the same manner,” in the context of Nishikawa’s Examples 1, 4 and 5, means using the same microporous membrane as that of Example 1, and using the same general fabrication steps and/or instruments, such as the same “Meyer bars”⁴ to coat the coating slurry onto the microporous membrane, but using different coating slurries made from different materials, which would not necessarily result in separators have the same final properties, such as thickness. Ex. 2001, ¶ 85; Ex. 1005, 11:12-32, 15:49-16:44, 16:24-29, 22:8-54.

85. Nishikawa itself demonstrates that “in the same manner” does not result in the same coating thickness. For example, Examples 2 and 3 of Nishikawa are also described as having been “produced in the same manner” as Example 1 yet the porous layer thicknesses of these examples, which are actually based on a measured thickness of the separator (unlike the thicknesses for Examples 4 and 5 that Dr. Guido derives), are significantly different from that of Example 1 at 10.9 μm (for two porous layers) for Example 2 and 8.5 μm (for one porous layer) for Example 3, as shown in the excerpt of Nishikawa’s Table 1 below.

⁴ Nishikawa appears to misspell “Mayer bars” as “Meyer bars.” The inventor of such coating devices was Charles Mayer. In this declaration, I refer to Mayer bars and Meyer bars interchangeably.

		Example 1	Example 2	Example 3
Coated surface		both surfaces	both surfaces	one surface
Weight per unit (g/m ²)		10.82	13.72	10.62
Coated amount (g/m ²)		3.83	6.73	3.63
Thickness	Separator	17.8	22.4	20.0
(μm)	Polyethylene microporous membrane	11.5	11.5	11.5
	Heat resistant porous layer	6.3	10.9	8.5

Ex. 1005, Table 1.

86. A POSA would understand that these measurements of layer thickness are made by measuring the overall thickness of the separator (as provided in Nishikawa's Table 1) and then subtracting the known 11.5 μm thickness of the microporous membrane substrate. Thus, one cannot separately determine the thicknesses of the individual layers in Examples 1 and 2, only a cumulative thickness for both layers

87. As shown in Nishikawa's Table 1 above, the 10.9 μm thickness of the porous layer of Example 2 (for two porous layers) is 73% larger than the 6.3 μm thickness of Example 1 (for two porous layers), despite the separator of Example 2 having been "*produced in the same manner as in Example 1 except that the aluminum hydroxide was changed to magnesium hydroxide having an average particle diameter of 0.8 μm.*" *Id.* 16:48-49. In addition, the 8.5 μm thickness of the porous layer of Example 3 (*for one layer*) is 35% larger, respectively, than the 6.3 μm thickness of Example 1 (*for two layers*), despite the separator of Example 3 also having been "produced in the same manner as in Example 1 except that the

coating slurry was supplied from one side of the pair of Meyer bars to form a heat resistant porous layer on one surface of the polyethylene microporous membrane.”

Id. 16:66-17:3. If the porous layer thickness of Example 3 were to be compared to the thickness of one porous layer of Example 1, which would presumably be less than 6.5 μm for two combined porous layers, and which would be a more reasonable comparison, the difference would be even larger and more pronounced.

88. As such, it is my opinion that the “produced in the same manner” language that Dr. Gido appears to rely on for his assumption that the porous layer thicknesses of Examples 4 and 5 will be the same as that of Example 1, does not mean resulting in the same thickness. Further, because the coating slurries, including the resin material and inorganic filler material that are used for the porous layers of Examples 4 and 5 differ from that used in Example 1, it is my opinion that the porous layer thicknesses of Examples 4 and 5, if measured, would be different from that of Example 1. Lastly, it is my opinion that the only reliable way to measure the porous layer thicknesses of Examples 4 and 5, in the context of Nishikawa’s disclosure, would have been to directly measure them. However, Nishikawa does not provide such measurements. Without such measurements, the POSA would not have been able to derive the requisite thickness values to anticipate the claims.

(ii) **Example 1, and Examples 4 and 5, Use
Different Materials for the Coating Slurry**

89. As explained above, the types of filler material, binder, and solvent used to produce a porous layer can directly affect the structural and physical properties of the resulting porous layer, including thicknesses, as well as its performance characteristics.

90. This can have multiple causes. For example, the thickness of the initial (wet) coating of slurry can vary with slurry material properties, even when using the same coating equipment and procedure. In addition, the coated layer will shrink to varying degrees upon drying of the slurry, depending on the fraction of liquid and the particle size distribution of the filler material, even when controlling the drying time and temperature.

91. Nishikawa's Examples 4 and 5 use coating slurry materials that are different from those of Example 1, and thus the coating slurries of Examples 4 and 5 are expected to result in porous layers with physical, structural, and performance characteristics that are different from that of Example 1. In particular, Nishikawa describes that in Example 1, the coating slurry is produced as described below.

Conex (a trade name, produced by Teijin Techno Products, Ltd.) as meta-type wholly aromatic polyamide and aluminum hydroxide (H-43M, produced by Showa Denko K.K.) having an average particle diameter of 0.8

μm were adjusted to a weight ratio of 25/75 and were mixed with a mixed solvent containing dimethylacetamide (DMAc) and tripropylene glycol (TPG) at a weight ratio of 50/50 to a concentration of the meta-type wholly aromatic polyamide of 5.5% by weight, thereby producing a coating slurry.

Ex. 1005, 16:15-23.

92. Nishikawa describes that for Example 4, the coating slurry is produced as described below.

160.5 g of isophthalic acid chloride was dissolved in 1,120 mL of tetrahydrofuran, to which a solution obtained by dissolving 85.2 g of m-phenylenediamine in 1,120 mL of tetrahydrofuran was gradually added in the form of thin flow under stirring, thereby providing a white turbid milky white solution. After continuing the stirring for approximately 5 minutes, an aqueous solution obtained by dissolving 167.6 g of sodium carbonate and 317 g of sodium chloride in 3,400 mL of water was quickly added thereto under stirring, followed by further stirring for 5 minutes. The reaction system was increased in viscosity after several seconds and then decreased in viscosity, thereby providing a white suspension liquid. After allowing to stand the suspension liquid, a transparent aqueous solution layer thus separated was

removed, and 185.3 g of white polymer of poly-m-phenylene isophthalamide was obtained by filtration.

The poly-m-phenylene isophthalamide thus obtained in the aforementioned manner and an inorganic filler containing aluminum hydroxide (H-43M, produced by Showa Denko K.K.) were mixed at a weight ratio of 25/75, and mixed in a concentration of poly-m-phenylene isophthalamide of 5.5% by weight with a mixed solvent containing dimethylacetamide (DMAc) and tripropylene glycol (TPG) at a weight ratio of 50/50, thereby providing a coating slurry. The particle size distribution of the inorganic filler was d90 of 1.05, d50 of 0.75 and d10 of 0.38.

Id. 22:10-43.

93. Nishikawa describes that for Example 5, the coating slurry is produced as described below.

A separator for a nonaqueous secondary battery of the invention was produced in the same manner as in Example 4 except that the inorganic filler was changed to aluminum hydroxide (H-42M, produced by Showa Denko K.K.) having a particle size distribution of d90 of 1.07, d50 of 1.02 and d10 of 0.50 by laser diffraction. The resulting separator was analyzed, and the results are shown in Table 2.

Id. 22:46-52.

94. In Table 1 below, I summarize the different resin and inorganic filler materials used for the coating slurries of Examples 1, 4 and 5, based on Nishikawa's disclosure.

Nishikawa Example	Example 1	Example 4	Example 5
Resin Material	Conex (a meta-type wholly aromatic polyamide)	Poly-m-phenylene isophthalamide	Poly-m-phenylene isophthalamide
Inorganic Filler Material	Aluminum hydroxide (H-43M) having a particle size distribution of: d50 - 0.8	Aluminum hydroxide (H-43M) having a particle size distribution of: • d90 - 1.05 • d50 - 0.75 • d10 - 0.38	Aluminum hydroxide (H-42M) having a particle size distribution of: • d90 - 1.07 • d50 - 1.02 • d10 - 0.50

Table 1. Summary of Coating Slurry Materials of Nishikawa's Examples 1, 4 and 5.⁵

95. As shown above, Nishikawa's Examples 4 and 5 used poly-m-phenylene isophthalamide as a resin for the coating slurry, whereas Example 1 uses Conex, a commercial resin that is described as being a meta-type wholly aromatic polyamide, and Nishikawa presents these resin materials as distinct materials with different sources and likely different manners of production. In particular,

⁵ See Ex. 1005, 16:15-23, 22:10-43, 22:46-52.

Nishikawa indicates that Example 1's Conex "meta-type wholly aromatic polyamide" is a commercial product produced by Teijin Techno Products, without providing the manner of production for it, whereas the poly-m-phenylene isophthalamide of Examples 4 and 5 was produced by the inventors of Nishikawa themselves, describing the method of production for it. *Id.* 16:15-16, 22:10-26.

96. A POSA would understand that the resin of Examples 4 and 5 is different from that of Example 1 by examining, for example, Example 8, which uses a resin made in the same exact manner as that of Example 4. Example 8 is intended to contrast with Example 1 in that the only difference is the resin, and thus, any difference in outcomes between Example 8 and Example 1 in Nishikawa are indicated as being solely due to the different resins. *Id.* 15:49-16:44, 23:27-24:5. A POSA would thus conclude that Example 4, being made with the same resin as Example 8, would likewise depart from Example 1 in porous layer properties. *Id.* 22:10-26, 23:35-49. And in fact, the separator thickness of Example 8 has a total thickness of 20 μm , while the separator thickness of Example 1 has a total thickness of 17.8 μm , and also has substantially different air permeability and membrane resistance values from those of Example 1. *Id.* Table 1, 24:2-5.

97. In addition, a POSA would understand that the resins of Example 1 and Examples 4 and 5 would have different molecular weight distributions from being different polymer samples with different sources and likely different

manners of production. That is, as with weight-based particle size distributions that exist for powders based on the different particle sizes in a powder sample, a polymer sample can also be characterized by its molecular weight distribution of polymer molecules having different molecular weights in that particular sample. This occurs because when a polymer is produced, the number of repeat units in the polymer varies from one polymer molecule to the next, such that there is a distribution of the number of repeat units and molecular weights in any polymer sample. The molecular weight distribution of a polymer sample can be characterized or summarized by the weight-average molecular weight (M_w) and the dispersity (called molecular weight index or MWD in Nishikawa and defined in Equation 6). Furthermore, Nishikawa teaches that the distinct fraction of low-molecular-weight polymer (i.e. with fewer repeat units such that molecular weight is less than 8000) in the resin is a significant indicator of outcomes. Ex. 1005, 8:20-25.

98. A POSA would understand that a polymer sample's mechanical and thermal properties are sensitive to its molecular weight distribution. Indeed, Nishikawa teaches and relies on this fact. Nishikawa's Examples 8, 9 and 10 are intended to show the notable effect of changing the molecular weight distribution of poly-m-phenylene isophthalamide and to be compared to the effect of instead using Conex resin in Example 1. *Id.* 23:27-25:14. The polymer sample's weight

distribution in turn depends on how the polymer was prepared, including purity of raw materials, stoichiometric ratios of reactants, and reaction conditions such as temperature and time. Thus, if any preparative steps for one resin differ from that of another resin, a POSA would necessarily conclude that the two resins have distinct behavior as adhesives and binders. And because the resins of Example 1 and Examples 4 and 5 are different resin samples from different sources and likely different production methods, a POSA would understand that they would have different properties.

99. Additionally, it is my understanding that Teijin Techno Products, the manufacturer of Example 1's Conex resin, markets different "tenacity" grades of Conex that result in a range of different material strengths, further confirming that the properties of Nishikawa's resins can be manipulated by the manner of production. *See, e.g.*, Ex. 2016 at 4-6.

100. Considering the above, a POSA would have understood that the resins of Example 1 and Examples 4 and 5 have different molecular weight distributions and that this translates into different slurry properties such as viscosity and different binding properties with solids. Therefore, a POSA would have expected porous layers prepared using such different resins to have different effective properties, including different thicknesses.

101. In addition, a POSA would have understood that the inorganic filler materials used in Examples 1, 4 and 5, despite all comprising aluminum hydroxide, have different particle size distribution properties. Moreover, the inorganic filler material for Example 5 is even from an entirely different commercial aluminum hydroxide material (H-42M) product than that used for Example 1 (H-43M).

102. It is my opinion that although Nishikawa's inorganic filler materials for Examples 1, 4 and 5 all comprise aluminum hydroxide, they would result in different Dv90/thickness ratios because the three inorganic filler materials have different particle size distribution d50 values.

b. The Dual Porous Layers of Example 1 Are Highly Non-Uniform and Uneven

103. Even assuming that the porous layers of Examples 4 and 5 were produced using the same coating slurry materials as those of Example 1, which is not the case, Petitioner's assumption would fail because the thicknesses of the porous layers of Example 1 itself are highly non-uniform, uneven, and unreliable, as explained below.

(i) Mayer Bars Produce Highly Non-Uniform Coatings

104. Nishikawa explains, with respect to Example 1, that after the coating slurry is prepared, the coating slurry is placed on a pair Mayer bars, and the microporous membrane is passed through the two Mayer bars:

A pair of Meyer bars (size number #6) were disposed to face each other with a gap of 20 μm . An appropriate amount of the coating slurry was placed on the Meyer bars, and the polyethylene microporous membrane was passed through the Meyer bars, thereby coating the coating slurry on both the surfaces of the polyethylene microporous membrane.

Ex. 1005, 16:24-29.

105. Nishikawa's Examples 4 and 5, which Dr. Guido points to as teaching the claimed Dv90/thickness range, had separators "produced in the same manner" as that of Example 1. As such, the porous layers of Examples 4 and 5 are also produced using the Mayer bars in the manner described above for Example 1.

106. A Mayer bar is a stainless steel rod also known as the Mayer rod, which is tightly wound with a stainless steel wire that can have varying diameters. The Mayer bar can be used to coat viscous and semi-viscous liquids like paints, inks, adhesives, and lacquers, by transferring coating liquid to the surface of a substrate. The wire wound on the rod necessarily creates irregularity in the outer surface profile of the Mayer bar device. The wet thickness after coating is generally dependent on the diameter of the wire wound on the rod.

107. Although Mayer bars are a popular method of coating in industry due to their simplicity and convenience, they result in substantial irregularities in the

coatings. This is because a Mayer bar deposits a coating by rotation of its irregular outer surface adjacent to, and in some instances pressing against, a substrate, which necessarily leaves streaks, or ribs, in the coating. Such nonuniformity is illustrated in the figure below, which shows the surface roughness (relative heights of peaks and valleys, relative to an arbitrary point of zero height) of an exemplary coating produced using a single Mayer bar.

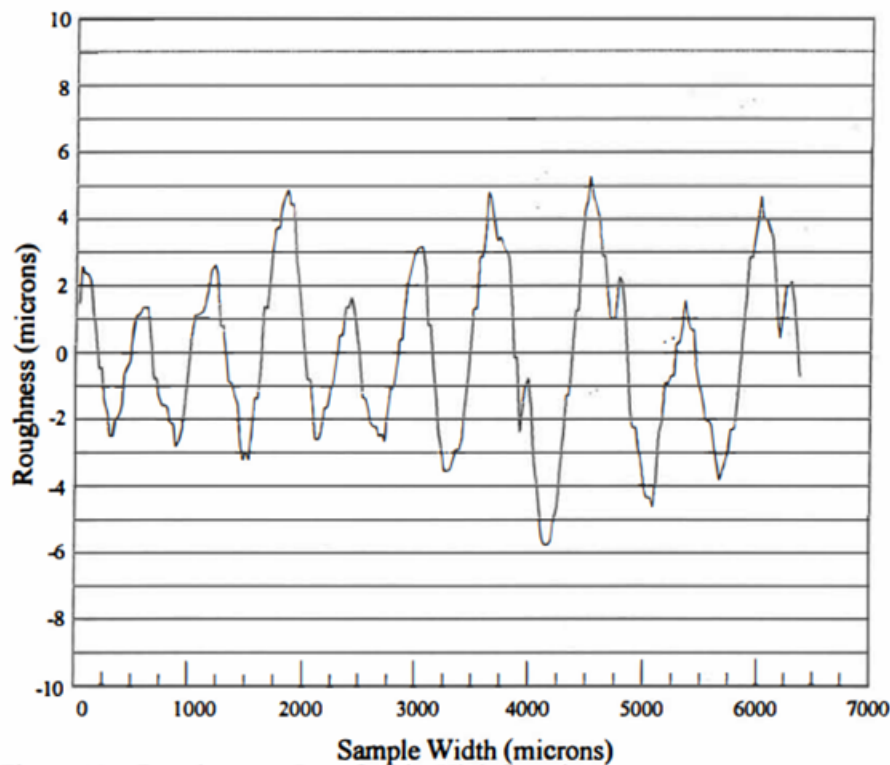


Figure 18. Roughness at Low Solids, High Speed.

Ex. 2017 at 68.

108. In the above example, the coating was produced using a slurry mixture of water, inorganic filler, polymer, and other components, with a wire diameter of 0.3 mm, and the difference between peaks and valleys from the

resulting coating is shown as being multiple microns (μm). The thinner the average coating thickness is, the more pronounced the effect of the irregularities on the local properties of the coating will be. If the average coating thickness is low enough, the types of valleys shown in the figure above could represent regions where there is essentially no coating. Dr. Gido's declaration itself mentions that a POSA would know to avoid a procedure that would lead to a nonuniform coating including with respect to the thickness of the coating. Ex. 1003, ¶ 128.

109. As such, a POSA would have understood that Mayer bars are not ideal methods for producing smooth, uniform coatings, particularly when the layers are relatively thin and where surface uniformity is important, as in the porous layers of the '987 Patent. If a Mayer bar-type method were nevertheless chosen for coating a separator porous layer, a POSA would have used multiple Mayer bar coatings in an attempt to smooth out the surface, as done in U.S. Patent No. 6,855,374, which recognizes the presence of nonuniformities and defects on a coating produced using a Mayer bar, and seeks to address such nonuniformities by rolling a substrate through up to ten sequential Mayer bars. *See* Ex. 2018, 1:16-18, 1:51-2:2, 7:3-30, Fig. 5, claim 11. Nishikawa, however, deposits the porous layer by passing the separator substrate only through one Mayer bar on each side of the substrate.

110. Nishikawa itself also states that Mayer bars should preferably be followed by “a pair of reverse rolls to scrape the excessive slurry” for improved

coating uniformity. Ex. 1005, 11:22-32. And yet this modification to stand-alone Mayer bars was not followed by Nishikawa, which would lead a POSA to understand that Nishikawa's porous layers are not uniformly coated.

111. As such, it is my opinion that Nishikawa's thickness measurements for Example 1 are unacceptably variable and hence unreliable.

(ii) **When Mayer Bars Are Used for Double Coating, the Non-Uniformity Is Even More Pronounced**

112. To obtain the alleged thickness of each porous layer in Examples 4 and 5, Dr. Gido subtracts the known thickness of the microporous membrane of Example 1, which is 11.5 μm , from the measured total thickness of the separator of Example 1, which is 17.8, to obtain a total, combined thickness of the porous layer of 6.3 μm , which Dr. Gido takes as the "total thickness of both heat resistant porous layers." Ex. 1003, ¶ 100; Ex. 1005, Table 1. However, Dr. Gido then proceeds to make an unsupported and incorrect assumption that "[t]hus, each of both heat resistant porous layers has half that thickness, namely, 3.15 μm ." Ex. 1003, ¶ 100.

113. Dr. Gido's assumption is incorrect because when Mayer bars are used for double coating two surfaces of the same substrate, as Nishikawa does for Examples 1, 4 and 5, the thicknesses of the two porous layers will be inherently different from each other. This is because using two Mayer bars to simultaneously

coat the two sides of a substrate involves the movement of the substrate between two rotating Mayer bars that are spaced a predetermined distance apart. While the substrate may be oriented in any direction, it is typically oriented in the horizontal direction, with one Mayer bar above the substrate and another Mayer bar below the substrate.

114. When a substrate is simultaneously double coated in this way, the thicknesses of the top coat and the bottom coat will necessarily be different. This is caused by a nearly unavoidable variation in the gap or contact force between the substrate and each Mayer bar. It is practically inevitable that the roll of substrate material being fed between the Mayer bars will be pulled more toward one bar and away from the other, where the asymmetry will depend on the orientation and placement of support rollers and the tension in the substrate. For instance, in the common horizontal orientation of the bars and substrate, gravity will pull the substrate toward the bottom bar and away from the top bar. Even when gravity is counteracted by another force, or in the rare case of a non-horizontal orientation, the roll of substrate material will be supported by other rollers and necessarily pulled closer to one of the two Mayer bars. Therefore, simultaneous double coating the two sides of a substrate using two Mayer bars presents additional non-uniformities in the thicknesses of the two coatings.

115. Therefore, when Mayer bars are used for simultaneous coating of two surfaces of the same substrate, as Nishikawa does for Examples 1, 4 and 5, the unreliability and non-uniformity of the thicknesses of the dual porous layers will be even more pronounced than for a single Mayer bar operation. In my opinion the unreliability is further amplified by the particular selection in Nishikawa's Example 1 (and by extension, Examples 4 and 5) of a gap between Mayer bars of 20 μm while the microporous membrane has a much lower thickness of 11.5 μm . This means that there is a substantial gap between the Mayer bars and the microporous membrane, which could be filled or not filled with a variable amount of liquid slurry on either side of the microporous membrane, leading to a substantial variability in coating thicknesses.

116. This opinion is reinforced by Nishikawa's own Example 3, which is intentionally made using the same exact resin material, same exact aluminum hydroxide inorganic filler material having the same average particle diameter, and in a separator "produced in the same manner as in Example 1 except that the coating slurry was supplied from one side of the pair of Meyer bars to form a heat resistant porous layer on one surface of the polyethylene microporous membrane." Ex. 1005, 16:66-17:3. Despite Example 3's separator being produced using the same resin and inorganic filler material as those of Example 1, with the only difference being that the porous layer is coated on one side as opposed to both

sides of the substrate, Example 3 has a porous layer thickness on one side of 8.5 μm , which is 2.2 μm or 35% larger than the combined thickness of 6.3 μm of the dual layers in Example 1, and 5.35 μm or 70% larger than the alleged 3.15 μm thickness of each porous layer of Example 1 that is incorrectly derived by Dr. Gido. Ex. 1005, Table 1.

117. As such, the top and bottom porous layers in Example 1 cannot be assumed to have the same thicknesses as Dr. Gido assumes. Rather, the only possible assumption that can be made regarding each individual porous layer, from the combined 6.3 μm thickness in Example 1, is that one of the two porous layers will have a thickness of between 0 and 6.3 μm , and the other porous layer will have a thickness equal to the difference between that thickness of the first porous layer, and 6.3 μm . All a POSA can assume from Nishikawa's 6.3 μm thickness for Example 1, is that the ***combined thickness*** of the two porous layers is 6.3 μm .

118. And even assuming that the weight particle size distribution d90 values of Examples 4 and 5 are equivalent to volume particle size distribution Dv90 values as Dr. Gido incorrectly assumes (which a POSA would know to be untrue), and that Examples 4 and 5 have the same combined total thickness for their porous layers of 6.3 μm as Dr. Gido incorrectly assumes (which a POSA could not know to be true), the possible Dv90/thickness ranges in Nishikawa's Examples 4 and 5 still do not anticipate the claimed Dv90/thickness range of Claim

1 because there are points within Nishikawa's ranges that nevertheless fall outside of the claimed range. I illustrate this in in Table 2 below, where I present the results of my calculations of the porous layer thickness ranges in Examples 4 and 5 required to meet the claimed Dv90/thickness range using the d90 values disclosed in Nishikawa, and the possible porous layer thickness ranges of Nishikawa's Example 4 and 5, which are broader than the former ranges required to meet the claimed range. The calculated thickness range required to meet the claimed range was obtained by inserting Nishikawa's d90 values for Examples 4 and 5 into the claimed Dv90/thickness range as follows:

Nishikawa's Example 4

$$0.3 < \text{Dv90/thickness} < 3$$

$$\text{and } d90 = 1.05$$

$$\text{therefore } 0.35 < \text{thickness} < 3.5$$

Nishikawa's Example 5

$$0.3 < \text{Dv90/thickness} < 3$$

$$\text{and } d90 = 1.07$$

$$\text{therefore } 0.36 < \text{thickness} < 3.6$$

Example	d90	Nishikawa's thickness range required to meet claimed Dv90/thickness range of 0.3 to 3	Nishikawa's possible thickness range
4	1.05	$0.35 < \text{thickness} < 3.5$	$0 < \text{thickness} < 6.3$
5	1.07	$0.36 < \text{thickness} < 3.6$	$0 < \text{thickness} < 6.3$

Table 2. Required and Possible Porous Layer Thickness Ranges of Examples 4 and 5 of Nishikawa.

119. As shown above, even making the incorrect assumptions that Dr. Gido makes and taking all of Dr. Gido's assumptions to be true, there are significant portions of the possible thickness ranges of the porous layers of Examples 4 and 5 that fall outside of the thickness ranges required to meet the claimed range – 0-0.35 μm and 3.5-6.3 μm for Example 4, and 0-0.36 μm and 3.6-6.3 μm for Example 5.

120. The '987 patent discloses multiple examples to demonstrate the importance of the range disclosed and claimed. Specifically, "[a]s can be seen from a comparison among examples 1-7 and comparative examples 1-2, the ratio of Dv90 of the inorganic particles to the thickness of the porous layer has an effect on the rate performance and cycle performance of the lithium-ion battery." Ex. 1001, 15:26-30. Comparative Examples 1-2 have Dv90 to porous layer thickness ratio values of 0.2 and 3.2 (respectively), which are outside the claimed range of 0.3-3.0. Ex. 1001, Table 1, Table 2. The '987 patent further confirms that if "the ratio of Dv90 of the inorganic particles to the thickness of the porous layer is too high (for example, comparative example 2), the pore size distribution of the porous layer

tends to be non-uniform, the surface of the porous layer is heterogeneous, the porous layer is easily detached from the surface of the porous substrate, and *defects are formed in the energy storage device (such as a lithium-ion battery)*” (Ex. 1001, 15:36-43) and “[i]f the ratio of Dv90 of the inorganic particles to the thickness of the porous layer is too low (for example, comparative example 1), the inorganic particles cannot be effectively exposed on the surface of the porous layer, which does not facilitate an exchange of the first solvent in the coating solution and the third solvent in the coagulating solution in the preparation process of the porous layer, cannot enhance diffusion, is not advantageous for the development of the pores, and *is also not advantageous for the improvement of the rate performance and cycle performance.*” Ex. 1001, 15:49-59.

121. For the reasons above, it is my opinion that Petitioner has failed to show that Nishikawa’s Examples 4 and 5 anticipate or render obvious the claimed Dv90/thickness range of claims 1 and 10.

3. Petitioner Fails to Show that Nishikawa Renders Obvious the Method Steps of Claim 10

122. Claim 10 of the ’987 patent recites:

10. A method for preparing the separator of claim 1, wherein the method comprises steps of:

mixing inorganic particles with a binder to generate a mixture;

adding a first solvent into the mixture;

stirring the mixture with the first solvent to obtain a uniform coating solution;

coating the uniform coating solution onto a surface of a porous substrate to form a wet film;

the coating solution is in a range from 7% to 25%;
and

wherein a ratio of Dv90 of the inorganic particles to the thickness of the porous layer is in a range from 0.3 to 3.0.

Ex. 1001, Claim 10.

123. As shown above, the steps of claim 10 recite: (1) mixing inorganic particles with a binder; then (2) adding *a first solvent* into the mixture; then (3) stirring the mixture with *the first solvent* to obtain a *uniform coating solution*.

124. In my opinion, Nishikawa does not disclose the claimed first solvent for the reasons below.

a. Nishikawa Teaches Using a Mixed Solvent Comprising DMAc and TPG, Not a Single DMAc Solvent as Dr. Gido Alleges

125. To allege that Nishikawa teaches the “first solvent” of claim 10, Dr. Gido states:

The *solvent* Nishikawa describes, dimethylacetamide, is one embodiment of the claimed “*first solvent*” described in the ’987 patent. *Compare Nishikawa, 22:26-33 with ’987 patent, 2:35-38.* A POSA would have understood this to teach adding a *solvent*, the dimethylacetamide, to

the mixture of the **inorganic filler** containing aluminum hydroxide with the poly-m-phenylene isophthalamide **resin**.

Ex. 1003, ¶ 64.

126. Dr. Gido's citation to Nishikawa at Ex. 1005, 22:26-33, however, relies on Nishikawa's express teaching of mixing a poly-m-phenylene isophthalamide and inorganic filler mixture with a "***mixed solvent*** containing ***dimethylacetamide (DMAc)*** and ***tripropylene glycol (TPG)*** at a ***weight ratio of 50/50***" for Examples 4 and 5. Ex. 1005, 22:26-33, 22:46-51. In other words, Dr. Gido's citation confirms that Nishikawa expressly discloses a mixed solvent comprising 50/50 DMAc/TPG and not simply dimethylacetamide as alleged by Dr. Gido. Yet without providing any reasoning or explanation, Dr. Gido asserts that a POSA would have understood from such express teaching of a 50/50 DMAc/TPG mixed solvent, that Nishikawa teaches using a single DMAc solvent. I disagree.

127. Nishikawa explains that a polar solvent such as the DMAc of Examples 4 and 5, and a poor solvent such as the TPG of Examples 4 and 5, are intentionally *used together* to "induce[] a microscopic phase separation structure to facilitate formation of pores upon providing the heat resistant porous layer." Ex. 1005, 11:1-7. A POSA would have thus understood that Nishikawa's express requirement of a mixed solvent comprising 50/50 DMAc/TPG in Examples 4 and 5

is intentional and is required by Nishikawa to achieve the solvent, coating slurry, and separator properties of Examples 4 and 5. A POSA would have understood that such properties can only be achieved by the complex chemical interactions that occur between Nishikawa's mixed solvent comprising 50/50 DMAc/TPG, and Nishikawa's resin. A POSA would have thus understood that using just a DMAc solvent as Dr. Guido suggests, instead of the 50/50 DMAc/TPG mixed solvent that Nishikawa requires, would not result in the same or equivalent coating slurry, porous layer, and separator properties of Nishikawa's Examples 4 and 5.

128. As such, a POSA would have no reason and would not have used a single DMAc solvent instead of the 50/50 DMAc/TPG mixed solvent expressly disclosed in Examples 4 and 5 of Nishikawa.

**b. Nishikawa's 50/50 DMAc/TPG Mixed Solvent
Teaches Away From Obtaining a Uniform Coating
Solution**

129. In addition, a POSA would not have considered the claimed "first solvent" to be obvious in view of Nishikawa's 50/50 DMAc/TPG mixed solvent of Examples 4 and 5, because such a mixed solution would not result in the "uniform coating solution" recited in claim 10. Ex. 1001, Claim 10. Specifically, claim 10 expressly recites that the "first solvent" is stirred with the mixture of inorganic particles and binder "to obtain a *uniform coating solution*." Ex. 1001, claim 10. The '987 Patent also emphasizes the importance of achieving a uniformly coated

porous layer. *Id.* 5:43-49, 6:31-32. A POSA would have understood that a more uniform coating solution would result in a more uniformly coated porous layer and would have thus understood the importance of using the claimed “first solvent” to obtain the claimed “uniform coating solution.”

130. Nishikawa’s 50/50 DMAc/TPG mixed solvent, on the other hand, comprises *an entire fifty percent by weight poor solvent*, namely TPG. A POSA would have interpreted Nishikawa’s “poor solvent” as a solvent in which Nishikawa’s resin is not completely soluble whereas a good solvent would dissolve the resin to a much greater degree, if not completely. A POSA would have further understood that when a mixed solvent comprising a poor solvent and a good solvent is mixed with Nishikawa’s resin, there would be competition between the good solvent’s resin-dissolving behavior, and the poor solvent’s poor resin-dissolving behavior.

131. A POSA would understand from Nishikawa’s own teachings that the presence of 50 percent by weight of poor solvent TPG in Nishikawa’s 50/50 DMAc/TPG mixed solvent would result in an irregular phase structure and the formation of irregular pores with variable sizes and locations and not to the formation of a uniform coating solution as recited in claim 10. Indeed, as noted above, Nishikawa states that “[t]he solvent may contain the polar solvent and additionally a poor solvent to the heat resistant resin, and the addition of the poor

solvent induces a microscopic phase separation structure to facilitate formation of pores upon providing the heat resistant porous layer.” Ex. 1005 11:1-5.

132. On the other hand, the “first solvent” of the ’987 Patent is selected from the group N-methylpyrrolidone (NMP), dimethylacetamide (DMAC) and dimethylformamide (DMF). Ex. 1001, 5:67-6:3. In contrast to the poor solvent of Nishikawa, each of these solvents is a highly polar organic solvent in which the binder is soluble and thus would be considered by a POSA to be a good solvent. Ex. 1001 5:66-67-6:3, 7:5-6. For example, each of the coating solutions for Examples 1 through 15 of the ’987 Patent, was made with an NMP first solvent. Ex. 1001, 10:44-46, 11:23-13:3.

133. As such, the claimed “first solvent” is a solvent that is able obtain a “uniform coating solution” as recited in claim 10, whereas Nishikawa’s mixed solvent comprises fifty percent in weight of a poor solvent TPG, and thus cannot result in the claimed uniform coating solution. In addition, a POSA would have understood that Nishikawa’s 50/50 DMAc/TPG mixed solvent would result in a significantly different morphology of pores in Nishikawa’s coated layer from those of the claimed porous layer made using the claimed “first solvent.” Therefore, a POSA would not have found it obvious to use Nishikawa’s 50/50 DMAc/TPG mixed solvent.

134. For the above reasons, it is my opinion that Nishikawa does not render obvious the claimed “first solvent” of claim 10.

4. Claims 2, 4-9 and 11-17 Are Not Unpatentable

135. Claims 2, 4-9 and 11-17 are not unpatentable for the same reasons as discussed above with respect to claims 1 and 10. I reserve the right to address claims 2, 4-9 and 11-17 individually if this proceeding is instituted.

B. Ground 4: Iwai Does Not Anticipate Claims 1-2 and 4-9

136. Petitioner contends that Iwai anticipates claims 1-2 and 4-9 of the '987 Patent. These claims recite:

1. A separator, comprising: a porous substrate; and
a porous layer arranged on a surface of the porous substrate, wherein the porous layer comprises inorganic particles and a binder, and a ratio of Dv90 of the inorganic particles to the thickness of the porous layer is in a range from 0.3 to 3.0.
2. The separator according to claim 1, wherein the porous layer has a thickness of 0.2 μm to 10 μm .
4. The separator according to claim 1, wherein a volume ratio of the inorganic particles to the binder is in a range from 0.2 to 3.0.
5. The separator according to claim 1, wherein the porous layer has a porosity of 20% to 90%.
6. The separator according to claim 1, wherein the inorganic particles are one or more selected from the group consisting of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, zirconia, cerium dioxide, nickel oxide, zinc oxide, calcium oxide,

boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.

7. The separator according to claim 1, wherein the binder is one or more selected from the group consisting of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylates, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

8. An energy storage device, comprising the separator according to claim 1.

9. The energy storage device according to claim 8, wherein the energy storage device is a lithium-ion battery.

1. Petitioner Fails to Show That Iwai Anticipates Claim 1

137. Dr. Guido points to Iwai's Example 7 and Comparative Example 2, and argues, that based on the "thickness a" and an assumed D90 apparently derived from "D90-D10" values of these examples, Iwai anticipates claim 1. Ex. 1003, ¶¶ 156-175.

138. Specifically, Dr. Guido notes that "*Iwai* defines 'volume average particle diameter' ["r"] as 'a particle diameter at 50% cumulative volume calculated from a smaller side in a volume particle size distribution'" and points to the r values of Example 7 and Comparative Example 2. *Id.* 159, 167. Dr. Guido then notes that "*Iwai* defines D10 as 'a particle diameter at which a cumulative volume

of particles reaches 10% from a smaller side in a volume particle size distribution” and assumes that “[a] POSA would have recognized that D10 for *Iwai*’s Example 7 separator must be greater than 0, because it would not be possible for particles at 10% of the inorganic filler volume to have a particle diameter of 0.” *Id.* ¶ 160. Dr. Gido then assumes that “a POSA would have recognized that D10 for *Iwai*’s Example 7 separator must be less than the volume average particle diameter of the inorganic filler for *Iwai*’s Example 7 separator, because it would not be possible for the particle diameter at 10% cumulative volume to be more than the particle diameter at 50% cumulative volume” and “[t]hus, a POSA would have recognized that D10 for *Iwai*’s Example 7 separator must be less than 1.2µm.” *Id.* Based on this assumption Dr. Gido then deduces that “[t]hus, a POSA would have recognized, D90 for *Iwai*’s Example 7 separator must be greater than 1.6µm and less than 2.8µm,” and that the Dv90/thickness ratio of Example 7 must be greater than 0.72 and less than 1.27. *Id.* 164-65. Dr. Gido then notes that based on similar calculations, a D90 value of Comparative Example 2 can be deduced to be between 1.1 µm and 1.9 µm, and a Dv90/thickness ratio of Comparative Example 2 can be deduced to be between 0.35 and 0.61. *Id.* 166-175.

139. I disagree with Dr. Gido’s assumptions and deductions and instead, it is my opinion, that there is not enough information in *Iwai* to disclose the claimed limitations.

a. Iwai Does Not Disclose a Dv90 Value

140. Iwai does not disclose a Dv90 value, let alone a Dv90/thickness range. Petitioner appears to admit as much as Petitioner relies on a series of assumptions and calculations to derive a particular range of alleged Dv90 values. Pet. at 47-48. Instead, at best, Iwai discloses a D90 – D10 *difference*. In particular, Iwai discloses “a *difference* between *a particle diameter at 90% cumulative volume of the filler* and *a particle diameter at 10% cumulative volume* of the filler being 2 μm or less.” Ex. 1006, ¶ [0035]; *see also id.* abstract, [0021], [0041]-[0042], Table 1. Iwai never discloses that a specific Dv90 (or D90) value must be considered to achieve any of its advantages or benefits, as the '987 Patent does – the improvement of rate or cycle performance of the battery. Ex. 1001, 15:26-36, Table 2.

141. A POSA familiar with powder processing would be accustomed to seeing and interpreting a D90 – D10 difference, or perhaps the parameter $(D90 - D10)/D50$, as signifying the broadness of the particle size distribution, that is, as a measurement for the degree to which a powder is comprised of particles of nearly the same size. Indeed, Iwai teaches that this metric reveals whether the filler exhibits the desirable feature of minimal variation in particle size. Ex. 1006, ¶ [0042]. A POSA would therefore not interpret presentation of the D90 – D10

difference in Iwai as suggesting or enabling reliable determination of individual D90 values.

142. Because Iwai does not expressly disclose the claimed Dv90, Dr. Gido appears to resort to various assumptions, calculations and derivations regarding D10, volume average particle diameter, and D90 values to provide a range of potential D90 values, as described above. Iwai, however, never suggests or directs a POSA to conduct an analysis to determine D90. Furthermore, Iwai does not provide enough information for a POSA to make such a determination. It is therefore my opinion that a POSA reading Iwai would have no reason to make the assumptions and perform the calculations and derivations that Dr. Gido makes and performs.

b. Iwai Does Not Disclose the Porous Layer Thickness of Claim 1

143. In addition, Petitioner fails to show that Iwai anticipates claim 1 because Iwai does not disclose the porous layer thickness of claim 1.

144. Dr. Gido points to Iwai's "Average thickness a (um) of adhesive porous layer" for Example 2 and Comparative Example 2 as a thickness that is equivalent to the claimed porous layer thickness. Ex. 1003, ¶¶ 165, 174. Iwai describes "thickness a" as "an average thickness (um) of the adhesive porous layer on one of the sides of the porous substrate." Ex. 1006, ¶ [0037].

145. As described below, however, not only is the “thickness a” of Iwai’s Example 7 and Comparative Example 2 that Petitioner points to a different measurement from that of the claimed porous layer thickness, but the thickness of Iwai’s adhesive porous layer and separator is intentionally highly irregular. Ex. 1006, Table 2, ¶¶ [0037], [0043]-[0045], [0096], [0098], [0170]-[0171]. That is, it is Iwai’s objective is to provide filler particles that result in “irregular portions... on the surface of the adhesive porous layer.” *Id.* [0096]; *see also id.* [0098]. This renders Iwai’s thickness a unreliable and inaccurate as a measurement that is allegedly equivalent to the claimed porous layer thickness.

(i) The Thickness “a” in Iwai Is the Thickness of the Resin Layer Without Accounting for the Filler Particles

146. Petitioner points to Iwai’s “thickness a” from Iwai’s Table 1 as being equivalent to the porous layer thickness of claim 1. Ex. 1003, ¶¶ 165, 174; Ex. 1006, Table 1. Iwai’s “thickness a,” however, constitutes the thickness of only Iwai’s PVDF resin, without accounting for the “volume average particle diameter r” of the filler particles, which are intended to protrude above the adhesive, and most especially when diameter r is greater than the thickness a of the resin layer. Ex. 1006, ¶¶ [0037], [0043]-[0045].

147. Iwai explains that the filler particle projecting, or protruding, from the surface of the adhesive porous layer, provides desirable advantages, noting that

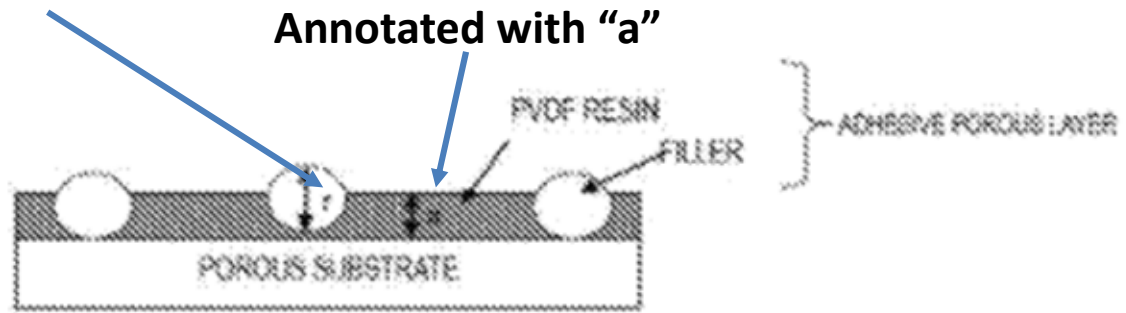
when the ratio “a/r” is between 0.5 to 3.0, “a state in which the filler is *projected at a proper height is formed on a surface of the adhesive porous layer* can be achieved,” which results in a separator with “favorable slidability” and “good handling property.” Ex. 1006, ¶ [0043]. Iwai then describes the disadvantages that occur when the filler particle does not protrude from the adhesive porous layer, noting that “in a case in which the ratio a/r exceeds 3.0, the filler is hardly projected from the surface of the adhesive porous layer, and slidability is hardly provided to the separator. As a result, a wrinkle is generated when conveying the separator, or a gauge band develops when winding the separator. Therefore, the handling property of the separator is insufficient.” *Id.* ¶ [0045].

148. It is clear from these disclosures in Iwai, that unlike the porous layer thickness of the '987 Patent, which constitutes the combined thickness of the binder plus inorganic particles that comprise the porous layer, Iwai's “thickness a” is a measure of just the adhesive porous layer portion, without accounting for any contribution to thickness from the filler particles whose “diameter r” values are in fact desired to be sufficiently large that the particles protrude significantly from the background adhesive layer.

149. In fact, during prosecution of Iwai, Iwai confirmed what was meant by “thickness a.” Specifically, Iwai confirmed that “‘a’ represents an average thickness (um) of the adhesive porous layer” and “‘r’ represents a volume average

particle diameter (um) of the filler contained in the adhesive porous layer,”
providing the illustration below, which shows a volume average particle diameter
“r” that is desirably larger than the thickness “a” of the adhesive porous layer:

Annotated with “r”



Ex. 2019 at 30.

150. As clearly labeled in the illustration above, thickness a only accounts for the resin matrix and does not account for contributions to the overall layer thickness from protruding filler particles of diameter r.

151. Iwai further confirmed that its advantages can be achieved when the diameter r of the filler and thickness a of the PVDF resin have a ratio such that the filler projects out from the adhesive porous layer, as shown in the excerpts from the prosecution history below:

The separator of the present invention achieves good adhesiveness to an electrode, along with exhibiting a good handling property derived from a favorable

slidability caused by the projections of the filler by satisfying both of conditions (i) and (ii).

Id. at 75.

... when the thickness of an adhesive layer containing a filler and particle sizing of the filler satisfies condition (ii), the filler is projected at a certain height on a surface of the adhesive layer. The projections of fillers form small gaps in an electrode/adhesive layer interface when a separator having the adhesive layer is stacked with an electrode in a battery.

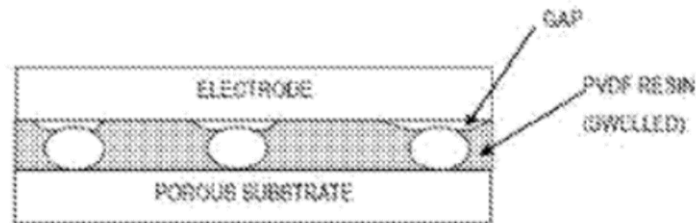
Id.

In summary, the separator of the present invention uses filler particles having a uniform size and adjusts the relationship between an average thickness of the adhesive porous layer (a) and the filler particle size (r) so that the filler particles suitably project from a surface of the adhesive porous layer.

Id. at 30.

152. Furthermore, the prosecution history of Iwai indicates that in Iwai, the formation of gaps as a result of such filler particle protrusions when an electrode is stacked (presumably as part of the battery assembly process), is a desired characteristic, as such gaps purportedly improve the cycle characteristics of the

battery. *Id.* The prosecution history of Iwai provides the following illustration to support these statements:



Id.

153. As shown above, Iwai's thickness a is, once again, a thickness of just the adhesive resin, and Iwai's diameter r of the filler particle is desired to protrude out from the adhesive layer so as to provide an inherently irregular surface, and so as to thereafter produce gaps between the separator and adjacent electrode when the electrode is stacked. These are completely different technical aims from those of the '987 Patent, where the claimed thickness is a ***uniform thickness of the porous layer that accounts for both the binder and inorganic particles***, and which desires to ***eliminate gaps between the separator and electrode*** through an appropriate porous layer thickness to prevent a reduction in the cycle capacity and safety performance of the lithium-ion battery. Ex. 1001, 1:27-31, 5:1-12. In fact, the '987 Patent explains that a non-uniform porous layer surface is undesirable because it "makes the porous layer easy to detach from the surface of the porous

substrate and forms defects in the energy storage device (such as a lithium-ion battery).” *Id.* 5:46-49.

(ii) **Iwai’s Surface Roughness Indicates that Its Adhesive Porous Layer Is Highly Non-Uniform**

154. Iwai discloses a non-uniform adhesive porous layer. Ex. 1006, ¶ [0068] (“In the invention, a surface roughness of the adhesive porous layer is preferably from 0.8 μm to 8.0 μm , more preferably from 0.9 μm to 6.0 μm , and still more preferably from 1.0 μm to 3.0 μm , in terms of the ten-point mean roughness (R_z).”). Iwai quantifies the result of its intentionally irregular and non-uniform thickness by disclosing surface roughness values for the separators of its examples and comparative examples. Ex. 1006, Table 2, ¶¶ [0170]-[0171].

155. In Example 7, for example, the thickness *a* of the resin layer (i.e., adhesive porous layer) is 2.2 μm , and the surface roughness of the separator is 1.7 μm . *Id.* Table 1, Table 2. I understand that such surface roughness means that the external surface of the porous layer, which is made up of the adhesive porous layer and protruding filler particles, will commonly vary by half of such surface roughness, i.e., +/- 0.85 μm . In my opinion, such a surface roughness value, in view of the relative thickness *a* of 2.2 μm , indicates that the thickness *a* of Iwai’s Example 7 is highly irregular and is not a reliable thickness value that a POSA

would or could expect to rely upon as a value that anticipates the '987 Patent's claims.

156. In Comparative Example 2, the thickness *a* of the resin layer (i.e., adhesive porous layer) is 3.1 μm , while the surface roughness of the separator is 1.3 μm . *Id.* I understand that such surface roughness means that the external surface of the porous layer, which is made up of the adhesive porous layer and protruding filler particles, will commonly vary by half of such surface roughness, i.e., $\pm 0.65 \mu\text{m}$. In my opinion, such a surface roughness value, in view of the thickness *a* of 3.1 μm , indicates that the thickness *a* of Iwai's Comparative Example 2 is highly irregular and is not a reliable thickness value.

157. These effects and indications are even more pronounced in Iwai's other examples. In Example 2, for example, the thickness *a* is 1.1 μm , while the surface roughness is 2.8 μm . *Id.* In Example 6, the thickness *a* is 3.0 μm , while the surface roughness is 4.2 μm . *Id.* These thickness *a* and surface roughness values strongly indicate that Iwai's adhesive layer and separator are not intended to be of uniform and regular thickness, but rather, of a highly irregular and rough surface and thickness.

158. Iwai further discloses a difference of coating amounts on each side. For example: "In the invention, in a case in which the adhesive porous layer is provided on both sides of the porous substrate, a difference between the coating

amount on one side and the coating amount of the other side is preferably 20% or less with respect to the total amount of the coating amounts on both sides.” *Id.* [0071]. It is my opinion that this further adds to the uncertainty of the thickness of Iwai’s adhesive porous layer, especially given the wide ranges proposed by Petitioner.

159. Accordingly, it is my opinion that Iwai’s thickness a is not a reliable nor an accurate reflection of the porous layer thickness that is claimed in claim 1, and thus Petitioner has failed to show that Iwai anticipates the claimed Dv90/thickness range of claim 1.

2. Claims 2 and 4-9 Are Not Unpatentable

160. Claims 2 and 4-9 are not unpatentable for the same reasons as discussed above with respect to claim 1. I reserve the right to address claims 2 and 4-9 individually if this proceeding is instituted.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on the information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on June 28, 2023 in Provo, Utah.

A handwritten signature in black ink, reading "Dean R. Wheeler", written over a horizontal line.

Dean R. Wheeler