

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHUHAI COSMX BATTERY CO., LTD.,
Petitioner

v.

NINGDE AMPEREX TECHNOLOGY LIMITED,
Patent Owner

Case IPR2025-00432
U.S. Patent No. 11,575,148

DECLARATION OF SAMUEL P. GIDO, PH.D

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I. INTRODUCTION

1. I have been retained by Lee & Hayes, P.C. as a technical expert for Zhuhai CosMX Battery Co., Ltd. (“CosMX” or “Petitioner”), who is the Petitioner in an *Inter Partes* review before the United States Patent and Trademark Office involving U.S. Patent No. 11,575,148 (“the ’148 Patent,” EX1001).

2. Specifically, I have been retained as an independent expert consultant by Petitioner to provide my opinions on the technology claimed in, and the patentability of claims 1-19 (“the challenged claims”) of the ’148 Patent. Although I am being compensated at my usual rate of \$520 per hour for the time I spend on this matter, no part of my compensation depends on the outcome of this proceeding, and I have no financial interest in any of the parties. I have no affiliation with either party in this case besides having been retained as an independent consultant in this matter.

3. I have personal knowledge of the facts and matters in this declaration and believe them to be true.

II. BACKGROUND AND QUALIFICATIONS

4. I have been on the faculty at the University of Massachusetts at Amherst since 1993. I am currently Associate Professor of Polymer Science and Engineering. I have broad expertise across the fields of polymers (plastics), polymer-nanoparticle composites, fluorinated polymers, polyolefins, porous materials, phase separations, and coating processes. I am an expert in and experienced user of a range

of materials characterization techniques including scattering, and spectroscopies, but with a particular emphasis on microscopy, especially electron microscopy. Over the years I have studied materials for a broad range of applications, including: batteries, fuels cells, adhesives, non-stick coatings, elastomers, composites and nanostructures. In addition to academic research, I have done research for, and/or consulted for a range of companies including: W.L. Gore, Boston Scientific, FujiFilm (Japan), Kureha Chemical Industry (Japan), Loctite Corp. (now Henkle), Rexam Graphics, St. Gobain, and Scapa Tape.

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

6. After graduating from Princeton in 1988, I moved on to a doctoral program at the Massachusetts Institute of Technology (MIT). My home department at MIT was Chemical Engineering, but I also was part of the interdisciplinary

Program in Polymer Science and Technology (PPST, <http://polymerscience.mit.edu>). I did my research and doctoral thesis under the direction of Prof. Edwin L. Thomas, who was in the Materials Science and Engineering Department at MIT. Prof. Thomas is a world-renowned expert in the study of polymer structure using electron microscopy. Therefore, my training and research at MIT focused on the use of electron microscopy, including SEM and transmission electron microscopy (TEM), to study a range of different topics including plastics, rubbers, copolymers, polymer-ceramic composites, phase behavior, and phase separations. After receiving my Ph.D. in 1993, I moved on to begin my career as an Assistant Professor in the Polymer Science and Engineering Department at the University of Massachusetts at Amherst. Over my academic career I have received millions of dollars of research funding from government (U.S. Army, National Science Foundation, U.S. Department of Education), foundations (Bill and Melinda Gates Foundation, W. M. Keck Foundation), and industry.

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

separation behavior (coagulation) of material to form unique, functional structures. One particular published study was on using phase separation to produce porous structures in high density polyethylene. EX1004 (Peer Reviewed Publication no. 65).

8. I have numerous publications and a U.S. Patent on fluorinated polymers for a range of applications, including in separators for batteries and fuel cells. I have done research on materials for batteries and fuel cells, including fluorinated polymers and polymer particle composites, with funding from Kureaha (Japan), and the U.S. Army. In these studies, we developed polymer chemistries, nanometer and micrometer scale composite structures and porous structures, and coating processes to enhance ion conductivity in the separator layers. Additionally, I have worked and continue to work as a consultant for W. L. Gore, a leading company in fluorinated polymers. I have consulted for industry on the topic of coating processes, particularly for Rexam Graphics and Scapa Tape. I was also a co-founder of a startup company, Smart Surfaces LLC, that developed environmentally friendly, non-stick coatings for boats (and other structures in a marine environment) to prevent fouling with marine organisms. Smart Surfaces was sold to FujiFilm in 2006, and I continued to consult for the resultant company: FujiFilm Smart Surfaces LLC. These coatings, were silicone based, contained ceramic filler particles, and cured by a coagulation (phase separation) process.

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

10. One of the best ways to really understand a topic is to teach it to someone else. I have taught and continue to teach topics, relevant to this matter, to our advanced graduate students (doctoral candidates) in the Polymer Science and Engineering Department at the University of Massachusetts at Amherst. In past years I have taught PSE 608 Introduction to Polymer Engineering, which includes topics such as mechanical properties, coatings processes, and diffusion of ions in materials. I have also taught in the past and am currently teaching PSE 602 Polymer Characterization Laboratory, in which the students gain practical laboratory experience with techniques of importance in this matter including SEM, and static laser light scattering (aka laser diffraction) for size determination. I teach PSE 608 Physical Chemistry of Polymers I and PSE 789 Physical Chemistry of Polymers II. In this sequence of classes, I cover, among other things, phase behavior and phase separations (coagulation), and the theory of laser light scattering. I also teach PSE 721 Polymer Morphology. This class focuses on nanometer and micrometer size

structure in polymers and composites, as well as the use of electron microscopy to study materials structure. In PSE 608 and also in PSE 721, polyethylene is repeatedly used as an example for in depth discussion of polymer structure, and characterization methods. I also teach a seminar class for freshman, FFYS 191POLY The Polymer Age, which focuses on popular and societal impacts of polymers. In this class, I present a seminar on lithium ion batteries with a particular focus on the materials used in their construction and the safety issues related to separators.

III. MATERIALS CONSIDERED

11. In forming my opinions expressed in this declaration, I have considered, among other things, the following documents. I confirm that to the best of my knowledge the accompanying exhibits are true and accurate copies of what they purport to be, and that an expert in the field would reasonably rely on them to formulate opinions such as those set forth in this Declaration. I understand the documents have been given the following exhibit numbers in this proceeding:

Exhibit No.	Description
1001	U.S. Patent No. 11,575,148 (“the ’148 patent”)
1002	File history of Application No. 17/061,427 (now U.S. Patent No. 11,575,148)
1005	U.S. Patent Application Publication No. 2017/0162849 A1 to Murakami et al. (“Murakami”)
1006	International Patent Application Publication No. WO 2015/178351 A1 to Honda et al (“Honda”)
1007	Certified Translation of International Patent Application Publication No. WO 2015/178351A1 to Honda et al. (“Honda”)
1008	Japan Patent Application No. 2017-137432 to Tanaka et al. (“Tanaka”)
1009	Certified English Translation of Japan Patent Application No. 2017-137432 to Tanaka et al. (“Tanaka”)
1010	U.S. Patent Application Publication No. 2012/0228214 A1 to Beard et al. (“Beard”)
1011	U.S. Patent Application Publication No. 2016/0013465 A1 to Akiike (“Akiike”)
1012	U.S. Patent Application Publication No. 2015/0280195 A1 to Schmitz, et al. (“Schmitz”)
1013	U.S. Patent Application Publication No. 2017/0194613 A1 to Murata et al. (“Murata”)
1014	File history of parent Application No. 16/000,764 (now U.S. Patent No. 10,833,355)
1017	U.S. Patent No. 9,065,119 to Nishikawa (“Nishikawa”)

12. In forming my opinions, I have also relied on my education and experience.

IV. RELEVANT LEGAL STANDARDS

13. I am not an attorney. My analysis and opinions are based on my background and expertise in this technical field, as well as the instructions I have been given by counsel for the legal standards relating to patentability.

14. I have been informed by counsel for Petitioner that the following legal principles may apply to analysis of patentability based on 35 U.S.C. §§ 102 for anticipation and 103 for obviousness. I have also been informed that, in an *inter partes* review proceeding such as this one, a patent claim is unpatentable if it is shown by a preponderance of the evidence that the claim would have been anticipated by a prior art patent or publication, or obvious by one or more properly combined prior art patents or publications.

A. Level of Ordinary Skill in the Art

15. I have been instructed to consider patentability of the Challenged Claims through the lens of a person of ordinary skill in the art (“POSITA”) at the time of the claimed priority date of the ’148 Patent—April 11, 2018. I am familiar with the level of ordinary skill in the subject matter of the ’148 Patent in 2018.

16. Based on my review of the technology, and drawing on my own experience in the field, my analysis below assumes that a POSITA would have had at least a bachelor’s degree in chemistry, chemical engineering, materials science, or a related field covering relevant principles of organic and inorganic chemistry,

polymer processing, ceramic materials, and ceramic processing, and three or more years of experience related to 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 similar applications of polymer chemistry, ceramic chemistry, and ceramic processing. This level of skill is approximate, and more experience would compensate for less formal education, and vice versa. It is consistent with the field provided by the '148 Patent: "the field of energy storage devices, and in particular, to a porous film and a lithium-ion battery." EX1001, 1:16-18.

17. Based on my qualifications discussed above, I qualified at least as a POSITA of the '148 Patent by 2004.

18. My analysis below considers how a POSITA would have understood the references listed above with respect to the challenged claims of the '148 Patent.

B. Anticipation

19. I have been informed a patent claim is unpatentable as anticipated under 35 U.S.C. § 102 if every limitation of the claimed invention is found in a single prior art reference--either expressly or required through inherency--as arranged in the claim.

C. Obviousness

20. I have been informed that, even if a single prior art reference does not disclose each and every element of a patent claim, the patent claim is still unpatentable as obvious under 35 U.S.C. § 103. It is my understanding that a claimed invention is unpatentable as obvious over a combination of prior art references if the differences between the claimed invention and the prior art are such that a POSITA would have found the subject matter as a whole obvious.

21. I understand that obviousness is determined by evaluating: (1) the scope and content of the prior art, (2) the differences between the prior art and the claim, (3) the level of ordinary skill in the art, and (4) any secondary considerations of non-obviousness. To establish obviousness based on a combination of the elements disclosed in the prior art, it is my understanding that a challenger must provide a clear articulation of the reason(s) why the claimed invention would have been obvious. I understand this articulation may, but does not necessarily, require record evidence of an explicit teaching, suggestion, or motivation to combine the prior art in the way recited in a patent claim. Rather, prior art may be combined based on an express teaching, suggestion, or motivation from the prior art itself, or from a reasoned explanation of an expert witness or some other rationale.

22. For example, it is my understanding that this articulation can come from a number of rationales, which include but are not limited to (1) combining prior art

elements according to known methods to yield predictable results; (2) simple substitution of one known element for another to obtain predictable results; (3) use of known technique to improve similar devices, methods, or products in the same way; (4) applying a known technique to a known device, method, or product ready for improvement to yield predictable results; (5) choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success, e.g., the combination is “obvious to try”; (6) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; and (7) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed limitation.

23. I further understand that these rationales may be found explicitly or implicitly: (1) in the prior art; (2) in the knowledge of those of ordinary skill in the art that certain references, or disclosures in those references, are of special interest or importance in the field; and/or (3) from the nature of the problem to be solved.

24. Additionally, I understand that the legal determination of the motivation to combine references allows recourse to logic, judgment, and common sense. In order to resist the temptation to read into prior art the teachings of the invention in issue, however, it should be apparent that the expert is not conflating

“common sense” and what appears obvious in hindsight. I understand that if the teachings of a prior art would lead a POSITA to make a modification that would render another prior art device inoperable, then such a modification may not be obvious. I also understand that if a proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there may be no suggestion or motivation to make the proposed modification.

D. Claim Construction

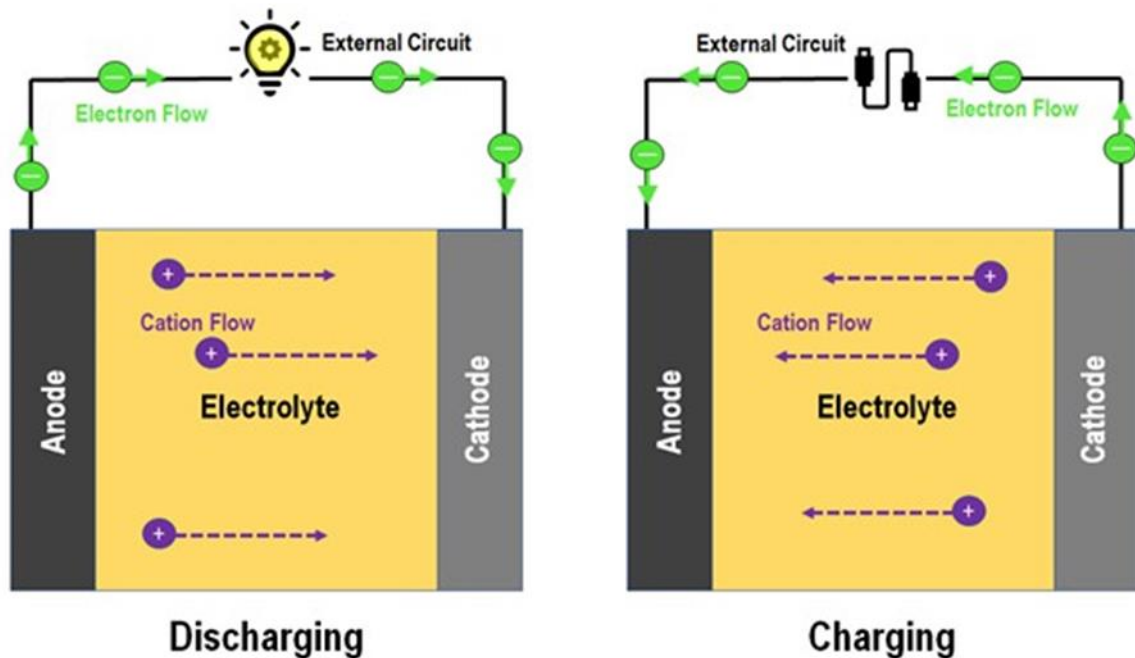
25. Counsel has instructed me that, in this proceeding, the words of a claim are to be given their plain and ordinary meaning, which the meaning understood by a person of ordinary skill in the art after reading the entire patent. This analysis focuses on how the patentee used the claim term in the claims, specification, and prosecution history. Dictionaries or extrinsic sources may assist in determining the plain and ordinary meaning, but extrinsic evidence cannot override a meaning that is unambiguous from the intrinsic evidence. I have applied the plain and ordinary meaning in my analysis below.

V. TECHNOLOGY BACKGROUND

A. Lithium-Ion Battery Technology

26. The basic structure of a battery is illustrated below.

General Battery Schematic



Battery Structure

27. As illustrated, the battery includes a negative electrode, called an anode, and a positive electrode, called a cathode. The anode and the cathode are separated from one another and immersed in a medium called an electrolyte through which ions—that is, atoms having either a positive or a negative electric charge—can be transported.

28. When the battery is discharged, as illustrated on the left, positive ions called cations (atoms missing one or more electrons) diffuse from the anode, through the electrolyte, to the cathode. To maintain electrical neutrality, electrons move separately through an external circuit from the anode to the cathode, where they are recombined with the cations to reform atoms. As the electrons make this journey

through the external circuit, they provide an electrical current, which can be used to, for example, light a lightbulb, as illustrated.

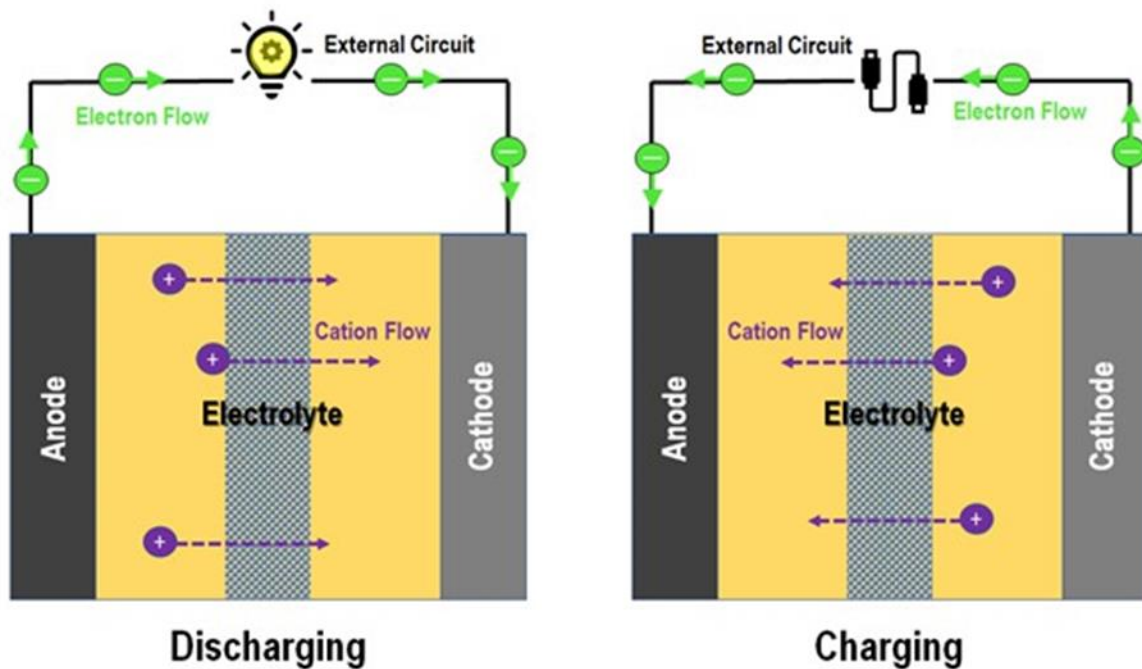
29. As illustrated on the right, charging the battery involves the reverse process. An external voltage is used to push electrons through the external circuit back to the anode, creating cations at the cathode that migrate through the electrolyte to meet the electrons and reform the atoms at the anode.

30. One type of battery is a lithium-ion battery. First commercialized in 1991, lithium-ion batteries became ubiquitous by the 2000s. But the prevalence of lithium-ion batteries posed an issue: in a battery, the anode and the cathode must never touch. If they do, an electrical short circuit will result, discharging the battery so quickly that the battery may catch fire or explode. Early lithium-ion batteries were susceptible to such short-circuiting. The battery industry responded by focusing on so-called separators.

B. Separator Technology

31. A separator, illustrated below, prevents short circuits between the anode and the cathode.

Li-Ion Battery with Separator

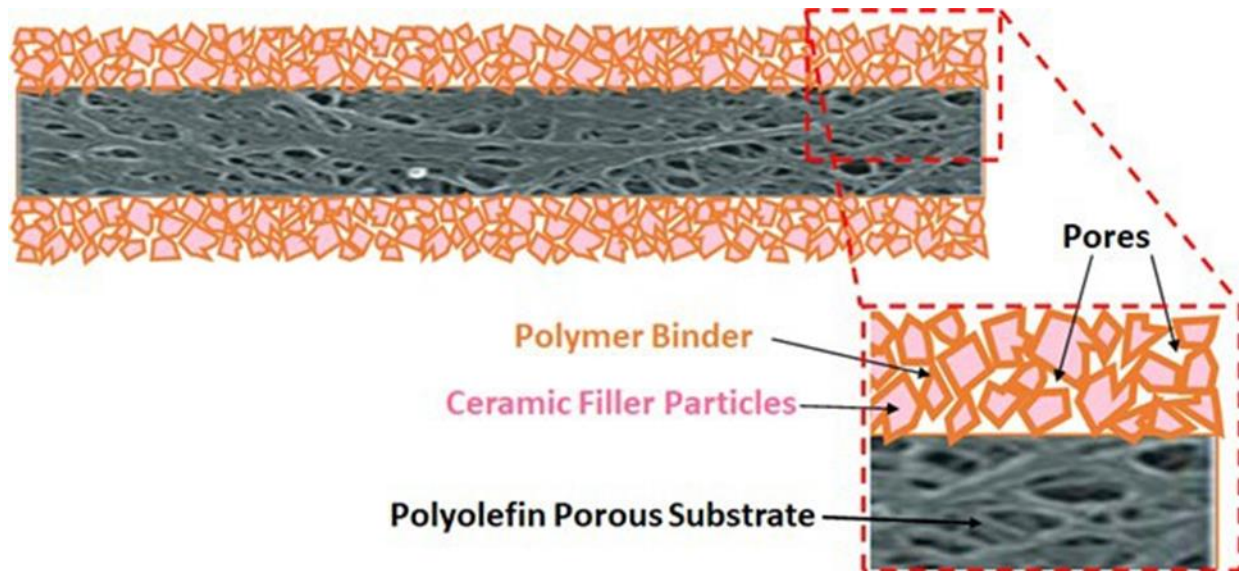


Separator Structure

32. Thus, separators must be electrically insulating, preventing the flow of current carried by electrons between the anode and the cathode. But separators must simultaneously permit the transport of cations through the electrolyte, allowing discharging and charging to occur, as described above. Thus, separators are typically both non-conducting, to prevent electron flow, and porous, to allow cation flow.

33. Well before 2018, conventional separators included a porous substrate and a porous layer formed on one or both sides of the porous substrate. It was likewise known to form the porous layer from a polymer binder and inorganic, such as ceramic, filler particles, such as particles of magnesia or alumina, as illustrated. See, e.g., EX1005, ¶¶ [0060], [0070]; EX1007, Abstract; EX1009, ¶¶ [0003],

[0039]. As those working in the art knew, a polymer binder is non-conducting and can be porous, while the addition of inorganic particles improves both mechanical strength and high-temperature stability.



Separator Structure

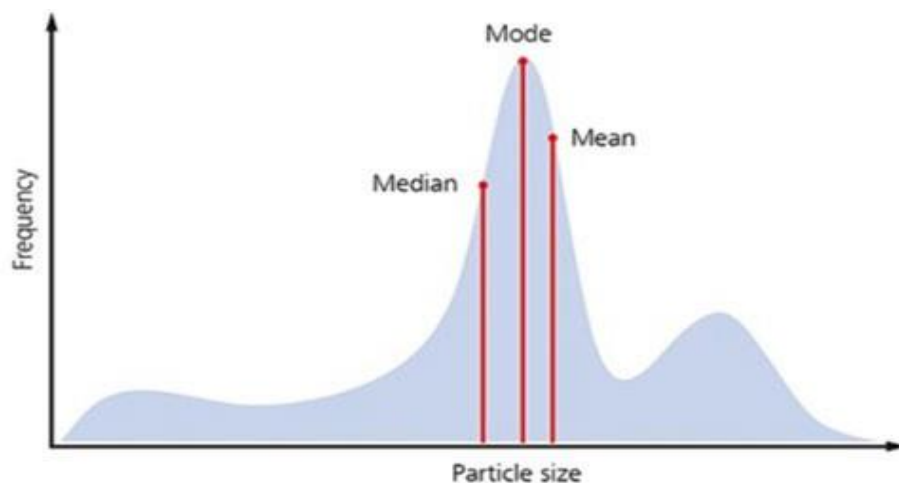
34. Over the last two decades, improving separators to promote battery safety has been a focus of extensive effort in the battery industry. One approach has been to make separators more robust by adjusting parameters of the polymer binder and the inorganic particles to achieve desirable properties in the porous layer, including not only mechanical strength and high-temperature stability, but also adhesion, internal resistance, flame retardancy, energy density, and other properties.

35. One parameter those skilled in the art knew to adjust was particle size of the inorganic particles. Specifically, it was known to adjust cumulative particle

size values known as “D10,” “D50,” and “D90.” *See, e.g.*, EX1005, ¶ [0018]; EX1011, ¶¶ [0010]-[0013].

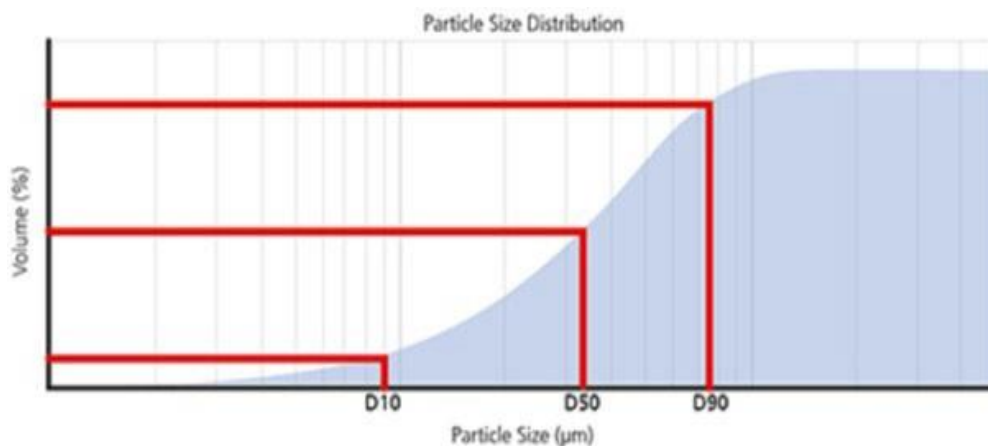
36. While D10, D50, and D90 may refer to particle size based on a cumulative weight (e.g., Dw90) or volume distribution (e.g., Dv90), the ’148 Patent and prior art references applied in the Grounds below use the latter metric based on volume. EX1001, 1:53-2:15; EX1005, ¶ [0018]; EX1011, ¶¶ [0010]-[0013].

37. These cumulative particle size values are typically used because inorganic particles are prepared through processes like pulverizing, grinding, or milling that produce particles of varying sizes. These varying particle sizes may be represented by, for example, a distribution in which a particle size (typically a diameter) is plotted against a frequency of particles having that particle size, as illustrated below.



Particle Size Distribution

38. As illustrated, it is possible that the distribution of particle sizes is multimodal, meaning the distribution has more than one peak rather than a strict bell shape. While certain values—mean, median, and mode—can be gleaned from the distribution, these values alone typically do not characterize the distribution overall. Thus, those skilled in the art frequently refer to cumulative particle size distributions, like that illustrated below, which provide a more complete picture.



Particle Size Distribution

39. In a cumulative particle size distribution, as illustrated, as particle size increases, a running total of the particle volume (as a percentage of the volume of all the particles in the distribution) of the particles up to that size is plotted. Eventually, at a large particle size, the cumulative particle size distribution reaches a plateau because all the particles in the distribution are accounted for.

40. The cumulative particle size distribution can be characterized by particle sizes at which the cumulative volume reaches different percentages of the

total. Shown in the figure, for example, are particle sizes designated D10, D50, and D90. D10 is typically used to refer to the particle size at which 10% of the total volume is reached—that is, 10% of the particles by volume have a size equal to or less than this value. Likewise, D50 is typically used to refer to the particle size at which 50% of the total volume is reached, and D90 is used to refer to the particle size at which 90% of the total volume is reached. Another value, D90-D10 (or “span”) can also be provided to indicate a difference between the D90 and D10 values, which indicates a breadth of the distribution.

41. Thus, it was known in the art to adjust particle size—including as indicated through cumulative particle size values D10, D50, and D90—of the inorganic particles to achieve desirable separator properties. Another parameter intertwined with inorganic particle size, and that those skilled in the art knew to adjust, was thickness of the porous layer containing those inorganic particles. EX1005, ¶¶ [0074], [0090], [0208] (Table 1, “Film Thickness of layer B”); EX1011, ¶¶ [0155], [0244]. Skilled artisans knew that particle size and thickness of the porous layer containing the particles were related parameters that needed to be adjusted together. For instance, a patent application published in 2015 taught that “[t]he choice of the exact particle size” in a porous layer “depends on the thickness of” the porous layer. EX1012, ¶ [0053]; *see also* EX1011, ¶¶ [0033], [0142] (adjusting D90

particle size and layer thickness to improve “battery properties such as high temperature cycle property” as well as “mechanical strength” and “heat resistance”).

42. Finally, it was known in the art to adjust pore size and porosity of the porous layer to improve permeability and thus ion conductivity. *See* EX1005, ¶¶ [0013]-[0015], [0066], [0093], [0121], [0209]-[0211] (adjusting pore diameter and “voidage” of the porous layer); EX1010, ¶¶ [0020], [0029], [0030], EX1011, ¶¶ [0094], [0096]; EX1012, ¶¶ [0101], [0102].

VI. THE '148 PATENT

43. I understand the '148 patent issued on February 7, 2023, from U.S. Application No. 17/061,427 (“the '427 Application”), which is a continuation of U.S. Application No. 16/000,764 (“the '764 Application”) filed June 5, 2018 (now U.S. Patent No. 10,833,355). EX1001, 1. I understand the '148 Patent claims a priority date of April 11, 2018 based on China Patent Application No. 201810322931.1. *Id.*

A. Specification and Claims

44. The '148 Patent describes a porous film for use in lithium-ion batteries and batteries incorporating this film, with the porous film being arranged on a surface of the separator, positive electrode, or negative electrode. *See, e.g.*, EX1001, Abstract, 1:42-2:56; 3:16-51. The porous film is composed of binder and inorganic particles fixed by the binder. *See, e.g., id.*, Abstract, 1:45-2:37, 3:16-51.

45. Among other parameters, the '148 Patent specifies ranges of inorganic particle sizes based on “volume accumulation” and relationships between those ranges:

- **Dv10:** “The inorganic particles have particle sizes such that particle size having a volume accumulation of 10% (Dv10) is in a range of 0.015 μm to 3 μm .” *Id.*, 1:53-55. Here, “(Dv10) refers to particle sizes which reach 10% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis.” *Id.*, 1:60-62.
- **Dv50:** Additionally, “particle size having a volume accumulation of 50% (Dv50) is in a range of 0.2 μm to 5[μm]” where “(Dv50) refers to particle sizes which reach 50% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis.” *Id.*, 1:56-57, 63-66.
- **Dv90:** Likewise, “particle size having a volume accumulation of 90% (Dv90) is in a range of 1 μm to 10 μm ,” where “(Dv90) refers to particle sizes which reach 90% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis.” *Id.*, 1:57-58, 1:67-2:3.

- **Dv10 < Dv50, Dv50 < Dv90:** “[P]article size having a volume accumulation of 10% (Dv10) is less than particle size having a volume accumulation of 50% (Dv50), and particle size having a volume accumulation of 50% (Dv50) is less than particle size having a volume accumulation of 90% (Dv90).” *Id.*, 2:4-9.
- **Dv90/Dv10 ratio:** The ’148 Patent also specifies ratio of Dv90 to Dv10 ratio, stating “the ratio of particle size having a volume accumulation of 90% (Dv90) to particle size having a volume accumulation of 10% (Dv10) is in a range of 2 to 100.” *Id.*, 2:10-15.

46. According to the ’148 Patent, with a particle size distribution obeying these ranges, as well as other attributes of composition and structure, “[t]he porous film ... has excellent adhesion” while “the pore structure of the porous film can still be well maintained ... , thereby reducing the probability of pore blockage ... and enabling the porous film to have high ionic conductivity.” *Id.*, 2:4-53. As a result, the ’148 Patent claims, “rate performance of the lithium-ion battery is greatly improved, and the provided lithium-ion battery has excellent rate performance and cycle performance.” *Id.*, 2:53-56.

47. Representative independent claim 1 of the ’148 Patent recites a porous film having the above-described particle size ranges and relationships between the ranges:

1. A porous film, comprising:

a binder; and

inorganic particles;

wherein the porous film comprises pores formed by the binder, the pores at least comprises a part of the inorganic particles, wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm , Dv50 is in a range of 0.2 μm to 5 μm , and Dv90 is in a range of 1 μm to 10 μm ; Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and Dv50 of the inorganic particles is less than Dv90 of the inorganic particles, and the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.

EX1001, 25:33-46. The '148 Patent discloses and claims other parameters, such as certain pore characteristics. *See, e.g., id.*, 1:48-52, 2:16-18, 2:33-37, 5:15-28, 5:40-42, 25:47-55, 26:4-10.

B. Prosecution History

1. The '427 Application

48. I understand that although the Examiner allowed the '427 Application in the first action on the merits, the Examiner's reasons for allowance established the unpatentability over Murata (EX1013) of a porous film comprising (1) a binder, (2) inorganic particles, (3) pores formed by the binder, and (4) the pores comprising

at least a part of the inorganic particles. EX1002, 20-23. Rather, according to the Examiner, the specific “particle sizes and ranges as required in the independent claims”—i.e., the Dv10, Dv50, and Dv90 ranges—distinguished the claims over the prior art:

The art made of record Murata et al. US 2017/0194613 discloses a porous film (membrane, see abstract and title), comprising: a binder (see abstract); and inorganic particles [0073-0075]. The porous film comprises pores formed by the binder [0086] given pores are found within the binder and porous layer. The pores at least comprise a part of the inorganic particles (filler). However, Murata fails to teach, suggest or render obvious the particles sizes and ranges as required in the independent claims 1 & 10.

Id., 22.

2. Parent '764 Application

49. I understand that the '764 Application, the parent of the '427 Application, provides more context around why the Examiner allowed the claims of the '148 Patent. In the first Office Action on the merits, I understand that the Examiner rejected the pending claims as anticipated or obvious over Murata. EX1014, 60-64. At that time, independent claim 1 broadly recited a porous film having (1) a binder, (2) inorganic particles, (3) pores formed by the binder, and (4) the pores comprising at least a part of the inorganic particles. *Id.*, 197. It also had a

further limitation that “the average wall thickness between the pores is in a range of 20 nm to 500 nm,” *id.*, now recited in dependent claims 3 and 12 of the ’148 Patent, EX1001, 25:49-51, 26:34-36.

50. Responding to the Office Action, I understand the applicant amended independent claim to add the Dv10, Dv50, and Dv90 ranges and relationships between the same:

1. A porous film, comprising:

a binder; and

inorganic particles;

wherein the porous film comprises pores formed by the binder, the pores at least comprises a part of the inorganic particles, and the average wall thickness between the pores is in a range of 20 nm to 500 nm, wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μ m to 3 μ m, Dv50 is in a range of 0.2 μ m to 5 μ m, Dv90 is in a range of 1 μ m to 10 μ m; Dv10 is less than Dv50, and Dv50 is less than Dv90; and the ratio of Dv90 to Dv10 is in a range of 2 to 100.

EX1014, 37 (underlining in original).

51. In the remarks, regarding claim 1 as written before the amendment, I understand the applicant argued that Murata does not disclose that “the resin binder

... forms a pore and the pore formed by the binder ... at least comprises a part of the inorganic particles.” *Id.*, 42. The applicant also disputed that Murata discloses the claimed wall thickness. *Id.* Regarding amended claim 1, the applicant further argued that “Murata does not disclose ... the particle size range of Dv10 Dv50, Dv90 of the inorganic particles or the ratio range of Dv90 and Dv10, which is not obvious to those skilled in the art.” *Id.*, 45.

52. I understand that the Examiner then allowed the amended claims, but only for a subset of the reasons provided by the applicant. *Id.*, 16-21. The Examiner rejected the applicant’s argument that Murata did not disclose the independent claim as written before the amendment adding the particle size limitations:

Murata et al. US 2017/0194613 discloses a porous film (membrane, see abstract and title), comprising: a binder (see abstract); and inorganic particles [0073-0075]. The porous film comprises pores formed by the binder [0086] given pores are found within the binder and porous layer. The pores at least comprises a part of the inorganic particles (filler).

EX1014, 19. Instead, I understand the Examiner found the amended claims to be allowable because “Murata fails to teach, suggest or render obvious the particle[] sizes and ranges as required in the independent claim[.]” *Id.*, 20.

53. Thus, in both the '427 Application and its parent '764 Application, I understand that the Examiner consistently held that the following was not allowable over the prior art: a porous film comprising (1) a binder, (2) inorganic particles, (3) pores formed by the binder, and (4) the pores comprising at least a part of the inorganic particles. In both applications, the Examiner repeatedly found that the features relating to “the particle[] sizes and ranges as required in the independent claim” made the claims allowable over the prior art of record. *Id.*

3. Petitioner’s new prior art addresses the reason the Examiner allowed the '148 Patent claims and applicant’s unpersuasive arguments rejected by the Examiner

54. I understand that none of the references that Petitioner relies upon in the Grounds below were before the Examiner during prosecution of either the '427 Application or its parent '764 Application. Moreover, in my opinion, Petitioner’s prior art references address the reason the Examiner allowed both applications: Murakami (EX1005) and Akiike (EX1011) both disclose porous films comprising binder and inorganic particles having the claimed Dv10, Dv50, and Dv90 ranges and relationships.

55. In my opinion, Petitioner’s prior art even addresses the reasons the applicant contended the independent claim of the '764 Application, as written before the inorganic particle size amendment, was allowable but the Examiner found unpersuasive. For example:

56. **Murakami (EX1005):** As explained in more detail in Ground 1, in addition to disclosing the claimed *Dv10*, *Dv50*, and *Dv90* ranges and relationships, Murakami describes a formation process like the '148 Patent that removes the solvent from the binder coating, leaving the porous layer. Murakami's pores are formed "by the binder" in a similar way to that disclosed in the specification of the '148 Patent.

57. Additionally, in my opinion, Murakami's description of its porous layer composition suggests or renders obvious that the pores of Murakami's porous layer include at least some portion of the filler material (claimed inorganic particles). In short, compared to the porous film described in the '148 Patent specification, it is my opinion that Murakami's porous layer has significantly more filler than binder resin.

58. Particles are part of the layer. It is possible to have some particles that are so big that they stick out of the top surface of a layer. Murakami teaches that the largest particles (approximated by D90) can be as big as 5 μm , while the porous layer (layer B) has a thickness range of 0.1 to 20 μm , preferably 2 to 15 μm . In Murakami's Examples 1 and 2 (which seem to best practice the invention) the largest particles (approximated by D90) are about one-third of the layer thickness (29% and 34% respectively). While a POSITA would not necessarily conclude that Murakami is teaching particles that are thicker than the layer they are in, still, particles that are $\frac{1}{3}$

the layer thickness will certainly be part of, and influence, the pore structure. This suggests or renders obvious that Murakami's pores include at least some portion of the filler.

59. **Beard (EX1010):** Beard discloses a porous membrane for a separator that has a high concentration of filler (inorganic particles) held together by a binder. EX1010, Abstract. The filler material is densely packed inside the pore walls of the porous membrane and, as shown in an annotated version of Beard's Figure 1 below, some particles extend into the voids of the pores, meaning that "the pores at least comprises a part of the inorganic particles," as claimed.

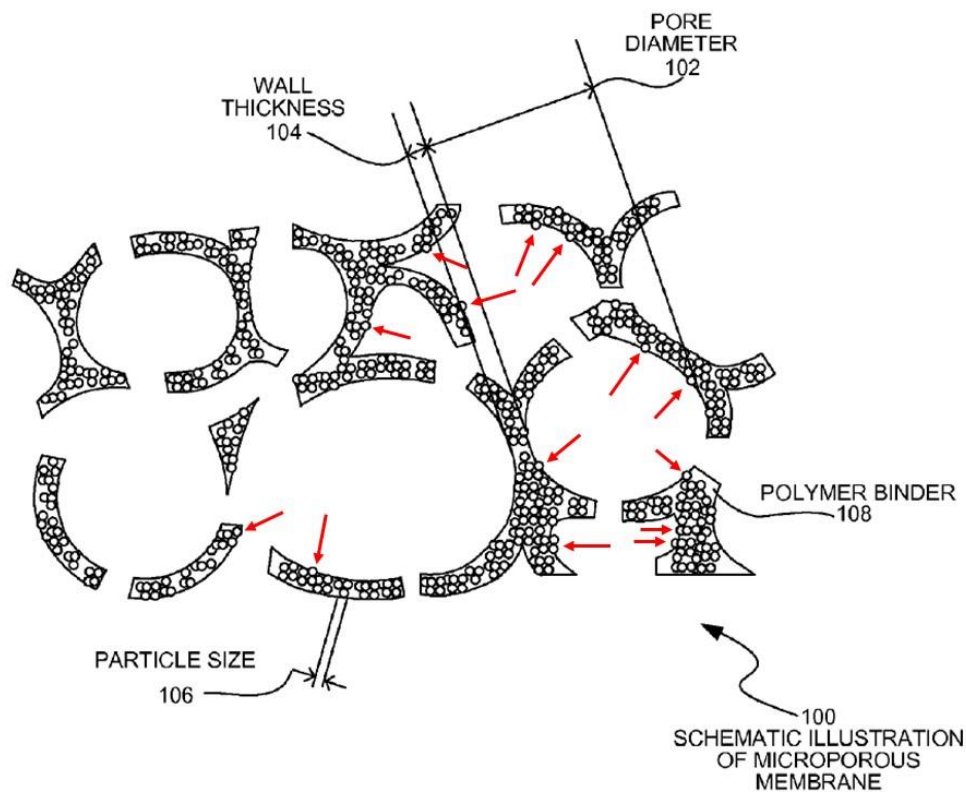


FIG. 1

60. **Akiike (EX1011):** Complementing Beard, Akiike discloses a separator having a porous membrane made of a polymer binder holding together inorganic non-conductive particles. Akiike expressly discloses that the inorganic particles have the claimed Dv10, Dv50, and Dv90 ranges and relationships.

61. In my opinion, if Petitioner's prior art were before the Office during original prosecution, the Examiner would not have allowed the challenged '148 Patent claims.

VII. CLAIM CONSTRUCTION

62. Counsel informs me that in IPR, all claim terms must be given their ordinary and customary meaning as understood by a POSITA at the time of the invention, in light of the specification and the prosecution history. For the purposes of this Petition, I understand that Petitioner submits that all claim terms should receive their plain and ordinary meaning in the context of the specification. No claim terms require express construction for purposes of granting the Petition, and it is my opinion that the prior art renders obvious the challenged claims under any reasonable construction.

VIII. SUMMARY OF GROUNDS OF INVALIDITY

63. After analyzing the '148 patent, prosecution history, prior art, and other documents identified above, it is my opinion that the challenged claims are rendered obvious as follows:

Ground	Claims	Reference(s)
Murakami as Primary Reference		
1	1, 2, 5-11, 14-19	U.S. Patent Application Publication No. 2017/0162849 (“Murakami”, EX1005)
2	3, 12	- Murakami - International Patent Application Publication No. WO 2015/178351A1 (“Honda”, EX1006)
3	4, 13	- Murakami - Japan Patent Application No. 2017-137432A (“Tanaka”, EX1008)
4	1, 2, 5-11, 14-19	- Murakami - U.S. Patent Application Publication No. 2012/0228214 (“Beard”, EX1010)
5	3, 12	- Murakami - Beard - Honda
6	4, 13	- Murakami - Beard - Tanaka
Beard as Primary Reference		
7	1-3, 5-12, 14-19	- Beard - U.S. Patent Application Publication No. 2016/0013465A1 (“Akiike”, EX1011)
8	4, 13	- Beard - Akiike - Tanaka

A. Murakami

64. Murakami is a U.S. Patent Application filed in 2015 and published in 2017. I have been asked to assume Murakami legally qualifies as prior art to the '148 Patent.

65. Murakami describes a “porous layer . . . and a separator formed by laminating the porous layer” for a non-aqueous electrolyte secondary battery. EX1005, Abstract. The porous layer includes a filler and a binder. *Id.*, ¶ [0017]. This filler preferably consists of inorganic particles. *Id.*, ¶ [0061]. Murakami discloses D10, D50, and D90 values based on volume for these inorganic particles. *Id.*, ¶ [0018].

B. Honda

66. Honda is an international application filed on May 18, 2015, and published on November 26, 2015. EX1006, 1; EX1007, 1. I have been asked to assume Honda legally qualifies as prior art to the '148 Patent.

67. Honda discloses a separator for nonaqueous secondary batteries comprising a porous base material containing thermoplastic resin and a porous layer containing polyvinylidene fluoride resin formed on one or both surfaces of the base material. EX1007, ¶ [0015]. The porous layer has a honeycomb structure with cells (pores) that open perpendicular to the surface and are arranged adjacent to each other

in the plane direction. *Id.*, ¶¶ [0017], [0038]-[0040]. The thickness of the walls dividing the porous layer into cells is 0.1 μm to 2 μm . *Id.*, ¶ [0045].

C. Tanaka

68. Tanaka is a Japan Patent Application filed in 2016 and published in August 2017. EX1008, 1; EX1009, 1. I have been asked to assume Tanaka legally qualifies as prior art to the '148 Patent.

69. Tanaka discloses a polyolefin body suitable for use as a separator for a lithium-ion battery. EX1009, ¶ [0069]. Tanaka controls the pore size distribution ratio D10/D90—the reciprocal metric as the '148 Patent's pore size distribution ratio R90/R10—to provide mechanical strength and high permeability through the body. *See id.*, ¶¶ [0019], [0020]. To achieve this control, Tanaka's manufacturing process includes steps controlled heating, and cooling to suppress fluctuation in pore volume and average diameter, allowing “the D10/D90 ratio to be controlled to a desired value.” *Id.*, ¶ [0020].

D. Beard

70. Beard is a U.S. Patent Application filed in 2012 and published in the same year. EX1010, 1. I have been asked to assume Beard legally qualifies as prior art to the '148 Patent.

71. Beard discloses a porous membrane, sometimes called a “microporous membrane,” comprising a polymer binder and a filler material. EX1010, Abstract,

¶¶ [0003], [0026], [0029]. According to Beard, “[m]icroporous polymer membranes suitable for battery separators, filters and other porous media applications, especially those incorporating high levels of desirable filler additives, may have the following properties: high levels of porosity, uniform pore distribution, well defined and controlled pore geometry, and high film strength, including good bond between filler particles and polymers.” *Id.*, ¶ [0065]; *see also id.*, ¶¶ [0010], [0030], [0033]. The filler may consist of inorganic particles such as titanium oxide (*id.*, ¶¶ [0036], [0054]), and the polymer binder forms pores because the polymer binder and filler material are suspended in a “liquid pore forming agent,” which is later removed “after solidification begins.” *Id.*, ¶¶ [0057]-[0059].

E. Akiike

72. Akiike is an international application filed on March 19, 2014, and published on January 14, 2016. EX1011. I have been asked to assume Akiike legally qualifies as prior art to the ’148 Patent.

73. Akiike describes “[a] slurry for a lithium ion secondary battery porous membrane” used in a battery separator. EX1011, Abstract; *see also id.*, ¶ [0001]. The separator includes “an organic separator layer; and a porous membrane obtained by applying onto the organic separator layer the slurry for a lithium ion secondary battery porous membrane.” *Id.*, ¶ [0016]. The slurry “includes non-conductive

particles, a water-soluble polymer, and a particulate polymer.” *Id.*, ¶ [0026]. “[T]he particulate polymer can function as a binder in the porous membrane.” *Id.*, ¶ [0067].

74. For the non-conductive particles, “it is particularly preferable to use the inorganic particles” (*id.*, ¶ [0042]) because they “have excellent dispersion stability in solvents” and “usually increase heat resistance of the porous membrane effectively” (*id.*, ¶ [0039]). Akiike discloses D10, D50, and D90 values based on volume for these inorganic particles. *Id.*, ¶¶ [0010]-[0013], [0031]-[0033] (preferred D10, D50, and D90 ranges), (Tables 1-4) (example values for D10, D50, and D90).

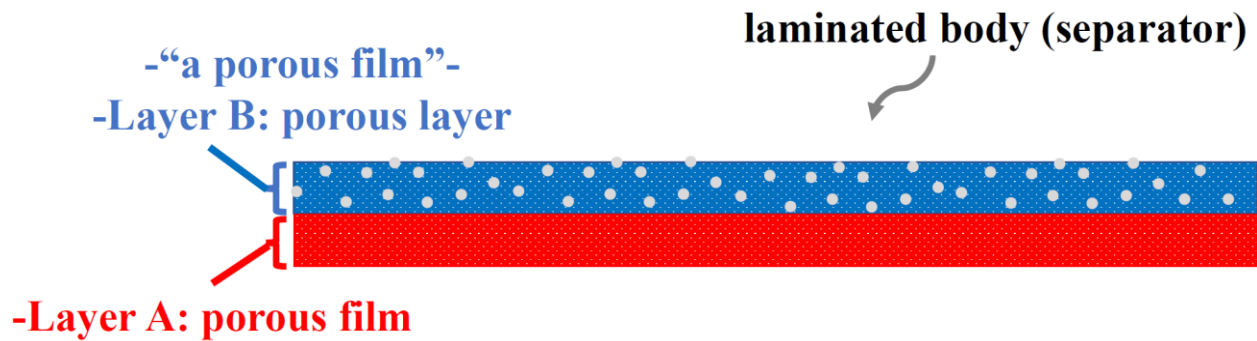
IX. GROUND 1: MURAKAMI RENDERS OBVIOUS CLAIMS 1, 2, 5-11, AND 14-19

A. Independent Claim 1

1. [1.pre]: “*A porous film, comprising:*”¹

75. In my opinion, Murakami discloses or suggests this element. Specifically, Murakami discloses *a porous film* (porous layer B):

¹ In my declaration, I use bracketed reference numerals to identify respective Challenged Claim Elements of the ’148 Patent.



Murakami's Porous Film²

76. Specifically, Murakami discloses “a separator that is a laminated body in which the porous layer is laminated onto one surface or each of both surfaces of the porous film, [which] has an excellent cycle characteristic.” EX1005, ¶ [0013]; *see also id.*, ¶¶ [0003], [0029]-[0048] (describing Murakami's porous film), [0049]-[0099] (describing Murakami's porous layer). In the Examples, Murakami refers to the porous film as layer A and the porous layer (claimed *porous film*) as layer B. *See, e.g.*, EX1005, ¶ [0124].

² The '148 Patent and Murakami use slightly different nomenclature to refer to parts of their separators. While Murakami's laminated body also has a “porous film,” layer A, on which the porous layer is coated, Murakami's “porous film” corresponds to what the '148 Patent calls the “porous substrate” *See* EX1001, 7:46-48. I rely on Murakami's “porous layer” as the claimed “porous film” because it corresponds to, and serves the same purpose, as the claimed “porous film.”

77. In this Ground, I rely on the following embodiments of Murakami, each separately rendering the claimed *porous film* obvious:

- Murakami's general description of the porous layer (*see* EX1005, ¶¶ [0013]-[0134]);
- The porous layer in the laminated body of Example 1 (*id.*, ¶¶ [0135]-[0156]); and
- The porous layer in the laminated body of Example 2 (*id.*, ¶¶ [0157]-[0169]).

78. My reliance on discrete Examples 1 and 2 of Murakami does not involve selecting from large lists of elements in a single reference as a single embodiment rendering the challenged claims unpatentable. Nonetheless, to the extent Patent Owner contends that Murakami discloses other potential permutations of laminated bodies or porous layer features, it is my opinion that a POSITA would have been motivated to implement the laminated bodies of Examples 1 and 2 with a reasonable expectation of success.

79. Indeed, in my opinion, Murakami teaches, suggests, and motivates a POSITA to use the Example 1 and 2 embodiments. Murakami observes a problem with conventional non-aqueous electrolyte secondary batteries in “retain[ing] initial discharge capacity ... after a charge-discharge cycle of the non-aqueous electrolyte secondary battery is repeated.” EX1005, ¶ [0010]. Murakami thus sought to develop

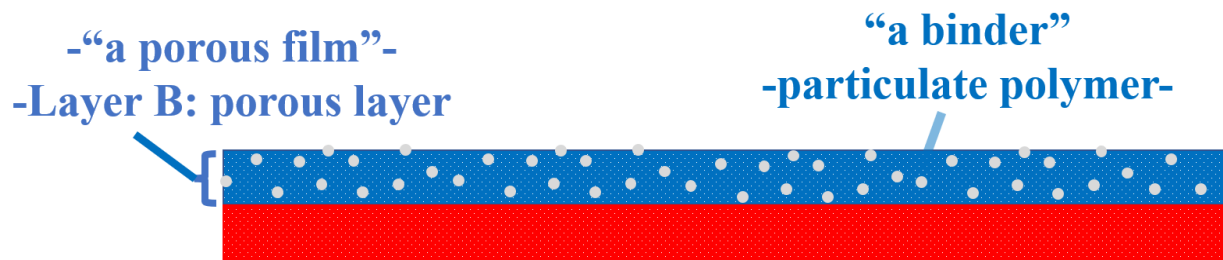
“a porous layer suitable for use as a member for the non-aqueous electrolyte secondary battery which has an excellent cycle characteristic, i.e., can substantially retain an initial discharge capacity even after a charge-discharge cycle is repeated.” *Id.*, ¶ [0024].

80. Murakami tested six Examples and one Comparative Example of the laminated body. *See id.*, ¶¶ [0123]-[0210]. Murakami “found that the porous layer whose degree of variability in voidage [i.e., porosity] therein is at most 16.0% can be suitably used as a member for a non-aqueous electrolyte secondary battery having an excellent cycle characteristic.” *Id.*, ¶ [0211]. Consistent with this, of all Examples, Examples 1 and 2 had the smallest voidage variability (3.1% and 3.8% respectively) and exhibited the best capacity retention of after 100 cycles—84%. *Id.*, ¶¶ [0208]-[209] (Tables 1 and 2). In my opinion, their superior performance would have enticed a POSITA to implement these Examples rather than attempt to prepare a laminated body having other features or characteristics.

81. Accordingly, it is my opinion that Murakami discloses *a porous film*, as claimed.

2. [1.1]: “a binder; and”

82. In my opinion, Murakami discloses or suggests this element. Specifically, Murakami’s porous layer B (*porous film*) has a binder resin (*binder*):



Murakami's Porous Film

83. Murakami discloses that “[t]he porous layer of the present invention ... contains a filler and a binder resin.” EX1005, ¶ [0017]; *see also id.*, ¶ [0053] (listing “[c]oncrete examples of the resin” including “polyolefins ...; fluorine-containing resins ...”). In the Examples, “[a]s a binder resin, sodium carboxymethyl cellulose (CMC) (manufactured by Daicel Corporation; CMC1110) was used.” *Id.*, ¶ [0140].

84. Accordingly, it is my opinion that Murakami discloses *a binder*, as claimed.

3. [1.2]: “*inorganic particles*,”

85. In my opinion, Murakami discloses or suggests this element. Specifically, in addition to the binder resin, Murakami's porous layer B contains a filler (*inorganic particles*):



Murakami's Porous Film

86. Specifically, Murakami discloses that the porous layer (*porous film*) “contains a filler.” EX1005, ¶¶ [0017], [0018], [0059]. While the filler may be organic, “[t]he filler is more preferably a filler made of inorganic oxide such as silica, calcium oxide, magnesium oxide, titanium oxide, alumina, mica, or zeolite, ...” *Id.*, ¶ [0061]. Murakami’s characterization of inorganic filler as preferable to organic filler, in my opinion, suggests or renders obvious using inorganic filler. In Murakami’s Examples, “ α -alumina ... was used as a filler,” and α -alumina is an inorganic material. *Id.*, ¶ [0161]; *see also id.*, ¶¶ [0140], [0185]. In my opinion, the filler consists of *particles*, as claimed, because they have certain “average particle diameter[s] obtained based on a volume,” discussed below. EX1005, ¶ [0018].

87. Accordingly, it is my opinion that Murakami discloses, suggests, or renders obvious *inorganic particles*, as claimed.

4. [1.3]: “*wherein the porous film comprises pores formed by the binder,*”

88. In my opinion, Murakami discloses or suggests this element. Murakami’s *porous film* (porous layer) *comprises pores formed by the binder* (binder resin), as claimed, in my opinion.

89. By definition, Murakami’s *porous layer* comprises *pores*. Indeed, Murakami discloses that the porous layer has certain a “voidage” (i.e., porosity) and pore diameter. See EX1005, Abstract, ¶¶ [0093], [0121], [0209], [0211], claims 10-13.

90. In my opinion, the pores of Murakami’s porous layer are *formed by the binder*, as claimed. First, like the Examiner found during prosecution for the Murata reference, in Murakami “[t]he porous film comprises pores formed by the binder [0086] given pores are found within the binder and porous layer.” EX1002, 22.³ That is, a POSITA would likely understand that “the filler is bound by the binder resin” containing the pores within the porous layer. EX1005, ¶ [0070].

91. Second, though not required by the broad claim language, Murakami’s process for coating the porous layer onto the porous film forms the pores in a similar way to the process described in the ’148 Patent. *Id.* In my opinion, this obviates the

³ Reference [0086] given by Examiner to location in Murata reference.

applicant's unpersuasive argument during prosecution that Murata's method did not disclose that "the resin binder of the porous layer ... forms a pore[.]" EX1014, 42.

92. Specifically, in Murakami, "a coating liquid for forming the porous layer is prepared by dissolving the resin in a solvent and ... dispersing the filler. Here, the resin can be dispersed in the solvent." EX1005, ¶ [0071]; *see also id.*, ¶ [0072]-[0073]. After applying the coating liquid to one or both surfaces of the porous film (*id.*, ¶¶ [0074]-[0079]), a drying process "remove[s] the solvent (dispersion medium) ... and then the coating liquid is dried so as to form a porous layer" (*id.*, ¶ [0088]). *See also id.*, ¶¶ [0087], [0089]. Optionally, before drying, "the coating liquid is substituted by another solvent" that "does not dissolve the resin contained in the coating liquid." *Id.*, ¶ [0087]. The process ultimately leaves the porous resin layer. *See, e.g.*, ¶¶ [0016], [0023], [0052], [0058], [0071], [0088].

93. The process Murakami describes, involving the addition of a second non-solvent for the resin, is a phase inversion or coagulation process. This type of coagulation process was a widely-used method to obtain porosity in coating layers containing particles and resin binder. For instance, Nishikawa, filed in 2011, teaches:

The separator for a nonaqueous secondary battery of the invention mentioned above can be produced by a method in which a solution containing a polyvinylidene-fluoride-based resin is applied directly onto a porous substrate, and then the polyvinylidene-fluoride-based resin is solidified to integrally form an adhesive porous layer on the porous substrate.

EX1017, 9:57-62.

Specifically, first, a polyvinylidene-fluoride-based resin is dissolved in a solvent to prepare a coating liquid. The coating liquid is applied onto a porous substrate, followed by immersion in a suitable coagulation liquid. As a result, the polyvinylidene-fluoride-based resin is solidified while inducing a phase separation phenomenon. In this step, the polyvinylidene-fluoride-based resin layer has a porous structure.

Id., 9:63-10:2.

94. Thus, in my opinion Murakami's porous layer not only contains *pores formed by the binder*, but Murakami forms those pores through a process like that described in the '148 Patent. The NIPS (non-solvent induced phase separation) process described in the '148 Patent involves coating a binder, dissolved in a first solvent, on a substrate and immersing the coating in a solution containing another mixed solvent. This mixed solvent is made up of a second and third solvent, and the

third solvent is a nonsolvent (or coagulating liquid) for the polymer binder resin. EX1001, 6:16-32. This extracts the first solvent, coagulating the binder to form pores. *Id.* Similarly, in Murakami, “it is possible to carry out drying after the solvent (dispersion medium) contained in the coating liquid is substituted by another solvent,” which “does not dissolve the resin contained in the coating liquid,” EX1005, ¶ [0087] and subsequently “the coating liquid is dried so as to form a porous layer.” EX1005, ¶ [0088]; *see also id.*, ¶¶ [0016], [0023], [0058], [0071], [0087] (discussing the process of forming the resin porous layer and characteristics of the porous layer). The ’148 Patent (EX1001), Nishikawa (EX1017), and Murakami (EX1005), all describe forming a porous layer by coating solution containing binder, and then causing that binder to phase separate (coagulate) out of solution to form a solid porous structure by the addition of a non-solvent, i.e. another solvent that does not dissolve the binder resin.

95. Accordingly, in my opinion, Murakami discloses or suggests element [1.3].

5. [1.4]: “*the pores at least comprises a part of the inorganic particles,*”

96. In my opinion, Murakami suggests or renders obvious this element, to the extent it is not indefinite. While Murakami does not expressly disclose this, it is

my opinion that Murakami's description of the porous layer's composition makes clear that this feature is inherent and/or renders it obvious.

97. First, as I explain below, Murakami's porous layer is predominantly composed of inorganic filler, with a filler-to-binder weight ratio of 97:3 in Examples 1 and 2. Given this composition, it is my opinion that a POSITA would understand that the pores in Murakami's porous layer necessarily include at least some portion of the inorganic filler or would have found this obvious.

98. Second, also explained below, Murakami's porous layer features 10% of the filler particles (D90 and larger) having diameters approximately 1/3 of the pores layer's thickness, so it is inevitable that some of these particles extend into the pores. Otherwise, the resulting structure would be densely packed with minimal porosity. This contradicts Murakami's description of a porous layer with high porosity (up to 70% or 90%) and pore diameters of 3 μm . Therefore, for the layer to achieve such high porosity, it is necessary or obvious for these larger filler particles to protrude into the pore spaces, and/or themselves comprise a part of the pore walls, ensuring that the pores inherently contain portions of the inorganic filler material.

99. **Amount of filler >> amount of binder resin:** Specifically, one way Murakami makes clear that the pores of the pores layer include at least some portion of the inorganic particles is that the Examples contain a *much* larger amount of filler (*inorganic particles*) than binder resin by weight. For example, in Layer B of

Examples 1 and 2, “3 parts by weight of CMC [the binder resin] was mixed with 100 parts by weight of the α -alumina.” EX1005, ¶ [0141]; *see also id.*, ¶ [0161] (In Example 2, “[a] coating liquid 2 was prepared by carrying out operation similar to that of Example 1”). This means that the binder layer comprises $100/103 = 97$ wt% filler in Examples 1 and 2.⁴ Likewise, in the description of the general embodiment, Murakami states that the filler content makes up most of the filler-binder combination by weight, preferably up to 99 wt%. EX1005, ¶ [0070].

100. The fraction or percent by volume of filler particles relative to binder resin is more relevant to how these components occupy space and are arranged in the Layer B “porous film.” By using the densities of the filler particles and the resin polymer, weight ratios and weight percentages can be converted into volume ratios and volume percentages. For Murakami’s Examples 1 and 2, the filler particles are α -alumina (density 3.97 g/cm^3)⁵, and the binder is sodium carboxymethyl cellulose

⁴ Although Murakami then adds a solvent comprising water and isopropyl alcohol that temporarily reduces the weight proportion of filler, *id.*, ¶ [0141], the solvent is dried and removed from the mixture to form the porous layer, *id.*, ¶¶ [0087]-[0089].

⁵ https://www.chemicalbook.com/ProductMSDSDetailCB9853056_EN.htm

(density 1.6 g/cm³)⁶. On a volume basis, there are 7.4 parts by volume binder resin for every 100 parts by volume of inorganic particles, or 93% particles by volume in the Layer B “porous films” of Murakami’s Examples 1 and 2. Thus, based on space filling volume, the filler particles still make up the overwhelming majority of the layers.

101. With Murakami’s binder composition consisting of nearly *all* filler material by weight or by volume, it is my opinion that a POSITA would have recognized as a necessary consequence that the pores of Murakami’s porous layer include at least some portion of the filler material. There is simply not enough resin material to completely subsume the much greater amount of filler—just enough for “the filler [to be] bound by the binder resin.” EX1005, ¶ [0070]. Similarly, the ’148 Patent explains that the porous film can have up to three times more inorganic particles than binder by volume—i.e., 75/25 inorganic particles to binder or 75 volume % particles. EX1001, 5:50-60. Thus, Murakami’s description of the binder composition makes clear that the feature of Murakami’s pores including at least some portion of inorganic particles is necessarily present.

⁶ https://www.chemicalbook.com/ChemicalProductProperty_EN_CB5209844.htm

102. In my opinion, a POSITA would understand that the surfaces of the inorganic particles may have some polymer (*binder*) molecules adsorbed to their surfaces, forming atomically or molecularly thin layers that a POSITA would understand to be inherently part of the particles rather than part of the binder. The surfaces of the inorganic particles would be considered by a POSITA to be the surfaces of the particles even if they include some molecularly thin attachment of polymer.

103. Even if Patent Owner disputes (wrongly) that Murakami's disclosure of the binder composition shows that Murakami's pores necessarily include at least some portion of filler material, it is my opinion that this disclosure certainly renders it obvious. I have been informed that to show inherency in an obviousness analysis, the prior art disclosure is sufficient if it shows that the natural result flowing from the operation as taught would result in the performance of the questioned function. Here, the natural result flowing from Murakami's disclosure—the porous layer consists of nearly all filler material and relatively little resin by weight—is that the pores of Murakami's porous layer would include at least some portion of filler material.

104. **Porous layer thickness vs. filler particle diameter:** In my opinion, Murakami also suggests or renders obvious that the pores of its porous layer include at least some filler material by its description of the porous layer film thickness

compared to the particle diameters of the filler material. For example, Examples 1 and 2 had respective Dv90 of the filler particles of 1.03 μm and 1.53 μm —meaning that at least 10 percent of the particles, by volume, had diameters equal to or greater than those values. EX1005, ¶¶ [0140], [0161].⁷ But Layer B—containing those filler particles—has respective film thicknesses of only 3.5 μm and 4.5 μm in Examples 1 and 2. EX1005, ¶ [0208] (Table 1). With the diameter of 10% of the filler particles being roughly 1/3, or greater, of the thickness of Layer B in which they sit, a POSITA would, in my opinion, recognize the feature of the pores of Layer B including at least some portion of the filler particles to be a necessary consequence flowing from the composition of Layer B.

105. Consistent with this, Murakami teaches that “[a] pore diameter of pores in the porous layer is preferably 3 μm or less, more preferably 1 μm or less[.]” EX1005, ¶ [0093]. The porous layer also has a high porosity, or “voidage,” up to 70% or 90%. *Id.* With such a high porosity and pore diameter which is comparable to the diameter 10% of the filler particles in that layer (i.e., Dv90 and greater), it is

⁷ Table 1 of Murakami agrees that Example 2 has a Dv90 of the inorganic particles of 1.53 μm but has a slightly different value (1.09 μm vs. 1.03 μm) for Dv90 of Example 1. EX1005, ¶ [0208] (Table 1).

my opinion that a POSITA would expect at least some pores to include at least some portion of the filler particles. Otherwise, if these particles do not extend into the pores, the resulting structure would be densely packed with minimal porosity. This contradicts Murakami's description of a porous layer with high porosity (up to 70% or 90%) and pore diameters of 3 μm . EX1005, ¶ [0093]. Therefore, for the layer to achieve such high porosity, it is necessary or would have been obvious for these larger filler particles to protrude into the pore spaces, ensuring that the pores inherently contain portions of the inorganic filler material.

106. Indeed, a POSITA would expect Murakami's porous layer to have at least as much inorganic filler particles included in pores as the porous film of the '148 Patent. This is because most Example porous films in the '148 Patent had a layer thickness of at least 24 μm along with a Dv90 of the inorganic particles of only 3.0 μm —a ratio of thickness to particle size (8x) much greater than that of Murakami (about 3x). EX1001, Table 2. In other words, Murakami's inorganic particles are larger compared to the thickness of Layer B than the diameter of the '148 Patent's inorganic particles compared to the thickness of its porous film.

107. The '148 Patent teaches “the porous film has a porosity of 20% to 90%.” EX1001, Claim 7, 5:40-41. Examples had porosities ranging from 42%-61%. *Id.*, Table 2, 5:41-42. Similarly, Murakami teaches “[a] voidage of the porous layer [i.e. “porous film”] is preferably 10 volume % to 90 volume %, more preferably 30

volume % to 70 volume %.” EX1005, ¶ [0093]. These voidage (i.e. porosity) numbers are the volume based percentage of open space (air) making up the porous films/layers in the ’148 patent and in Murakami. The solid materials making up the layers (binder and particles) need to be contained in remaining space or (100% - voidage %). In the examples of the ’148 patent, the binder polymer and particles must be contained in 39-58% of the volume of the porous film. When practicing the upper end of Murakami’s preferred voidage range of 70%, all the binder polymer and particles must be contained in only 30% of Layer B (“porous film”). In short, Murakami’s porous layer has even less “room” to avoid having portions of particles included in the pores than the ’148 Patent’s example porous films. If the ’148 Patent’s porous film has inorganic particles included in the pores, so must Murakami’s porous layer.

108. Accordingly, it is my opinion that Murakami suggests or renders obvious element [1.4].

6. [1.5]: “*wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm ,*”

[1.6]: “*Dv50 is in a range of 0.2 μm to 5 μm , and*”

[1.7] “*Dv90 is in a range of 1 μm to 10 μm ,*”

109. In my opinion, Murakami discloses or suggests these elements. As mentioned above, I rely on Murakami’s general description of the porous layer, as

well as Examples 1 and 2, as distinct embodiments rendering obvious the challenged claims. *Supra* Section IX.A.1. Each of these embodiments discloses or suggests the claimed *Dv10*, *Dv50*, and *Dv90* ranges:

Embodiment	<i>Dv10</i> (μm)	Claimed <i>Dv10</i> Range (μm)	<i>Dv50</i> (μm)	Claimed <i>Dv50</i> Range (μm)	<i>Dv90</i> (μm)	Claimed <i>Dv50</i> Range (μm)
General Description	0.005 to 0.4	0.015 to 3	0.01 to 1.0	0.2 to 5.0	0.5 to 5.0	1 to 10
Example 1	0.22		0.44		1.03	
Example 2	0.26		0.66		1.53	

110. As indicated in the Table above, in the general description, Murakami states that “[t]he porous layer of the present invention preferably contains a filler in which, in terms of average particle diameter obtained based on a *volume*, (i) D10 is 0.005 μm to 0.4 μm , D50 is 0.01 μm to 1.0 μm , and D90 is 0.5 μm to 5.0 μm [.]” EX1005, ¶ [0018]. Murakami’s *Dv10*, *Dv50*, and *Dv90*⁸ ranges overlap the

⁸ Murakami’s values for D10, D50, and D90 refer respectively to *Dv10*, *Dv50*, and *Dv90* because Murakami explains that they are expressed “in terms of average particle diameter obtained *based on a volume*[.]” EX1005, ¶ [0018]; see also *id.*, ¶ [0066], claim 10 (D values “based on a volume”).

corresponding claimed *Dv10*, *Dv50*, and *Dv90* ranges, which I understand renders each range obvious.

111. In Example 1, “[a]s a filler, α -alumina (D10: 0.22 μm , D50: 0.44 μm , D90: 1.03 μm) was used.” EX1005, ¶ [0140]. In Example 2, “coating liquid 2 was prepared by carrying out operation similar to that of Example 1, except that α -alumina (D10: 0.26 μm , D50: 0.66 μm , D90: 1.53 μm) was used as a filler.” *Id.*, ¶ [0161]. In both Murakami Examples 1 and 2, each *Dv10*, *Dv50*, and *Dv90* value falls squarely within its respective claimed range, rendering the claimed ranges obvious.

112. Accordingly, it is my opinion that Murakami discloses or suggest elements [1.5] through [1.7].

7. [1.8]: “*Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and*”

113. In my opinion, Murakami discloses or suggests this element. As explained above, Murakami’s general embodiment and Examples 1 and 2 have the following *Dv10* and *Dv50* values:

Embodiment	<i>Dv10</i> (μm)	<i>Dv50</i> (μm)
General Description	0.005 to 0.4	0.01 to 1.0
Example 1	0.22	0.44
Example 2	0.26	0.66

Supra Section IX.A.6; EX1005, ¶¶ [0018], [0140], [0161]. In each case, the former is less than the latter: (1) in the general description, the *Dv10* range 0.005 μm to 0.4 μm covers a lower span than the *Dv50* range 0.1 μm to 1.0 μm ; (2) in Example 1, a *Dv10* of 0.22 μm is less than a *Dv50* of 0.44 μm ; and (3) in Example 2, a *Dv10* of 0.26 μm is less than a *Dv50* of 0.66 μm .

114. The condition that *Dv10* of the inorganic particles is less than *Dv50* is obvious to a POSITA as a fact that is always true of any distribution of particle sizes. Firstly, it is mathematically impossible for *Dv10* to be greater than *Dv50*. Secondly, in order for *Dv10* to be equal to *Dv50* it would be necessary for the distribution of particle sizes, up to 50 volume percent, to be completely monodisperse—i.e., all the particles need to be exactly the same size. A POSITA understands that this is an impossibility, given that the inorganic particles are made by a random and chaotic process of pulverizing and grinding inorganic materials, which by its nature leads to variability in particle size.

115. Accordingly, it is my opinion that Murakami discloses or suggests element [1.8].

8. [1.9]: “*Dv50 of the inorganic particles is less than Dv90 of the inorganic particles, and*”

116. In my opinion, Murakami discloses or suggests this element. As explained above, Murakami’s general embodiment and Examples 1 and 2 have the following *Dv50* and *Dv90* values:

Embodiment	<i>Dv50</i> (μm)	<i>Dv90</i> (μm)
General Description	0.01 to 1.0	0.5 to 5.0
Example 1	0.44	1.03
Example 2	0.66	1.53

Supra Section IX.A.6; EX1005, ¶¶ [0018], [0140], [0161]. In each case, the former is less than the latter: (1) in the general description, the *Dv50* range 0.01 μm to 1.0 μm covers a lower span than the *Dv90* range 0.5 μm to 5.0 μm; (2) in Example 1, a *Dv50* of 0.44 μm is less than a *Dv90* of 1.03μm; and (3) in Example 2, a *Dv50* of 0.66 μm is less than a *Dv90* of 1.53 μm.

117. For the same reason that *Dv10* is necessarily less than *Dv50*, it is obvious to a POSITA that *Dv50* is necessarily less than *Dv90*. This fact is always true of any distribution of particle sizes. Firstly, it is mathematically impossible for *Dv50* to be greater than *Dv90*. Secondly, in order for *Dv50* to be equal to *Dv90* it would be necessary for the distribution of particle sizes, up to 90 volume percent, to be completely monodisperse, i.e. all the particles need to be exactly the same size. A POSITA understands that this is an impossibility, given that the inorganic particles

are made by a random and chaotic process of pulverizing and grinding inorganic materials, which by its nature leads to variability in particle size.

118. Accordingly, it is my opinion that Murakami discloses or suggests element [1.9].

9. [1.10]: “*the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.*”

119. In my opinion, Murakami discloses or suggests this element. As explained above, Murakami’s general embodiment and Examples 1 and 2 have the following Dv90 and Dv10 values, yielding the following ratios:

Embodiment	Dv90 (μm)	Dv10 (μm)	Ratio	Claimed Ratio
General Description	0.5 to 5.0	0.005 to 0.4	1.25 to 1000	2 to 100
Example 1	1.03	0.22	4.68	
Example 2	1.53	0.26	5.88	

Supra Section IX.A.6; EX1005, ¶¶ [0018], [0140], [0161]. In order to calculate the range of ratios in the above table from Murakami’s stated Dv10 and Dv90 ranges, one gets the lower value by dividing the smallest Dv90 value (0.5 μm) by the largest Dv10 value (0.4 μm), and one gets the upper value by dividing the largest Dv90 value (5.0 μm) by the smallest Dv10 value (0.005 μm).

120. In each case, Murakami’s Dv90/Dv10 ratio overlaps, or falls squarely within, the claimed range of 2 to 100, thus rendering it obvious. While Murakami’s

range of $Dv90/Dv10$ is broader than the '148 Patent's claimed range, the fact that the two Examples, which best embody the Murakami invention, fall squarely in the claimed range, indicates that a POSITA would be motivated to pick the subrange of Murakami that corresponds to the claimed range.

121. Accordingly, it is my opinion that Murakami renders obvious element [1.10].

B. Dependent Claim 2

1. [2.1]: “*The porous film according to claim 1, wherein the porous film has an average pore size of 0.3 μm to 20 μm .*”

122. In my opinion, Murakami discloses or suggests this element. Specifically, Murakami discloses “[a] pore diameter of each of pores in the porous film is preferably 3 μm or less, more preferably 1 μm or less,” EX1005, ¶ [0037], falling within or overlapping the claimed range. Accordingly, it is my opinion that Murakami renders obvious claim 2.

C. Dependent Claim 5

1. [5.1]: “*The porous film according to claim 1, wherein the inorganic particles are at least one selected from the group consisting of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.*”

123. In my opinion, Murakami discloses or suggests this claim element. Specifically, Murakami discloses the following exemplary filler materials, with at least the italicized materials being examples recited in claim 5:

The filler is more preferably a filler made of inorganic oxide such as *silica, calcium oxide, magnesium oxide, titanium oxide, alumina*, mica, or zeolite, further preferably at least one kind of filler selected from among a group consisting of *silica, magnesium oxide, titanium oxide*, and *alumina*, and particularly preferably *alumina*.

EX1005, ¶ [0061].⁹ I note that magnesium oxide, as taught by Murakami, is another name for *magnesia*, as recited in the claim. Moreover, Examples 1 and 2 used α -alumina as filler. *Id.*, ¶¶ [0140], [0161]. Accordingly, it is my opinion that Murakami discloses this element.

⁹ I note that, in my declaration, emphasis is added unless specified otherwise.

D. Dependent Claim 6

- a. [6.1]: “*The porous film according to claim 1, wherein the binder is at least one selected from the group consisting of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.*”

124. In my opinion, Murakami discloses or suggests this element. Regarding the general embodiment, Murakami teaches “[t]he binder resin is particularly preferably any of the fluorine-containing resins, the aromatic polyamides, and the water-soluble polymers.” EX1005, ¶ [0057]. *Polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polytetrafluoroethylene and polyhexafluoropropylene*, as recited in Claim 6, are examples of fluorine-containing resins. *Aromatic polyamides*, as taught by Murakami, are examples of *polyamide*, as recited in Claim 6. Murakami teaches “water-soluble polymers” (EX1005, ¶ [0053]); several of the binder resins recited in ’148 Patent claim 6 are water soluble polymers, including polyacrylic acid, polyacrylic acid salt, and sodium carboxymethylcellulose. And, in Examples 1 and 2, “[a]s a binder resin, sodium carboxymethyl cellulose (CMC) (manufactured by Daicel Corporation; CMC1110) was used”—one of the claimed options. *Id.*, ¶ [0140]. Accordingly, it is my opinion that Murakami discloses this element.

E. Dependent Claim 7

1. [7.1]: “*The porous film according to claim 1, wherein the porous film has a porosity of 20% to 90%.*”

125. In my opinion, Murakami discloses or suggests this element. Specifically, Murakami discloses that “[a] voidage of the porous layer is preferably 10 volume % to 90 volume %, more preferably 30 volume % to 70 volume % so as to obtain a sufficient ion permeability.” EX1005, ¶ [0093]. Each of Murakami’s preferred voidage ranges overlaps or falls within the claimed range, thus rendering it obvious. Accordingly, it is my opinion that Murakami renders obvious claim 7.

F. Dependent Claim 8

1. [8.1]: “*The porous film according to claim 1, wherein the porous film has a thickness of 0.2 to 10 μm .*”

126. In my opinion, Murakami discloses or suggests this element. In the general embodiment, Murakami’s porous layer (Layer B) (the claimed *porous film*) has a thickness “preferably 0.1 μm to 20 μm ” and “more preferably 2 μm to 15 μm ,” EX1005, ¶ [0090], both of which overlap the claimed range and thus render it obvious. And in both of relied upon Examples 1 and 2, the thickness of the porous layer (3.5 μm and 4.5 μm , respectively) falls within the claimed range and thus renders it obvious. EX1005, ¶ [0208] (Table 1). Accordingly, it is my opinion that Murakami renders obvious claim 8.

G. Dependent Claim 9

1. [9.1]: “*The porous film according to claim 1, wherein a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.*”

127. In my opinion, Murakami discloses this element. Specifically, Murakami discloses that “[the] filler content is preferably 1 volume % to 99 volume %, more preferably 5 volume% to 95 volume%, relative to the porous layer.” EX1005, ¶ [0069]. This converts into a ratio of inorganic particles to binder preferably 0.01 to 99 and, more preferably, 0.05 to 19. Both Murakami’s preferred ranges overlap the claimed range, rendering it obvious. Accordingly, it is my opinion that Murakami renders claim 9 obvious.

H. Independent Claim 10

1. [10.pre]: “*A lithium-ion battery, comprising:*”

128. In my opinion, Murakami discloses this element. Specifically, Murakami discloses that “[t]he porous layer of the present invention and a separator formed by laminating the porous layer are suitable as a member for a non-aqueous electrolyte secondary battery that has an excellent cycle characteristic.” EX1005, Abstract. Murakami also discloses that a lithium-ion secondary battery is a type of non-aqueous electrolyte secondary battery. *Id.*, ¶ [0002]. *See also id.*, ¶ [0106] (“In the non-aqueous electrolyte secondary battery according to the present invention, it is possible to use, for example, a non-aqueous electrolyte obtained by dissolving

lithium salt into an organic solvent.”). In Murakami’s examples, the positive electrode was prepared using $\text{LiNi}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3}\text{O}_2$. *Id.*, ¶ [0148]. The lithium containing composition of the electrolyte and of the cathode render it obvious to a POSITA that Murakami is teaching “a lithium-ion battery.”

129. Accordingly, it is my opinion that Murakami renders obvious element [10.pre].

2. [10.1]: “a positive electrode;”

[10.2]: “a negative electrode;”

130. In my opinion, Murakami discloses these elements. Specifically, Murakami discloses that “[t]he porous layer of the present invention can be ... formed on a surface of at least one of a *positive electrode* and a *negative electrode*. EX1005, ¶ [0029]; see also *id.*, ¶ [0021]. Murakami also prepared and tested the Example 1 and 2 porous layers on non-aqueous electrolyte secondary battery, which has positive and negative electrodes. See *id.*, ¶¶ [0146]-[0156], [0166]-[0169].

131. Accordingly, it is my opinion that Murakami renders obvious elements [10.1] and [10.2].

3. [10.3]: “a separator, arranged between the positive electrode and the negative electrode;”

132. In my opinion, Murakami discloses this element. Specifically, Murakami discloses arranging the laminated layer (*separator*) including porous layer *between the positive and the negative electrode*, as claimed:

A member of the present invention for a non-aqueous electrolyte secondary battery is made up of a positive electrode, the separator, and a negative electrode which are arranged in this order.

EX1005, ¶ [0021]; *see also id.*, ¶ [0013] (Layer B is part of “a separator that is a laminated body in which the porous layer is laminated onto one surface or each of both surfaces of the porous film.” *Id.*, ¶ [0013].

133. Accordingly, it is my opinion that Murakami renders obvious element [10.3].

4. [10.4]: “non-aqueous electrolyte; and”

134. In my opinion, Murakami discloses this element. Specifically, Murakami discloses “[a] non-aqueous electrolyte secondary battery.” EX1005, ¶ [0022]. The reference notes that “it is possible to use, for example, a non-aqueous electrolyte obtained by dissolving lithium salt into an organic solvent.” *Id.*, ¶ [0106].

135. Accordingly, it is my opinion that Murakami renders obvious element [10.4].

5. Remaining elements [10.5] through [10.15]

136. In my opinion, Murakami discloses, suggests, and/or renders obvious the remaining elements of claim 10 for the reasons discussed above for substantively identical corresponding elements of independent claim 1:

Claim 10 Element	Language	Corresponding Claim 1 Element	Analysis
[10.5]	<i>a porous film, comprising:</i>	[1.pre]	Section IX.A.1
[10.6]	<i>a binder; and</i>	[1.1]	Section IX.A.2
[10.7]	<i>inorganic particles;</i>	[1.2]	Section IX.A.3
[10.8]	<i>wherein the porous film comprises pores formed by the binder,</i>	[1.3]	Section IX.A.4
[10.9]	<i>the pores at least comprises a part of the inorganic particles,</i>	[1.4]	Section IX.A.5
[10.10]	<i>wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm,</i>	[1.5]	Section IX.A.6
[10.11]	<i>Dv50 is in a range of 0.2 μm to 5 μm,</i>	[1.6]	Section IX.A.6
[10.12]	<i>Dv90 is in a range of 1 μm to 10 μm;</i>	[1.7]	Section IX.A.6
[10.13]	<i>Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and</i>	[1.8]	Section IX.A.7

Claim 10 Element	Language	Corresponding Claim 1 Element	Analysis
[10.14]	<i>Dv50 of the inorganic particles is less than Dv90 of the inorganic particles; and</i>	[1.9]	Section IX.A.8
[10.15]	<i>the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.</i>	[1.10]	Section IX.A.9

I. Dependent Claim 19

1. [19.1]: “*The lithium-ion battery according to claim 10, wherein the porous film is arranged on a surface of at least one selected from the group consisting of the positive electrode, the negative electrode and the separator.*”

137. In my opinion, Murakami discloses or suggests this element. Specifically, Murakami discloses that “[t]he separator of the present invention is formed by laminating the porous layer on one surface or each of both surfaces of a porous film which contains polyolefin as a main component.” EX1005, ¶ [0019]. Moreover, as explained above, the porous layer (Layer B) of Murakami is part of “a separator that is a laminated body in which the porous layer is laminated onto one surface or each of both surfaces of the porous film, [which] has an excellent cycle characteristic.” *Id.*, ¶ [0013].

138. Accordingly, it is my opinion that Murakami renders obvious dependent claim 19.

J. Remaining Dependent Claims 11 and 14-18

139. In my opinion, Murakami discloses, suggests, and/or renders obvious claims 11 and 14-18 for the reasons discussed above for substantively identical corresponding elements of claims 2 and 5-9:

Remaining Claim Element	Claim Language	Previous Claim Element	Analysis
[11.1]	<i>The lithium-ion battery according to claim 10, wherein the porous film has an average pore size of 0.3 μm to 20 μm.</i>	[2.1]	Section IX.B.1
[14.1]	<i>The lithium-ion battery according to claim 10, wherein the inorganic particles are at least one selected from the group consisting of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.</i>	[5.1]	Section IX.C.1
[15.1]	<i>The lithium-ion battery according to claim 10, wherein the binder is at least one selected from the group consisting of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.</i>	[6.1]	Section IX.D.1

Remaining Claim Element	Claim Language	Previous Claim Element	Analysis
[16.1]	<i>The lithium-ion battery according to claim 10, wherein the porous film has a porosity of 20% to 90%.</i>	[7.1]	Section IX.E.1
[17.1]	<i>The lithium-ion battery according to claim 10, wherein the porous film has a thickness of 0.2 to 10 μm.</i>	[8.1]	Section IX.F.1
[18.1]	<i>The lithium-ion battery according to claim 10, wherein a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.</i>	[9.1]	Section IX.G.1

X. GROUND 2: MURAKAMI AND HONDA RENDER OBVIOUS CLAIMS 3 AND 12

A. Dependent Claims 3, 12

1. [3.1]: “*The porous film according to claim 1, wherein the average wall thickness between the pores is in a range of 20 nm to 500 nm.*”

[12.1] “*The lithium-ion battery according to claim 10, wherein the average wall thickness between the pores is in a range of 20 nm to 500 nm.*”

140. Murakami does not expressly disclose a wall thickness of the pores of Murakami’s porous layer. In my opinion, however, Honda discloses a pore wall thickness falling in the claimed range recited in dependent claims 3 and 12 and provides motivation for a POSITA to configure Murakami’s porous layer to have the claimed wall thickness.

a. Honda discloses elements [3.1], [12.1]

141. In my opinion, Honda discloses or suggests this element. Specifically, Honda discloses “[a] separator for nonaqueous secondary batteries, which is provided with: a porous base that contains a thermoplastic resin; and a porous layer that is provided on one surface or both surfaces of the porous base and contains a polyvinylidene fluoride resin.” EX1007, Abstract. Honda’s “porous layer” is the element that corresponds to Murakami’s Layer B and to the *porous film* claimed in the ’148 Patent. Honda’s porous layer has a “honeycomb structure” (*id.*, ¶ [0017]), which Honda describes as “a structure in which a large number of cells that are open in a direction perpendicular to a surface of a porous layer are aligned adjacent to each other in the direction perpendicular to the surface of a porous layer” (*id.*, ¶ [0038]). *See also id.*, ¶¶ [0039]-[0045] (discussing the honeycomb structure).

142. Honda teaches that “a thickness of a partition wall constituting a honeycomb structure (that is, a partition wall in which a porous layer is partitioned into a large number of cells) is, for example, 0.1 μm to 2 μm .” *Id.*, ¶ [0045]. This range corresponds to a wall thickness of 100 nm to 2000 nm, overlapping the claimed range of 20 nm to 500 nm.

143. Accordingly, it is my opinion that Honda discloses claims 3 and 12.

2. Rationale to combine Murakami and Honda

144. In my opinion, Honda and Murakami teach, suggest, and motivate a POSITA to configure the pore walls of Murakami's porous layer to have a thickness of 100 nm to 2000 nm. Initially, Honda and Murakami are analogous prior art to each other and the '148 Patent because they are directed to the same field of endeavor—porous films used as separators for lithium-ion batteries. *See, e.g.*, EX1001, 1:29-37, 2:38-46; EX1005, Abstract, ¶¶ [0001]-[0005]; EX1007, Abstract.

145. Honda explains that this wall thickness allows micropores to interconnect the larger pores in the porous layer: “[i]t is preferable that a large number of micropores are present in the partition wall constituting the honeycomb structure, and it is preferable that the pores of adjacent cells are connected by the micropores.” EX1007, ¶ [0045]. In other words, with thin pore walls, micropores can interconnect the larger pores, increasing interconnectedness of the pores and porosity of the separator. In my opinion, Honda's technique increases porosity in two ways: (1) thinner pore walls increase porosity; and (2) micropores interconnecting the larger pores further increases porosity, and the interconnectedness of pores. Murakami prefers “[a] voidage of the porous layer” to be as high as 90 vol% (EX1005, ¶ [0093]), motivating a POSITA to use Honda's wall thickness to achieve this aim.

146. Furthermore, in my opinion, a POSITA would have had a reasonable expectation of success in achieving Honda's "honeycomb" structure in the porous layer of Murakami. Indeed, Honda describes a "preferable" method (i) to induce formation of the honeycomb structure like Murakami's and the '148 Patent's phase separation (i.e., coagulation, phase inversion, or NIPS) methods using multiple solvents:

Specific examples of the method for forming the porous layer having the honeycomb structure include the methods in (i) to (iii) below, and...the method in (i) below is preferable.

(i) A method including: producing a coating liquid by dissolving a polyvinylidene fluoride resin in a mixed solvent formed by mixing a good solvent and a poor solvent; forming a coating layer by coating the coating liquid on a porous base material; and removing the poor solvent from the coating layer after inducing a phase separation phenomenon by selectively removing the good solvent from the coating layer.

EX1007, ¶¶ [0082]-[0083]; *see also* EX1001, 6:16-32; EX1005, ¶ [0087] ("the solvent (dispersion medium) contained in the coating liquid is substituted by another solvent" and then "evaporated" when forming the porous layer). Thus, to the extent that Murakami's process did not already form Honda's honeycomb structure, a

POSITA could, in my opinion, have reasonably achieved Honda's honeycomb structure in Murakami's porous layer with only routine skill in the art.

147. Accordingly, in my opinion, Murakami and Honda render obvious claims 3 and 12.

XI. GROUND 3: MURAKAMI AND TANAKA RENDER OBVIOUS CLAIMS 4 AND 13

A. Dependent Claims 4, 13

1. [4.1]: “*The porous film according to claim 1, wherein a pore size distribution coefficient of the pores in the porous film is in a range of 1 to 5.*”

[13.1]: “*The lithium-ion battery according to claim 10, wherein a pore size distribution coefficient of the pores in the porous film is in a range of 1 to 5.*”

148. Murakami does not expressly disclose that *a pore size distribution coefficient of the pores in Murakami's porous layer is in a range of 1 to 5*, as recited in claims 4 and 13. Tanaka, however, discloses this feature, and in my opinion a POSITA would have found it obvious to configure Murakami's porous layer to have the claimed *pore size distribution*.

a. Tanaka discloses elements [4.1] and [13.1]

149. Tanaka describes “a polyolefin porous sintered compact” (EX1009, Abstract) layer that can be used as “a separator for a lithium ion secondary cell or a lead storage cell” (*id.*, ¶ [0069]). Tanaka explains that:

[t]he present embodiment has a narrow median pore distribution diameter range, and when the pore diameters corresponding to the cumulative 10% diameter and the cumulative 90% diameter from the large diameter side of the cumulative pore distribution are defined as D10 and D90, respectively, the D10/D90 ratio is 10 or less, preferably 8 or less, and more preferably 6 or less. Note that, theoretically, the value of the D10/D90 ratio cannot be smaller than 1.

Id., ¶ [0019]; *see also id.*, Abstract. Additionally, “the D10/D90 ratio of example 1 was 2.73[.]” *Id.*, ¶ [0073]. Because the ’148 Patent defines R90 and R10 “from the side of *small* pore size” (EX1001, 5:15-23) while Tanaka defines D90 and D10 “from the *large* diameter side” (EX1009, ¶¶ [0015], [0019]), Tanaka’s D10 corresponds to the ’148 Patent’s R90, and Tanaka’s D90 corresponds to the ’148 Patent’s R10. Thus, the distribution coefficient, which the ’148 patent defines as R90/R10 (EX1001, 5:23-24), is D10/D90 in Tanaka.

150. Tanaka’s D10/D90 ratio corresponds to the ’148 Patent’s R90/R10 ratio—the claimed *pore size distribution coefficient*. The ’148 Patent explains that “[t]he pore size distribution coefficient D is equal to R90/R10” where “R10 represents pore sizes which reach 10% of the cumulative pore sizes from the side of small pore size in the pore size distribution curve” and “R90 represents pore sizes which reach 90% of the cumulative pore sizes from the side of small pore size in the

pore size distribution curve.” EX1001, 5:17-24; *see also id.*, 22:21-35. Tanaka’s D90 and D10 values likewise refer to pore sizes: “median *pore diameter* corresponding to 10% *cumulative* and 90% *cumulative* from the large diameter side of the cumulative pore distribution [are] *D10* and *D90*, respectively[.]” EX1009, Abstract.

151. In the context of the ’148 Patent, Tanaka has the following *pore size distribution coefficient*:

Tanaka Embodiment	R90/R10
Preferred	$1 \leq R90/R10 \leq 10$
More preferred	$1 \leq R90/R10 \leq 8$
Most preferred	$1 \leq R90/R10 \leq 6$

EX1009, Abstract, ¶ [0019]. Tanaka’s preferred R90/R10 ranges overlap the claimed range, thus rendering it obvious.

152. Moreover, nearly every Tanaka example had a D10/D90 (i.e., R90/R10) *pore size distribution coefficient* between 1 and 5:

Example	R90/R10
1	2.7
2	4.9
3	2.5
4	3.9
5	4.3
6	2.9
7	9.5
8	4.9

EX1009, Table 1. Thus, Tanaka’s Examples separately render obvious the claimed coefficient range of 1 to 5.

153. Accordingly, it is my opinion that Tanaka discloses claims 4 and 13.

b. Rationale to combine Murakami and Tanaka

154. In my opinion, the references provide teaching, suggestion, and motivation to configure Murakami’s porous layer to have Tanaka’s *pore size distribution coefficient* of ≤ 10 or equal to 2.73. Initially, Murakami and Tanaka are analogous art to each other and the ’148 Patent because they relate to the same field of endeavor—porous layers used for battery separators. *See, e.g.*, EX1001, 1:29-37, 2:38-46; EX1005, Abstract, ¶¶ [0001]-[0005]; EX1009 ¶ [0069].

155. **Mechanical strength:** Tanaka explains that “by controlling pore size distribution, it is possible to obtain ... excellent mechanical strength and durability, thereby arriving at the present invention.” EX1009, ¶ [0010]. Tanaka explains that

the control of pore size distribute they teach is quantified by the D10/D90 ratio, and by keeping this ratio in the preferred ranges “not only is deformation or breakage suppressed but also durability can be improved.” *Id.*, ¶ [0019]. Mechanical strength, durability and resistance to breakage have long been prized attributes for battery separator materials, which need to withstand stressful processes such as winding on a cylindrical mandrel during battery construction.

156. In my opinion, the desire to improve mechanical strength and durability of Murakami’s separator would have enticed a POSITA to incorporate Tanaka’s D10/D90 ratios.

157. **High permeability:** Beyond mechanical strength, Tanaka teaches that by “controlling pore size distribution” (i.e., D10/D90 ratio) it is possible to “ensure high air permeability.” *Id.*, ¶ [0010]. A POSITA knows that air permeability, typically measured by the Gurly Number, of lithium-ion battery separators is measured to indicate their potential ion permeability. Therefore, in Murakami’s separator, improved air permeability would translate to higher ion permeability and stronger ion conductivity, further motivating the combination. Tanaka teaches many possible applications beyond lithium-ion battery separators, including those that rely on high permeability of the layer by air or water. While air and water are not present in lithium-ion batteries, a POSITA would be searching the technical literature for examples of highly permeable membranes from which to draw inspiration, because

a POSITA would know that high air permeability translates into high ion permeability, a critical property of battery separators. In my opinion, this would have motivated the POSITA because Murakami teaches reducing pore size variability because it facilitates uniform ion transport across the entire separator, material. (EX1005, ¶ [0099]), a necessary condition for achieving high ion transport.

158. In my opinion, a POSITA would have had a reasonable expectation of success incorporating Tanaka's D10/D90 pore size ratio (i.e. pore size distribution coefficient) into Murakami's separator. Tanaka describes a technique specifically to "control" the D10/D90 ratio to have "a desired value." This involves a process of heating at moderate temperatures (95°C to 115°C) followed by cooling in order to reduce the contraction of the pores. EX1009, ¶ [0020].

159. A POSITA would be motivated to try the same type of process to influence the pore size distribution coefficient and thus the permeability characteristics of Murakami's porous layer.

160. Notably, as part of the process to form the porous layer, Murakami teaches heating up to 120°C—i.e., similarly moderate temperatures to those used by Tanaka. EX1005, ¶ [0087]. Murakami also teaches this heating achieves the same objective as Tanaka's heating treatment, which is to control the pore size distribution, and thereby "to avoid a decrease in air permeability caused by shrinkage of pores in the porous film." *Id.* Thus, in my opinion, a POSITA could have

incorporated Tanaka's heating process as part of Murakami's process, to control of the pore size distribution coefficient to Tanaka's desired ranges when forming the porous layer.

161. Accordingly, it is my opinion that Murakami and Tanaka render obvious claims 4 and 13.

**XII. GROUNDS 4-6: MURAKAMI, MURAKAMI/HONDA, AND
MURAKAMI/TANAKA—FURTHER IN VIEW OF BEARD—
RENDER OBVIOUS THE CHALLENGED CLAIMS**

162. Patent Owner may contend that Murakami does not disclose or suggest Elements [1.3]'s and [10.9]'s requirement that "*the porous film comprises pores formed by the binder*" and/or Element [1.4]'s and [10.9]'s requirement that "*the pores at least comprises a part of the inorganic particles.*" While Patent Owner would be incorrect for the reasons discussed above in Sections IX.A.5, IX.A.6, IX.H.5, and IX.H.5, in my opinion, Beard separately discloses this feature and provides rationale to incorporate it into Murakami's porous layer with a reasonable expectation of success.

163. Accordingly, for the reasons below, my opinions are as follows: (1) Murakami and Beard render obvious challenged 1, 2, 5-11, and 14-19; (2) Murakami/Honda and Beard render obvious claims 3 and 12; and (3) Murakami/Tanaka and Beard render obvious claims 4 and 13. For the remaining

claim elements not addressed below, I incorporate by reference my analysis for those elements above in Grounds 1-3.

A. Beard discloses Elements [1.3] and [10.8]

164. Beard describes “[a] porous membrane [that] may have a high concentration of spherical fillers with a polymer binder.” EX1010, Abstract. Beard also teaches that the filler particles may be inorganic materials like ceramic, glass, oxide, or metal. *Id.*, ¶ [0013]; *see also* ¶ [0036] (“The membrane 202 is filled with TiO₂ particles). Beard further teaches that its porous membrane can be used in “an electrochemical cell, such as a battery,” where “a highly filled membrane may be used as a separator between an anode and cathode.” *Id.*, ¶ [0033].

165. In Figure 1 below, Beard “show[s] a cross section of porous material that may have filler material.” *Id.*, ¶ [0017]. As highlighted, *the porous film* (porous membrane) *comprises pores formed by the binder* (polymer binder 108):

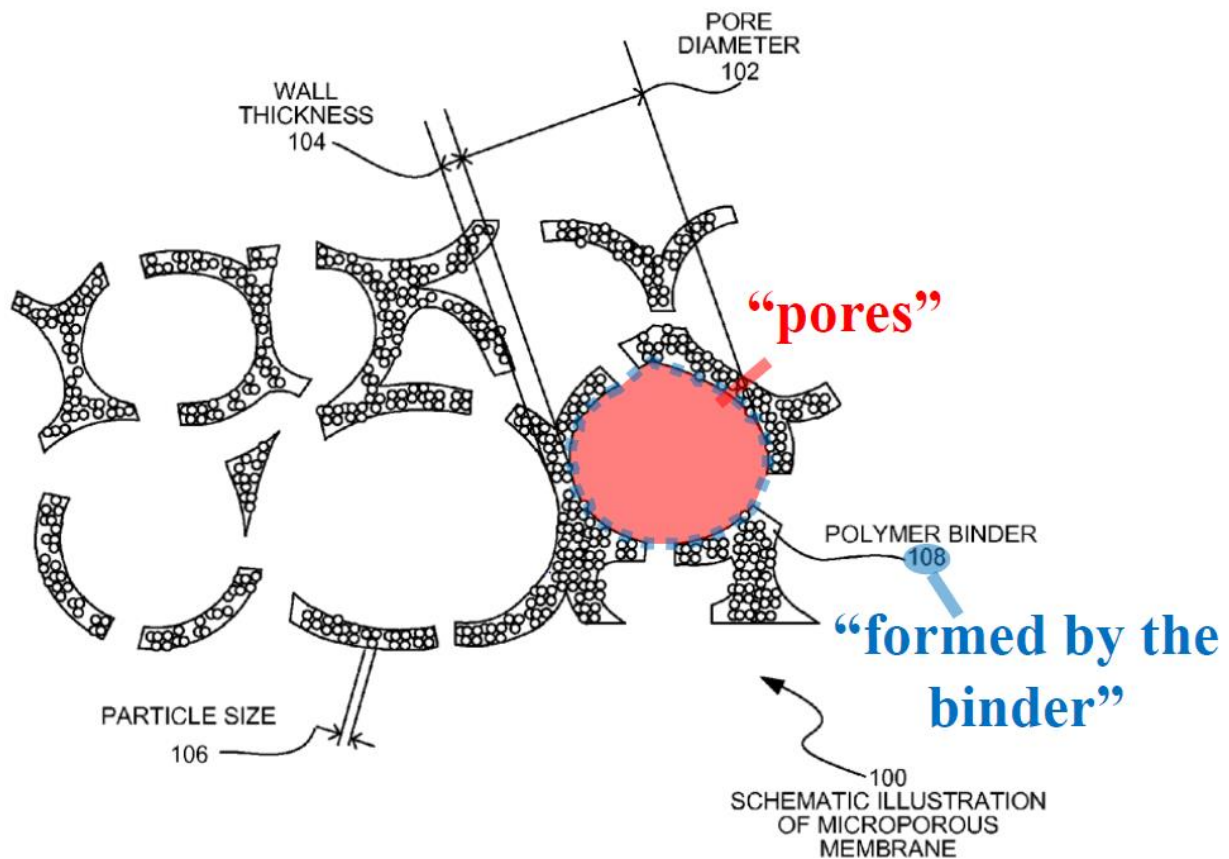


FIG. 1

Beard, FIG. 1*¹⁰

166. **Pores:** By definition, Beard’s *microporous* layer comprises *pores*. Beard teaches that the microporous layer has certain porosity, pore sizes (i.e., diameters), and pore wall thicknesses. See, e.g., EX1010, ¶¶ [0010]-[0012], [0030]-

¹⁰ I use an asterisk to indicated annotated or otherwise modified figures from the references.

[0031] (discussing porosity), [0020], [0027], [0031], [0038] (discussing pore diameter), [0011]-[0012], [0021], [0028], [0031] (discussing pore wall thickness).

167. ***Formed by the binder:*** The pores in Beard's porous membrane are formed *by the binder* (i.e., the polymer binder), as claimed. This is apparent from Figure 1 of Beard, which shows polymer binder 108 defining the pore voids. In my opinion, Beard also expressly teaches by explaining that the manufacturing process melts or dissolves the polymer, mixes the polymer with a pore-forming agent and filler material, and then solidifies it. EX1010, ¶¶ [0057]-[0060]. The pore-forming agent is removed "after solidification begins," leaving behind the porous layer—i.e., pores created by the binder. *Id.*, ¶ [0059]. The pore forming agent, as taught by Beard, is a solvent for the binder polymer. It is specifically a relatively poor solvent that tends to induce coagulation of the binder polymer or phase separation of the polymer binder upon cooling. *Id.*, ¶¶ [0057]-[0059].

168. According to Beard, two main factors—the amount of pore-forming agent and degree of thermodynamic energy required to wet the polymer—control how the pores in the porous layer are *formed by the binder*:

In general, any liquid in which a polymer is dissolved, dispersed or otherwise deployed may be used to create a microporous structure upon cooling and/or drying if the polymer precipitates or gels into a diffuse physical network. Two factors may control the pore formation:

1. The amount of pore forming liquid (i.e., a liquid with low solvating power toward the polymer phase and/or low miscibility with any high strength solvents that are present) within the polymer solution or melt.
2. The degree of the thermodynamic energy required for the liquid to wet the polymer gel or solid phase material.

When high levels of a liquid with a high level of thermodynamically unfavorable wetting towards the polymer is used in the formation process, the liquid may provide higher levels of porosity in the membrane as a result of the liquid/solid interactions. However, ... [this] may not only provide higher total void content but may also provide larger pore geometries as the thermodynamic properties of such polymer solutions resist shrinkage more effectively upon liquid removal.

EX1010, ¶¶ [0066]-[0069].

169. Not only does Beard's porous membrane contain *pores formed by the binder* as claimed, but Beard forms those pores through a solvent/nonsolvent coagulation process like that described in the '148 Patent, as well as in both Murakami and Honda. As discussed, the NIPS process described in the '148 Patent specification involves coating a binder, dissolved in a first solvent, on a substrate and immersing the coating in a solution containing another poor (unfavorable)

solvent (i.e. a nonsolvent). EX1001, 6:16-32. This extracts the first solvent into the other nonsolvent, coagulating the binder to form pores. *Id.* Similarly, Beard uses a “liquid pore forming agent,” which is a poor solvent or non-solvent from which the polymer binder coagulates (separates) to form the porous structure.

170. Beard teaches different ways to carry out the coagulation, or NIPS, process for forming a porous structure. One method uses a mixture of a good solvent and a poor solvent (i.e. nonsolvent), and the other involves changing the quality (good or poor) of a solvent by changing the temperature. EX1010, ¶¶ [0057]-[0060] Both of these methods of carrying out a phase inversion (i.e., phase separation, coagulation, or NIPS) process were well known in the art of battery separators, as well as more broadly, as a way to produce porous materials and other microstructured materials for a wide range of applications.

171. Beard explains that, in this type of process, a change in the energy of interaction between the solvent and the polymer, from a favorable interaction to an unfavorable interaction, brings about a separation of the polymer from the solvent (coagulation), which leads to the formation of a solid porous structure. This change in energy can occur by changing the composition of a mixed solvent to reduce the amount of good solvent and increase the influence of the poor solvent (as described by Honda, EX1007, ¶¶ [0083]-[0088]). This can occur when a wet film is immersed in a poor solvent (as is done in the '148 patent), or when one component of a mixed

solvent evaporates faster than the other (as described by Murakami, EX1005, ¶ [0087]). This can also occur or by changing the temperature, since the energy of interaction of a solvent with a polymer is a function of temperature. EX1010, ¶¶ [0057]-[0060] The interaction energy tends to become less favorable as the temperature is lowered:

In some embodiments, the surface free energy of the liquid in the forming process may change during the formation. For example, the liquid may be heated or cooled during the forming process, and the Surface free energy of the liquid may change during the heating or cooling process. In another example, a liquid having two different components may change surface free energy as one of the components is driven off during the formation process. In an example using acetone and water to form a PVDF membrane, the liquid consisting of acetone and water may change Surface free energy when the acetone is evaporated off, leaving the water. In such an example, the Surface free energy prior to formation may be a combination of the acetone and water, while the surface free energy after the formation process may be that of water alone.

Id., ¶ [0060].

172. The variant described by Beard using a mixed solvent, which changes its energy of interaction with the polymer as its composition changes, is the same general type of coagulation or phase inversion process taught by the '148 patent, and by Murakami and by Honda. Beard allows for both methods (mixed solvent and temperature changes) of solidifying a polymer binder from solution to form a microporous structure. EX1010, ¶¶ [0057]-[0060].

173. Accordingly, it is my opinion that Beard discloses elements [1.3] and [10.8].

B. Beard discloses Elements [1.4] and [10.9]

174. In my opinion, Beard also teaches Elements [1.4] and [10.9] in two ways. First, Beard's *pore walls* comprise a part of the inorganic filler, as highlighted in Figure 1 below:



Beard, FIG. 1*

175. As seen above, “fillers are very tightly packed *into the pore walls* of [the] microporous membrane.” EX1010, ¶ [0012]; *see also* ¶¶ [0010] (“*Within the pore walls*, a highly packed spherical filler material may be bound with a polymer.”), [0003] (“*Within the pore walls... , a densely packed filler material...*”). Describing the way Beard’s pores walls comprise inorganic filler, Beard explains that “smaller fibrous particles may be captured inside the polymer binder 108[.]” EX1010, ¶ [0025]. Thus, Beard’s pore walls comprise densely packed, smaller filler particles.

176. Second, Beard’s pore voids comprise at least some filler material. The ’148 Patent provides no information about what it means for pores to at least

comprise a part of the inorganic particles besides repeating the claim language. See, *e.g.*, EX1001, Abstract, 1:45-50. And the broad claim language does not require the inorganic particles to be inside the pore voids themselves. Regardless, even if such an interpretation were adopted, Figure 1 of Beard shows at least some inorganic filler particles protruding beyond the pore wall and into the void itself:

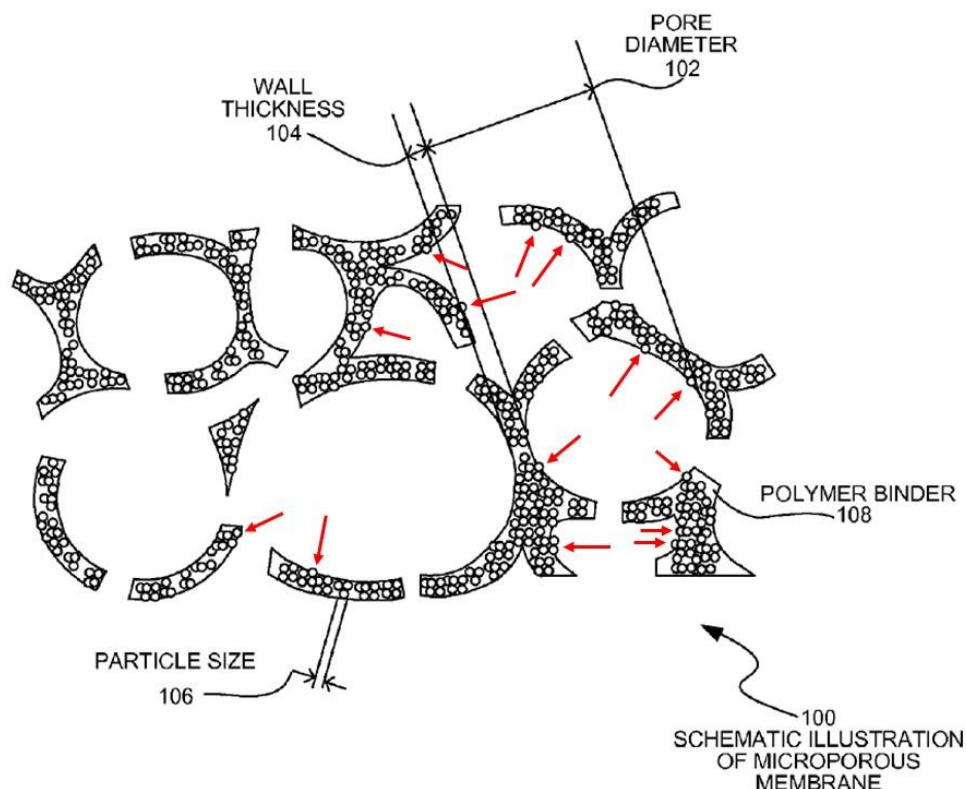


FIG. 1

Beard, FIG. 1*

Additionally, although the particles shown in Figure 1 above do not appear to be “fibrous,” Beard explains that “larger fibrous particles, greater than 1 micron may extend through, across or between the pores creating a porous fibrous network

independent of the fillers deployed within the polymer membrane walls that surround the larger fibrous particles.” EX1010, ¶ [0025]. I note that the claim language of the ’148 Patent recites generic inorganic particles and thus does not require the inorganic particles to be fibrous or non-fibrous. The term “fibrous” implies a rod-like particle shape, which is considerably longer than it is wide. Beard teaches that the particles may be “glass.” EX1010, ¶ [0013]. Glass generally refers to an inorganic silica material, which is a particle material claimed by the ’148 Patent. EX1001, claim 14. A common form of glass used as a filler are finely chopped glass fibers, which are fibrous.

177. Accordingly, it is my opinion that Beard discloses or suggests elements [1.4] and [10.9].

C. Rationale to Combine Murakami and Beard

178. In my opinion, a POSITA would have been motivated, with a reasonable expectation of success, to implement, in Murakami’s porous layer, Beard’s porous membrane structure with inorganic particles densely packed in the pore walls. Initially, Beard is analogous art to Murakami and the ’148 Patent because Beard also relates to the same field of endeavor—separators for lithium-ion batteries. *See, e.g.*, EX1001, 1:29-37, 2:38-46; EX1010, ¶¶ [0002], [0009], [0030], [0033].

179. Beard explains that “[g]ood results may be achieved when the solid particles are contained exclusively or largely within the pore walls and when an

open, continuous pore structure is provided throughout the film.” EX1010, ¶ [0086]. Specifically, “incorporating high levels of desirable filler additives...may have the following properties: high levels of porosity, uniform pore distribution, well defined and controlled pore geometry, and high film strength, including good bond between filler particles and polymers.” EX1010, ¶ [0065]. Beard notes that its “highly filled membrane,” when used as a battery separator, helps prevent the porous structure from melting and collapsing, resulting in a “catastrophic release of energy” in a short circuit. *Id.*, ¶ [0033]. Based on these teachings and the desire to achieve Beard’s “good results,” a POSITA would have wanted to implement Beard’s pore structure, densely packed with particles, in Murakami. This would provide a separator with improved porosity, pore distribution, and pore geometry while ensuring high mechanical strength to prevent collapse of the separator and a resulting short circuit.

180. In my opinion, a POSITA would have had a reasonable expectation of success in combining Murakami and Beard. For example, Beard teaches that “[t]he manufacturing process” for the porous membrane “may suspend the filler material and the polymer in the pore forming agent, then solidify the polymer and filler material with the pore forming agent present.” EX1010, ¶ [0057]. “After the polymer begins to gel, the pore forming agent may be removed.” *Id.*; *see also id.*, ¶¶ [0058]-[0059]. Similarly, in Murakami’s process to form the porous layer, “the resin can be dispersed in the solvent” (EX1005, ¶ [0071]), which “dissolves the resin uniformly

and stably” and “disperses the filler uniformly and stably” (*id.*, ¶ [0072]). The solvent is then removed to form the porous layer. *Id.*, ¶ [0087]. Thus, to the extent that Murakami’s process does not already create a pore structure with inorganic particles densely packed within the pore walls as taught by Beard, a POSITA would have been able to utilize Murakami’s and Beard’s disclosures to do so.

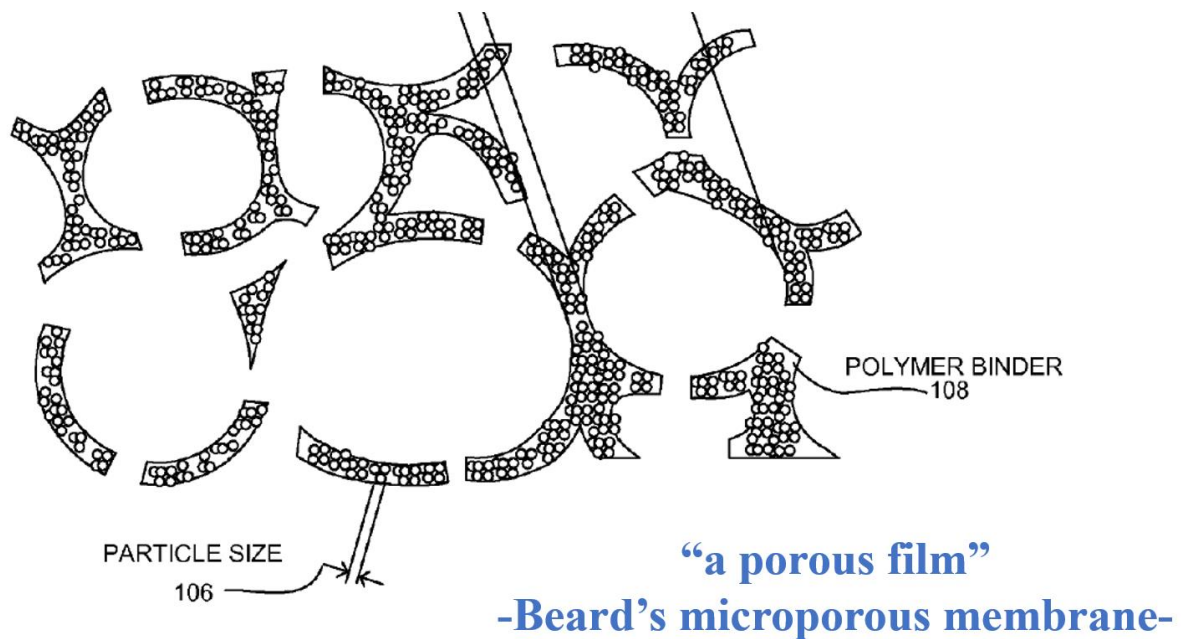
181. Accordingly, in my opinion, Murakami in view of Beard render obvious challenged claims 1, 2, 5-11, and 14-19. For the same reasons, Murakami and Beard, further combined with Honda, render obvious challenged claims 3 and 12. And, likewise, Murakami and Beard, further combined with Tanaka, render obvious challenged claims 4 and 14.

XIII. GROUND 7: BEARD AND AKIIKE RENDER OBVIOUS CLAIMS 1-3, 5-12, AND 14-19

A. Independent Claim 1

1. [1.pre]: “*A porous film, comprising:*”

182. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses a “microporous membrane” (*porous film*). EX1010, ¶¶ [0009], [0012], [0043], [0050]-[0053]; *see also id.*, Abstract, ¶¶ [0001], [0010]. Beard’s “[m]icroporous polymer membranes [are] suitable for battery separators[.]” EX1010, ¶ [0065].



EX1010, FIG. 1*

183. Accordingly, it is my opinion that Beard discloses element [1.pre].

2. [1.1]: “a binder; and”

184. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses that the porous membrane 100 has “a polymer binder,” disclosing the claimed *binder*. EX1010, Abstract; *see also id.*, ¶¶ [0003], [0025], [0026], [0033], [0054], [0057] (discussing the polymer binder):

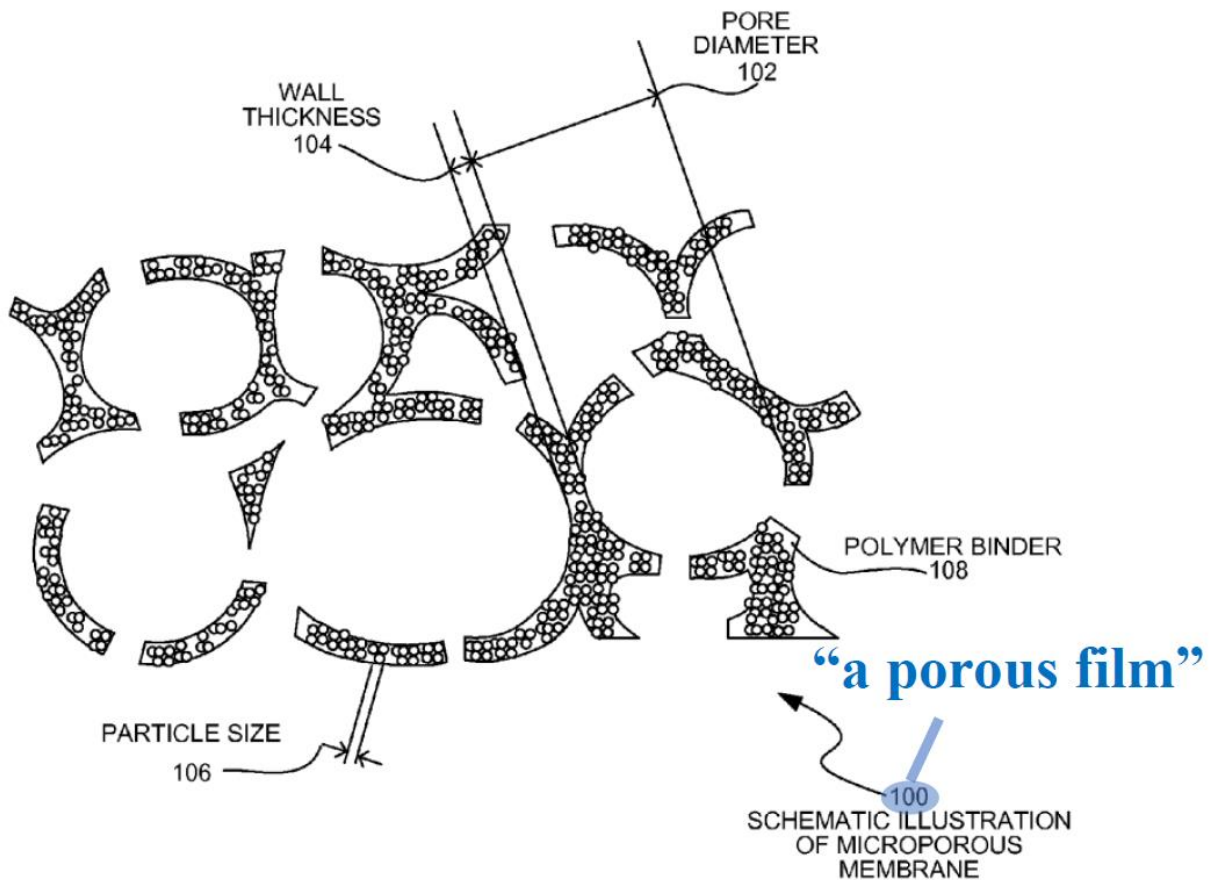


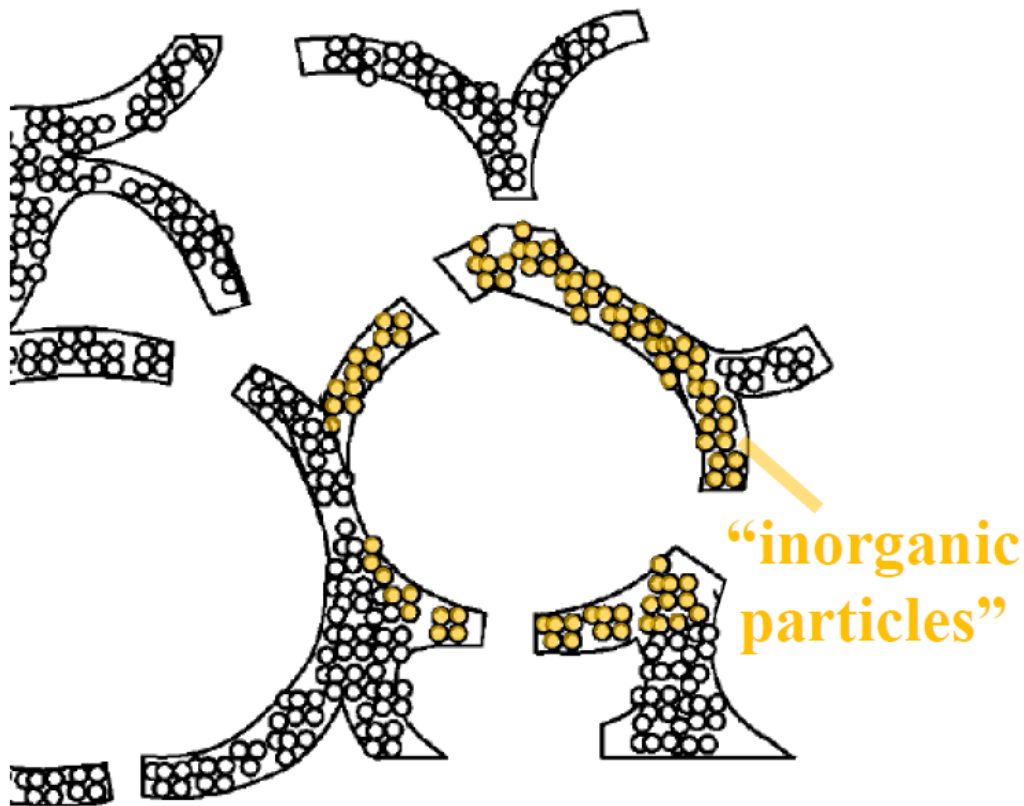
FIG. 1

Beard, FIG. 1*

185. Accordingly, it is my opinion that Beard discloses element [1.1].

3. [1.2]: “*inorganic particles*,”

186. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses that the polymer binder contains “a high concentration of spherical fillers,” corresponding to the claimed *inorganic particles*. EX1010, Abstract; see also *id.*, ¶¶ [0003], [0010]-[0013] (discussing the filler material).



Beard, FIG. 1*

187. Beard discloses that the spherical filler particles can be *inorganic particles*, as claimed. For example, Beard teaches that “[t]he filler materials may be any solid material, such as ceramic, glass, oxide, carbon, composite, plastic, polymer composite, metal, cellulose in any shape or morphology” and “the particles may be spherical or nearly spherical in shape.” EX1010, ¶ [0013]. At least ceramic, glass, oxide, and metal are inorganic materials.

188. Moreover, Beard explains that when using the porous membrane as a battery separator, “[t]he filler material, presumably manufactured from a higher

temperature material, may serve to” prevent a short circuit and thermal runaway in the case of battery failure. EX1010, ¶ [0033]. Inorganic materials, like the examples listed in Beard, withstand the high temperatures generated by batteries. Moreover, Beard’s examples used TiO₂ (an inorganic material) particles as the filler material. *Id.*, ¶ [0054]; *see also id.*, ¶¶ [0036]-[0037], [0049]-[0050], claim 14 (disclosing and claiming the use of TiO₂ as the filler material). Thus, Beard discloses *inorganic particles*, and in my opinion renders their use obvious in the context of a porous membrane for a battery separator.

189. Accordingly, it is my opinion that Beard discloses element [1.2].

4. [1.3]: “*wherein the porous film comprises pores formed by the binder,*”

190. In my opinion, for the results discussed above, Beard discloses or suggests this element. *Supra* Section XII.A.

5. [1.4]: “*the pores at least comprises a part of the inorganic particles,*”

191. In my opinion, for the results discussed above, Beard discloses or suggests this element. *Supra* Section XII.B.

6. [1.5]: “*wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm ,*”

[1.6]: “*Dv50 is in a range of 0.2 μm to 5 μm , and*”

[1.7]: “*Dv90 is in a range of 1 μm to 10 μm ;*”

192. In my opinion, Beard does not specify particle size distributions of its inorganic filler particles. Akiike, however, discloses a porous membrane with inorganic particle size distributions falling in the claimed ranges, and provides motivation to use those particle size distributions for Beard’s inorganic filler.

a. Akiike discloses elements [1.5]-[1.7]

193. Akiike teaches the use of “non-conductive particles” and that “[a]s such non-conductive particles, any of inorganic particles and organic particles may be used.” EX1011, ¶ [0038].

194. In my opinion, Akiike discloses or suggest these claim elements. As an initial matter, while terms like D10, D50, and D90 may sometimes refer to different types of cumulative distributions (e.g., volume or weight) of particles, Akiike always uses these terms to refer to “cumulative *volume*” distributions—i.e., the claimed *Dv10*, *Dv50*, and *Dv90*, respectively. *See, e.g.*, EX1011, ¶¶ [0010], [0031]-[0033], claim 2.

195. Akiike also always uses the D values to refer the distribution of the *non-conductive particles* in the porous membrane—i.e., the claimed *inorganic particles*

discussed above. *See, e.g., id.*, ¶¶ [0010] (“an accumulated particle size distribution of the *non-conductive particles* ... a particle diameter D90”), [0033] (“D90 herein represents a diameter ... in the accumulated particle size distribution of the *non-conductive particles*”), [0036] (“D90 of the *non-conductive particles* in the porous membrane”), [0037], [0048], [0049] (“D90 of the *non-conductive particles*”), [0194] (“D90 of *Non-Conductive Particles*”).

196. Akiike’s general disclosure specifies ranges for D10, D50, and D90 substantially overlapping the claimed *Dv10*, *Dv50*, and *Dv90*:

D10	Preferably	0.2 μm to 0.4 μm	EX1011, ¶ [0031]
	More preferably	0.3 μm to 0.4 μm	
D50	Preferably	0.5 μm to 0.9 μm	EX1011, ¶ [0032]
	More Preferably	0.7 μm to 0.9 μm	
D90	Preferably	1.0 μm to 3.0 μm	EX1011, ¶ [0033]
	More preferably	1.2 μm to 2.0 μm	
	Further preferably	1.2 μm to 2.0 μm	

197. Thus, in my opinion, Akiike discloses or suggests the claimed ranges.

198. Separately, all Akiike’s Examples exhibit *Dv10*, *Dv50*, and *Dv90* values within the respective claimed ranges of *0.015 μm to 3 μm*, of *0.2 μm to 5 μm*, and *1 μm to 10 μm*:

Akiike’s Example	D10 (μm)	D50 (μm)	D90 (μm)
-------------------------	-----------------	-----------------	-----------------

1	0.39	0.87	1.38
2	0.33	0.71	1.25
3	0.39	0.87	1.38
4	0.39	0.87	1.38
5	0.39	0.87	1.38
6	0.39	0.87	1.38
7	0.39	0.87	1.38
8	0.39	0.87	1.38
9	0.39	0.87	1.38
10	0.31	0.72	1.01
11	0.39	0.87	1.38
12	0.39	0.87	1.38
13	0.38	0.88	1.41
14	0.32	0.72	1.22
Comp. Ex. 1	0.39	0.87	1.38
Comp. Ex. 2	0.39	0.87	1.38
Comp. Ex 3	0.39	0.87	1.38

See EX1011, Tables 1-5. Thus, in my opinion, Akiike's Examples render the claimed ranges obvious.

b. Rationale to combine Beard and Akiike

199. For the reasons discussed below, it is my opinion that a POSITA would have found it obvious to combine Beard and Akiike so Beard's inorganic particles have particle sizes in which Dv10 is in a range of 0.015 μm to 3 μm , Dv50 is in a range of 0.2 μm to 5 μm , and Dv90 is in a range of 1 μm to 10 μm , as claimed.

200. In my opinion, the references provide teaching, suggestion, and motivation to do so. Beard explains that its membrane contains “a highly packed spherical filler material ... bound with a polymer” in the pore walls. EX1010, ¶ [0010]. Beard also mentions that “the filler particle size may be on the order of 0.001 microns or more,” but does not provide size distributions—volumetric or otherwise—of the filler particles. *Id.*, ¶ [0011]. Lacking these implementation details, it is my opinion that a POSITA would have looked to a similar separator porous membrane reference like Akiike for guidance on the appropriate size distributions for Beard’s filler particles.

201. Akiike recommends inorganic particles because “[i]norganic particles have excellent dispersion stability” and “inorganic particles can usually increase heat resistance.” EX1011, ¶ [0039]. Beard lists high temperature stability as a goal of adding inorganic particles. EX1010, ¶ [0033]. Beard teaches a coating process requiring dispersion of the particles: “[t]he manufacturing process may suspend the filler material and the polymer in the pore forming agent.” *Id.*, ¶ [0057]. Thus, it is my opinion that a POSITA would be motivated to combine Beard with Akiike to achieve dispersion stability and heat resistance. Akiike teaches using the same type of inorganic particles as Beard, specifically “titanium oxide (titania)” (EX1011, ¶ [0039]) which Beard refers to as TiO_2 (EX1010, ¶¶ [0036], [0054]), further enhancing the motivation to combine.

- **Motivation for Dv10 in a range of 0.015 μm to 3 μm**

202. As discussed above, Akiike discloses that D10 (*Dv10*) of its non-conductive particles (*inorganic particles*) is “preferably 0.2 μm or more and more preferably 0.3 μm or more, and preferably 0.4 μm or less,” Consistent with Akiike’s Examples. EX1011, ¶ [0031]. Keeping D10 (*Dv10*) values above this minimum size reduces the number of inorganic particles with “extremely small sizes,” improving “battery properties such as high temperature cycle property.” *Id.* Reducing the number of extremely small particles also reduces “resistance against the passage of ions through the porous membrane” and decreases overall surface area of the membrane, which reduces water absorption and thereby reduces corrosion. *Id.*, ¶ [0034]. Keeping D10 (*Dv10*) values under 0.4 μm , on the other hand, reduces the number of extremely large inorganic particles, improving mechanical strength and heat resistance of the porous membrane. *Id.*, ¶¶ [0031]-[0034]. Accordingly, it is my opinion that a POSITA would have been motivated to use inorganic particles such that *Dv10 is in a range of 0.015 μm to 3 μm* , as claimed.

- **Motivation for Dv50 in a range of 0.2 μm to 5 μm**

203. As discussed above, Akiike discloses that D50 (*Dv50*) of its non-conductive particles (*inorganic particles*) is “preferably 0.5 μm or more and more preferably 0.7 μm or more, and preferably 0.9 μm or less,” consistent with Akiike’s Examples. EX1011, ¶ [0032]. Keeping D50 (*Dv50*) values above a floor of 0.5 μm

and preferably above 0.7 μm also reduces the number of inorganic particles with “extremely small sizes,” improving “battery properties such as high temperature cycle property.” *Id.* On the other hand, keeping D50 (*Dv50*) values below a ceiling of 0.9 μm reduces the number of extremely large inorganic particles, improving mechanical strength and heat resistance of the porous membrane. *Id.* Accordingly, it is my opinion that a POSITA would have been motivated to use inorganic particles such that *Dv50 is in a range of 0.2 μm to 5 μm* , as claimed.

- **Motivation for Dv90 in a range of 1 μm to 10 μm**

204. As discussed above, Akiike discloses that D90 (*Dv90*) of its non-conductive particles (*inorganic particles*) is “preferably 1.0 μm or more and more preferably 1.2 μm or more, and preferably 3.0 μm or less,” consistent with Akiike’s Examples. EX1011, ¶ [0033]. Again, Akiike explains that keeping D90 of the inorganic particles within these bounds reduces the number of very large and very small inorganic particles, improving temperature cycling, mechanical strength, and heat resistance of the porous membrane. *Id.* Akiike also teaches that reducing the number of extremely large inorganic particles allows denser packing of the inorganic particles in the porous membrane, providing “excellent mechanical strength, heat resistance, and electrical insulation...” *Id.*, ¶ [0035]. Accordingly, it is my opinion that a POSITA would have been motivated to use inorganic particles such that *Dv90 is in a range of 1 μm to 10 μm* , as claimed.

- **Reasonable expectation of success**

205. In my opinion, a POSITA would have had a reasonable expectation of success in using Akiike's particle size distributions in Beard's porous membrane. For example, both Beard and Akiike use a polymer binder. *Compare* EX1010, ¶ [0025] *with* EX1011, ¶ [0067]. Beard teaches that its "polymer binder ... ha[s] an affinity for the filler materials and may hold the filler materials together in a porous structure with high tortuosity and consistent pore size" (EX1010, Abstract) and identifies TiO₂ as an example filler material (*id.*, ¶ [0023]). Akiike also identifies titania (which is TiO₂) as a suitable inorganic filler. EX1011, ¶ [0039] ("titanium oxide (titania)"). Therefore, in my opinion, a POSITA would expect Beard's binder to have an affinity for Akiike's inorganic particles, resulting in a separator that performs as the references describe.

206. Accordingly, it is my opinion that Beard and Akiike render obvious element [1.7].

7. [1.8]: “*Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and*”

[1.9]: “*Dv50 of the inorganic particles is less than Dv90 of the inorganic particles, and*”

[1.10]: “*the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.*”

207. In my opinion, the above-described combination of Beard and Akiike renders elements [1.8] to [1.10] obvious. First, in all Akiike’s disclosed preferred ranges, the ranges for D10 fall below the ranges for D50, and the ranges for D50 fall below the ranges for D90:

D10	Preferably	0.2 μm to 0.4 μm	EX1011, ¶ [0031]
	More preferably	0.3 μm to 0.4 μm	
D50	Preferably	0.5 μm to 0.9 μm	EX1011, ¶ [0032]
	More Preferably	0.7 μm to 0.9 μm	
D90	Preferably	1.0 μm to 3.0 μm	EX1011, ¶ [0033]
	More preferably	1.2 μm to 2.0 μm	
	Further preferably	1.2 μm to 1.5 μm	

208. Separately, the particle size distributions in all Akiike’s Examples, which would have been obvious to implement in Beard for the reasons above, satisfy these claim elements:

Akiike’s Example	D10 (μm)	D50 (μm)	D90 (μm)	D90/D10
1	0.39	0.87	1.38	3.54
2	0.33	0.71	1.25	3.79

Akiike's Example	D10 (μm)	D50 (μm)	D90 (μm)	D90/D10
3	0.39	0.87	1.38	3.54
4	0.39	0.87	1.38	3.54
5	0.39	0.87	1.38	3.54
6	0.39	0.87	1.38	3.54
7	0.39	0.87	1.38	3.54
8	0.39	0.87	1.38	3.54
9	0.39	0.87	1.38	3.54
10	0.31	0.72	1.01	3.26
11	0.39	0.87	1.38	3.54
12	0.39	0.87	1.38	3.54
13	0.38	0.88	1.41	3.71
14	0.32	0.72	1.22	3.81
Comp. Ex. 1	0.39	0.87	1.38	3.54
Comp. Ex. 2	0.39	0.87	1.38	3.54
Comp. Ex 3	0.39	0.87	1.38	3.54

See EX1011, Tables 1-5.

209. As discussed above, it is virtually impossible for claim elements [1.8] and [1.9] not to be satisfied by any particle size distribution. *Supra* Sections IX.A.7, IX.A.8.

B. Dependent Claim 2

1. [2.1]: “*The porous film according to claim 1, wherein the porous film has an average pore size of 0.3 μm to 20 μm .*”

210. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses that “[t]he pore diameter 102 may vary from 0.01 to 10 microns, with a typical size of 0.1 to 1 micron.” EX1010, ¶ [0020]. At least in a general sense, a POSITA could reasonably consider Beard’s “typical” size to be an “average” size, and that range of 0.1 to 1 micron overlaps the claimed range.

211. Accordingly, it is my opinion that Beard discloses claim 2.

C. Dependent Claim 3

1. [3.1]: “*The porous film according to claim 1, wherein the average wall thickness between the pores is in a range of 20 nm to 500 nm.*”

212. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses that “[t]he pore wall thickness may be on the order of 0.02 microns.” EX1010, ¶ [0011]. This pore wall thickness corresponds to 20 nm. Beard further discloses that “[t]he wall thickness 104 may vary from 0.01 to 0.05 microns,” which corresponds to 10 nm to 50 nm, falling within the claimed range. *Id.*, ¶ [0021].

213. Accordingly, it is my opinion that Beard discloses claim 3.

D. Dependent Claim 5

1. [5.1]: “*The porous film according to claim 1, wherein the inorganic particles are at least one selected from the group consisting of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.*”

214. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses that TiO₂ (*titanium oxide*) was used as a filler particle (*inorganic particle*) in every example. EX1010, ¶ [0054]; *see also id.*, ¶¶ [0036], [0049], [0050], claim 14. Claim 3 of Beard also recites that the filler may be “ceramic, glass, oxide, carbon, composite, plastic, polymer composite, metal, and cellulose.”

215. Beard teaches inorganic particles but provides a limited set of examples, and no specific compounds, just classes of compounds, such as ceramics, oxides and glasses. If needed, in my opinion, a POSITA attempting to implement Beard would look to Akiike for examples of ceramics, oxides and glasses to use as fillers. Akiike specifies ceramics:

aluminum oxide (alumina), aluminum oxide hydrates (boehmite (AlOOH), aluminum hydroxide ($\text{Al}(\text{OH})_3$)), silicon oxide, magnesium oxide (magnesia), magnesium hydroxide, calcium oxide, titanium oxide (titania), BaTiO_3 , ZrO , and an alumina-silica complex oxide; particles of nitrides such as aluminum nitride and boron nitride.

EX1011, ¶ [0039]. Akiike specifies oxides: “aluminum oxide (alumina), aluminum oxide hydrates (boehmite (AlOOH), aluminum hydroxide ($\text{Al}(\text{OH})_3$)), silicon oxide, magnesium oxide (magnesia), magnesium hydroxide, calcium oxide, titanium oxide (titania), BaTiO_3 , ZrO , and an alumina-silica complex oxide.” *Id.* Akiike specifies glasses: “silicon oxide.” *Id.*

216. Beard combined with Akiike teaches many of the same inorganic particles as claimed by the '148 patent:

preferable examples of inorganic materials of the non-conductive particles may include particles of oxides such as aluminum oxide (alumina), aluminum oxide hydrates (boehmite (AlOOH), aluminum hydroxide ($\text{Al}(\text{OH})_3$)), silicon oxide [i.e. silica], magnesium oxide (magnesia), magnesium hydroxide, calcium oxide, titanium oxide (titania)... barium sulfate....

Id., ¶ [0039].

217. Accordingly, it is my opinion that Beard alone or in combination with Akiike discloses claim 5.

E. Dependent Claim 6

1. [6.1]: “*The porous film according to claim 1, wherein the binder is at least one selected from the group consisting of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.*”

218. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses that PVDF (*polyvinylidene fluoride*) was used as a binder. EX1010, ¶ [0054] (“Several example materials have been manufactured using PVDF polymer binder with TiO₂ fillers using a two-liquid casting process.”). *See also id.*, ¶ [0014], (“The membrane may use various polymers, such as polyethylene, polypropylene, PET, PVDF, acrylic, PVC, amide, or other polymers.”). In addition to PVDF, “acrylic” is a category of polymers that includes the claimed binder materials *polyacrylate, polyacrylic acid, polyacrylic acid salt*, and “amide” refers to *polyamide* as claimed.

219. Accordingly, it is my opinion that Beard discloses claim 6.

F. Dependent Claim 7

1. [7.1]: “*The porous film according to claim 1, wherein the porous film has a porosity of 20% to 90%.*”

220. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses that its microporous membrane (*porous film*) “may have a porosity of greater than 50%[.]” EX1010, ¶ [0011]. Beard further discloses that “an example membrane may have 70% voids[.]” *Id.*, ¶ [0029]. In each of Beard’s Examples, samples had “voids percentages from 69-81%.” *Id.*, ¶ [0054]. Each of these disclosures falls in or overlaps the claimed porosity range of 20% to 90%.

221. Accordingly, it is my opinion that Beard discloses claim 7.

G. Dependent Claim 8

1. [8.1]: “*The porous film according to claim 1, wherein the porous film has a thickness of 0.2 to 10 μm .*”

222. Beard does not expressly disclose a thickness for its porous membrane, so a POSITA looking to create Beard’s separator would have looked to Akiike for implementation details. And Akiike teaches several preferred thickness ranges for its porous membrane—all overlapping or falling within the claimed thickness range:

The thickness of the porous membrane is preferably 0.1 μm or more, more preferably 0.2 μm or more, and particularly preferably 0.3 μm or more, and is preferably 20 μm or less, more preferably 15 μm or less, and particularly preferably 10 μm or less. By adjusting the thickness of the porous membrane to the lower limit value or more of the aforementioned range, heat resistance of the porous membrane can be further improved. On the other hand, by adjusting it to the upper limit value or less, reduction of ion permeability caused by the porous membrane can be reduced.

EX1011, ¶ [0155]. Notably, the most preferred range of 0.3 μm to 10 μm falls entirely within the claimed range.

223. Because Akiike also teaches a porous membrane for a lithium-ion battery separator, in my opinion, a POSITA would have found it obvious to make Beard's porous membrane have the preferred thickness disclosed by Akiike. Giving the POSITA a reasonable expectation of success, Akiike teaches that its preferred thickness ranges balance the competing benefits of heat resistance and ion permeability. *Id.* Thus, a POSITA would have expected using Akiike's disclosed thickness for Beard's separator to result in a separator having good performance in both heat resistance and lithium ion conductivity.

H. Dependent Claim 9

1. [9.1]: “*The porous film according to claim 1, wherein a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.*”

224. In my opinion, Beard discloses or suggests this element. Specifically, Beard discloses that the volume of filler (*inorganic particles*) to polymer (*binder*) “may be 1:1, 1:2, 2:1, 1:1.5, 1.5:1, or some other ratio.” EX1010, ¶ [0029]. Each of these ratios falls in the claimed range. When converted into the form used in the claim, Beard's ratios are: 1.0, 0.5, 2.0, 0.67, and 1.5.

225. Accordingly, it is my opinion that Beard discloses claim 9.

I. Independent Claim 10

1. [10.pre]: “*A lithium-ion battery, comprising:*”
[10.1]: “*a positive electrode;*”
[10.2]: “*a negative electrode;*”
[10.3]: “*a separator, arranged between the positive electrode and the negative electrode;*”
[10.4]: “*non-aqueous electrolyte; and*”

226. In my opinion, although Beard focuses on other aspects and thus has limited detail, Beard discloses, suggests, or renders obvious these conventional, inherent parts of a lithium-ion battery. For example, Beard's “FIG. 4 is a chart showing discharge power for several lithium ion batteries constructed with different microporous membranes.” EX1010, ¶ [0009]; *see also id.*, ¶ [0051] (“The discharge

power graph 402 shows the discharge capabilities of lithium ion batteries constructed with different separator materials.”). Thus, Beard discloses using its separator in a lithium-ion battery, which necessitates (and certainly renders obvious) a positive electrode, a negative electrode, and a non-aqueous electrolyte. A POSITA understands that a lithium-ion battery requires an electrolyte to function but is incompatible with water, necessitating and rendering obvious a non-aqueous electrolyte, as claimed.

227. To the extent a POSITA needed lithium-ion battery implementation details, it is my opinion that the POSITA would have looked to Akiike. And, in my opinion, Akiike discloses these claim elements. For instance, Akiike discloses a *lithium-ion battery, positive electrode, negative electrode*, separator, and electrolytic solution. EX1011, ¶ [0016] (disclosing “[a] lithium ion secondary battery comprising: a positive electrode, a negative electrode, the separator for a lithium ion secondary battery according to (7), and an electrolytic solution”). Akiike, in my opinion, therefore, discloses elements [10.pre]-[10.2].

228. Akiike, in my opinion, further discloses *a separator, arranged between the positive electrode and the negative electrode*, as claimed. *Id.*, ¶ [0157] (“[T]he lithium ion secondary battery of the present invention includes a positive electrode, the separator of the present invention, and a negative electrode in this order, ...” Accordingly, it is my opinion that Akiike also discloses element [10.3].

229. Akiike, in my opinion, further discloses a *non-aqueous electrolyte*, as claimed. *Id.*, ¶ [0183] (“As the electrolyte solution, e.g., a solution of a lithium salt as a supporting electrolyte in a non-aqueous solvent may be used.”). Accordingly, it is my opinion that Akiike discloses element [10.4].

230. A POSITA would have found it obvious to implement Beard’s porous membrane separator in a lithium-ion battery as described by Akiike in order to make a functioning battery with Beard’s separator. Beard, for instance, discloses that its porous membrane (*porous film*) can be used in “devices such as batteries,” leading a POSITA to this combination. EX1010, ¶ [0002]; *see also id.*, ¶ [0033] (Beard discloses that its porous membrane (*porous film*) “may be used as a separator between an anode and cathode.”). Akiike also prompts this combination by teaching that its lithium-ion battery uses a separator similar to that of Beard’s separator. *See, e.g.*, EX1011, ¶¶ [0016], [0138]-[0186].

231. Accordingly, in my opinion, Beard alone or in combination with Akiike discloses or renders obvious elements [10.pre] to [10.4].

2. Remaining elements [10.5] through [10.15]

232. In my opinion, Beard discloses, suggests, and/or renders obvious the remaining elements of claim 10 for the reasons discussed above for substantively identical corresponding elements of independent claim 1:

Claim 10 Element	Language	Corresponding Claim 1 Element	Analysis
[10.5]	<i>a porous film, comprising:</i>	[1.pre]	Section XIII.A.1
[10.6]	<i>a binder; and</i>	[1.1]	Section XIII.A.2
[10.7]	<i>inorganic particles;</i>	[1.2]	Section XIII.A.3
[10.8]	<i>wherein the porous film comprises pores formed by the binder,</i>	[1.3]	Section XIII.A.4
[10.9]	<i>the pores at least comprises a part of the inorganic particles,</i>	[1.4]	Section XIII.A.5
[10.10]	<i>wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm,</i>	[1.5]	Section XIII.A.6
[10.11]	<i>Dv50 is in a range of 0.2 μm to 5 μm,</i>	[1.6]	Section XIII.A.6
[10.12]	<i>Dv90 is in a range of 1 μm to 10 μm;</i>	[1.7]	Section XIII.A.6
[10.13]	<i>Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and</i>	[1.8]	Section XIII.A.7
[10.14]	<i>Dv50 of the inorganic particles is less than Dv90 of the inorganic particles; and</i>	[1.9]	Section XIII.A.7
[10.15]	<i>the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.</i>	[1.10]	Section XIII.A.7

J. Dependent Claim 19

1. [19.1]: “*The lithium-ion battery according to claim 10, wherein the porous film is arranged on a surface of at least one selected from the group consisting of the positive electrode, the negative electrode and the separator.*”

233. In my opinion, Beard discloses, suggests, or renders obvious this element. Specifically, Beard teaches that, “[i]n ... a battery,” Beard’s “highly filled [porous] membrane may be used as a separator between an anode and cathode ” to facilitate ion transfer while preventing short circuits “when the porous structure collapses” from very high temperature. EX1010, ¶ [0033]; *see also id.*, ¶¶ [0030], [0051], [0055], [0056] (discussing use of porous membrane as a battery separator). Because the porous membrane sits between the two battery electrodes, in my opinion Beard discloses or suggests claim 19.

234. Akiike also discloses this element. Specifically, Akiike teaches that “porous membrane is obtained by applying onto the organic separator layer the porous membrane slurry of the present invention and drying the slurry. In this process, the porous membrane may be formed on either one side or both sides of the organic separator layer.” EX1011, ¶ [0144]. To the extent a POSITA needed more guidance to implement Beard’s separator in a lithium-ion battery, it is my opinion that the POSITA would have looked to Akiike and, based on its teachings, found it obvious to arrange Beard’s “porous film ... on a surface of at least one selected from

the group consisting of the positive electrode, the negative electrode and the separator,” as claimed.

K. Remaining Dependent Claims 11, 12, and 14-18

235. Beard discloses, suggests, and/or renders obvious claims 11, 12, and 14-18 for the reasons discussed above for substantively identical corresponding claims 2, 3, and 5-9:

Remaining Claim Elements	Language	Corresponding Previous Claim Element	Analysis
[11.1]	<i>The lithium-ion battery according to claim 10, wherein the porous film has an average pore size of 0.3 μm to 20 μm.</i>	[2.1]	Section XIII.B.1
[12.1]	<i>The lithium-ion battery according to claim 10, wherein the average wall thickness between the pores is in a range of 20 nm to 500 nm.</i>	[3.1]	Section XIII.C.1

Remaining Claim Elements	Language	Corresponding Previous Claim Element	Analysis
[14.1]	<i>The lithium-ion battery according to claim 10, wherein the inorganic particles are at least one selected from the group consisting of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.</i>	[5.1]	Section XIII.D.1
[15.1]	<i>The lithium-ion battery according to claim 10, wherein the binder is at least one selected from the group consisting of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.</i>	[6.1]	Section XIII.E.1

Remaining Claim Elements	Language	Corresponding Previous Claim Element	Analysis
[16.1]	<i>The lithium-ion battery according to claim 10, wherein the porous film has a porosity of 20% to 90%.</i>	[7.1]	Section XIII.F.1
[17.1]	<i>The lithium-ion battery according to claim 10, wherein the porous film has a thickness of 0.2 to 10 μm.</i>	[8.1]	Section XIII.G.1
[18.1]	<i>The lithium-ion battery according to claim 10, wherein a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.</i>	[9.1]	Section XIII.H.1

XIV. GROUND 8: BEARD AND AKIIKE, FURTHER IN VIEW OF TANAKA, RENDER OBVIOUS CLAIMS 4 AND 13

A. Dependent Claims 4, 13

1. Tanaka discloses elements [4.1], [13.1]

236. See discussion above for elements [4.1], [13.1] in Ground 3. *Supra* Section XI.A.1.a.

2. Rationale to combine Beard and Tanaka

237. The same rationale discussed above for the Murakami-Tanaka combination in Ground 3 would have motivated a POSITA to combine Beard and Tanaka. *Supra* Section XI.A.1.b.

238. Additionally, Beard and Tanaka are analogous prior art. Beard relates to a porous membrane used as a separator in a lithium-ion battery, like the '148 Patent. *See, e.g.*, EX1010, ¶¶ [0030], [0033], [0050], [0051], [0054], [0056]; EX1001, 1:29-37, 2:38-46. And, as discussed, Tanaka also relates to a porous, polyolefin body used as “a separator for a lithium ion secondary cell ... and the like.” *See, e.g.*, EX1009, ¶ [0069], *see also id.*, Abstract. Thus, in my opinion, a POSITA would have looked to Beard and Tanaka for the proposed combination.

239. Beard notes that membranes “suitable for battery separators” should have “uniform pore distribution” and “high film strength.” EX1010, ¶ [0065]. This would have motivated a POSITA to look to Tanaka’s technique to tune the D10/D90 ratio for uniform pore size distribution and increased mechanical strength. *Supra* Section XI.A.1.b.

240. In my opinion, a POSITA would have had a reasonable expectation of success affecting Tanaka’s D10/D90 pore distribution size ratio in Beard’s porous membrane. As explained, Tanaka describes a technique to “control” this ratio to have “a desired value” by a heat treatment suppressing pore deformation and thereby suppressing fluctuation of pore volume and average diameter. EX1009, ¶ [0020]. In my opinion, a POSITA could have incorporated Tanaka’s technique in Beard’s manufacturing process where “the polymer may be heated ... then cooled to form the microporous structure.” EX1010, ¶ [0058]. Thus, within Beard’s existing

process, a POSITA could have, in my opinion, subjected Beard's porous membrane to a heating process, in accordance with Tanaka's teachings, to control the pore size distribution ratio.

241. In my opinion, a POSITA would have expected Tanaka's technique to work in Beard because both references teach forming their porous layers from common polymers, including polyethylene and polypropylene. *Compare* EX1010, ¶ [0014] ("various polymers, such as polyethylene, polypropylene ...") with EX1009, ¶ [0026] ("Examples of the polyolefin used ... include, but are not limited to, homopolymers of ethylene, propylene, ..."). Thus, in my opinion, a POSITA could reasonably expect Tanaka's heating and cooling technique to work with Beard's polyolefin separator, allowing control over the D90/D10 ratio as described by Tanaka.

XV. CONCLUSION

For these reasons, it is my opinion that the Challenged Claims of the '148 Patent are unpatentable.

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

Dated:

Jan 9, 2025

By:



Samuel P. Gido, Ph.D.