

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHUHAI COSMX BATTERY CO., LTD.

Petitioner

v.

MAXELL, LTD.

Patent Owner

Case IPR2023-00226

Patent No. 9,166,251

DECLARATION OF MARC JUZKOW

TABLE OF CONTENTS

EXHIBIT LIST	vii
I. INTRODUCTION	1
II. PROFESSIONAL BACKGROUND.....	1
III. COMPENSATION	3
IV. LEGAL CONSIDERATIONS	4
A. Anticipation	4
B. Obviousness.....	4
C. Written Description Support & Enablement	6
V. OVERVIEW OF TASK & BASIS FOR OPINIONS	6
VI. LEVEL OF SKILL IN THE RELEVANT ART	7
VII. OVERVIEW OF THE TECHNICAL FIELD	8
A. General Battery Function	8
B. Existing Separators.....	10
C. Separator Features	12
D. Positive Active Materials	14
E. Separator Production	15
VIII. PRIOR ART.....	17
A. Yoshida (EX1005).....	17
B. Katayama (EX1006).....	20
IX. THE '251 PATENT.....	22
A. Overview	22
B. Prior Art and Perceived Shortcomings.....	24
C. '251 Patent's Asserted Improvement to Prior Art	24
D. Challenged Claims	25
E. Prosecution History	32
F. Priority Date	34
G. Claim Construction.....	35
i. Particle Size.....	35

X.	Comparison of Prior Art to '251 Patent's Challenged Claims.....	36
A.	Ground 1 - Claims 1-37 are Obvious over Yoshida and Katayama ...	36
1.	Motivation to Combine Yoshida and Katayama	36
2.	Modification of Yoshida in view of Katayama	47
3.	Claim 1	49
4.	Limitation 2: "The battery separator according to claim 1, wherein a thermal shrinkage ratio in a width direction is 10% or less at 200° C."	64
5.	Limitation 3: "The battery separator according to claim 1, wherein the content of the heat-resistant fine particles in the heat-resistant layer is 80 vol % or more of the total volume of components in the heat-resistant layer."	67
6.	Limitation 4: "The battery separator according to claim 1, wherein the heat-resistant fine particles are inorganic fine particles."	67
7.	Limitation 5: "The battery separator according to claim 4, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, BaTiO ₃ , boehmite, zeolite, and kaoline."	68
8.	Limitation 6: "The battery separator according to claim 1, wherein the heat-resistant fine particles include plate-like particles."	68
9.	Limitation 7: "The battery separator according to claim 1, wherein the heat-resistant layer has a thickness of 2 μm to 6 μm."	69
10.	Limitation 8: "The battery separator according to claim 1, wherein the thermoplastic resin includes polyolefin."	69
11.	Limitation 9: "The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 1.5 μm or less."	70
12.	Claim 10	70
13.	Limitation 11: "The nonaqueous electrolyte battery according to claim 10, wherein a thermal shrinkage ratio of the separator is 10% or less at a temperature T (° C.)	

- that is 10° C. lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200° C.).” 75
14. Limitation 12: “The nonaqueous electrolyte battery according to claim 10, wherein a width of the separator is larger than that of the negative electrode at a temperature T (° C.) that is 10° C. lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200° C.).” 76
15. Limitation 13 “The nonaqueous electrolyte battery according to claim 10, wherein the positive active material is at least one selected from the group consisting of the following: a spinel-type lithium-containing complex oxide expressed as a general formula $\text{Li}_{1+t}\text{Mn}_{(2-x)}\text{M}^1_x\text{O}_4$ (where M^1 is at least one element selected from the group consisting of Fe, Ni, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 \leq t \leq 0.1$, and $0 \leq x \leq 0.6$); an olivine-type lithium-containing complex oxide expressed as a general formula LiM^2PO_4 (where M^2 is Co, Ni, Mn, or Fe); a lithium-containing complex oxide having a layered crystal structure expressed as a general formula $\text{Li}_{(1+a)}\text{M}^3_{2b}\text{Mn}_{(0.5-b)}\text{Ni}_{(0.5-b)}\text{O}_2$ (where M^3 is at least one element selected from the group consisting of Fe, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 < a < 0.1$, and $0 \leq b \leq 0.05$); and a lithium-containing complex oxide expressed as a general formula $\text{Li}_{(1+y+\alpha)}\text{Ni}_{(1-y-z-\delta)/2}\text{Mn}_{(1-y-z-\delta)/2}\text{M}^4_z\text{O}_2$ (where M^4 is at least one element selected from the group consisting of Ti, Cr, Fe, Co, Cu, Zn, Al, Ge, Sn, Mg, and Zr, $-0.1 \leq y \leq 0.1$, $-0.05 \leq \alpha \leq 0.05$, $0 \leq z < 0.45$, and $-0.24 \leq \delta \leq 0.6$).” 77
16. Limitation 14: “The nonaqueous electrolyte battery according to claim 10, wherein a content of the heat-resistant fine particles in the heat-resistant layer of the separator is 80 vol % or more of a total volume of components in the heat-resistant layer.” 78

17. Limitation 15: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator are inorganic fine particles.” 78
18. Limitation 16: “The nonaqueous electrolyte battery according to claim 15, wherein the inorganic fine particles include line particles of at least one selected from the group consisting of alumina, silica, BaTiO₃, boehmite, zeolite, and kaoline.” 78
19. Limitation 17: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator include plate-like particles.” 79
20. Limitation 18: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer of the separator has a thickness of 2 μ m to 6 μ m.” 79
21. Limitation 19: “The nonaqueous electrolyte battery according to claim 10, wherein the thermoplastic resin of the separator includes polyolefin.” 79
22. Limitation 20: “The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is located on a negative electrode side.” 79
23. Limitation 21: “The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material.” 80
24. Limitation 22: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 1.5 μ m or less.” 81
25. Limitation 23: “The battery separator according to claim 1, wherein the shutdown layer has a thickness of 16 μ m or less.” 81
26. Limitation 24: “The battery separator according to claim 1, wherein a content of the binder in the heat-resistant layer is 1 to 20 vol % of a total volume of components in the heat-resistant layer.” 81

27. Limitation 25: “The battery separator according to claim 1, wherein the binder includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol % of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.” 82
28. Limitation 26: “The battery separator according to claim 1, wherein the heat-resistant line particles have an average particle size of 0.3 μm or more.” 82
29. Limitation 27: “The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator has a thickness of 16 μm or less.” 83
30. Limitation 28: “The nonaqueous electrolyte battery according to claim 10, wherein a content of the binder in the heat-resistant layer of the separator is 1 to 20 vol % of a total volume of components in the heat-resistant layer.” 83
31. Limitation 29: “The nonaqueous electrolyte battery according to claim 10, wherein the binder of the separator includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol % of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.” 83
32. Limitation 30: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 0.3 μm or more.” 84

33.	Limitation 31: “The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material, and a charging potential of the positive electrode is 4.3 V or more.”	84
34.	Limitation 32: “The battery separator according to claim 1, wherein the heat-resistant layer has a porosity of 20% to 60%.”	85
35.	Limitation 33: “The battery separator according to claim 1, wherein the whole separator has a porosity of 30% to 70%.”	85
36.	Limitation 34: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer has a porosity of 20% to 60%.”	86
37.	Limitation 35: “The nonaqueous electrolyte battery according to claim 10, wherein the whole separator has a porosity of 30% to 70%.”	86
38.	Limitation 36: “The battery separator according to claim 1, wherein the microporous film is formed by a solvent extraction method, a dry drawing method, or a wet drawing method.”	86
39.	Limitation 37: “The nonaqueous electrolyte battery according to claim 10, wherein the microporous film is formed by a solvent extraction method, a dry drawing method, or a wet drawing method.”	87
XI.	CONCLUSION.....	88

EXHIBIT LIST

Exhibit	Shorthand	Description
1001	'251 Patent	U.S. Patent No. 9,166,251 (the '251 Patent)
1002	File History	Prosecution History of the '251 Patent
1003	Juzkow Declaration	Declaration of Marc Juzkow
1004	Juzkow CV	<i>Curriculum Vitae</i> of Marc Juzkow
1005	Yoshida	European Patent Application Publication EP 1115166
1006	Katayama	International Patent Application Publication WO 2007/066768
1007	Miyatake	Japanese Patent Application Publication No. 2007-335294
1008	JP 575	Japanese Patent Application No. 2007-259575
1009	Roth	Abuse Response of 18650 Li-Ion Cells with Different Cathodes Using EC:EMC/LiPF ₆ and EC:PC:DMC/LiPF ₆ Electrolytes, <i>ECS Transactions</i> , 11 (19) 19-41 (2008) November 19, 2007
1010	Dahn	Thermal stability of Li _x CoO ₂ , Li _x NiO ₂ and b-MnO ₂ and consequences for the safety of Li-ion cells, <i>Solid State Ionics</i> 69 (1994) 265-270
1011	Arora	Battery Separators, Pankaj Arora and John Zhang, <i>Chem. Rev.</i> 2004, 1004, 4419-4462
1012	Harris	F.W. Harris, <i>J. Chem. Ed.</i> , 58, (11), 837, 1981
1013	Celgard	U.S. Patent No. 6,432,586
1014	Linden	“Handbook of Batteries”, David Linden, Thomas Reddy, McGraw-Hill, 3 rd Ed., 2001

1015	LG Patent	International Patent Application Publication WO 2006/068428
1016	Maleki	<i>Thermal Stability Studies of Li-Ion Cells and Components</i> , Hossein Maleki, Guoping Deng,* Anaba Anani, and Jason Howard, Journal of The Electrochemical Society, 146 (9) 3224-3229 (1999)
1017	Xiaoping	U.S. Patent Application Pub. No. US 2004/0209156
1018	Samii	U.S. Patent No. 6,949,315
1019	JP 527	Japanese Patent Application No. 2008-039527
1020	ATL Petition	<i>Amperex Tech. Ltd. v. Maxell, Ltd.</i> , IPR2021-01442 (PTAB Sept. 23, 2021) (Paper 2)
1021		Draft Stipulation

I. INTRODUCTION

1. My name is Marc Juzkow. I have been retained by Zhuhai CosMX Battery Co., Ltd. as an independent expert in the relevant art.

II. PROFESSIONAL BACKGROUND

2. Exhibit 1004 is a true and correct copy of my curriculum vitae (“CV”). As set forth in my CV, I have worked for over 35 years directly in the industry to which the ’251 patent applies. I am a Founding Partner of Lithiumion Expert Services, LLC. I have also worked at Joby Aviation, LLC since 2021 as Cell Supplier Lead, responsible for the selection and design of lithium-ion cells for an eVTOL aircraft.

3. I received my Master of Science (M.S.) degree in the field of Chemistry from Simon Fraser University in Burnaby, British Columbia, Canada.

4. After starting my career as a Research Scientist in 1985 with lithium metal cells, we transitioned into developing lithium-ion cells in the early 1990’s where I was Manager, Product Development, and Product Evaluation. Our company, Moli Energy was the first North American company to commercialize lithium-ion technology in 1994. Between 2000 and 2003, I transitioned into electrochemical double layer capacitor, where we developed spirally wound cells. I set up and was Chief Technology Officer of a battery cell testing company, Mobile Power Solutions, between 2005 and 2008. Between 2007 and 2014, at Leyden Energy,

where I was VP of R&D, we designed and assembled lithium-ion cylindrical and pouch cells. Leyden subcontracted the manufacturing of both polymer pouch and cylindrical cells, assembling over 2 million cells. Immediately following Leyden Energy's Chapter 11, I hired five Leyden engineers and assembly technicians, purchased equipment and die sets, and started a contract services company. Our typical customer was either a start-up or a large industrial chemical company that had new lithium-ion cell components but were not skilled in the art of lithium-ion cell assembly, nor had the equipment required. We also subcontracted on several Department of Energy contracts, providing cell design, assembly and testing services. At Iontensity, we assembled and tested coin cells and Al foil-polymer laminate packaged lithium-ion cells for our customers who typically provided us with one of the many components that make up a lithium-ion cell. We were responsible for chemical and mechanical cell design, assembling electrodes, final cell assembly and testing. As I was the leader of a small group of engineers and technicians, it was important to be hands-on in my role as a team member and for training additional personnel we hired. I personally mixed cathode and anode slurries, coated electrodes on a 2m long roll-to-roll coater, punched electrodes, assembled coin cells and pouch cells, and ran performance testing. Following Iontensity, I was the Principal Cell Specialist at NIO, responsible for the lithium-ion cell technology for this autonomous electric vehicle company. Particularly

important to this case, I have visited facilities that made and coated separators, and I have assembled cells with many types of separators over the years. At Moli Energy, I also submitted a Canadian patent application regarding the testing of separators.

5. Through my extensive career in the lithium-ion battery industry, I have gained knowledge and expertise in the design and manufacturing of design of lithium ion button cell batteries. I have been named as an inventor on several United States patents all within the area of lithium ion cells.

6. Because of my background, training, education and experience, I am qualified as an expert to explain the background of the technology encompassed by U.S. Patent No. 9,166,251 (the “’251 Patent”) as well as to opine on the validity of the claims of the ’251 Patent in view of the prior art references discussed herein.

7. Other background references, of which I had been previously aware, not cited herein directly that a person of ordinary skill in the art at the time of invention (“POSITA” or “one of ordinary skill in the art”) would have recognized as being related to the subject matter of the ’251 patent

III. COMPENSATION

8. My work on this matter is being billed at my customary rate of 500.00 dollars per hour for all in-office tasks performed and my customary rate of 800 dollars per hour for all out-of-office and testifying tasks performed. Also, I am being

reimbursed for reasonable expenses I incur in relation to my services. I will be paid regardless of the outcome of any proceeding that my work is used in.

IV. LEGAL CONSIDERATIONS

9. I am not an attorney. My understanding of the law is based on information provided by counsel for Zhuhai CosMX Battery Co., Ltd.

A. Anticipation

10. I understand that a reference anticipates a claim if it discloses each and every element recited in the claim, arranged as in the claim, so as to enable a person of ordinary skill in the art (POSITA) to make and use the claimed invention without the need for undue experimentation in light of the general knowledge available in the art. I understand that a U.S. Patent document is presumed to have sufficient description to include sufficient detail for a person of ordinary skill in the art to make and use the subject matter that document describes.

B. Obviousness

11. I understand that a claimed invention is obvious and, therefore, not patentable if the subject matter claimed would have been obvious to a person of ordinary skill in the art at the time that the invention of the '251 Patent (a "POSITA"), which I have been asked to treat September 30, 2008, the date the PCT application was filed, as the earliest possible priority date of the challenged claims.

I have also been asked to offer my opinions treating the time of the invention as September 30, 2008.

12. I understand that a claim can be obvious in view of a single prior art reference (e.g., via modification of that prior art reference) or multiple prior art references (e.g., via a combination of two or more prior art references), if such a modification or combination was within the skill of a POSITA. I understand that there must be some articulated reasoning with some rational underpinning to support a conclusion of obviousness. I further understand that exemplary rationales that may support a conclusion of obviousness include: (1) simply arranging old elements in a way in which each element performs the same function it was known to perform, and the arrangement yields expected results, (2) merely substituting one element for another known element in the field, if the substitution yields no more than a predictable result, (3) combining elements in a way that was “obvious to try” because of a design need or market pressure, where there was a finite number of identified, predictable solutions, (4) that design incentives or other market forces in a field would have prompted variations in a work that were predictable to a person of ordinary skill in the art, and (5) that there was some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify or combine prior art references to arrive at the claimed invention.

C. Written Description Support & Enablement

13. I understand that a patent generally includes claims that recite particular inventions, and a patent specification that must describe the claimed invention in sufficient detail to convey to a person of skill in the art (POSITA) that the patentee had possession of the claimed invention at the time of the application, i.e., that the patentee invented what is claimed, including all features or “limitations” of that claim. I further understand that a description that merely renders the invention obvious does not satisfy the written description requirement. I also understand that, in addition to the written description requirement noted above, the specification must describe the manner and process of making and using the invention so as to enable a POSITA to make and use the full scope of the invention without undue experimentation.

14. Additionally, my understandings as to claim interpretation and the person of ordinary skill in the art are detailed below. *See* §§VI, IX.G.

V. OVERVIEW OF TASK & BASIS FOR OPINIONS

15. I have been asked to review the '251 Patent.

16. I have been asked to provide opinions related to certain issues from the perspective of a person of ordinary skill, having knowledge of the relevant art, as of September 30, 2008, (*see* §IX.F) and—except where otherwise noted—the opinions

stated in this declaration are from that perspective. The qualifications and abilities of such a person are described in Section VI below.

17. My opinions are based on my education, training, and experience as well as items that I reviewed to prepare my opinions, including the documents listed in the Exhibit List included with the Petition and any other items I reference in my below analysis.

18. I understand that other issues may arise that require further explanation, and I will provide that explanation if appropriate. As a result, I respectfully reserve the right to update and supplement this declaration and the information and opinions provided herein.

VI. LEVEL OF SKILL IN THE RELEVANT ART

19. I understand that the level of ordinary skill may be reflected by the prior art of record, and that a person of ordinary skill in the art (“POSITA”) to which the claimed subject matter pertains would have the capability of understanding the scientific and engineering principles applicable to the pertinent art.

20. I understand there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including (1) the levels of education and experience of persons working in the field at the time of the invention; (2) the sophistication of the technology; (3) the types of problems encountered in the field;

(4) the prior art solutions to those problems; and (5) the rapidity with which innovations are made.

21. A POSITA as of September 30, 2008¹—the '251 Patent's earliest priority date to which the '251 Patent is entitled, (*see* §IX.F)—would have had a bachelor's degree in chemistry, chemical engineering, materials science, or a related field, and at least three to four years of experience in design, development, and/or testing of batteries and battery materials, or the equivalent, with additional education substituting for experience and vice versa. The prior art and the '251 Patent also evidence this level of ordinary skill. Such a POSITA would have been familiar with the concepts and types of batteries described below.

VII. OVERVIEW OF THE TECHNICAL FIELD

22. The field of battery technology is well-developed with the below-described features and properties, among others, known to a POSITA.

A. General Battery Function

23. Nonaqueous electrolyte batteries, like lithium ion batteries, have long been popular power sources for cellphones and laptop computers. EX1001, 1:22-26. Conventional lithium ion batteries were typically limited to a charge potential

¹ All statements in this Petition about the knowledge and skills of, and what would have been obvious to, a POSITA are offered from this perspective as of this date.

of 4.2 V. EX1017, [0003]. However, it was known to a POSITA that “the positive electrode materials and negative electrode materials used in the current secondary lithium ion battery have relatively higher theoretical capacity, and the problem merely lies in the lower actual utilization rate of said capacity.” *Id.* As a result, by the early 2000s, charge potentials of 4.35 V and more were known for lithium ion batteries. *See, e.g., id.*, [0019] (disclosing “charge cut-off voltages from 4.2 V to 4.3 V, 4.35 V, 4.40 V, 4.45 V, and 4.6 V”).

24. A battery consists of one or more cells, connected in series, parallel or a combination thereof. Each battery cell has (a) a negative electrode (“anode”) and a positive electrode (“cathode”)—each with active material(s), binder(s), and conductive additive(s) coated onto a metallic current collector; (b) an electrolyte containing a lithium salt(s) dissolved in a liquid solution of solvents and additive(s); and (c) a separator positioned between the anode and cathode. EX1013, 1:44-51, 2:1-3:8. Liquid electrolyte can be substituted with gel or solid electrolytes. *Id.*, 2:32.

25. When a load (e.g., mobile phone or laptop computer) is connected to the battery cell, lithium ions in the negative electrode are deintercalated (migrate) into the electrolyte as positive ions and electrons are released through the current collector. EX1015, 2:8-26. The lithium ions are transported via the electrolyte to the positive electrode and, simultaneously, electrons move from the negative electrode to the positive electrode through the external load, powering the device.

EX017, 1:51–58. When connected to a charging device, electrons flow externally from the positive to the negative electrode and, internally, positive lithium ions are released from the cathode and transported through the electrolyte to intercalate in the anode. EX1015, 2:8-26.

26. The separator is positioned between the cathode and anode, electrically isolating the electrodes but allowing for ionic transport through the separator's pores which are filled with the electrolyte. EX1013, 2:60-63, 3:9-25. Contact between the electrodes will short the battery, risking a thermal runaway. *Id.*, 1:27-35. Thermal runaway results when the interior of the cell reaches a temperature at which the internal components react, releasing energy in the form of heat, sparks, smoke and/or fire. *Id.*

B. Existing Separators

27. In the 1990s, separators in lithium-ion cells typically included a single, microporous layer of polypropylene (PP). *See* EX1014, 1077. The most common was Celgard 2400, a 25 um separator with 40% porosity. *Id.*, Table 34.15; EX1011, Table 4, 4443-44. Celgard 2400 was commonly used for separators in non-aqueous batteries due to its (1) high porosity for low internal impedance and high rate capability; (2) tortuous paths in its pores to prevent lithium dendrite growth from the anode to the cathode; (3) ease of filling with electrolyte; and (4) physical strength

for handling during the manufacturing process and safety in mechanically abusive conditions (e.g. crushing or heavy impact). *See* EX1011, Table 4.

28. If the internal temperature of a cell exceeded approximately 165° C, the PP would melt. The separator's pores would close, halting ionic flow and increasing the internal impedance. *Id.* Where such heating was caused by a short circuit or overcharging, increasing the separator impedance could prevent continued heating and reduce the risk of thermal runaway. If, however, the temperature continued to increase, the PP separator would eventually shrink in the planar direction, allowing the electrodes to internally short and permitting high currents that would generate significant internal heat and lead to thermal runaway. EX1013, 1:27-35. Ultimately, it was found that at temperatures in excess of 165°C, particularly for cells using less thermally stable cathode materials (e.g., LiCoO₂), PP separators would not prevent all thermal runaways. *See* EX1011, 4436-40.

29. Two main options were recognized to address this problem: (1) shutting the cell down at a lower temperature and/or (2) preventing the separator shrinking at temperatures above the separator's melting point. EX1014, 1102-03.

30. First, it was discovered that some polyethylene (PE) films would melt at ~135°C, lowering the shutdown temperature, but would undesirably also exhibit shrinkage at a lower temperature than PP. *Id.* PE therefore could provide a lower shutdown temperature (and theoretically larger margin between the shutdown

temperature and the heat generation starting temperature of the electrode material), but increased risk if the temperature continued to rise because PE shrinks at an even lower temperature than does PP. EX1011, 4424.

31. To address this issue, Celgard developed Celgard 2320, a three-layer polymer separator with a PE layer sandwiched between two PP layers. *Id.*, 4423-24, Table 4. PE provided early shutdown (~135° C), while PP provided higher melt integrity (less shrinkage) up to about 183°C. *Id.*, 4434-35, Table 6. However, in some cases, even the PP shrinking temperature was too low to prevent contact between electrodes.

32. Second, POSITAs added a heat resistant layer (e.g., with ceramic) to the separator to prevent substantial separator shrinkage at temperatures above those at which PP shrank. *Id.*, 4423-24. In one example, Degussa (now Evonik) developed Separion, a multilayer separator that added such a heat-resistant layer to a polyolefin shutdown layer. *Id.*

C. Separator Features

33. As more companies began developing lithium-ion cells, multiple separator styles were used. A POSITA would have understood that the separator influences various characteristics of cell performance, including cell capacity and volumetric energy density, high-rate performance and fast charging, high-temperature storage, long-term cycling, and safety. *Id.*, Table 7.

34. Many features impact the performance and safety parameters considered in cell design, including the active cathode materials, which had varying thermal stability (temperature at which they reacted to generate heat and oxygen, leading to thermal runaway). EX1009, Fig. 8, EX1011, 4429-35. The size of the pores and the percentage porosity were also factors in the cell performance as a separator's porosity affects the internal resistance of the separator, which relates to the charge and discharge rate capability. EX1009, Fig. 8, EX1011, 4429-35.

35. The thickness of the separator must also be considered as thicker separators decrease volumetric energy density. Thicker separators reduce the volume available for active materials, yielding cells with lower capacity and volumetric energy density. EX1011, Table 7. From a performance standpoint, cell designer prefers a thin separator but must weigh this against the strength of the separator in handling during cell assembly and its capability to provide abuse tolerance and prevent thermal runaway. *Id.* Therefore, thickness would be an important design feature to consider when designing a battery.

36. A POSITA would have also understood the importance of ensuring sufficient separator strength. Strong 16 μm and 20 μm separators (e.g., Celgard 2320) are available. *Id.*, 4424-46. A POSITA would have also considered the size of particles when designing a cell. For example, a heat resistant layer of 2 μm to 4 μm would prevent shrinking at high temperatures. EX1013, 3:9-22.

37. Finally, a POSITA would have understood that shutdown temperature of a shutdown layer was adjustable by selecting and/or adjusting the composition of the thermoplastic resin (e.g., vol %, ratio, and density). *See* §VII.B. A POSITA would have known that a polymer, such as a thermoplastic resin, is characterized by their molecular weight. *See* EX1012 at 840-841. A POSITA therefore would have understood that selecting thermoplastic resins with different molecular weights, and/or combining such resins with different molecular weights, would have been expected to vary the melting temperature and resulting shutdown temperature of a shutdown layer.

D. Positive Active Materials

38. A POSITA designing a lithium-ion cell would have been familiar with the general properties of the positive active materials.

39. A POSITA would have understood that the positive electrode material would have impacted the characteristics of a battery, including heat generation starting temperature. *Id.* In other words, a POSITA would have been familiar with which materials would exhibit “high” heat generation temperatures and “low” heat generation temperatures. *Id.* While a POSITA could have run Thermal Gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC) or Accelerated Rate Calorimetry (ARC) tests to determine the exact heat generation starting temperature of various positive active materials, these values were widely available in the

literature. *See* EX1009, EX1010, EX1016. A POSITA would have been familiar with the “high” heat generation temperatures of LiMn_2O_4 and LiMPO_4 (wherein M is Co, Ni, Mn, or Fe), as well as of $\text{LiCo}_{0.33}\text{Ni}_{0.33}\text{Mn}_{0.33}\text{O}_2$. *See* EX1006, [0106].

40. A POSITA would recognize that positive active materials would have influenced desired separator melting and shrinkage temperatures. *Id.* For example, positive active materials with lower thermal stability (i.e., that undergo exothermic reactions at lower temperatures) require separators that shutdown at lower temperatures to be effective. Separator shutdown, resulting in pore closure to increase cell impedance, is needed for added safety, but must occur prior to the exothermic reactions. And positive active materials with higher thermal stability require separators that do not shrink at lower temperatures, where contact between the electrodes would generate significant heat increasing the internal cell temperature to the onset temperature of the exothermic reaction. *Id.* Similarly, thermal stability and thermal runaway temperatures were known for different positive electrodes and for the shutdown temperatures of various separators. *See e.g.*, EX1009, 38 (disclosing the shutdown temperatures for three separator examples); EX1010.

E. Separator Production

41. A POSITA would have known that there were two primary processes for microporous film manufacturing, the type of film required for lithium-ion cells:

the dry process, which uses a polymer raw material, and the wet process, which uses a polymer and solvent and optionally fillers.

42. The dry process begins with the melting of a polyolefin resin, typically PE or PP, and extruding the resin into a film bubble. The film is annealed and stretched, resulting in an anisotropic structure with tortuous micropores through the bulk interior. PE and PP microporous separators were available from Celgard and Ube.

43. The wet process involves the mixing of a hydrocarbon liquid with a polyolefin resin, heating and melting the mixture, then extruding the melt onto a sheet and extracting the liquid with a volatile solvent. The properties and structure of these films can be modified by controlling the composition of the solutions in the gelation and solidification processes, and by the stretching step. Ultrahigh molecular weight PE resin is preferred to provide mechanical strength with increased melt integrity. The films manufactured with the wet process have isotropic properties. However, the wet process may result in larger pore sizes and higher overall porosity. PE microporous separators were available from Asahi and Tonen. EX1011, 4420-21, Table 2.

44. A dry drawn anisotropic separator has better mechanical strength in the machine direction (length) versus the transverse direction (width). Wet processes result in similar mechanical strength in all directions. *Id.* When exposed to elevated

temperatures, wet-process separators typically shrink in both directions, whereas dry-process separators, Celgard 2400 for example, will shrink in the machine direction but not in the transverse direction. *Id.*

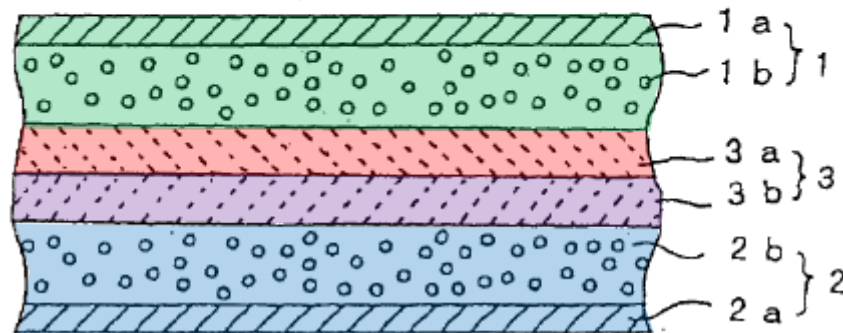
VIII. PRIOR ART

A. Yoshida (EX1005)

45. European Patent Application Publication EP 1,115,166 to Yoshida was filed June 22, 1999 and published July 11, 2001. Therefore, I understand that Yoshida is prior art under §§102(a) and (b).

46. Yoshida discloses a nonaqueous electrolyte battery separator and battery including the separator. EX1005, [0001], [0006]. The separator includes a [purple] heat-resistant layer and a [red] shutdown layer integrated into a multilayer structure interposed between a [green] positive electrode and [blue] negative electrode.

FIG. 1



Id., [0013], [0021], FIG. 1.²

47. Yoshida's overarching aim is to improve safety at high temperatures by avoiding separator shrinkage that can cause internal shorts and thermal runaways. EX1005, Abstract; *see also* §VII, above.

48. Yoshida explains that the “thermoplastic resin” of its shutdown layer can have a shutdown temperature—“of softening and shrink of the minute holes”—of 60°C to 150°C. EX1005, [0022].

49. Yoshida also explains that its heat-resistant layer includes fine particles having higher heat resistance than a thermoplastic resin of the shutdown layer.

² All colorized figures herein are annotated.

EX1005, [0007], [0009], [0011], [0013], [0015], [0017], [0020] And these fine particles can include “[o]rganic or inorganic material such as silica, alumina, titanium oxide or clay.” EX1005, [0025].

50. Yoshida also discloses that, within the heat-resistant layer, “[t]he average particle size of the[se] ... particles is preferably *at most 0.5 μm* ,” because “particles having larger size than that do not efficiently *aggregate* and sufficient ion conductivity improvement of the electrolytic gel can not be expected when the aggregated particles are mixed.” EX1005, [0026] (emphasis added).

51. Yoshida goes on to explain that “[t]he average particle size *of the aggregate* is preferably at least 0.2 μm to at most 2.0 μm ,” because “[w]hen it is smaller than 0.2 μm , sufficient ion conductivity improvement of the electrolytic gel can not be expected when it is mixed” and “[w]hen it is larger than 2.0 μm , it is not preferable since film thickness becomes too large.” *Id.* (emphasis added). As indicated by Yoshida’s explanation that the 0.5 μm is important to allow the individual particles to aggregate, the distinction between individual particles and aggregated particles refers to the physical groupings of the smaller, individual particles to form larger, aggregated particles in the process of forming the second [heat-resistant] layer.

52. Yoshida discloses that its multi-layer separator improves safety because it reduces thermal shrinkage. EX1005, [0008], [0014].

53. Yoshida does not describe layer thicknesses, porosity, particular shrinkage levels at elevated temperatures, or separator production; and includes limited examples of other details like positive active materials.

B. Katayama (EX1006)

54. International Patent Application Publication WO 2007/066768 to Katayama was filed December 8, 2005 and published June 14, 2007, therefore, I understand that Katayama is prior art under §§102(a) and (b).

55. Katayama discloses a nonaqueous electrolyte battery with a separator that includes a porous, resin shutdown layer and a heat-resistant layer including a filler, which separator layers can be integrated with each other and/or the electrodes. EX1006, [0002], [0015] (overall structure), [0022] (shutdown layer), [0023] (heat-resistant layer), [0073] (separator can be “integrated with the electrodes”). Katayama describes specific details about the materials and dimensions of the separator layers, including the following:

56. Katayama describes that the thickness of the first [shutdown] layer is 1-15 μm (preferably 3-10 μm), and the thickness of the second [heat-resistant] layer is 2-30 μm (preferably 4-20 μm). EX1006, [0082].

57. The thermal shrinkage rate of the separator is “1% or less” and “preferably is as close as 0% as possible.” EX1006; [0090].

58. The overall separator has a porosity of 15-70%, and more preferably 20-60%. EX1006, [0083]. And the second [heat-resistant] separator layer has a porosity of 10% to 50%. EX1006, [0051], [0085].

59. In the heat-resistant layer, “the content of the filler . . . is preferably at least 50 vol. %, ... and further preferably at least 80 vol. % of the entire volume of the whole solid contents.” EX1006, [0059]; *see also id.*, [0125], [0156].

60. Katayama’s filler includes fine particles such as inorganic oxides. EX1006, [0053]-[0054]. To prevent a short circuit, “plate-like particles are preferred.” EX1006, [0056]. Katayama explains that these particles have an average particle size of 1.5 μm or less. *See* EX1006, [0124], [0150], [0154].

61. Katayama’s shutdown layer also includes a thermoplastic resin like a polyolefin. EX1006, [0027].

62. Katayama also describes exemplary solvent-extraction methods of forming the microporous film of the shutdown layer, for example sequentially “applying a composition (a liquid composition such as a slurry or the like)” for either the shutdown layer or the heat-resistant layer, “subsequently drying at a predetermined temperature; and applying the other composition, followed by drying at a predetermined temperature.” *Id.*, [0091].

63. For a battery including its separator, Katayama discloses examples of positive active materials for the positive electrode—for example, LiMn_2O_4 ,

LiMnPO₄, and LiFePO₄—that exhibit a heat generation starting temperatures of 180°C or higher. EX1006, [0106].

IX. THE '251 PATENT

64. Entitled “Battery Separator and Nonaqueous Electrolyte Battery,” the '251 Patent is directed to a battery and battery separator having “excellent safety in a high-temperature environment.” EX1001, 2:56-58; *see also id.*, 1:16-18, 2:14-19.

A. Overview

65. The '251 Patent describes a separator for use in a nonaqueous electrolyte battery. *Id.*, Abstract. The '251 Patent discloses a separator with multiple layers including a heat-resistant layer that suppresses shrinkage and a shutdown layer that shuts down the battery. *Id.*, 4:27-34. Specifically, the '251 Patent discloses: “[t]o suppress thermal shrinkage and provide a shutdown property, it is preferable that the separator of the nonaqueous electrolyte battery of the present invention has a multilayer structure. Specifically, the multilayer structure includes a heat-resistant layer for suppressing the thermal shrinkage and isolating the positive electrode from the negative electrode at high temperatures and a shutdown layer for ensuring the shutdown property.” *Id.* “To suppress thermal shrinkage and provide a shutdown property, it is preferable that the separator of the nonaqueous electrolyte battery of the present invention has a multilayer structure ... includ[ing] a heat-resistant layer for suppressing the thermal shrinkage and isolating the positive

electrode from the negative electrode at high temperatures and a shutdown layer for ensuring the shutdown property.” *Id.*, 4:27-34.

66. The thickness of the shutdown layer “is preferably 5 μm to 30 μm .” *Id.*, 9:54–56. The thickness of the heat-resistant layer “is in the range of preferably 1 μm , more preferably 2 μm , even more preferably 4 μm to preferably 20 μm , more preferably 10 μm .” *Id.*, 9:56-60. Further, the sum of the thickness of the two layers is between 6 and 23 and the ratio of the thickness of the heat-resistant layer to the thickness of the shutdown layer is between 0.5 and 4. *Id.*, Claim 1.

67. “The heat-resistant layer ... is preferably a porous layer including heat-resistant fine particles and a binder” *Id.*, 5:3-5. “Specific examples of the inorganic fine particles include ... inorganic oxides such as an iron oxide, silica (SiO_2), alumina (Al_2O_3), TiO_2 , and BaTiO_3 ” *Id.*, 5:10-20. “The content of the heat-resistant fine particles in the heat-resistant layer is ... more preferably 50 vol % or more ... of components in the heat-resistant layer.” *Id.*, 8:12-15. The heat-resistant fine particles range in average size from 0.2 μm to 2 μm , with no more than 10 vol %, respectively, being less than 0.2 μm or over 2 μm . *Id.*, 5:62-6:3. “[T]he shutdown temperature is preferably at least 20° C. lower than the exothermic peak temperature of the positive electrode (i.e., the temperature at an apex of the exothermic peak of the DSC curve that is obtained to determine the heat generation

starting temperature, as described above), and more preferably 150° C. or lower.”

Id., 4:46-59.

B. Prior Art and Perceived Shortcomings

68. The '251 Patent describes “commonly used separator easily shrinks when the temperature in the battery becomes extremely high, and can cause a short circuit.” *Id.*, 1:33-35. Additionally, existing technology used separators with thicknesses of 30 µm or less and short circuits occurred. *Id.*, 1:52-55. Existing technology focused on shutdowns at 120°C, failing to ensure safety of batteries at higher temperatures. *Id.*, 1:55-64.

C. '251 Patent's Asserted Improvement to Prior Art

69. To overcome the purported shortcomings, the '251 Patent proposes “a battery separator that can constitute a nonaqueous electrolyte battery having excellent safety in a high-temperature environment, and a nonaqueous electrolyte battery using the battery separator.” *Id.*, 2:15-19. The separator purports to “reliably prevent a short circuit due to contact between the positive electrode and the negative electrode at high temperatures.” *Id.*, 2:54-56. “As a result of these effects, it is possible to provide a nonaqueous electrolyte battery having excellent safety in a high-temperature environment.” *Id.*, 2:56-58. As explained in Section VII, it was well-known before the '251 Patent to implement such a separator in non-aqueous electrolyte batteries.

D. Challenged Claims

70. I understand that Claims 1-37 of the '251 Patent are challenged claims. Claims 1 and 10 are independent. Claims 2-9, 23-26, 32, 33, and 36 depend from independent Claim 1, and Claims 11-22, 27-31, 34, 35, and 37 depend from independent Claim 10.

71. '251 Claim 1 reads:

- 1[p] A battery separator comprising:
- 1[a] heat-resistant fine particles; and
- 1[b] a thermoplastic resin,
- 1[c] wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,
- 1[d] the thermoplastic resin constitutes a shutdown layer formed of a heat-shrinkable microporous film,
- 1[e] the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,
- 1[f] the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4,
- 1[g] a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol % or more of a total volume of components in the heat-resistant layer,
- 1[h] a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol % or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol % or less, and
- 1[i] a shutdown is effected in a range of 135° C. to 150° C.

72. '251 Claim 2 reads:

- 2 The battery separator according to claim 1, wherein a thermal shrinkage ratio in a width direction is 10% or less at 200° C.

73. '251 Claim 3 reads:

- 3 The battery separator according to claim 1, wherein the content of the heat-resistant fine particles in the heat-resistant layer is 80 vol % or more of the total volume of components in the heat-resistant layer.

74. '251 Claim 4 reads:

- 4 The battery separator according to claim 1, wherein the heat-resistant fine particles are inorganic fine particles.

75. '251 Claim 5 reads:

- 5 The battery separator according to claim 4, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, BaTiO₃, boehmite, zeolite, and kaoline.

76. '251 Claim 6 reads:

- 6 The battery separator according to claim 1, wherein the heat-resistant fine particles include plate-like particles.

77. '251 Claim 7 reads:

- 7 The battery separator according to claim 1, wherein the heat-resistant layer has a thickness of 2 μm to 6 μm .

78. '251 Claim 8 reads:

- 8 The battery separator according to claim 1, wherein the thermoplastic resin includes polyolefin.

79. '251 Claim 9 reads:

- 9 The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 1.5 μm or less.

80. '251 Claim 10 reads:

- 10[p] A nonaqueous electrolyte batter comprising:
- 10[a] a positive electrode having a positive active material capable of intercalating and deintercalating a lithium ion;
- 10[b] a negative electrode having a negative active material capable of intercalating and deintercalating a lithium ion;
- 10[c] a separator interposed between the positive electrode and the negative electrode; and
- 10[d] a nonaqueous electrolyte,
- 10[e] wherein a heat generation starting temperature of the positive electrode is 180° C. or higher, and
- 10[f] wherein the separator is the battery separator according to claim 1.

81. '251 Claim 11 reads:

- 11 The nonaqueous electrolyte battery according to claim 10, wherein a thermal shrinkage ratio of the separator is 10% or less at a temperature T (° C.) that is 10° C. lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200° C.).

82. '251 Claim 12 reads:

- 12 The nonaqueous electrolyte battery according to claim 10, wherein a width of the separator is larger than that of the negative electrode at a temperature T (° C.) that is 10° C. lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200° C.).

83. '251 Claim 13 reads:

- 13 The nonaqueous electrolyte battery according to claim 10, wherein the positive active material is at least one selected from the group consisting of the following: a spinel-type lithium-containing complex oxide expressed as a general formula $\text{Li}_{1+t}\text{Mn}_{(2-x)}\text{M1}_x\text{O}_4$ (where M1 is at least one element selected from the group consisting

of Fe, Ni, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 \leq t \leq 0.1$, and $0 \leq x \leq 0.6$); an olivine-type lithium-containing complex oxide expressed as a general formula LiM_2PO_4 (where M2 is Co, Ni, Mn, or Fe); a lithium-containing complex oxide having a layered crystal structure expressed as a general formula $\text{Li}(1+a)\text{M}_3\text{2bMn}(0.5-b)\text{Ni}(0.5-b)\text{O}_2$ (where M3 is at least one element selected from the group consisting of Fe, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 < a < 0.1$, and $0 \leq b \leq 0.05$); and a lithium-containing complex oxide expressed as a general formula $\text{Li}(1+y+\alpha)\text{Ni}(1-y-z-\delta)/2\text{Mn}(1-y-z-\delta)/2\text{M}_4\text{zO}_2$ (where M4 is at least one element selected from the group consisting of Ti, Cr, Fe, Co, Cu, Zn, Al, Ge, Sn, Mg, and Zr, $-0.1 \leq y \leq 0.1$, $-0.05 \leq \alpha \leq 0.05$, $0 \leq z < 0.45$, and $-0.24 \leq \delta \leq 0.6$).

84. '251 Claim 14 reads:

14 The nonaqueous electrolyte battery according to claim 10, wherein a content of the heat-resistant fine particles in the heat-resistant layer of the separator is 80 vol % or more of a total volume of components in the heat-resistant layer.

85. '251 Claim 15 reads:

15 The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator are inorganic fine particles.

86. '251 Claim 16 reads:

16 The nonaqueous electrolyte battery according to claim 15, wherein the inorganic fine particles include line particles of at least one selected from the group consisting of alumina, silica, BaTiO_3 , boehmite, zeolite, and kaoline.

87. '251 Claim 17 reads:

- 17 The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator include plate-like particles.
88. '251 Claim 18 reads:
- 18 The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer of the separator has a thickness of 2 μm to 6 μm .
89. '251 Claim 19 reads:
- 19 The nonaqueous electrolyte battery according to claim 10, wherein the thermoplastic resin of the separator includes polyolefin.
90. '251 Claim 20 reads:
- 20 The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is located on a negative electrode side.
91. '251 Claim 21 reads:
- 21 The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material.
92. '251 Claim 22 reads:
- 22 The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 1.5 μm or less.
93. '251 Claim 23 reads:
- 23 The battery separator according to claim 1, wherein the shutdown layer has a thickness of 16 μm or less.
94. '251 Claim 24 reads:

- 24 The battery separator according to claim 1, wherein a content of the binder in the heat-resistant layer is 1 to 20 vol % of a total volume of components in the heat-resistant layer.
95. '251 Claim 25 reads:
- 25 The battery separator according to claim 1, wherein the binder includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol % of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.
96. '251 Claim 26 reads:
- 26 The battery separator according to claim 1, wherein the heat-resistant line particles have an average particle size of 0.3 μm or more.
97. '251 Claim 27 reads:
- 27 The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator has a thickness of 16 μm or less.
98. '251 Claim 28 reads:
- 28 The nonaqueous electrolyte battery according to claim 10, wherein a content of the binder in the heat-resistant layer of the separator is 1 to 20 vol % of a total volume of components in the heat-resistant layer.
99. '251 Claim 29 reads:

- 29 The nonaqueous electrolyte battery according to claim 10, wherein the binder of the separator includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol % of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.
100. '251 Claim 30 reads:
- 30 The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 0.3 μm or more.
101. '251 Claim 31 reads:
- 31 The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material, and a charging potential of the positive electrode is 4.3 V or more.
102. '251 Claim 32 reads:
- 32 The battery separator according to claim 1, wherein the heat-resistant layer has a porosity of 20% to 60%.
103. '251 Claim 33 reads:
- 33 The battery separator according to claim 1, wherein the whole separator has a porosity of 30% to 70%.
104. '251 Claim 34 reads:
- 34 The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer has a porosity of 20% to 60%.

105. '251 Claim 35 reads:

35 The nonaqueous electrolyte battery according to claim 10, wherein the whole separator has a porosity of 30% to 70%.

106. '251 Claim 36 reads:

36 The battery separator according to claim 1, wherein the microporous film is formed by a solvent extraction method, a dry drawing method, or a wet drawing method.

107. '251 Claim 37 reads:

37 The nonaqueous electrolyte battery according to claim 10, wherein the microporous film is formed by a solvent extraction method, a dry drawing method, or a wet drawing method.

E. Prosecution History

108. The '251 Patent was filed on February 17, 2010. The Examiner initially rejected the claims as obvious over US 2008/0038631 (Nakura) and US 2007/0264577 (Katayama '577). EX1002, 685/946. In response, the Applicant amended claim 1 to require at least 50 vol % of heat-resistant particles and claims 3 and 14 to require at least 80 vol % of heat-resistant particles based on the total volume. *Id.*, 752–53/946, 755/946, 759–60/946.

109. Then, the Examiner issued a Final Office Action, maintaining the rejections based on Nakura and Katayama '577. *Id.*, 775–781/946. In response, the Applicant argued that a POSITA would not combine Nakura and Katayama '577 because Nakura “states that the ratio of the filler in the porous membrane that is

integrated with the positive electrode or the negative electrode is 50% by weight or more. Therefore, [Nakura] does not disclose that the lower limit of the content of the fine particles in the heat-resistant layer of the separator is set to 50 vol%” and “[o]n the other hand, [Katayama ’577] teaches that the content of the filler particles is preferably at least 20 vol%, and more preferably at least 50 vol% of the total volume of the whole ingredients of the separator so as to improve the effect of preventing the internal short-circuit.” *Id.*, 788–791/946. The Examiner did not agree with the Applicants arguments and issued an Advisory Action. *Id.*, 797–799/946.

110. The Applicant then filed a Request for Continued Examination (*Id.*, 801/946), expanding on the arguments that a POSITA would not combine Nakura and Katayama ’577. *Id.*, 814–818/946. The Examiner then issued a Non-Final Office Action, maintaining the rejections based on Nakura and Katayama ’577. *Id.*, 830–835/946. The Applicant then amended independent claim 1 to require that “the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4” to overcome Nakura. *Id.*, 839/946, 849/946. The Examiner maintained the rejection in a Final Office Action (*Id.*, 865–867/946) and, in response, the Applicant argued that the combination of Nakura and Katayama ’577 would lead to a short-circuit. *Id.*, 879/946. After these arguments, the Examiner allowed the application. *Id.*, 885–891/946.

F. Priority Date

111. The challenged claims are not entitled to the foreign priority applications' priority dates because their disclosures are not sufficient to convey to a POSITA all features of the independent claim of the '251 Patent. For example, neither of the priority documents (JP 2008/039527 or JP 2007/259575) discloses "a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol % or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol % or less." Rather, unlike the '251 Patent, the priority documents only provide average particle sizes and do not specify the claimed size distribution. *Contrast* EX1001, 15:53-57 *with* EX1008, [0083] and EX1019, [0107]. It is literally impossible to derive particle size distribution from average particle size alone. But the foreign priority documents applications each provide only a single generic reference to average particle size in the range 0.001-15 μm (EX1008, [0033]) or 0.01-10 μm (EX1019, [0025]), respectively. Nor does either application offer other guidance from which a POSITA could derive the much-narrower claimed range (less than 10 vol. % below 0.2 and less than 10 vol. % above 2 μm) from the much larger ranges disclosed in the foreign priority applications. Therefore, my understanding is that the earliest possible priority date of the challenged claims of the '251 Patent is September 30, 2008, the

date of filing of the PCT application that first included the narrower range now required by every claims of the '251 Patent.

G. Claim Construction

112. I understand claim terms are given their “ordinary and customary meaning ... as understood by [a POSITA] and the prosecution history.” 37 C.F.R. § 42.100(b). I further understand that a claim term is interpreted according to its ordinary and customary meaning as a POSITA would have understood the term in light of the surrounding claim language, other claims, the specification, and the patent’s prosecution history, which are referred to as intrinsic evidence. I also understand that prior art references cited in the patent’s prosecution history are considered intrinsic evidence. I further understand that evidence outside the patent and its prosecution history (e.g., dictionaries and technical articles), may inform the context in which a POSITA would have understood the claims of a patent. I understand this ordinary and customary meaning applies absent unique circumstances, such as where a patent clearly expresses an intent to set forth a special meaning for a term, or a claim term does not convey any particular structure to a POSITA (e.g., “means”).

i. Particle Size

113. Petitioner believes formal construction is unnecessary, but notes that particle size measurements of micro-scale particles typically involves indirect

measurement. For example, the '251 Patent describes the measurement of particle size using a “laser diffraction particle size analyzer (e.g. LA-920 manufactured by Horiba, Ltd.).” EX1001, 6:49-54. This approach was consistent with measurements of other examples of such micro-scale particles in this particular art. *See, e.g.*, EX1006, [0049] (“number-average particle diameter measured by using a laser scattering particle size distribution meter (such as “LA-920” manufactured by HORIBA)”).

X. COMPARISON OF PRIOR ART TO '251 PATENT'S CHALLENGED CLAIMS

A. Ground 1 - Claims 1-37 are Obvious over Yoshida and Katayama

1. Motivation to Combine Yoshida and Katayama

114. A POSITA would have been motivated to develop a heat-resistant separator because doing so was desirable to improve the safety of a battery at increased temperatures. *See* EX1005, [0004]; EX1001, 1:20-45 (describing “Background Art”); §VII.B. For example, Yoshida discloses the importance of a separator that can both limit ion flow above a shutdown temperature, and prevent “shrink and generation of holes” as temperature further increases. EX1005, [0004], [0005].

115. Yoshida describes an integrated, multilayer separator with shutdown and heat-resistant layers between positive and negative electrodes. EX1005, FIG. 1, [0013], [0021]. Katayama similarly discloses a battery separator with a heat-

resistant layer and a shutdown layer. EX1006, [0002], [0015] (overall structure), [0022] (shutdown layer), [0023] (heat-resistant layer), [0073] (separator can be “integrated with the electrodes”). Katayama also shares a similar focus of a battery or “electrochemical device having excellent safety at a high temperature.” *Id.*, Abstract.

116. Particularity given their similar structures and goals of improving battery safety at high temperatures a POSITA would have been motivated look to Katayama for details of Yoshida’s components. Specifically, a POSITA would have been motivated to incorporate Katayama’s layer thicknesses, porosity, particle details, binder materials, and manufacturing processes as the practical details of implementing the overall structure and benefits described by Yoshida. A POSITA would have been motivated to incorporate these details from Katayama for each of several, independent reasons.

117. First, a POSITA would have been motivated to look to Katayama for details of Yoshida’s components to accomplish Yoshida’s goals of improved overall battery safety at increased temperatures, which Katayama also sought to achieve. *See* EX1005, Abstract, [0001], [0004]; EX1006, [0001] (“separator with ... excellent dimensional stability at a high temperature”). Yoshida does not explicitly disclose all details of its separator and battery materials. A POSITA reviewing Yoshida would therefore have been motivated to look elsewhere for certain details of

Yoshida's multi-layer separators and batteries. As explained in more detail below, a POSITA would have recognized that Katayama's explanation of certain materials and details of a similar nonaqueous battery with similar separator structure would have been highly relevant to selecting materials and details for, and understanding certain properties of, Yoshida's battery and its components.

118. Second, a POSITA would have been motivated to look to Katayama for details of Yoshida's components to ensure the implementation of Yoshida's separator and overall battery with acceptable performance characteristics for the primary battery function. A POSITA would have understood, and Katayama confirms, that Katayama's separator layer thicknesses and porosities, filler particles and vol. % in the heat-resistant layer could be used in Yoshida's battery to achieve desirable battery performance characteristics. For example, Katayama explains how its properties—such as layer thicknesses (EX1006, [0081]-[0082]), porosity levels (*id.*, [0083]), and filler vol. % for the heat-resistant layer (*id.*, [0058]-[0059])—are chosen to achieve desirable battery performance characteristics like energy density while improving safety at high temperatures.

119. Third, a POSITA would have been motivated to incorporate various parameters and details from Katayama's structure because Katayama explicitly touts the benefits of doing so in a nonaqueous battery like Yoshida's with a multi-layer separator. For example, Katayama explains the benefits of its layer thicknesses

(EX1006, [0081]-[0082]), porosity levels (*id.*, [0083]), filler vol. % for the heat-resistant layer (*id.*, [0058]-[0059]), binders (*id.*, [0068]-[0069]), and manufacturing processes (*id.*, [0089]).

120. Fourth, a POSITA would have found the incorporation of these details from Katayama to be a simple substitution because a POSITA would have been familiar with the properties of the materials, which were known in the art, and further considered these materials to behave predictably. Therefore, a simple substitution of the materials in this well-developed field would have been expected to yield predictable and desirable results—*e.g.*, improved heat resistance of the battery, a stated goal of Yoshida and Katayama.

121. **Thickness and Porosity**. Yoshida does not offer any express guidance as to the thickness or porosity of its separator layers. A POSITA would have known that the thickness and porosity of these separator layers are two physical properties of that impact the overall safety and heat-resistance of the battery, as well as electrical performance; and would have been motivated to reduce thickness while maintaining sufficient physical strength. *See* Section VII.C; EX1006 at [0049] (“When the particle diameter is too large, the thickness of the first separator layer is increased, and thus the energy density of the electrochemical device is decreased”).

122. In the specific context of a battery separator with similar structure and similar materials, which achieves a similar goal of improved safety at high-

temperatures, Katayama discloses desirable ranges for layer thicknesses and porosity. Thus, a POSITA would have been motivated to implement Yoshida's multi-layer separator with Katayama's separator-layer thicknesses and porosity levels. Specifically, Katayama discloses a shutdown layer thickness of 1-15 μm ("more preferably" 3-10 μm), a heat-resistant layer thickness of 2-30 μm ("more preferably" 4-20 μm), and a total separator thickness of 3-30 μm ("more preferably" 5-20 μm . EX1006, [0081]-[0082]. Katayama explains that the lower ends of these narrower ranges are more preferable minimums for "further improving the effect of preventing a short circuit ..., securing the strength of the separator, and keeping the handleability," and the upper ends of these narrower ranges are "more preferable" maximums for "further increasing the energy density" of the battery. *Id.*, [0082].

123. For porosity of the overall separator, Katayama teaches 15% or more and, "more preferably 20% or more ... for securing the liquid capacity for the electrolyte and improving the ionic permeability," and, on the upper end limited to "70% or less, and more preferably 60% or less." EX1006, [0083]. And, for porosity of the second [heat-resistant] layer, Katayama discloses a range of 10% to 50%. *Id.*, [0051], [0085].

124. Thus, a POSITA would have viewed these ranges of thickness and porosity—details Yoshida does not expressly list—to have been desirable, if not optimal, for balancing the desirable separator characteristics of short circuit

protection, separator strength and handleability, energy density, and ionic permeability.

125. **Filler Particles & Volume % in Heat-Resistant Layer.** For the particles in its second porous [heat-resistant] layer 3b, Yoshida lists several possible materials (EX1005, [0025]) and the general limit that their average particle size “is preferably at most 0.5 μm ” (*id.*, [0026]), but does not include specific particle size distributions. Particularly in view of Yoshida’s cautions about aggregate being too large or too small (*id.*), a POSITA would have understood that particle size distribution could impact the formation of such aggregates. As such, a POSITA would have been motivated to look to Katayama for particle details, including particle size distribution (which can vary for a given average particle size)—that had been used successfully for heat-resistant layers. Katayama’s Example 1 includes one such example: “silica (SiO_2) fine particles (average particle diameter: 0.4 μm ; particle size distribution: 0.3 to 0.7 μm).” EX1006, [0124]. Notably, the silica material of these particles is expressly called out by Yoshida as suitable for its heat-resistant layer (EX1005, [0025]), and the average particle size of these particles meets Yoshida’s requirement that “the average particle size ... is preferably at most 0.5 μm ” (*id.*, [0026]), which would confirm for a POSITA the suitability of these particles for use in Yoshida’s heat-resistant layer. So too does Katayama express a preference for inorganic fine particles, of which silica is one type. EX1006, [0053]

(“inorganic fine particles are used more preferably from the viewpoint of the stability or the like”).

126. Katayama also explains that the second layer is primarily included to prevent a short circuit between electrodes, which “becomes difficult” if the filler content is too low. *Id.*, [0059]. As such, Katayama teaches the desirability of a filler content in the heat-resistant layer of “preferably at least 50 vol. %, ... and further preferably at least 80 vol. % of the entire volume of the whole solid contents.” *Id.* Katayama’s Example 1 also ties together these disclosed values of particle size distribution and vol. % with the separator porosity addressed above. *See* EX1006, [0124] (particle size distribution), [0125] (58% volume content of silica particles), and [0178] (Table 1: Example 1, second [heat-resistant] separator layer with 25% porosity).

127. Particularly given the necessity of preventing shorts between electrodes, a POSITA would have recognized Katayama’s teachings of minimum volume % for the filler particles, and the particular particle size distribution of Katayama’s Example 1, as desirable options for Yoshida’s heat-resistant layer.

128. **Binder Materials.** Yoshida explains that “any binder can be used if it dissolves [in] t[he] solvent but does not dissolve in the electrolytic solution of the battery” (EX1005, [0027]), but does not offer further guidance. A POSITA thus would have been motivated to look to Katayama for binders that would improve

desirable battery characteristics, such as heat resistance and handleability. *See* §VII.A. Katayama lists numerous organic binders, but explains that “a heat-resistant binder having a heat-resistant temperature of 150° C or higher is used preferably,” and that “binders with high flexibility such as EVA [ethylene-vinyl acetate copolymer], ethylene-acrylic acid copolymers, fluorine-based rubber, and SBR are preferable.” EX1006, [0068]-[0069]. Katayama also explicitly lists EVA as “having 20 mol % to 35 mol % of a structural unit derived from vinyl acetate.” *Id.*, [0068]. Katayama also explains that the inclusion of a binder in the heat-resistant layer to secure the filler particles allows the “second separator [heat-resistant] layer [to] function[] to some extent as a base material of the separator, and thus the handleability is not a significant problem in the case where the separator is integrated with the electrodes.” *Id.*, [0073]. A POSITA therefore would have recognized Katayama’s “preferable” binder examples as desirable options for Yoshida’s separator.

129. **Positive Active Materials.** Yoshida does not offer guidance on selecting electrode materials, and mentions just one example of a positive active material for a cathode. EX1005, [0032]. A POSITA thus would have been motivated to look to Katayama for positive active materials that would improve desirable battery characteristics, such as enhanced safety at elevated temperatures (e.g., via high heat generation starting temperatures). §VII.D. Katayama discloses

several examples of suitable positive active materials, noting that “there is no particular limitation.” EX1006, [0106]. Specific examples include LiFePO_4 and $\text{LiMn}_{1/3}\text{Ni}_{1/3}\text{Co}_{1/3}\text{O}_2$. *Id.* Katayama discloses that any of its examples can be used, such that a POSITA would have viewed any of Katayama’s specific examples to be suitable options, particularly given Katayama’s stated benefit of “excellent safety at high temperature.” EX1006, Abstract; §VII.D.

130. Additionally, a POSITA would have been familiar with the properties of such positive active materials, including their heat generation starting temperatures, at least those that were relatively higher and lower. A POSITA would have recognized these two particular examples as (a) having previously been used successfully in nonaqueous batteries, and (b) having higher heat generation starting temperatures. A POSITA would have also recognized that a higher heat generation starting temperature can improve battery safety at high temperature by increasing the temperature at which the positive active material adds further energy (heat) to a battery whose temperature is already increasing, for example due to external short circuit or overcharging. *See* §VII.D.

131. Ultimately, a POSITA would have been motivated to use a proven positive active material with a relatively high heat generation starting temperature, and would have expected Katayama’s disclosed materials to satisfy this criteria

given Katayama's own use of them in batteries with "excellent safety at high temperature." EX1006, Abstract.

132. A POSITA would therefore have viewed LiFePO_4 and $\text{LiMn}_{1/3}\text{Ni}_{1/3}\text{Co}_{1/3}\text{O}_2$ as desirable material options for Yoshida's positive electrode.

133. **Separator Production.** Yoshida does not discuss the process for forming the first [shutdown] layer of its separator (*see* EX1005, [0022]), mentioning in its examples only one commercially available film (*see id.*, [0031], [0037], [0039], [0042], [0045], [0048]). A POSITA therefore would have been motivated to look to Katayama for particular manufacturing processes for forming its shutdown layer (and overall separator) in a way that would meet Yoshida's goal of improved overall battery safety at increased temperatures, which Katayama also sought to achieve, while achieving layer thicknesses that Yoshida teaches for desirable battery characteristics like energy density, shutdown performance, and handleability. As explained in Section VIII.B above, Katayama discloses manufacturing both separator layers using wet, solvent-extraction processes.

134. A POSITA would have known there are two primary categories of processes for manufacturing films for lithium-ion cells—a dry process and a wet process, with potential tradeoffs in battery performance between the two. §VII.E. And Katayama explicitly describes a direct benefit of using its own solvent-extraction methods, particularly over a conventional drawn film like that used in

Yoshida's examples. EX1006, [0089]. In particular, Katayama explains that its two-layer separator produced "without applying intensive stress unlike a conventional separator formed of a porous film of PE, there is little or no residual stress after the production, and thermal shrinkage is less likely to occur also due to the presence of the second separator layer in that thermal shrinkage is less likely to occur." EX1006, [0089]. Consistent with Yoshida's own teachings (EX1005, Abstract), a POSITA would have recognized that minimizing shrinkage was desirable to avoid internal shorting and thereby improving battery safety at elevated temperatures, and therefore would have viewed Katayama's solvent-extraction methods of producing both separator layers—shutdown layer 3a and heat-resistant layer 3b—as desirable options for use in making Yoshida's overall separator structure.

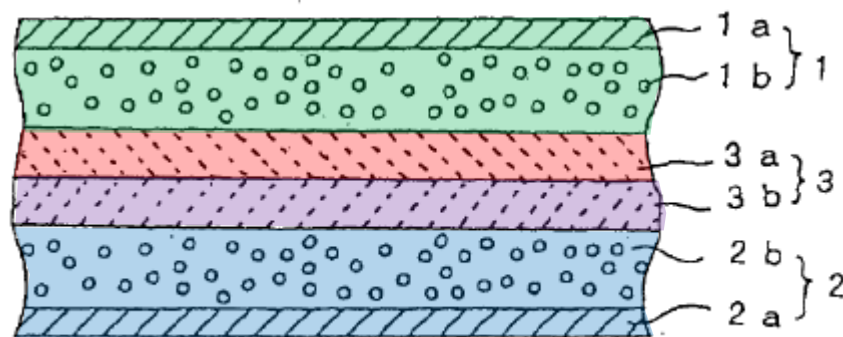
135. **Expectation of Success.** In addition to the explicit teachings of Yoshida, those of Katayama would have led a POSITA to reasonably expected the above-described aspects of Katayama to be effective in implementing the battery of Yoshida with desirable properties, specifically as a battery or "electrochemical device having excellent safety at a high temperature." EX1006, Abstract. Not only does Katayama explain the desirable benefits of its features, as explained above, but the field of battery technology was well-developed with particular understanding of the functionality of these features (§VII), such that a POSITA would have had an independent understanding that would have led to a reasonable expectation that the

above-described features of Katayama would function as Katayama described when incorporated into the highly similar context of Yoshida's battery

2. *Modification of Yoshida in view of Katayama*

136. The combined Yoshida/Katayama separator includes a [purple] heat-resistant layer and a [red] shutdown layer integrated into a multilayer structure interposed between a [green] positive electrode and [blue] negative electrode.

FIG. 1



EX1005, [0013], [0021], FIG. 1.

137. **Shutdown Layer**. In the separator of the Yoshida-Katayama battery, the first, shutdown layer 3a would include a “thermoplastic resin” and have a shutdown temperature—“of softening and shrink of the minute holes”—of 60°C to 150°C. EX1005, [0022]. While Yoshida expressly discloses shutdown temperatures as high as 150°C, for the additional reasons explained below with Limitation 1[i], it

would have been obvious for a POSITA to select the materials of shutdown layer 3a to have a shutdown temperature of 135°C to 150°C.

138. For the reasons explained above in Section X.A.1, shutdown layer 3a would be formed via Katayama's solvent-extraction method.

139. **Heat-Resistant Layer.** For the reasons explained above in Section X.A.1, heat-resistant second layer 3b would be constituted by at least 50 vol. % of the silica particles of Katayama's Example 1 (EX1006, [0059], [0124]) and any of the binders Katayama discloses as preferred—EVA, ethylene-acrylic acid copolymers, fluorine-based rubber, or SBR (*id.*, [0068]-[0069])—and would have a porosity of 10-50% (*id.*, [0051], [0085]).

140. As explained above in Section X.A.1, heat-resistant layer 3b would be formed via Katayama's solvent-extraction method.

141. **Thicknesses of Layers & Overall Separator.** For the reasons explained above in Section X.A.1, shutdown layer 3a would have a thickness of 3-10 µm, heat-resistant layer 3b would have a thickness of 4-20 µm, and the overall separator would have a combined thickness of 5-30 µm (more preferably 5-20 µm). EX1006, [0081]-[0082].

142. **Porosity of Overall Separator.** For the reasons explained above in Section X.A.1, the porosity of the overall separator would be from 20% to 60%. EX1006, [0083].

143. **Positive Active Material.** For the reasons explained above in Section X.A.1, Yoshida-Katayama renders obvious the use of any of the positive active materials disclosed in Katayama, including LiFePO_4 and $\text{LiMn}_{1/3}\text{Ni}_{1/3}\text{Co}_{1/3}\text{O}_2$.

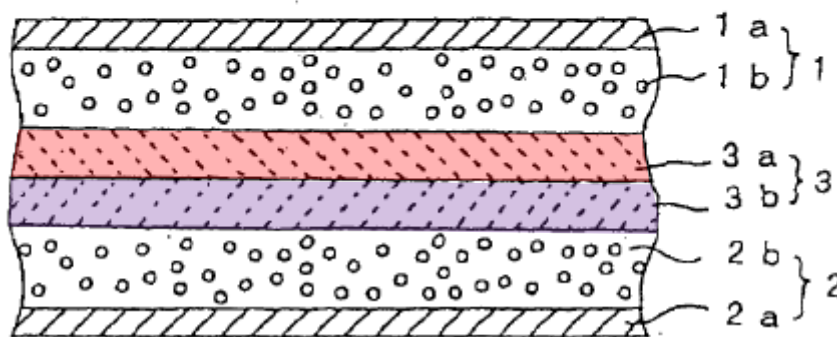
144. Ultimately, it would have been obvious for a POSITA to combine the teachings of Yoshida and Katayama in a way that included every limitation of the claims, as explained in detail below.

3. *Claim 1*

a. **Limitation 1[p]: “A battery separator comprising:”**

145. Without conceding that the preamble limits, Yoshida-Katayama renders obvious a battery separator. As explained above in Sections X.A.1-X.A.2, the Yoshida-Katayama structure is a nonaqueous electrolyte battery having a multilayer separator with a [purple] heat-resistant layer and a [red] shutdown layer.

FIG. 1

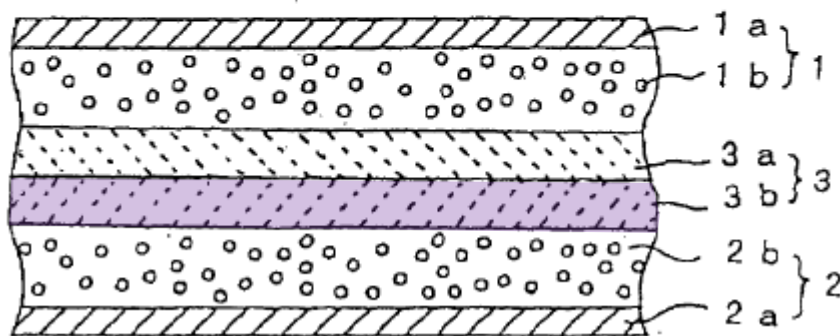


EX1005, [0002]-[0003], [0020]-[0023], FIG. 1

b. Limitation 1[a]: “heat-resistant fine particles; and”

146. Yoshida-Katayama renders obvious heat-resistant fine particles. Yoshida describes examples of the heat-resistant fine particles, including that the “particles may be the one which is non-conductive and insoluble to the electrolyte.” *Id.*, [0025]. It further describes that the heat-resistant fine particles may be organic or inorganic material, “such as silica, alumina, titanium oxide or clay may be used without any particular limitation.” *Id.*, [0025]. Yoshida also describes the size of the fine particles. *Id.*, [0026]. Yoshida states “[t]he average particle size of the above particles is preferably at most 0.5 μm .” *Id.* The [purple] second porous layer 3b comprising fine particles having higher heat resistance than that of the first porous layer is depicted in FIG. 1.

FIG. 1



EX1005, FIG. 1. Yoshida also claims a battery with a “second porous layer” that “comprises fine particles having higher heat resistance.” EX1005, claim 3.

147. As explained above in Sections X.A.1-X.A.2, the Yoshida-Katayama structure includes a [purple] heat-resistant layer 3b (EX1005, [0021], [0023]-[0024]) that includes the silica particles of Katayama’s Example 1. EX1006, [0124]. These particles are heat-resistant. EX1006, Abstract (filler is “heat-resistant”), [0025] (same), [0054] (silica an example of filler); EX1005, [0025] (listing silica as example of fine particles having “high heat resistance”).

c. Limitation 1[b]: “a thermoplastic resin,”

148. Yoshida-Katayama renders obvious a thermoplastic resin. Yoshida’s battery separator includes “a first porous layer [the shutdown layer] containing a thermoplastic resin as a main component.” *Id.*, [0007]; *see also id.*, [0009]–[0022].

149. As explained above in Sections X.A.1-X.A.2, the Yoshida-Katayama structure includes a [red] shutdown layer 3a, of which “the main component” is a “thermoplastic resin.” EX1005, [0022].

d. Limitation 1[c]: “wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,”

150. Yoshida-Katayama renders obvious a heat-resistant layer formed of heat-resistant fine particles and a binder. Yoshida discloses a second porous layer [heat-resistant layer] including fine particles having a higher heat resistances than

the first porous layer [the shutdown layer]. *Id.*, [0007], [0025]; *see also* Limitation 1[a]. Yoshida further discloses mixing a binder with the heat-resistant particles to form the heat-resistant layer. EX1005, [0027]. “The particles can be mixed with various solvent and binder.” *Id.* “As the binder, any binder can be used if it dissolves to solvent but does not dissolve in the electrolytic solution of the battery.” *Id.*

151. As explained above in Sections X.A.1-X.A.2 and for Limitation 1[a], the Yoshida-Katayama structure includes a [purple] heat-resistant layer 3b (EX1005, [0021], [0023]-[0024]) that includes the silica fine particles of Katayama’s Example 1 (EX1006, [0124]) and a binder (EX1005, [0027]; EX1006, [0068]-[0069].

e. Limitation 1[d]: “the thermoplastic resin constitutes a shutdown layer formed of a heat-shrinkable microporous film,”

152. Yoshida-Katayama renders obvious a thermoplastic resin that acts as a shutdown layer and is formed of a heat-shrinkable microporous film. As explained above in Sections X.A.1-X.A.2 , the Yoshida-Katayama structure includes a [red] shutdown layer 3a that includes a “thermoplastic resin” and has a shutdown temperature—“of softening and shrink of the minute holes”—of 60°C to 150°C. EX1005, [0022]; *see also* EX1005, [0036] (“When the battery was heated to 120°C . . . there was an effect that melting of the polypropylene part of the separator 3 (the first porous layer 3a) *shut down ion conductivity.*”), [0020] (“[T]he thermoplastic resin melts and minute holes of the separator become smaller, leading to cut off of

ion conductivity, when a temperature increases under unusual conditions such as short circuit.”).

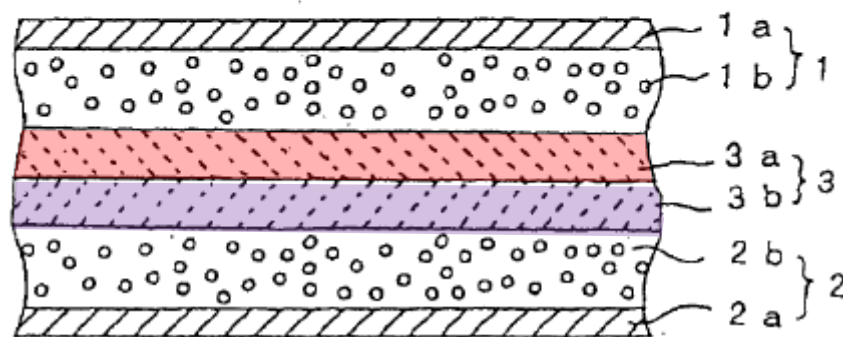
153. For the reasons explained above in Section X.A.1, shutdown layer 3a would be formed via Katayama’s solvent-extraction method and would therefore be a porous film. EX1006, [0021] (“porous film”); *see also* EX1005, [0020] (“The separator of the present invention comprises a porous film containing these thermoplastic resins as a main component (hereinafter referred to as the first porous layer).”). Yoshida also explains that the pores are “minute holes” (EX1005, [0020]) and a nonaqueous battery requires “a [separator] layer between the both electrodes through which lithium ions can move and which has no electric conductivity.” *Id.*, [0003]. A POSITA would have understood that—in the context of a separator layer on the order of 20 μm , such “minute holes” would necessarily be micropores, or else the shutdown layer would not be able to perform its shutdown function because initial melting of the thermoplastic would not necessarily close the pores. Rather, with larger (greater than micro-scale) pores, lithium metal dendrites will continue to grow, leading to an internal short circuit. Indeed, a POSITA would have understood that a general requirement for Lithium-ion battery separators was for the pores to be smaller than 1 μm . *See, e.g.*, EX1013, 4429 (Table 5), 4428 (“submicrometer pore size”).

154. Finally, the thermoplastic resin is heat-shrinkable. EX1005, [0020]. Yoshida describes the resin as having a “*temperature of* softening and *shrink* of the minute holes.” *Id.*, [0022], [0020]; Limitation 1[b].

f. Limitation 1[e]: “the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,”

155. Yoshida-Katayama renders obvious heat-resistant and shutdown layers integrated into a multilayer structure. As shown below, Yoshida discloses a [purple] heat-resistant layer and a [red] shutdown layer integrated into a multilayer structure.

FIG. 1



EX1005, FIG. 1. “Numeral 3 indicates a separator interposed between the positive electrode 1 and the negative electrode 2, and it is obtained by *laminating a first porous layer 3a* [the shutdown layer] containing a thermoplastic resin as a main

component *onto a second porous layer 3b* [the heat-resistant layer] whose heat resistance is higher than that of the first porous layer 3a.” *Id.*, [0021].

g. Limitation 1[f]: “the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4,”

156. As explained above in Sections X.A.1-X.A.2, Yoshida-Katayama renders obvious the shutdown layer 3a having a thickness (A) of 3-10 μm, the heat-resistant layer 3b having a thickness (B) of 4-20 μm, and the overall separator having a combined thickness (sum of A and B) of 7-30 μm. EX1006, [0081]-[0082].

157. I have been informed by counsel for Zhuhai CosMX Battery Co., Ltd that a prior art reference that discloses an overlapping range, even if such range only partially overlaps, is sufficient for anticipation.

158. For the limitation that $5 \leq A \leq 30 \mu\text{m}$,³ Yoshida-Katayama rendered obvious that the thickness (A) of shutdown layer 3a is 3-10 μm. EX1006, [0081]-[0082]. Most—roughly 71%—of this “preferred” range $((10-5)/(10-3) = 71\%)$ overlaps a significant portion of the claimed range.

³ Despite reciting $5 \leq B \leq 30$, the $A + B \leq 23$ limitation means claim 1 precludes A from exceeding 22 because the claim also requires that $A \geq 1$.

159. For the limitation that $1 \leq B \leq 10 \text{ } \mu\text{m}$, Yoshida-Katayama renders obvious that the thickness (B) of heat-resistant layer 3b is 4-17 μm . EX1006, [0081]-[0082]. Nearly half—roughly 46%—of this “preferred” range falls within the claimed range $((10-4)/(17-4) = 46\%)$.

160. For the limitation that $6 \leq A+B \leq 23$, the preferred minimum thicknesses of 3 μm for the shutdown layer and 4 μm for the heat-resistant layer results in a minimum preferred sum of A and B of 7 μm , and the preferred maximum thicknesses of 10 μm for the shutdown layer and 20 μm for the heat-resistant layer results in a maximum preferred sum of A and B of 30 μm . As such, the preferred range of A + B is 7 to 30 μm , with corresponding ratios A/B of 3/4 at the minimum preferred layer thicknesses to 1/2 at the max preferred layer thicknesses. Thus, all of the disclosed preferred range of ratios falls within the claimed range of ratios, and the majority—roughly 70%—of the disclosed preferred range of the sum of A and B $((23-7)/(30-7) = 70\%)$ overlaps the claimed range of 6 to 23.

161. Moreover, Katayama discloses that the separator should have an overall “thickness of ... more preferably not more than 20 μm . EX1006, [0081]. A POSITA therefore would have been guided by Katayama to limit the total separator thickness to 20 μm . Given the change in A/B aspect ratio from 3/4 (0.75) at the minimum preferred layer thicknesses to 1/2 (0.5) at the maximum preferred layer thicknesses,

a POSITA would have inferred that Katayama's preferred aspect ratio at a total separator thickness of 20 μm could be simply interpolated as follows:

$$A/B_{20\mu\text{m}} = 0.5 + \left((0.75 - 0.5) \times \frac{(20 - 7)}{(30 - 7)} \right) = 0.64$$

162. Thus, a POSITA would have reasonably inferred that a desirable aspect ratio at the maximum preferred total thickness of 20 μm would have been 0.64, which results in $A = 7.8 \mu\text{m}$, and $B = 12.2 \mu\text{m}$. Applying these as the upper ends of Katayama's preferred ranges results in $3 \leq A \leq 7.8 \mu\text{m}$, and $4 \leq B \leq 12.2 \mu\text{m}$. With this approach of $A/B = 0.64$, most—roughly 58%—of this most-preferred A range falls within the claimed range $((7.8-5)/(7.8-3) = 58\%)$, as does the aspect ratio (0.64), the corresponding B values (7.81 μm to 12.2 μm), and the sum of $A+B$ (from 12.81 μm to 20 μm).

163. Even applying the more-conservative maximum-thickness A/B aspect ratio (1/2) to the maximum preferred total thickness of 20 μm results in $A = \sim 6.67 \mu\text{m}$, and $B = \sim 13.33 \mu\text{m}$. Applying these as the upper ends of Katayama's preferred ranges results in $3 \leq A \leq 6.67 \mu\text{m}$, and $4 \leq B \leq 13.33 \mu\text{m}$. With this approach of $A/B = 0.50$, a significant portion—roughly 35%—of this most-preferred A range falls within the claimed range $((6.67-5)/(6.67-3) = 35\%)$, as does the aspect ratio (0.5), the corresponding B values (10 μm to 13.33 μm), and the sum of $A+B$ (from 15 μm to 20 μm).

164. Likewise, applying the minimum-thickness A/B aspect ratio (3/4) to the maximum preferred total thickness of 20 μm results in $A = 8.57 \mu\text{m}$, and $B = 11.43 \mu\text{m}$. Applying these as the upper ends of Katayama's preferred ranges results in $3 \leq A \leq 8.57 \mu\text{m}$, and $4 \leq B \leq 11.43 \mu\text{m}$. With this approach of $A/B = 0.75$, most—roughly 64%—of this most-preferred A range falls within the claimed range $((8.57-5)/(8.57-3) = 64\%)$, as does the aspect ratio (0.75), the corresponding B values (6.67 μm to 11.43 μm), and the sum of A+B (from 11.67 μm to 20 μm).

165. Finally, varying the respective layer thicknesses within the limited preferred ranges set forth by Katayama would have involved no more than routine optimization that—with only two thicknesses to vary—would have inevitably included values that met all aspects of this Limitation 1[f].

166. Thus, regardless of the approach for which Patent Owner might argue, Yoshida-Katayama renders obvious particular layer thicknesses of each of A and B, and corresponding total thicknesses of A and B and aspect ratio A/B, significant portions of which overlap those of Limitation 1[f].

h. Limitation 1[g]: “a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol % or more of a total volume of components in the heat-resistant layer,”

167. Yoshida-Katayama renders obvious a content of heat-resistant fine particles in the heat-resistant layer of a separator is 50 vol % or more of a total

volume of components in the heat-resistant layer. As explained above in Sections X.A.1-X.A.2, the silica particles of Katayama's Example 1 would have constituted at least 50 vol. % of the total volume of components in heat-resistant second layer 3b of the Yoshida-Katayama structure. EX1006, [0059], [0124]. Katayama discloses "the content of the filler in the second separator layer is preferably *at least 50 vol. %*, more preferably at least 70 vol. %, and further preferably at least 80 vol. % of the entire volume of the whole solid contents." *Id.*, [0059].

168. In one example, the "*volume content* of the alumina fine particles in the second separator layer *was calculated to be 87%.*" *Id.*, [0156]. Therefore, a POSITA would have understood Katayama to disclose the content of the heat-resistant fine particles in the heat-resistant layer is 80 vol % or more of a total volume.

169. Similarly, a POSITA would have understood Yoshida to disclose the content of the heat-resistant fine particles in the heat-resistant layer is 80 vol % or more of a total volume. EX1005, [0031]. As discussed above, Yoshida discloses the weight % of the binder, which a POSITA would have been able to use to determine the vol. % of the heat-resistant fine particles in the heat resistant layer. *Id.*

170. For example, Yoshida discloses an example where alumina staple is mixed with poly(vinylidene fluoride). *Id.* In this example, Yoshida discloses that

the weight % of poly(vinylidene fluoride) as 10, which a POSITA would have understood to mean that there was 90 weight % alumina in the heat-resistant layer. To calculate vol. %, a POSITA known the densities of alumina and poly(vinylidene fluoride) to be 3.965 g/cm³ and 1.82 g/cm³, respectively. The vol % of alumina in Example 1 is **80.51 (i.e., more than 80 vol %)**, determined by the following calculation: $\left(100 \times \frac{90}{3.965}\right) \div \left(\frac{90}{3.965} + \frac{10}{1.82}\right)$.

171. Therefore, in addition to the desirability of such a volume content of particles taught by Katayama, a POSITA would have recognized that such content levels were consistent with Yoshida's, and therefore would have reasonably expected to be successful in using such particle content levels in Yoshida's structure.

i. Limitation 1[h]: “a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol % or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol % or less, and”

172. Yoshida-Katayama renders obvious the heat-resistant layer having particles with this size distribution. As explained above in Sections X.A.1-X.A.2 and for Limitation 1[c], the Yoshida-Katayama structure includes a [purple] heat-resistant layer 3b (EX1005, [0021], [0023]-[0024]) that includes the silica fine particles of Katayama's Example 1 (EX1006, [0124]) and a binder (EX1005, [0027]; EX1006, [0068]-[0069]). These particles are “silica (SiO₂) fine particles (average

particle diameter: 0.4 μm ; particle size distribution: 0.3 to 0.7 μm).” EX1006, [0123].

173. A POSITA would have understood this disclosure to mean that the D10 value is 0.3 μm , the D50 value is 0.4 μm , and the D90 value is 0.7 μm . What this means is that 10% of the particles had a particle size of less than 0.3 μm , and 90% of the particles had a particle size less than 0.7 μm . Particle size distribution is common described as D10, D50, and D90, wherein 10% of the particles are lower than D10, the average is D50, and 90% of the particles are smaller than D90. A POSITA would understand such a disclosure to mean that 0.3 μm is D10 and 0.7 μm is D90.. Importantly, D10, D50, and D90 values are all the same for particles of a given material, whether referring to mass or volume. Mass is converted to volume by dividing mass by density, and volume is converted to mass by multiplying volume by density. In either, the density is the same for each of D10, D50, and D90; meaning D10, D50, and D90 are the same for mass % and volume % of a given material. Thus, a POSITA would have understood from Katayama’s disclosure that a proportion of particles with particle size of 0.3 μm or less is 10 vol. % or less (i.e., necessarily *less than* 10 vol. % have a particle size of 0.2 μm or smaller), and a proportion of particles with particle size of 0.7 μm or more is 10 vol. % or less (necessarily *less than* 10 vol. % have a particle size of 0.7 μm or larger); which is within the limits of Limitation 1[h].

j. Limitation 1[i]: “a shutdown is effected in a range of 135° C. to 150° C.”

174. Yoshida-Katayama renders obvious a separator with a “shutdown effected in a range of 135°C. to 150°C.” As explained above in Sections X.A.1-X.A.2, Yoshida-Katayama renders obvious a shutdown layer 3a with a shutdown temperature—“of softening and shrink of the minute holes”—of 60°C to 150°C. EX1005, [0022]. This range overlaps the claimed range.

175. Additionally, a POSITA would have recognized Yoshida’s disclosure for what it is—an express indication that shutdown temperatures throughout the entire range would be desirable in different implementations of Yoshida’s battery. *See* EX1009, 38, Figure 23 (shutdown temperatures of commercially available separators of 131°C, 139°C, 143°C). With active materials having higher heat generation starting temperatures like 229°C and a stable heat-resistant layer 3b, a POSITA would have found it desirable to for the shutdown layer 3a to have a shutdown temperature at the upper end of Yoshida’s disclosed range—i.e., 135°C to 150°C. In such implementations, with other battery materials that can reliably survive temperatures in excess of 180°C (*see, e.g.*, EX1006, [0075]), a POSITA would have recognized that a shutdown temperature lower than 135° C (e.g., 130°C) would be relatively inefficient in that it would melt and permanently disable a battery

cell at a temperature that is unnecessarily low. Typically materials with low shutdown temperature have lower shrinkage temperatures.

176. On the other hand, with other battery materials that can reliably survive temperatures in excess of 180°C (*see, e.g.*, EX1006, [0075]), a POSITA would have recognized that a higher shutdown temperature such as 140°C would have desirably allowed for increased charging rates (and associated higher temperatures), use in higher-temperature environments, or both. *See, e.g.*, EX1018, Table 1 (listing 138°C and 145°C separator shutdown temperatures). Indeed, even with what PO may see as a choice to pursue relatively lower shutdown temperatures, Katayama discloses three examples—Examples 5 and 11, and Comparative Example 3—having shutdown temperatures of 135°C and 137°C based on the unique composition of the shutdown layer. EX1006, Table 3

177. A POSITA would have also reasonably expected success in implementing shutdown temperatures within the range disclosed by Yoshida. First, Yoshida expressly discloses such temperatures and materials that could be configured to achieve them. EX1005, [0022]. Second, Katayama includes examples of separators with shutdown temperatures within the claimed range—i.e., 135°C and 137°C. EX1006, [0184] Table 3. And, third, a POSITA would have independently understood that shutdown temperature was adjustable by selecting and/or adjusting

the composition of the thermoplastic resin (e.g., vol %, ratio, and density). See §VII.C.

178. Thus, Yoshida-Katayama renders obvious a shutdown layer with a shutdown temperature in the range of 135°C to 150°C.

4. *Limitation 2: “The battery separator according to claim 1, wherein a thermal shrinkage ratio in a width direction is 10% or less at 200° C.”*

179. Yoshida-Katayama renders obvious a separator with a thermal shrinkage ratio in a width direction of 10% or less at 200°C. As explained above in Sections X.A.1-X.A.2 and for Limitation 1[g], the content of the silica particles in heat-resistant layer 3b of the Yoshida-Katayama structure would have included “preferably at least 50 vol. %, ... of the entire volume of the whole solid contents.” EX1006, [0059]. Additionally, in at least some configurations, a POSITA would have been motivated to “further preferably” increase this particle content at least 80 vol. % to further improve the likelihood that the heat-resistant layer can fulfill its primary function of preventing a short circuit between electrodes, as taught by Katayama. *Id.*

180. Such a heat-resistant layer inherently would have had a thermal shrinkage ratio in a width direction of 10% or less at 200°C. First, 80 vol. % or more of the heat-resistant layer 3b would have been defined by the particles of Katayama’s Example 1 (see Limitation 1[h]) that are silica (SiO₂), which are a ceramic. Such

ceramics were known to have very low thermal shrinkage ratios of 1% or less *See, e.g.,* EX1007, [0051] (“Examples of this kind of heat-resistant material [“that can be used for the separator”] ... include ... ceramic (thermal shrinkage: 1% or less)”). And a heat-resistant layer formed by Katayama’s solvent extraction method (*see* Sections X.A.1-X.A.2), even when integrated with a polyolefin shutdown layer, would inherently exhibit thermal shrinkage of 10% or less at 200°C.

181. The '251 Patent itself confirms that this Yoshida-Katayama separator would inherently exhibit a thermal shrinkage ratio of less than 10% at 200° C. For example, Table 1 of the '251 Patent lists thermal shrinkage ratios at 200°C of 2% and 1% for Examples 1 and 4, respectively, both of which utilize a ceramic particle content of 80 vol. % or more. EX1001, 18:15-35, Table 1. Example 4 has ceramic particle content of 91 vol. % boehmite, a binder content of 9 vol. % of SBR, and a heat-resistant layer thickness of 6 μm , together yielding a thermal shrinkage ratio of 1% at 200°C. Therefore, a POSITA would have expected that at roughly the midpoint of a particle content range of 80-100 vol. %, the shrinkage would be 1% based on Katayama’s teachings and confirmed by the '251 Patent. Example 1 has a significantly higher particle content of roughly 95 vol. % (based on 4000 g of boehmite at $\sim 3 \text{ g/cm}^3$ (*see* EX1006, [0131]), and 80 g of acrylic resin binder at $\sim 1.2 \text{ g/cm}^3$ (*see* EX1006, [0125])) and a shrinkage ratio of 2%. A POSITA would have understood that the heat-resistant layer resists shrinkage of the attached shutdown

layer, such that a solids content as high as 95% could increase shrinkage, as reflected in Example 1 relative to Example 4, because it leaves very little binder to resist relative movement between the particles. A POSITA also would have understood that increasing binder relative to that 5 vol. % level would—to a point—resist relative movement between particles and thereby decrease shrinkage, as reflected in Example 4 relative to Example 1. A POSITA would have expected the further increasing content of binder relative to the 9 vol. % of Example 4 would decrease shrinkage, at least to 20 vol. % binder and 80 vol. % particles, consistent with Katayama's "more preferred" threshold of 80 vol. % particles. Conservatively, a POSITA therefore would have expected that shrinkage would be less than or equal to 2% when particle content at least 80 vol. %.

182. Based on Katayama's teachings that this low shrinkage prevents short circuits and improves the safety of the electrochemical device at a high temperature (EX1006; [0090]), and the knowledge (confirmed by Katayama) that solids content impacts shrinkage, a POSITA would have been motivated to minimize shrinkage by optimizing the particle content within Katayama's preferred range of 80 vol. %, and—as confirmed by the '251 Patent's own measured data—that optimization would necessarily have yielded a two-layer separator with (1) a thermoplastic resin, microporous film shutdown layer, and (2) a heat-resistant layer with ≥ 80 vol. %

ceramic that necessarily would have exhibited a thermal shrinkage ratio of less than 2% (well under 10%).

5. ***Limitation 3: “The battery separator according to claim 1, wherein the content of the heat-resistant fine particles in the heat-resistant layer is 80 vol % or more of the total volume of components in the heat-resistant layer.”***

183. Yoshida-Katayama renders obvious a separator with a heat-resistant layer having this particle content. *See* Limitation 2 (80 vol. %).

6. ***Limitation 4: “The battery separator according to claim 1, wherein the heat-resistant fine particles are inorganic fine particles.”***

184. Yoshida-Katayama renders obvious a battery separator with heat-resistant inorganic fine particles. As explained above in Sections X.A.1-X.A.2 and for Claim 1[h], the Yoshida-Katayama structure includes a [purple] heat-resistant layer 3b (EX1005, [0021], [0023]-[0024]) that includes the silica fine particles of Katayama’s Example 1 (EX1006, [0124]). These “silica fine particles ... contain 25 vol % of plate-like particles.” EX1006, [0126]. A POSITA would have recognized, and Katayama confirms, that silica (SiO₂) is inorganic. EX1006, [0054]. Further, Yoshida discloses “an organic or inorganic powder (fine particles)” as the heat-resistant layer. EX1005, [0024]. It also describe the heat-resistant fine particles as organic or inorganic material, “such as silica, alumina, titanium oxide or clay may be used without any particular limitation” (*id.*, [0025]), and expresses a clear

preference for inorganic fine particles. *Id.*, [0053] (“inorganic fine particles are used more preferably from the viewpoint of the stability or the like”). A POSITA would have understood that silica or SiO₂ (like alumina and titanium dioxide) is a ceramic, which is inorganic.

7. ***Limitation 5: “The battery separator according to claim 4, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, BaTiO₃, boehmite, zeolite, and kaoline.”***

185. Yoshida-Katayama renders obvious a separator with fine particles of silica. *See* Limitation 4 (silica).

8. ***Limitation 6: “The battery separator according to claim 1, wherein the heat-resistant fine particles include plate-like particles.”***

186. Yoshida-Katayama renders obvious a separator with heat-resistant fine particles that include plate-like particles. As explained above in Sections X.A.1-X.A.2 and for Limitation 1[h], the Yoshida-Katayama structure includes a [purple] heat-resistant layer 3b (EX1005, [0021], [0023]-[0024]) that includes the silica fine particles of Katayama’s Example 1 (EX1006, [0124]) and a binder (EX1005, [0027]; EX1006, [0068]-[0069]). These “silica fine particles ... contain 25 vol % of plate-like particles.” EX1006, [0126]. And Yoshida confirms the desirability of heat-resistant fine particles in the heat-resistant layer that include plate-like particles such as “*an organic or inorganic plate.*” EX1005, [0024].

9. Limitation 7: “The battery separator according to claim 1, wherein the heat-resistant layer has a thickness of 2 μm to 6 μm .”

187. Yoshida-Katayama renders obvious a separator with a heat-resistant layer that has a thickness of 2 μm to 6 μm . As explained above in Sections X.A.1-X.A.2 and for Limitation 1[f], Yoshida-Katayama renders obvious the heat-resistant layer 3b having a thickness of 4-20 μm . EX1006, [0081]-[0082]. This “preferred” range overlaps the claimed range.

10. Limitation 8: “The battery separator according to claim 1, wherein the thermoplastic resin includes polyolefin.”

188. Yoshida-Katayama renders obvious a separator with thermoplastic resin that includes polyolefin. See Limitation 1[b] (thermoplastic resin). Yoshida discloses “a ***polyolefin*** such as polypropylene or polyethylene” as an example of its thermoplastic resin. EX1005, [0022].

189. And Katayama confirms the desirability of polyolefins “[s]pecific examples contain ***polyethylene (PE), copolymer polyolefin, or a polyolefin derivative (such as chlorinated polyethylene), a polyolefin wax***, a petroleum wax, and a carnauba wax.” EX1006, [0027].

11. Limitation 9: “The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 1.5 μm or less.”

190. Yoshida-Katayama renders obvious a separator with heat-resistant fine particles having an average particle size of 1.5 μm or less. As explained above in Sections X.A.1-X.A.2 and for Limitation 1[c], the Yoshida-Katayama structure includes a [purple] heat-resistant layer 3b (EX1005, [0021], [0023]-[0024]) that includes the silica fine particles of Katayama’s Example 1 (EX1006, [0124]). These particles have an “average particle diameter: 0.4 μm ” (EX1006, [0123]) which is measured using the same “LA-920” analyzer used in the ’251 Patent itself. *Compare id.*, [0049] with EX1001, 6:49-53.

12. Claim 10

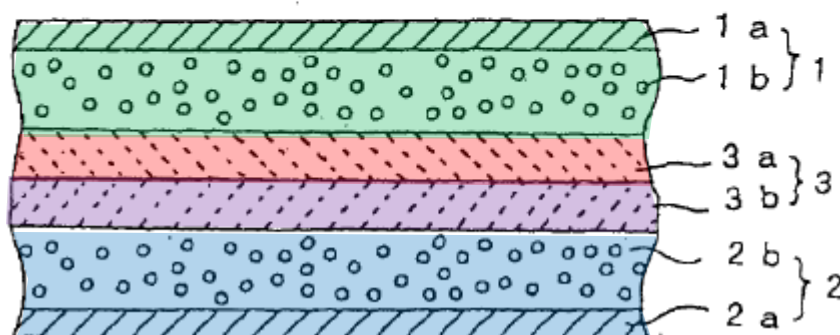
a. Limitation 10[p]: “A nonaqueous electrolyte batter[y] comprising:”

191. Yoshida-Katayama renders obvious a nonaqueous electrolyte battery. *See* Limitation 1[p]. Yoshida discloses lithium-ion batteries. EX1005, [0002], [0003], [0053], claim 4, 5. A POSITA would have understood that a lithium-ion battery is a nonaqueous electrolyte battery, as confirmed by Yoshida’s description of a lithium-ion battery as a type of non-aqueous battery. *Id.*, [0003], [0053].

b. Limitation 10[a]: “a positive electrode having a positive active material capable of intercalating and deintercalating a lithium ion;”

192. Yoshida-Katayama renders obvious a positive electrode having a positive active material capable of intercalating and deintercalating a lithium ion. Yoshida discloses a [green] positive electrode, labeled “1” in Figure 1, used in lithium ion batteries. *Id.*, FIG. 1, [0003]. Yoshida also discloses that “[t]hese non-aqueous batteries comprise a *positive electrode*, a negative electrode and an ion conductive layer sandwiched between the both electrodes as major components.” *Id.* In order to measure the energy density per weight of the example batteries, the batteries were charged and discharged and as a result lithium ions were intercalated and deintercalated in the positive electrode. *Id.*, [0035], [0040], [0043], [0046], [0049]. A POSITA would have understood that a positive electrode in a lithium secondary battery necessarily is inherently capable of deintercalating and intercalating lithium ions, or else the battery would not function.

FIG. 1



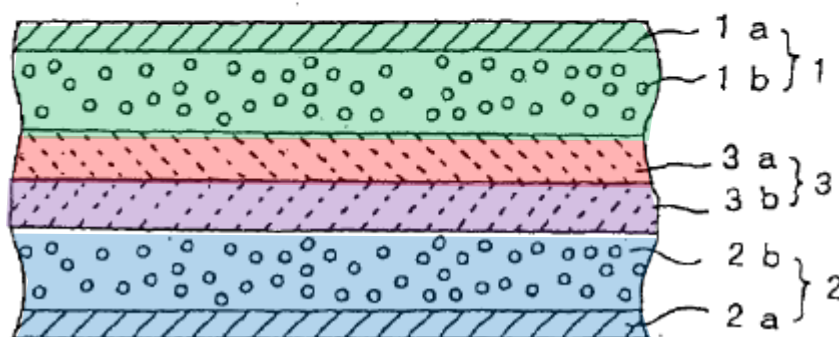
Id., FIG. 1.

c. Limitation 10[b]: “a negative electrode having a negative active material capable of intercalating and deintercalating a lithium ion;”

193. Yoshida-Katayama renders obvious a negative electrode having a negative active material capable of intercalating and deintercalating a lithium ion. Yoshida discloses a [blue] negative electrode, labeled “2” in Figure 1, used in lithium ion batteries. *Id.*, FIG. 1; [0003]. Yoshida also discloses that “[t]hese non-aqueous batteries comprise a positive electrode, a *negative electrode* and an ion conductive layer sandwiched between the both electrodes as major components.” *Id.* In order to measure the energy density per weight of the example batteries, the batteries were charged and discharged and as a result lithium ions were intercalated and deintercalated in the positive electrode. *Id.*, [0035], [0040], [0043], [0046], [0049].

A POSITA would have understood that a negative electrode in a lithium secondary battery necessarily is inherently capable of intercalating and deintercalating lithium ions, or else the battery would not function.

FIG. 1



Id., FIG. 1.

d. Limitation 10[c]: “a separator interposed between the positive electrode and the negative electrode; and”

194. Yoshida-Katayama renders obvious a separator interposed between the positive electrode and the negative electrode. Yoshida’s battery includes “a [red/purple] separator [3] interposed between the positive electrode 1 and the negative electrode 2.” EX1005, [0021].

e. Limitation 10[d]: “a nonaqueous electrolyte,”

195. Yoshida-Katayama renders obvious a nonaqueous electrolyte. Yoshida discloses a nonaqueous electrolyte filled in the battery. *Id.*, [0003] (“non-aqueous solution is filled to constitute the ion conductive layer”). Within this context, in its five Example batteries, Yoshida used an electrolytic solution containing lithium hexafluorophosphate as an electrolyte with ethylene carbonate and 1,2-dimethoxyethane as solvents. *Id.*, [0034] A POSITA would have understood this solution to be a nonaqueous electrolyte. Katayama also discloses “The separator of the present invention is used for an electrochemical device with a non-aqueous electrolyte.” EX1006, [0043].

f. Limitation 10[e]: “wherein a heat generation starting temperature of the positive electrode is 180° C. or higher, and”

196. Yoshida-Katayama renders obvious a positive electrode with a heat generation starting temperature of 180°C or higher. As explained above in Sections X.A.1-X.A.2, Yoshida-Katayama render obvious at least the use LiFeO_4 and $\text{LiMn}_{1/3}\text{Ni}_{1/3}\text{Co}_{1/3}\text{O}_2$ for Yoshida’s positive electrode 1. These two materials each inherently have a high heat generation starting temperature of 229°C. *See, e.g.*, EX1001, 14:24-26 (Example 1 including $\text{LiCo}_{0.33}\text{Ni}_{0.33}\text{Mn}_{0.33}\text{O}_2$ as positive active material), 15:47-49 (Example 3 including LiFePO_4 as positive active material),

18:15-30, Table 1 (listing heat generation starting temperature of 229°C for each of Example 1 and Example 3).

g. Limitation 10[f]: “wherein the separator is the battery separator according to claim 1.”

197. Yoshida-Katayama renders obvious including the separator of claim 1 in the nonaqueous battery of claim 10. As explained above, Yoshida-Katayama renders obvious a battery separator as claimed in claim 1, particularly in the context of a nonaqueous battery such as that of claim 10. *See* Limitations 1[p]-1[i]; EX1005, [0002]-[0003]; EX1006, [0002].

198. Additionally, each of dependent claims 2-9, 23-26, and 32-33 is mapped to Yoshida-Katayama in that same context of such a nonaqueous battery, such that Yoshida-Katayama also renders obvious the separator features of claims 2-9, 23-26, and 32-33 in that same context of the nonaqueous battery of claim 10. *See* Claims 2-9, 23-26, 32-33; EX1005, [0002]-[0003]; EX1006, [0002].

13. Limitation 11: “The nonaqueous electrolyte battery according to claim 10, wherein a thermal shrinkage ratio of the separator is 10% or less at a temperature T (° C.) that is 10° C. lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200° C.).”

199. In my opinion, Yoshida-Katayama renders obvious a nonaqueous electrolyte battery according to claim 10, wherein a thermal shrinkage ratio of the separator is 10% or less at a temperature T (° C.) that is 10° C. lower than the heat

generation starting temperature of the positive electrode (where an upper limit of T is 200°C). *See* Limitation 10[f] and Limitation 2.

14. Limitation 12: “The nonaqueous electrolyte battery according to claim 10, wherein a width of the separator is larger than that of the negative electrode at a temperature T ($^{\circ}\text{C}$.) that is 10°C . lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C .)”

200. Yoshida-Katayama renders obvious a nonaqueous electrolyte battery wherein a width of the separator is larger than that of the negative electrode at the specified temperature. *See* Limitation 11 (separator shrinkage of 2% or less).

201. Yoshida discloses exemplary dimensions for a battery in which positive and negative electrodes had dimensions of 50 mm x 200 mm, and the separator was cut to a width of 52 mm x 210 mm. EX1005, [0034]. It would have been obvious for the Yoshida-Katayama structure to be implemented with these dimensions explicitly disclosed by Yoshida.

202. As explained above in Sections X.A.1-X.A.2, heat-resistant layer 3b of the Yoshida-Katayama structure would have been made by a solvent-extraction method (EX1006, [0089], [0091]), which a POSITA would have expected to result in isotropic shrinkage properties that are the same in both the width and length directions. §VII.E. Thus, applying the maximum of 2% shrinkage at 200°C to the 52 mm x 210 mm dimensions of the separator, would result in the separator having dimensions of 50.96 mm x 205.8 mm. A POSITA would have considered the short

dimension to be the width. However, both of these are larger than the corresponding “cold” dimension, such that this example would meet Limitation 12 regardless of which is considered the width.

15. **Limitation 13** “*The nonaqueous electrolyte battery according to claim 10, wherein the positive active material is at least one selected from the group consisting of the following: a spinel-type lithium-containing complex oxide expressed as a general formula $\text{Li}_{1+t}\text{Mn}_{(2-x)}\text{M}^1_x\text{O}_4$ (where M^1 is at least one element selected from the group consisting of Fe, Ni, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 \leq t \leq 0.1$, and $0 \leq x \leq 0.6$); an olivine-type lithium-containing complex oxide expressed as a general formula LiM^2PO_4 (where M^2 is Co, Ni, Mn, or Fe); a lithium-containing complex oxide having a layered crystal structure expressed as a general formula $\text{Li}_{(1+a)}\text{M}^3_{2b}\text{Mn}_{(0.5-b)}\text{Ni}_{(0.5-b)}\text{O}_2$ (where M^3 is at least one element selected from the group consisting of Fe, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 < a < 0.1$, and $0 \leq b \leq 0.05$); and a lithium-containing complex oxide expressed as a general formula $\text{Li}_{(1+y+a)}\text{Ni}_{(1-y-z-\delta)/2}\text{Mn}_{(1-y-z-\delta)/2}\text{M}^4_z\text{O}_2$ (where M^4 is at least one element selected from the group consisting of Ti, Cr, Fe, Co, Cu, Zn, Al, Ge, Sn, Mg, and Zr, $-0.1 \leq y \leq 0.1$, $-0.05 \leq a \leq 0.05$, $0 \leq z < 0.45$, and $-0.24 \leq \delta \leq 0.6$).”*

203. Yoshida-Katayama renders obvious a nonaqueous electrolyte battery with one of the listed materials. As explained above in Sections X.A.1-X.A.2, Yoshida-Katayama render obvious for Yoshida’s positive electrode at least the use LiFePO_4 and $\text{LiMn}_{1/3}\text{Ni}_{1/3}\text{Co}_{1/3}\text{O}_2$, both of which are included in Limitation 13. EX1006, [0106]. Katayama confirms that its LiFePO_4 is an “olivine-type compound.” EX1006, [0106].

- 16. Limitation 14: “The nonaqueous electrolyte battery according to claim 10, wherein a content of the heat-resistant fine particles in the heat-resistant layer of the separator is 80 vol % or more of a total volume of components in the heat-resistant layer.”**

204. The combination of Yoshida and Katayama discloses or renders obvious this limitation. A POSITA would have understood that the Yoshida-Katayama combination contains a separator with a heat-resistant layer wherein the content of the heat-resistant fine particles in the heat-resistant layer is 80 vol% or more of the total volume of components of the heat-resistant layer. See Limitation 10[f] and Limitation 3.

- 17. Limitation 15: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator are inorganic fine particles.”**

205. The combination of Yoshida and Katayama discloses or renders obvious this limitation. A POSITA would have understood that the Yoshida-Katayama combination includes heat-resistant fine particles in the separator that are inorganic fine particles. See Limitation 10[f] and Limitation 4.

- 18. Limitation 16: “The nonaqueous electrolyte battery according to claim 15, wherein the inorganic fine particles include line particles of at least one selected from the group consisting of alumina, silica, BaTiO₃, boehmite, zeolite, and kaoline.”**

206. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 5.

19. Limitation 17: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator include plate-like particles.”

207. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 6.

20. Limitation 18: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer of the separator has a thickness of 2 μm to 6 μm .”

208. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 7.

21. Limitation 19: “The nonaqueous electrolyte battery according to claim 10, wherein the thermoplastic resin of the separator includes polyolefin.”

209. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 8.

22. Limitation 20: “The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is located on a negative electrode side.”

210. Yoshida-Katayama renders obvious a battery with a shutdown layer of the separator that may be located on a negative electrode side. A POSITA would have understood that in Yoshida’s battery cell with a positive electrode, Yoshida’s two-layer separator, and a negative electrode, there were only two options for positioning the separator layer: (1) with the shutdown layer 3a facing and in contact with the positive electrode, and the heat-resistant layer 3b facing and in contact with

the negative electrode, and (2) with the heat-resistant layer 3b facing and in contact with the positive electrode, and the shutdown layer facing and in contact with the negative electrode. While Yoshida depicts the first option (EX1005, FIG. 1), Yoshida does not explain any reason to prefer that configuration. And Katayama confirms that—in such a two-layer separator, the shutdown layer can be formed only on the negative electrode. EX1006, [0149]. A POSITA therefore would have understood that Yoshida's battery could be formed with the shutdown layer 3a facing and in contact with the negative electrode—i.e., on the negative electrode side of the separator—and the heat-resistant layer 3b facing and in contact with the positive electrode, and that doing so was an obvious choice of one of two available options.

211. Additionally, a POSITA would have been motivated to position the shutdown layer on the negative side of the separator. A POSITA would have known that a polyolefin shutdown layer could only oxidize on the positive electrode, and would therefore have been motivated to position an olefin shutdown layer on the negative electrode side of the separator to simply avoid that risk.

23. *Limitation 21: “The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material.”*

212. Yoshida-Katayama renders obvious a battery with a shutdown layer of the separator that where is the shutdown layer is not in contact with the positive active material. As explained for Limitation 20, it would have been obvious for a

POSITA to reverse the orientation of Yoshida's separator layers—i.e., with the shutdown layer 3b in contact with the positive electrode, such that the shutdown layer 3a would not be in contact with the positive electrode or its positive active material 1b.

24. Limitation 22: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 1.5 μm or less.”

213. The combination of Yoshida and Katayama discloses or renders obvious this limitation. *See* Limitation 10[f] and Limitation 9.

25. Limitation 23: “The battery separator according to claim 1, wherein the shutdown layer has a thickness of 16 μm or less.”

214. Yoshida-Katayama renders obvious a separator with a shutdown layer that has a thickness of 16 μm or less. As explained above in Sections X.A.1-X.A.2 and for Limitation 1[f], Yoshida-Katayama renders obvious the shutdown layer 3a having a thickness of 3-10 μm . EX1006, [0081]-[0082]. This “preferred” range falls entirely within the claimed range.

26. Limitation 24: “The battery separator according to claim 1, wherein a content of the binder in the heat-resistant layer is 1 to 20 vol % of a total volume of components in the heat-resistant layer.”

215. Yoshida-Katayama renders obvious a separator with a heat-resistant layer having 1 to 20 vol % of binder. As explained above for Limitation 3, Yoshida-Katayama renders obvious 80 vol. % or more of particles in the heat-resistant layer.

Because the heat-resistant layer is formed by mixing the particles with solvent and binder, and then evaporating (removing) the solvent, a particle content of 80 vol. % or more means that the binder content is necessarily 1 to 20 vol. %.

27. Limitation 25: “The battery separator according to claim 1, wherein the binder includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol % of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.”

216. Yoshida-Katayama renders obvious a separator with the binder includes at least one of the listed options. As explained above in Sections X.A.1-X.A.2, the heat-resistant layer 3b of the Yoshida-Katayama structure would include any of the binders Katayama discloses as preferred—EVA, ethylene-acrylic acid copolymers, fluorine-based rubber, or SBR (EX1006, [0068]-[0069]), all of which are included in Limitation 25.

28. Limitation 26: “The battery separator according to claim 1, wherein the heat-resistant line particles have an average particle size of 0.3 μm or more.”

217. Yoshida-Katayama renders obvious a separator wherein the heat-resistant line particles have an average particle size of 0.3 μm or more. As explained above in Sections X.A.1-X.A.2 and for Limitation 1[c], the Yoshida-Katayama structure includes a [purple] heat-resistant layer 3b (EX1005, [0021], [0023]-[0024])

that includes the silica fine particles of Katayama's Example 1 (EX1006, [0124]). These particles have an "average particle diameter: 0.4 μm " (EX1006, [0123]) which is measured using the same "LA-920" analyzer used in the '251 Patent itself. Compare *id.*, [0049] with EX1001, 6:49-53.

29. Limitation 27: "The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator has a thickness of 16 μm or less."

218. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 23.

30. Limitation 28: "The nonaqueous electrolyte battery according to claim 10, wherein a content of the binder in the heat-resistant layer of the separator is 1 to 20 vol % of a total volume of components in the heat-resistant layer."

219. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 24.

31. Limitation 29: "The nonaqueous electrolyte battery according to claim 10, wherein the binder of the separator includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol % of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin."

220. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 25.

32. *Limitation 30: “The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 0.3 μm or more.”*

221. The combination of Yoshida and Katayama discloses or renders obvious this limitation. A POSITA would have understood that the Yoshida-Katayama combination includes heat-resistant fine particles in the separator with an average particle size of greater than 0.3 μm . See Limitation 10[f] and Limitation 26.

33. *Limitation 31: “The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material, and a charging potential of the positive electrode is 4.3 V or more.”*

222. Yoshida-Katayama renders obvious a battery wherein the shutdown layer of the separator is not in contact with the positive active material, and a charging potential of the positive electrode is 4.3 V or more. See Limitation 21 (shutdown layer not in contact with positive active material). As explained in Section VII.A, a POSITA understood that current cathode materials then used in lithium ion batteries had higher theoretical capacities, and high voltage lithium ion batteries had been developed and were known to a POSITA by the early 2000s. EX1017, [0019] (disclosing “charge cut-off voltages of 4.3 V, 4.35 V, 4.40 V, 4.45 V, and 4.6 V”). As such, it would have been obvious in view of a POSITA’s knowledge of higher-voltage lithium ion battery cells to implement the Yoshida-Katayama battery with a charge potential of 4.3 V or more.

34. Limitation 32: “The battery separator according to claim 1, wherein the heat-resistant layer has a porosity of 20% to 60%.”

223. Yoshida-Katayama renders obvious a separator with a heat-resistant layer that has a porosity of 20% to 60%. As explained above in Sections X.A.1-X.A.2, the heat-resistant layer 3b would have a porosity of 10-50% (EX1006, [0051], [0085]). The majority of this range—75%—overlaps the claimed range $((50-20)/(50-10) = 75\%)$.

224. Moreover, given Katayama’s guidance that the porosity of the overall separator is preferably 20% to 60%, with the 20% floor being necessary to secure liquid capacity for the electrolyte and improving the ionic permeability, a POSITA would have been motivated to configure the heat-resistant layer 3b to have a porosity of at least 20% to ensure that heat-resistant layer 3b would not unduly restrict the porosity of the overall separator. A POSITA would have had a reasonable expectation of success in doing so, at least because 20%-50% porosity is within (and most of) Katayama’s disclosed range of porosities.

35. Limitation 33: “The battery separator according to claim 1, wherein the whole separator has a porosity of 30% to 70%.”

225. Yoshida-Katayama renders obvious a separator with a porosity of 30% to 70%. As explained above in Sections X.A.1-X.A.2, Yoshida-Katayama renders obvious a separator with an overall porosity of 20% to 60%. EX1006, [0083]. The majority of this range—75%—overlaps the claimed range $((60-30)/(60-20) = 75\%)$.

226. Moreover, given Katayama's guidance that the porosity of the overall separator is preferably 20% to 60%, with the 20% floor being necessary to secure liquid capacity for the electrolyte and improving the ionic permeability, a POSITA would have been motivated to configure the heat-resistant layer 3b to have a porosity of at least 20% to ensure that heat-resistant layer 3b would not unduly restrict the porosity of the overall separator. A POSITA would have had a reasonable expectation of success in doing so, at least because 20%-50% porosity is within (and most of) Katayama's disclosed range of porosities.

36. Limitation 34: "The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer has a porosity of 20% to 60%."

227. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 32.

37. Limitation 35: "The nonaqueous electrolyte battery according to claim 10, wherein the whole separator has a porosity of 30% to 70%."

228. The combination of Yoshida and Katayama discloses or renders obvious this limitation. See Limitation 10[f] and Limitation 33.

38. Limitation 36: "The battery separator according to claim 1, wherein the microporous film is formed by a solvent extraction method, a dry drawing method, or a wet drawing method."

229. Yoshida-Katayama renders obvious a separator wherein the microporous film is formed by a solvent extraction method. As explained above in

Sections X.A.1-X.A.2, shutdown layer 3a of the Yoshida-Katayama structure would have been made by a solvent-extraction method. EX1006, [0089], [0091].

39. Limitation 37: “The nonaqueous electrolyte battery according to claim 10, wherein the microporous film is formed by a solvent extraction method, a dry drawing method, or a wet drawing method.”

230. The combination of Yoshida and Katayama discloses or renders obvious this limitation. A POSITA would have understood that Yoshida uses a microporous film formed by a dry drawing method (Celgard 2400). EX1005 [0031]. The Yoshida-Katayama combination includes a microporous film formed by includes “applying the composition for forming the first separator layer or the composition for forming the second separator layer *on a porous base; applying the other composition before the composition applied first is dried; and drying.*” EX1006, [0098]; *see* Limitation 10[f] and Limitation 36.

XI. CONCLUSION

231. All statements made herein of my own knowledge are true, all statements made herein on information and belief are believed to be true, and these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

December 13, 2022
Date



Marc Juzkow