

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHUHAI COSMX BATTERY CO., LTD.,
Petitioner

v.

NINGDE AMPEREX TECHNOLOGY LIMITED,
Patent Owner

Case IPR2026-00399
U.S. Patent No. 12,374,686

**DECLARATION OF YU ZHU, Ph.D., IN SUPPORT OF PETITION FOR
INTER PARTES REVIEW OF U.S. PATENT NO. 12,374,686**

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b. [1.1] a positive electrode;	182
c. [1.2] a separator; and	183
d. [1.3] a negative electrode;	183
e. [1.4] wherein the negative electrode comprises a negative current collector;	183
f. [1.5.1] a negative active material layer, ...	184
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k.	[1.6.4] a length of a long axis of the negative active material layer is a second length, and	196
l.	[1.7.1] the negative electrode satisfies the following relationship formula (I) $0.5 \geq D \geq 0.6 \times G$	196
m.	[1.7.2] wherein D is a ratio of the first length to the second length, ...	198
n.	[1.7.3] G is a weight percentage of the silicon-based material, and	200
o.	[1.7.4] the weight percentage of the silicon-based material is less than or equal to 70%.	201
p.	Claim 10: [10.P] An electronic apparatus, comprising an electrochemical apparatus, wherein the electrochemical apparatus comprises:	204
q.	[10.1] a positive electrode;	204
r.	[10.2] a separator; and	205
s.	[10.3] a negative electrode,.....	205
t.	[10.4] wherein the negative electrode comprises: a negative current collector;	205
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I. INTRODUCTION

1. I have been retained as a technical expert on behalf of Zhuhai CosMX Battery Co., Ltd. (“Petitioner,” “CosMX”) to provide an analysis of U.S. Patent No. 10,916,686 (“the ’686 patent”). I understand that Petitioner is requesting that the Patent Trial and Appeal Board (“PTAB” or “Board”) institute an *inter partes* review (“IPR”) of the ’686 patent.

2. I have been asked to provide my independent analysis of the ’686 patent and its claims in light of the prior-art publications cited below.

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

II. MY PROFESSIONAL EXPERIENCE AND QUALIFICATIONS

4. A copy of my *curriculum vitae* (“CV”) is submitted with this Declaration as Exhibit 1004. As set forth in my CV, I am a Professor in the School of Polymer Science and Polymer Engineering at The University of Akron, with expertise in polymer materials, composite and porous materials, and electrochemical energy-storage systems, including lithium-ion battery materials, electrode architectures, and related processing and manufacturing considerations.

5. I have been a member of the faculty at The University of Akron since August 2012. I am currently a Professor in the School of Polymer Science and Polymer Engineering, and I also serve as the Director of the Akron Functional Materials Center.

6. I received my Bachelor of Science degree in Chemical Engineering from Nanjing University of Technology in 1997. I received my Ph.D. in Chemistry from the University of Cologne (Germany) in 2007. My doctoral research focused on the synthesis and characterization of conjugated polymers for electronic and electrochemical applications. My formal education provided a strong foundation in materials science, electrochemistry, polymer chemistry, and structure–property relationships directly relevant to battery technology, such as lithium batteries and batteries comprising silicon-containing material.

7. After receiving my Ph.D., I worked as a Postdoctoral Research Associate at Rice University. My research at this time encompassed electrode materials, including graphene, for secondary batteries. Throughout my career, my research has focused on polymer and composite materials, porous and nanostructured materials, and coating and processing techniques relevant to electrochemical energy-storage devices. This work includes the design and characterization of materials used in lithium-ion batteries, including electrode

materials, conductive and structural composites, and coatings, as well as the effects of processing conditions on material morphology and performance.

8. I have authored or co-authored more than 80 peer-reviewed journal publications in leading materials science, polymer science, and energy-storage journals. My publications address topics such as polymer and composite structure, particle and domain morphology, transport properties in functional materials, and materials strategies for improving performance, durability, and safety in electrochemical energy-storage systems

9. In addition to my scholarly publications, I am an inventor or co-inventor on multiple issued U.S. and foreign patents relating to polymer materials, composite structures, coatings, and functional materials used in energy, electronic, and electrochemical applications. These patented technologies involve material formulations, layered and coated structures, and manufacturing-relevant processing considerations that overlap with the cathode structures, insulating layers, and electrochemical device configurations at issue in this proceeding.

10. I am also an active member of several professional scientific organizations, including the American Chemical Society (ACS), the Electrochemical Society (ECS), the Materials Research Society (MRS), and the American Physical Society (APS). Through these organizations, I regularly engage

with ongoing research developments, technical standards, and the state of the art in materials science and electrochemical energy-storage technologies.

11. My research routinely addresses electrode formulations, layered material architectures, coating and calendaring processes, particle-size distributions, and structure–property relationships that govern electrochemical performance and mechanical safety in lithium-ion battery electrodes. My work is directly relevant to multilayer cathode active material structures for lithium-ion batteries and processing tolerances affecting battery safety and performance.

12. I regularly employ and interpret a broad range of materials characterization techniques relevant to polymeric and electrochemical materials, including electron microscopy, scattering and spectroscopy techniques, and thermal and mechanical characterization. I am experienced in correlating microstructural features—such as particle sizes, porosity, phase separation, coating morphology, and layer thicknesses—with electrochemical performance and safety characteristics of lithium-ion battery electrodes.

13. This work has been supported by competitive funding from government agencies and industry, including the National Science Foundation, the U.S. Department of Energy, the Air Force Office of Scientific Research, and industrial partners. I have received multiple honors and awards recognizing my

contributions to materials science and polymer-based energy technologies, including an NSF CAREER Award and an Air Force Summer Faculty Fellowship.

14. Teaching is also an integral part of my professional activity. At the University of Akron, I teach undergraduate- and graduate-level courses in chemistry, polymer science, polymer materials for energy storage, and laboratory courses in polymer characterization. By teaching, mentoring, and supervising undergraduate and graduate students and postdoctoral researchers, I have maintained and continue to maintain familiarity with the level of knowledge and skill possessed by persons of ordinary skill in the art in the fields of polymer materials and battery technology, including lithium batteries and batteries comprising silicon-containing material.

15. Based on my education, research, teaching, and professional experience, I am highly familiar with the state of the art in lithium-ion battery and polymer-based energy-storage technologies as of the relevant timeframe, including conventional and multilayer cathode structures, the use of insulating layers on current collectors, processing techniques, and strategies for improving battery safety, energy density, and reliability.

16. As a result of the foregoing experience and qualifications, I am qualified to offer opinions on the technical issues addressed in this Declaration,

including the understanding of a person of ordinary skill in the art and the teachings of the prior art relevant to the '686 patent.

VI. DESCRIPTION OF THE RELEVANT FIELD AND A PERSON OF ORDINARY SKILL IN THE RELEVANT FIELD (“POSA”)

17. I have carefully reviewed the '686 patent.

18. Based on my review of these materials, I believe that the relevant field for purposes of the '686 patent is battery construction materials and their properties.

19. In my opinion, “a person of ordinary skill in the relevant field” is a hypothetical person to whom an expert in the relevant field could assign a routine task with reasonable confidence that the task would be successfully carried out. I have been informed that evidence of the level of ordinary skill in the art can be determined based on information about the field including: the types of problems encountered, known solutions, the speed of innovation, sophistication, and the educational level of active workers. I have considered these types of information along with my own background working with students and other professionals in the field to reach my conclusion.

20. I have been advised that a person of ordinary skill in the “relevant field” (art), (i.e., a “POSA”), must be able to make and use the claimed invention based on the information disclosed in the specification of the patent. Accordingly, where information is required to make and use the claimed invention but has not

been expressly disclosed in the specification, the patentee effectively acknowledges that such information should be considered to be within the knowledge of the hypothetical POSA. Whether I use the acronym POSA or not, all of my opinions throughout this Declaration are based on the understanding of a POSA at the time of the effective filing date of the '686 patent.

21. Based on my analysis of the '686 patent, it is my opinion that a POSA as of the effective filing date of the patent would have had at least an undergraduate degree in chemistry, chemical engineering, polymer science and engineering, or materials science and engineering and two years of work experience in the field of battery materials and construction. A higher level of education, such as a master's degree in one of these same fields, could substitute for work experience. Based on my educational background and experience, I qualify as at least a POSA at the time of the alleged invention of the patent. And, based on my experience, I have an understanding of the capabilities of a person of ordinary skill in the relevant field. I have supervised, directed, and instructed many such persons over the course of my career.

IV. LEGAL PRINCIPLES

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

23. I have been informed that prior art is that which was known or used by others in the U.S., or was patented or published anywhere, before the earliest filing date of the application for the patent at issue (also known as the effective filing date or critical date). I further have been informed that prior art includes that which was patented or published anywhere, or was in public use, on sale, or offered for sale in this country, more than one year prior to the critical date. I have also been informed that prior art includes that which was described in a U.S. patent granted on an application for a patent (or in a published application for a U.S. patent) that was filed by another in the U.S. before the critical date.

A. Obviousness

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

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

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

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

yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

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

B. Inherency

29. I understand that, although a reference may not expressly disclose a claim limitation, the prior art nonetheless teaches the claim limitation if the prior art necessarily includes the claim limitation. Thus, an inherent disclosure is present where the claimed structure must inevitably result from the express disclosure of the prior art. In this way, I understand that limitations may be disclosed, taught, or suggested in the prior art explicitly or inherently.

30. I understand that if the prior art teaches a composition, then the properties of that composition are necessarily present. A prior-art disclosure may therefore *inherently* disclose a claim element reciting the properties of a composition by disclosing that composition. In other words, where a patentee claims a composition, product, or apparatus in terms of a function, property, or characteristic and the composition of the prior art is the same as that of the claim

but the function is not explicitly disclosed by the reference, the reference may nonetheless teach or suggest the claim.

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

C. Claim Construction

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

IV. MATERIALS CONSIDERED AND BASIS OF OPINIONS

33. My opinions are based on more than 20 years of working with polymers, composites, and materials for a wide range of applications including

batteries and fuel cells, as well as my teaching and research experience. My opinions are also based on investigation and study of the relevant materials, including the patent at issue and its file history, and the prior art.

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

Exhibit No.	Description
1001	U.S. Patent No. 12,374,686
1002	File History of U.S. Patent No. 12,374,686
1004	<i>Curriculum Vitae</i> of Yu Zhu, Ph.D.
1005	Chinese Publication No. 108899475 with Certified English Language Translation (“Hu”)
1006	Japanese Publication No. 2016-122628 with Certified English Language Translation (“Takano”)
1007	U.S. Patent Application Publication No. 2015/0207111 (“Tao”)
1008	U.S. Patent Application Publication No. 2018/0040881 (“Kusagawa”)
1009	Zhibo, M., et al., “Effect of Tab Position on Cylindrical Li-ion Battery Performance,” <i>Battery Bimonthly</i> , Vol. 45, pp. 258-260 (October 2015) with Certified English Language Translation
1010	Chinese Publication No. 103797607 with Certified English Language Translation (“Kakinuma”)
1011	Chinese Publication No. 204809314 with Certified English Language Translation (“Guo”)
1012	U.S. Patent Application Publication No. 2018/0034109 (“Wang”)
1013	Yao, X-Y., et al., “Tab Design and Failures in Cylindrical Li-ion Batteries,” <i>IEEE Access</i> , Vol. 7, pp. 24082-24095 (15 February 2019)

Exhibit No.	Description
1014	Zhao, W., et al., “Effect of tab design on large-format Li-ion cell performance,” <i>Journal of Power Sources</i> , Vol. 257, pp. 70-79 (2014)
1015	Obrovac, M.N. & Chevrier, V.L. “Alloy Negative Electrodes for Li-Ion Batteries,” <i>Chem. Rev.</i> 2014, 114, 11444-11502.
1016	Zhang, Y., Zhu, Y., Fu, L., Meng, J., Yu, N., Wang, J. & Wu, Y. “Si/C Composites as Negative Electrodes for High Energy Lithium Ion Batteries,” <i>Chin. J. Chem.</i> , 2017, 35, 21-29.
1017	“Silane Coupling Agents: Combination of Organic and Inorganic Materials,” <i>Resins & Oligomers, Silanes Product Selection Guide</i> , Shin-Etsu Chemical Co., Ltd. (Oct. 2023)
1018	Ma, F., Fu, Y., Battaglia, V. & Prasher, R. “Microrheological modeling of lithium ion battery anode slurry,” <i>Journal of Power Sources</i> , 438 (2019) 226994, 1-8.
1019	U.S. Patent Application Publication No. 2017/0214041 A1 to Minami et al.
1020	Kumudinie, C. “Polymer–Ceramic Nanocomposites: Interfacial Bonding Agents,” <i>Encyclopedia of Materials: Science and Technology</i> , Buschow, K.; et al., eds., Elsevier (2001), 7574-7577, 9780080431529
1021	Chinese Publication No. 101714624 A with Certified English Language Translation (“Li”)
1022	U.S. Patent Application Publication No. 2018/0366775 (“Tao2”) (Continuation Application of Tao, containing identical, cleaner) figures

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

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

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

VI. THE DATE OF THE '686 PATENT

38. The '686 patent was filed on March 21, 2022, and has been in force since being granted on July 29, 2025. The '686 patent is a continuation of PCT/CN2020/087515 filed on April 28, 2020. For purposes of my analysis here, I have been advised by counsel to assume a date of April 28, 2020, as the date governing my analysis (i.e., the effective filing date). I will note that an earlier or later date, by even as much as a year, would not impact the relevant analysis in this report.

VII. BACKGROUND OF CONVENTIONAL BATTERY TECHNOLOGY

39. Well before the earliest filing date of the '686 patent, high-capacity electrochemical devices such as lithium-ion ("Li-ion") batteries were widely used in consumer electronics and other applications requiring rechargeable energy

storage. All conventional batteries include a positive electrode, a negative electrode, and a separator between them. The negative electrode includes a negative current collector, a negative active material layer, and various additives and binders. Negative active materials are typically carbon based, often including silicon or other transition metal particles.

40. More specifically, and prior to the critical date of the '686 patent, it was well known that negative electrode materials for lithium ion batteries normally used graphite. EX1016, 21; EX1015, 11444; EX1008, [0003]; EX1007, [0038]. However, it was an art-recognized problem that graphite-based negative electrode active materials had limited capacity. *See, e.g.*, EX1008, [0004] (“carbon materials that are currently used have already exhibited a capacity close to the theoretical capacity”); EX1016, 21 (“There is no room for improvement because the energy density of graphite negative electrode has almost reached its theoretical specific capacity”); EX1015, 11445 (“[m]ost studies set out to make materials that improve on the specific capacity of graphite”).

41. One well-known solution to the limited specific capacity of graphite was to include silicon in the negative electrode active material. EX1015, 11455; EX1016, Abstract, 21-22; EX1008, [0004]. Indeed, the art taught that “silicon materials, such as silicon and silicon oxide, having a higher capacity than carbon materials have recently attracted more attention as negative electrode active

materials of non-aqueous electrolyte secondary batteries.” EX1008, [0004]; *see also* EX1016, Abstract (“Silicon is very promising negative electrode materials for improving the energy density of lithium-ion batteries (LIBs) because of its high specific capacity, moderate potential, environmental friendliness, and low cost”), 21 (“Si is considered one of the most promising materials [for lithium ion negative electrode batteries] because of its exceptionally high specific capacity”).

42. In other words, it was well-known at the time in the art that graphite was a popular negative electrode active material component, and that silicon was an established improvement to graphite-based anode active materials because it addressed multiple different widely recognized shortcomings of graphite.

43. However, the art also recognized that silicon presents its own drawbacks: specifically, silicon is a relatively volume-expansive material compared to graphite. EX1008, [0005]; EX1016, 21. Specifically, silicon in negative active materials was known to exhibit “huge volume variation” when charging and discharging. EX1016, 21. It “undergo[es] larger expansion and shrinkage with charging and discharging than carbon materials.” (EX1008, [0005]). For that reason, pure silicon by itself was not suitable as a negative electrode material for rechargeable batteries without proper volume expansion mitigation.

44. Indeed, “[t]o overcome this problem [with expansion and shrinkage] the most successful strategy is to incorporate other components (metals, oxides, carbon, polymer) which act as stress buffering matrices into Si which can accommodate the strain, especially the carbon medium.” EX1016, 21-22. In other words, it was understood in the art at the time that anode active materials containing a mixture of both carbon and silicon would provide a balance between the advantages and shortcomings of both materials.

45. Carbon-silicon composites had documented success in solving both the problem of limited graphite energy capacity and expansive silicon materials. “Starting from about 1999, several groups studied Si/C materials for battery anodes [negative electrodes]. The mechanical properties of graphitic carbon make it able to buffer the volume expansion of Si while the high conductivity of C can efficiently complement the high lithiation capacity of Si.” EX1016, 22; *see also* EX1008, [0066] (“The amount of the silicon material in the negative electrode active material is preferably, but not necessarily, 3% by mass or more relative to the total mass of the silicon material and the graphite. The silicon material present in an amount of 3% by mass or more can improve the load characteristic of the non-aqueous electrolyte secondary battery”). Accordingly, not only did those skilled in the art recognize the advantages of carbon-silicon composite materials in

negative electrode composition, but the skilled artisan had a rough idea of the optimal balance between carbon and silicon in such composite active materials.

46. The geometry of secondary lithium batteries generally takes two forms: (1) a stacked or flat laminate comprising layers of positive and negative electrodes with separators in between, or (2) a wound layered structure commonly called a “jelly roll.” In both types, the battery is permeated with electrolytic fluid and is designed to allow ions to pass between the negative and positive electrode active materials. Metal tabs connect the electrodes to external circuitry, which in turn connects with whatever electronic device draws power from the battery.

47. Jelly roll style batteries can have a single tab or several tabs in a multi-tab design. EX1013, 24087. It was well understood that “multiple tabs divide the electrode into different sections, so the electron transport losses can be reduced, and the energy density can be fully accessed in large-format cells,” and furthermore, “[t]he current distribution inside a battery is a major determinant of its performance, which can be significantly affected by the tab locations.” EX1013, 24087.

48. It was also appreciated that the “[u]se of multiple tabs effectively improves large cell’s usable energy density” by minimizing “in-plane electron transport losses through long electrodes.” EX1014, 70. As tab number increases, cell performance is expected to approach that of smaller “coin cells,” though “the

outcome of using excessive tabs is increased manufacture cost and decreased reliability due to tabs welded together.” EX1014, 71. Thus, an “optimal number” of tabs exists for large-format cells. EX1014, 71. Ultimately, “tab number and location can mitigate ... Ohmic loss, thereby significantly improving the cell performance.” EX1014, 73, 78. Furthermore, it was known in that art that a single, centered tab can reduce internal resistance. *See* EX1009, Abstract, “When changing tab from the side to the middle, the current collector resistance decreased to one-quarter, the AC internal resistance of the 18650-type Li-ion battery decreased from 29.37 mΩ to 14.3 mΩ.”

49. The number of tabs, their relative locations along the edge of the electrode, the thicknesses of the electrode layers, and the various distances among them were all well-understood principles of battery geometry. It was also generally understood how differences in battery geometry could influence the performance, energy density, and reliability of the resulting battery.

VIII. THE '686 PATENT

50. The '686 patent claims are purportedly directed to an electrochemical apparatus with a recited negative electrode arrangement and active material composition. EX1001, Abstract. The '686 patent employs a common technique—using a negative lead, or “tab” in a recess in the middle of an active material, and controlling the silicon content of said active material, to achieve its goals of

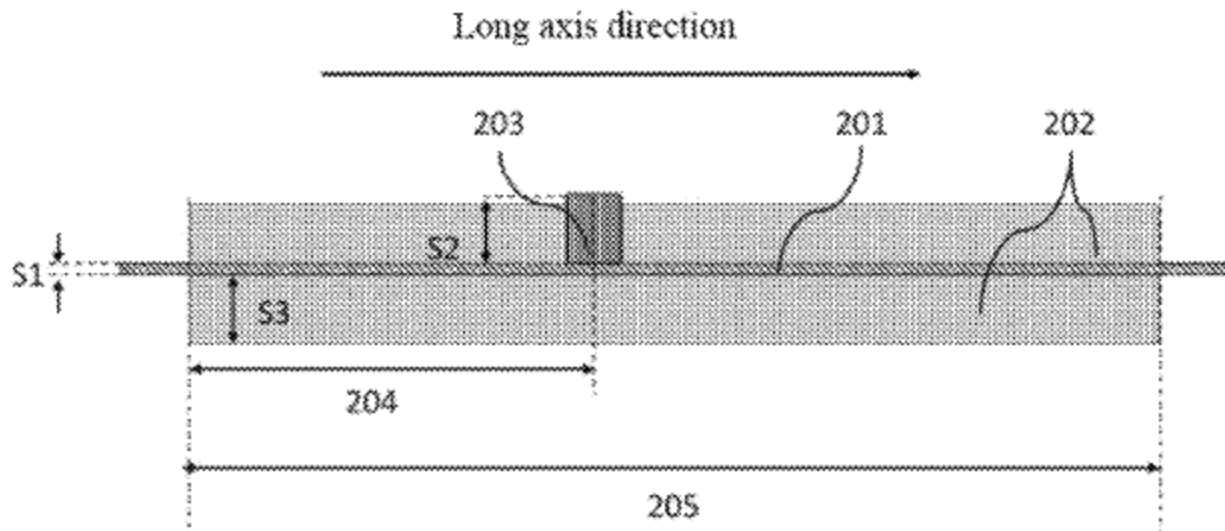
superior battery performance. EX1001, Abstract, 1:45-2:19. The improved characteristics of this battery are allegedly increased machinability, low manufacturing cost, improved energy density, and increased cycle and safety performance. EX1001, 4:24-58, 4:35-17, 4:38-47.

A. Specification

51. The '686 patent discloses an electrochemical apparatus as described below:

As shown in FIG. 4 and FIG. 5, this application provides a negative electrode, including: a negative current collector 201, a negative active material layer 202, and a negative tab 203. The negative tab 203 is arranged on a side edge of a long axis of the negative current collector 201 and is in contact with the negative active material layer 202. The negative active material layer 202 contains a silicon-based material, a distance between a central position of the negative tab 203 and either end of the negative active material layer 202 in a long axis direction is a first length 204, and a length of a long axis of the negative active material layer is a second length 205.

52. EX1001, 4:50-63. The '686 patent also describes that the composition of its negative active material is limited by the equation $0.5 \geq D \geq 0.6 \times G$, wherein D is a ratio of the first length 204 to the second length 205, and G is a weight percentage of the silicon-based material in the negative active material. EX1001, 4:66-5:1. This electrochemical apparatus is depicted in the figure below.



EX1001, FIG. 4.

53. The '686 patent states that the electrochemical apparatus examples of its disclosure “lower direct current resistance and better discharge rate, and also shows better cycle capacity” as a result of its silicon content. EX1001, 16:60-67. It also states that by arranging the negative tab position and controlling the silicon content, the “safety performance of the electrochemical apparatus” is increased. EX1001, 16:60-67.

B. Overview of the Claims

54. The claims of the '686 patent are separated into two sets. Claims 1 and 10 are the independent claims, and recite essentially identical limitations, and differ only in their preambles.

55. Claim 1 of the '686 patent is reproduced here:

[1.P] An electrochemical apparatus, comprising:

[1.1] a positive electrode;

- [1.2] a separator; and
- [1.3] a negative electrode;
- [1.4] wherein the negative electrode comprises a negative current collector;
- [1.5.1] a negative active material layer,
- [1.5.2] wherein the negative active material layer contains a silicon-based material; and
- [1.6.1] a negative tab,
- [1.6.2] wherein the negative tab is arranged on a side edge of a long axis of the negative current collector,
- [1.6.3] a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length,
- [1.6.4] a length of a long axis of the negative active material layer is a second length, and
- [1.7.1] the negative electrode satisfies the following relationship formula (I): $0.5 \geq D \geq 0.6 \times G$ formula (I)
- [1.7.2] wherein D is a ratio of the first length to the second length,
- [1.7.3] G is a weight percentage of the silicon-based material, and
- [1.7.4] the weight percentage of the silicon-based material is less than or equal to 70%.

EX1001, 17:30-53.

56. Claims 2-9 depend directly or indirectly from claim 1 and recite:

- Claim 2: Negative tab, current collector, and active material thickness;
- Claim 3: The composition of the silicon-based material;

- Claim 4: The location of the negative tab relative to the active material length;
- Claim 5: The number of layers that the electrochemical apparatus is wound;
- Claim 6: The position of the negative tab in a wound electrochemical apparatus;
- Claims 7 and 8: An additional material, carbon-based layer; and
- Claim 9: A groove, wherein the negative tab is positioned.

EX1001, 17:30-18:31.

57. Claim 10 differs from claim 1 only that it recites an “electronic apparatus, comprising an electrochemical apparatus” as its preamble, rather than just the preamble of “an electrochemical apparatus.” EX1001, 18:32.

58. Claims 11-14 depend directly from claim 10. EX1001, 18:68-19:11. The additional limitations of claim 11 are identical to that of claim 2; the additional limitations of claim 12 are nearly identical to those of claim 3; the additional limitations of claim 13 are identical to those of claim 4; and the additional limitations of claim 14 are identical to those of claim 5. EX1001, 18:68-19:11.

C. Prosecution History

59. As discussed above, the ’686 patent issued from U.S. Appl. No. 17/699,555 filed March 21, 2022, that claimed benefit as a continuation of PCT

Application Number PCT/CN2020/087515 that was filed April 28, 2020. The '555 application was filed with 14 original claims, all directed to either an electrochemical apparatus or an electronic apparatus comprising an electrochemical apparatus. EX1002, 1-11, 39-41.

60. The U.S. Patent and Trademark Office (“the Office” or “USPTO”) issued a first Non-Final Office Action on September 23, 2024. EX1002, 634-42. Claims 1, 3, 5-9, 10, and 14 were allowed. EX1002, 638-41. Claims 2, 4, and 11-13 were rejected under 35 U.S.C. § 112(b) as being indefinite. EX1002, 636-38. Claims 2, 4, and 11-13 were indicated as allowable if rewritten to overcome the rejections. EX1002, 641.

61. Although three U.S. Patent Application Publications, twenty Foreign Patent Documents, and eight Non-Patent Literature Documents were cited by the Patent Owner across two Information Disclosure Statements (EX1002, 596-605), only one Foreign Patent Document (JP-2016122628-A to Takano, or “Takano,” *see* EX1006) and one Non-Patent Document (the Takano abstract) were cited by the Examiner in the rejection.

62. Among all claim elements in the application claim set, the Examiner alleged that only a single limitation—“wherein the negative tab is arranged on a side edge of a long axis of the negative current collector”—was taught in the art. EX1002, 638-40. To support this allegation, the Examiner first noted that Takano

“teaches a negative electrode current collecting tab 23 that has two parts positioned in the x and y directions, along the long axis direction,” and “[t]herefore, it appears that a portion of the negative tab 23 *is arranged on a side edge of a long axis of the negative current collector.*” EX1002, 639-40. The Examiner then alleged that Takano does not teach or suggest the remaining claim elements from claims 1 or 10, and that “the instant claims are patentably distinct from the prior art of record” as a result. EX1002, 639-40.

63. On December 20, 2024, Applicant submitted an Amendment and Reply amending claims 2, 4, and 11-13 in accordance with the recommendations of the Examiner. EX1002, 833-38.

64. On March 25, 2025, the Office issued a Notice of Allowance without any reasons for allowance. EX1002, 845-49.

IX. CLAIM CONSTRUCTION

65. I understand that, during an *inter partes* review, claim terms must be given their ordinary and customary meaning as understood by a POSA as of the effective filing date, in light of the specification and the prosecution history of the patent. I understand that, solely for the purposes of this Petition, all claim terms should receive their plain and ordinary meaning in the context of the '686 patent specification. I further understand that, even if other terms end up being expressly

construed in another proceeding, such express constructions are not necessary here, as they are not needed to resolve a controversy in this proceeding.

X. OVERVIEW OF PRIOR ART

A. Guo

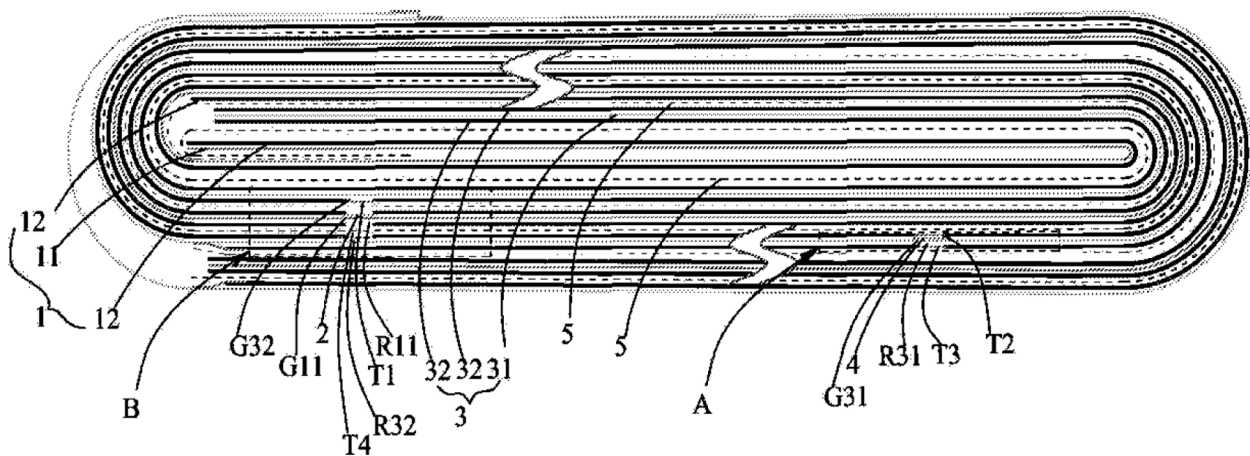
66. Chinese Patent Publication No. CN204809314U to Guo *et al.* (“Guo”) is a utility model patent entry granted and published on November 25, 2015. I understand it is prior art under 35 U.S.C. § 102(a)(1). Guo’s publication date precedes the ’686 patent’s earliest effective filing date of April 28, 2020, by over four years. Guo discloses a secondary battery cell for a secondary battery used in various electronic products. EX1011, [0002], [0004]. Guo’s novel feature includes anode-tab- and cathode-tab-accommodating grooves, which Guo states improves energy density and safety performance of the secondary battery. EX1011, [0004-0007].

67. Guo’s secondary battery cell is an electrochemical apparatus comprising: a positive electrode (“cathode sheet,” EX1011, Abstract), a separator (“separator,” EX1011, Abstract), and a negative electrode (“anode sheet,” EX1011, Abstract), wherein the positive electrode comprises a positive current collector (“cathode current collector,” EX1011, [0045]), a positive active material layer (“cathode membrane,” EX1011, ¶45), and a positive tab (“cathode tab,” EX1011, [0044], [0056], [0062], [0083]), and wherein the negative electrode comprises a negative current collector (“anode current collector,” EX1011, [0066]), a negative

active material layer (“anode membrane,” EX1011, [0066]), and a negative tab (“anode tab,” EX1011, [0066]).

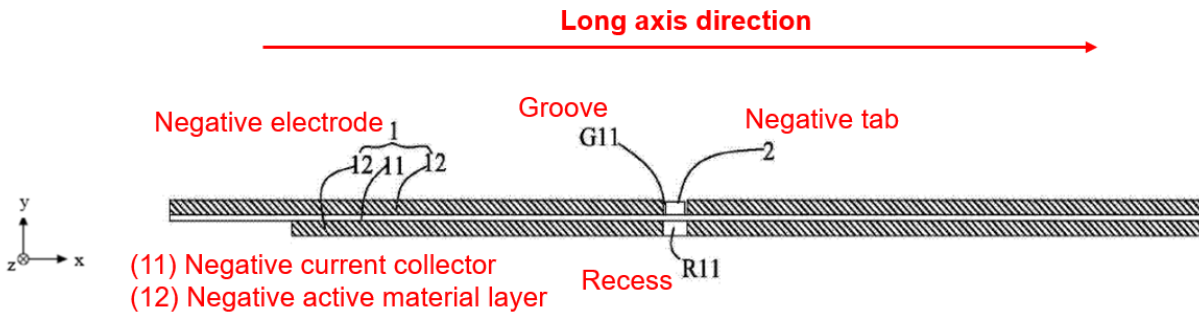
68. Guo discloses an electrochemical apparatus of a winding structure. As described in Guo, “FIG. 1 is a schematic structural diagram of a wound-formed secondary battery cell according to an embodiment of the present utility model.” EX1011, [0008].

69. Regarding the winding structure, Guo illustrates a negative electrode (“anode sheet 1”) and positive electrode (“cathode sheet 3”) separated by a separator (“separator 5”) in a “wound-formed” geometry as follows:

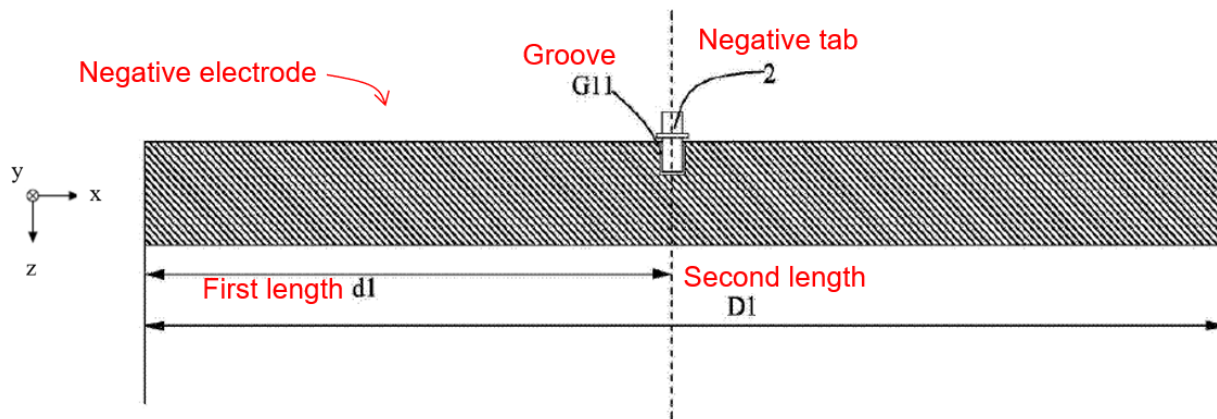


EX1011, FIG. 1.

70. The annotated Guo Figures 3a and 3b below show different views of the disclosed negative electrode, including the aforementioned negative current collector, negative active material layer, and negative tab components.



EX1011, FIG. 3a (annotated).



EX1011, FIG. 3b (annotated).

B. Hu

71. Chinese Patent Publication No. CN108899475A to Hu *et al.* (“Hu”) published on November 27, 2018. I understand it is prior art under 35 U.S.C. § 102(a)(1). Hu’s publication date precedes the ’686 patent’s earliest effective filing date of April 28, 2020, by over a year. Hu discloses a high-energy-density lithium-ion battery. EX1005, [0006]. Hu’s novel features include a negative electrode with a negative active material containing a silicon-based material, which Hu states improves sheer stability of a negative active material component, and

positioning of positive and negative electrode tabs, which Hu states reduces internal resistance of the battery. EX1005, [0014]-[0019], [0023]-[0028].

72. Hu's high-energy-density lithium-ion battery is an electrochemical apparatuses comprising: a positive electrode ("positive electrode sheet," EX1005, Abstract, Claim 1, [0037]), a separator ("separator," EX1005, Abstract, Claim 1, [0037]), and a negative electrode ("negative electrode sheet," EX1005, Abstract, Claim 1, [0037]), wherein the negative electrode comprises a negative current collector ("current collector," EX1005, [0004]), a negative active material layer ("negative electrode active material," EX1005, [0014]), and a negative tab ("negative electrode tab," EX1005, [0020]).

C. Kakinuma

73. Chinese Patent Publication No. CN103797607B to Kakinuma *et al.* ("Kakinuma") is a patent granted and published on January 6, 2016. I understand it is prior art under 35 U.S.C. § 102(a)(1). Kakinuma's publication date precedes the '686 patent's earliest effective filing date of April 28, 2020, by over four years. Kakinuma discloses a cylindrical battery with a battery case. EX1010, [0001], [0009]-[0018]. Kakinuma's novel feature includes a case sealing member and case sealing gasket, which Kakinuma states improves battery characteristics and enhances long-term reliability and safety. EX1010, [0018], [0020].

74. Kakinuma's cylindrical battery is an electrochemical apparatus comprising: a positive electrode ("positive electrode plate," EX1010, [0051]-[0052], [0062]-[0064]), a separator ("separator," EX1010, [0051], [0073]-[0075]), and a negative electrode ("negative electrode plate," EX1010, ¶¶51, 92-94), wherein the negative electrode comprises a negative current collector ("negative electrode core material," EX1010, [0053], [0057], [0094]), a negative active material layer ("negative electrode mixture slurry," EX1010, [0093]-[0094]), and a negative tab ("negative electrode lead," EX1010, [0053], [0098]-[0099]). Kakinuma discloses preferred thicknesses for the negative current collector, the negative tab, and the negative active material layer. EX1010, [0053], [0057].

D. Kusagawa

75. US Patent Application Publication No. US 2018/0040881 A1 to Kusagawa *et al.* ("Kusagawa") is a utility patent application filed on August 28, 2017, and published on February 8, 2018. EX1008. Kusagawa claims priority to PCT application No. PCT/JP2016/000922, which was filed on February 22, 2016. I understand it is prior art under 35 U.S.C. § 102(a)(1). Kusagawa's priority date precedes the '686 patent's earliest effective filing date of April 28, 2020, by over four years. Kusagawa discloses a non-aqueous electrolyte secondary battery. EX1008, Abstract, [0016]. Kusagawa's novel features include using a silicon material and graphite as negative electrode active materials, which Kusagawa

states provides “high capacity and a good load characteristic.” EX1008, [0015]. In this context, in Example 15, Kusagawa discloses negative electrode active materials comprising a weight percentage of silicon-based material of 0.836%, (see Section XIV.C.2), where silicon and graphite particles are bonded to each other with amorphous carbon. EX1008, [0042]-[0043]. Kusagawa’s non-aqueous electrolyte secondary battery is an electrochemical apparatus comprising: a positive electrode (“positive electrode plate,” EX1008, Abstract, [0016], [0032]), a separator (“separator,” EX1008, Abstract, [0016], [0034]), and a negative electrode (“negative electrode plate,” EX1008, Abstract, [0016], [0027]-[0028]), wherein the negative electrode comprises a negative current collector (“negative electrode current collector,” EX1008, Abstract, [0016], [0028]), a negative active material layer (“negative electrode mixture layer,” EX1008, Abstract, [0016], [0028]), and a negative tab (“negative electrode tab,” EX1008, Abstract, [0016], [0028]).

E. Tao

76. US Patent Application Publication No. US US2015/0207111 A1 to Tao *et al.* (“Tao”) is a utility patent application filed on January 14, 2015, and published on July 23, 2015. EX1007. I understand it is prior art under 35 U.S.C. § 102(a)(1). Tao’s priority date precedes the ’686 patent’s earliest effective filing date of April 28, 2020, by over five years.

77. Tao is directed to a lithium-ion battery with “desirable safety

performance.” EX1007, Abstract. Tao teaches compositions and arrangements of negative electrodes, specifically, a “negative plate having a negative film” which also comprises a negative lead soldered in a recess in the middle of this negative film. EX1007, Abstract. Tao teaches that its battery exhibits positive characteristics such as increased safety metrics, improved battery life, and improved energy density. EX1007, Abstract. Tao teaches that modern demands on lithium-ion batteries require reduced battery thickness and increased energy density, and that the batteries of its disclosure achieve this goal through control of the negative electrode components’ arrangement. EX1007, [0003], [0009], [0014], [0020].

78. Tao teaches several active material compositions. *See* EX1007, Examples 1-5. One such active material composition is a graphite-based composition comprising “95 wt % negative active material graphite, 2 wt % bonding agent SBR, 1 wt % thickener CMC and 2 wt % conductive agent graphite in solvent deionized water.” EX1007, [0038]. Tao teaches that these components are combined to form a “slurry,” which is then coated on a copper foil to form a film. EX1007, [0038], [0008]. Once the active material is coated on the foil, a portion of active material is removed at a “middle portion” of the plate to form a recess. EX1007, [0038]. A negative tab (referred to as a “lead” in Tao) is then soldered into the recess to form the negative plate. EX1007, [0008]-[0009].

79. Tao also teaches a negative active material composition in its Example 2 that “is almost the same as Example 1, except that: ... The negative active material is silicon.” EX1007, [0041], [0047]. As such, replacing the negative active material graphite in Example 1 with silicon, Tao teaches a negative active material that is 95 wt % silicon, 2 wt % bonding agent SBR, 1 wt % thickener CMC and 2 wt % conductive agent graphite in solvent deionized water. EX1007, [0041], [0047]; *see also* EX1007, Example 3, [0054] (describing another silicon-based negative active material composition). Tao praises the performance of the batteries described in its Examples, teaching that “the safety performance of the lithium ion battery” is “improved remarkably” for Examples 1-3. EX1007, Table 1, [0073]. Tao also shows that “the structure of the positive plate and negative plate according to the present invention” overcome challenges with uneven battery thickness and improve battery capacity, energy density, and internal resistance. EX1007, Table 2, [0075].

80. Tao discusses the result of using silicon in its negative active material, teaching that “[a]s clearly shown in Table 3, if the negative active material for use in the negative plate is apt to serious volume expansion, such as silicon,” the battery can become deformed. EX1007, [0077], Table 3. Indeed, Tao teaches that “adopting silicon as active material undertakes serious volume expansion.” EX1007, [0077]; *see also* EX1007, [0005] (“The film around the corners [of the

current collector in a prior art reference] is readily peeled off, especially when the negative active material adopts an expansive substance, such as silicon.”). Tao teaches that a way to solve this problem is with its recited electrode recess arrangements, which it describes as improving the known issue of silicon expansion. EX1007, [0077].

F. Wang

81. US Patent Application Publication No. US 2018/0034109 A1 to Wang *et al.* (“Wang”) is a utility patent application filed on July 14, 2017, and published on February 1, 2018. Wang claims priority to CN application No. 201610629113.7, which was filed on August 1, 2016. I understand it is prior art under 35 U.S.C. § 102(a)(1). Wang’s priority date precedes the ’686 patent’s earliest effective filing date of April 28, 2020, by over three years. Wang teaches an improvement to a wound battery cell configuration, and teaches that this configuration improves energy density, reduces cost, and reduces the risk of cell deformation. EX1012, Title, ¶¶8, 20, 48.

82. Wang’s wound battery cell an electrochemical apparatus comprising: a positive electrode (“second electrode plate,” EX1012, Abstract, [0008], [0048]), a separator (“first separator” and “second separator,” EX1012, Abstract, [0008], [0048]), and a negative electrode (“first electrode plate,” EX1012, Abstract, [0008], [0048]), wherein the negative electrode comprises a negative current

collector (“first current collector,” EX1012, [0008], [0049]), a negative active material layer (“first active material layer,” EX1012, Abstract, [0008], [0049]), and a negative tab (“first electrode tab,” EX1012, [0008], [0009], [0049]).

XI. GROUND 1A: CLAIMS 1, 3, 4, 9, 10, 12 AND 13 WOULD HAVE BEEN OBVIOUS IN VIEW OF GUO IN COMBINATION WITH HU.

A. Guo and Hu are analogous art

83. Guo and Hu are analogous art to the claims and each other because they disclose very similar electrochemical apparatuses (“battery” in both Guo (EX1011, Abstract) and Hu (EX1005, [0002])), each disclosing many elements of the claims from the ’686 patent. The electrochemical apparatuses of both Guo and Hu each comprise: a positive electrode (“cathode sheet” in Guo (EX1011, Abstract), “positive electrode sheet” in Hu (EX1005, Abstract, Claim 1, [0037])), a separator (“separator” in Guo (EX1011, Abstract), “separator” in Hu (EX1005, Abstract, Claim 1, ¶37)), and a negative electrode (“anode sheet” in Guo (EX1011, Abstract), “negative electrode sheet” in Hu (EX1005, Abstract, Claim 1, [0037])), wherein the negative electrode comprises a negative current collector (“anode current collector” in Guo (EX1011, [0066]), “current collector” in Hu (EX1005, [0004])), a negative active material layer (“anode membrane” in Guo (EX1011, [0066]), “negative electrode active material” in Hu (EX1005, [0014])), and a negative tab (“anode tab” in Guo (EX1011, [0066]), “negative electrode tab” in Hu (EX1005, [0020])).

84. Additionally, a POSA would understand Guo and Hu are analogous art because the geometries of their electrochemical apparatuses are inherently compatible. Hu states that development of its disclosed “high-energy-density lithium-ion battery” is driven by market demand from the “cylindrical lithium-ion battery market,” implying that Hu’s electrochemical apparatus is inherently compatible with a cylindrical geometry. EX1005, [0005]. A POSA would understand that a winding structure is compatible with a cylindrical battery geometry because it is known in the art (*See* EX1010, [0098] for an example method describing electrode plates “wound together” to form a “cylindrical battery”).

85. Finally, just as the ‘686 patent describes the need for an electrochemical apparatus “to have higher energy density,” and “higher safety,” both Guo and Hu disclose goals of improving energy density and safety. EX1001, 1:27-28; EX1011, [0004], [0079]; EX1005, Abstract, [0033].

B. Application of Guo and Hu to claims 1, 3, 4, 9, 10, 12, and 13

86. The combination of Guo and Hu discloses or renders obvious every element of claims 1, 3, 4, 9, 10, 12, and 13.

87. The following explains how each claimed element of the ‘686 patent is disclosed by Guo and/or Hu. In view of Guo’s and Hu’s disclosures, a POSA would have modified Guo in view of Hu to arrive at an electrochemical apparatus

as claimed in the '686 patent. Also discussed below, a POSA would have been motivated to modify Guo with the teachings in Hu to arrive at the claimed invention with a reasonable expectation of success. The sections below address claims and their limitations individually, but also explain why, as a general matter, a POSA would have started with the battery presented in Guo, knowing that Guo does not teach all relevant details as it relates to certain components and/or aspects of the battery. As it relates to details omitted or easily modified in Guo's battery, a POSA would have looked to Hu (closely analogous art) to fill in gaps or make modifications, and especially when doing so would improve the performance of Guo's battery, for the reasons taught in Hu. Thus, each of claims 1, 3, 4, 9, 10, 12, and 13 would have been obvious to a POSA in view of Guo and Hu.

C. Claim 1: [1.P] An electrochemical apparatus, comprising:

88. Guo discloses an electrochemical apparatus. Guo is directed to a “electrochemical energy storage devices, and more particularly to a secondary battery cell.” EX1011, [0001].

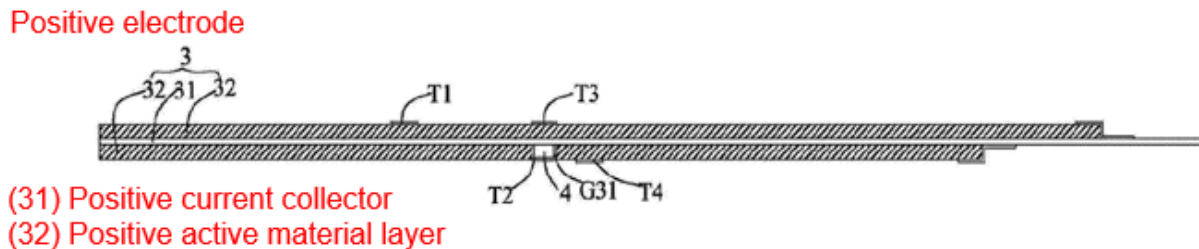
89. Guo's secondary battery cell is the claimed “electrochemical apparatus.”

D. [1.1] a positive electrode;

90. Guo discloses a positive electrode. At EX1011, [0005], Guo introduces “a secondary battery cell, comprising an anode sheet, an anode tab, a cathode sheet, a cathode tab, and a separator.” A POSA would recognize these

secondary battery cell components as terms commonly used in the art to describe a negative electrode, a negative tab, a positive electrode, a positive tab, and a separator, respectively.

91. Guo also notes that “[t]he cathode sheet comprises a cathode current collector and a cathode membrane disposed on the surface of the cathode current collector.” EX1011, [0005]. A POSA would recognize the arrangement of elements within Guo Figure 2a as teaching a positive electrode comprising a positive current collector with a positive active material layer disposed on the positive current collector. Thus, Guo’s cathode membrane is the claimed “positive active material layer.”



EX1011, FIG. 2a (annotated).

92. Guo’s cathode sheet is thus the claimed “positive electrode.”

E. [1.2] a separator; and

93. Guo discloses a separator. *See* EX1011, [0005] (“The separator is placed between the anode sheet and the cathode sheet”).

94. As discussed above, Guo’s cathode sheet is the claimed “positive electrode,” and as discussed below, Guo’s anode sheet is the claimed “negative

electrode.” Thus, the separator is disposed similarly within Guo’s embodiment as in the ’686 patent, which states that “[t]he separator is arranged between the positive electrode and the negative electrode.” EX1001, 7:36-37.

95. A POSA would recognize that the similarities between Guo’s separator and the ’686 patent’s separator indicate that each is intended to serve the same functional purpose within its respective electrochemical apparatus. Accordingly, a POSA would have understood that Guo discloses claim element 1.2.

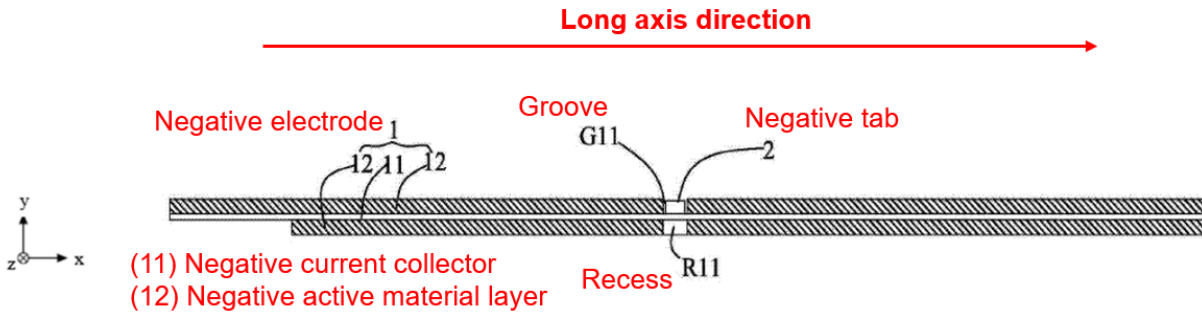
F. [1.3] a negative electrode;

96. Guo discloses a negative electrode.

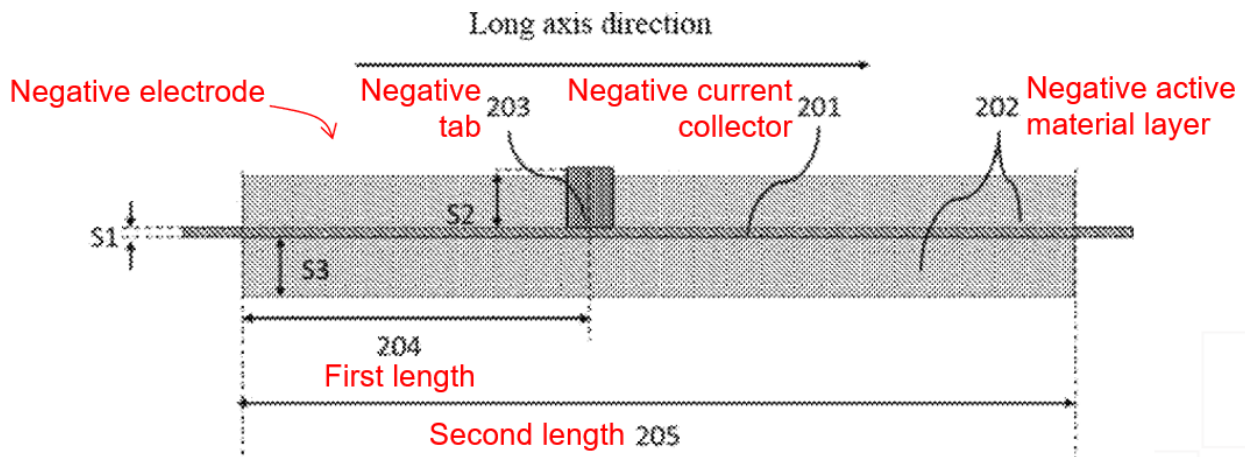
97. As discussed above, Guo discloses “a secondary battery cell, comprising an anode sheet, an anode tab, a cathode sheet, a cathode tab, and a separator.” EX1011, [0005]. A POSA would recognize these secondary battery cell components as terms commonly used in the art to describe a negative electrode, a negative tab, a positive electrode, a positive tab, and a separator, respectively. Guo also notes that “[t]he anode sheet comprises an anode current collector and an anode membrane disposed on the surface of the anode current collector,” all of which are elements a POSA would recognize as composing a negative electrode. EX1011, [0005].

98. The annotated Guo Figure 3a below shows the disclosed “anode sheet

1” (labeled here as a “negative electrode 1”) alongside Fig. 4 of the ’686 patent, further illustrating that Guo discloses a negative electrode structure that a POSA would recognize as comparable to the claimed “negative electrode” of the ’686 patent.



EX1011, FIG. 3a (annotated).



EX1001, FIG. 4 (annotated).

99. Accordingly, a POSA would have understood that Guo discloses claim element 1.3.

G. [1.4] wherein the negative electrode comprises a negative current collector;

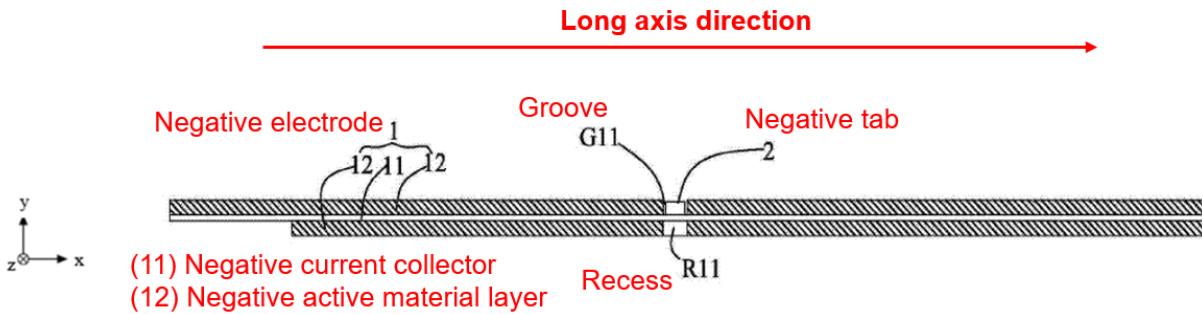
100. Guo discloses a negative electrode comprising a negative current collector.

101. As discussed above, Guo discloses a negative electrode which comprises “an anode current collector.” EX1011, [0005]. Additionally, Guo states that “the anode sheet is formed with an anode tab accommodating groove, the bottom of which is an **anode current collector** and the peripheral side of which is an anode membrane, and the anode tab is accommodated within the anode tab accommodating groove and is electrically connected to the anode current collector at the anode tab accommodating groove.” EX1011, [0005].¹ A POSA would interpret this description as disclosing a negative electrode comprising a negative current collector.

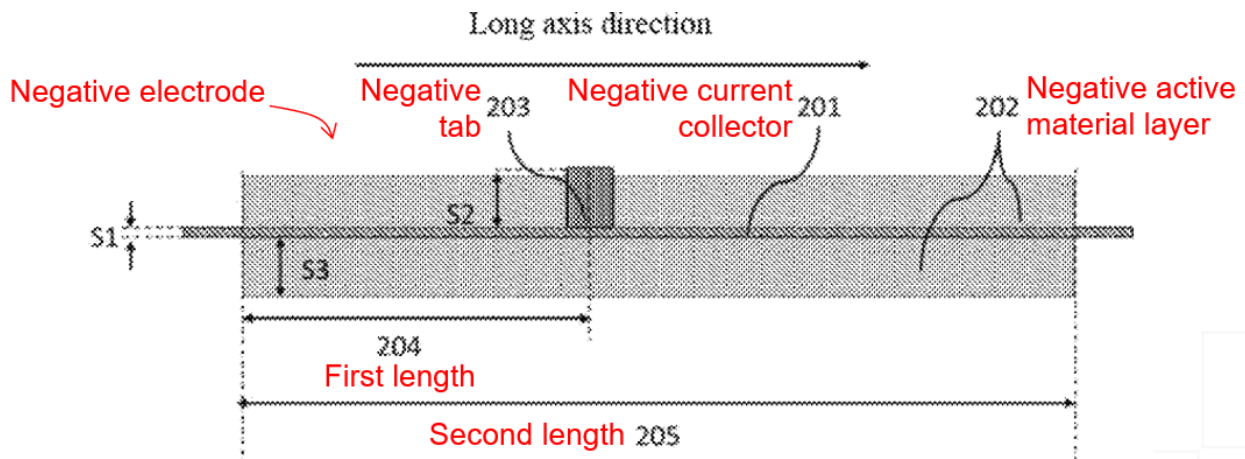
102. The comparison between Guo’s Figure 3a and Figure 4 of the ’686 patent further emphasizes the similarities between Guo’s anode current collector (labeled in the annotated Figure 3a as a “negative current collector 11”) and the “negative current collector.” A POSA would recognize that Guo’s anode current collector is disposed within a negative electrode such that it performs the same function within an electrochemical apparatus as the claimed “negative current

¹ Emphasis is added throughout, except where otherwise indicated.

collector” of the ’686 patent.



EX1011, FIG. 3a (annotated).



EX1001, FIG. 4 (annotated).

103. Accordingly, a POSA would have understood that Guo discloses claim element 1.4.

H. [1.5.1] a negative active material layer,

104. Guo discloses a negative active material layer.

105. As discussed above, Guo discloses a negative electrode comprising a negative current collector and an “anode membrane disposed on the surface of” the negative current collector. EX1011, [0005]. A POSA would recognize the

arrangement of elements within Guo Figure 3a as teaching a negative electrode comprising a negative current collector with a negative active material layer disposed on the negative current collector. Thus, Guo's anode membrane is the claimed "negative active material layer."

106. Beyond the arrangement of components comprising the negative electrode, a POSA would further look towards Guo's description forming the electrochemical apparatus to understand the anode membrane. In EX1011, [0057], [0069], Guo describes forming an anode membrane by "applying and drying the anode membrane slurry." A POSA would recognize this language as a description of a common method for forming a negative active material layer. EX1018, Abstract, 1.

107. A POSA would understand that the electrochemical active anode materials, such as graphite, are powder material. And the powder materials need to be dispersed in solvent with additional processing aiding materials to be able to cast film on the current collector, resulting the negative active material layer. EX1019, [0026], [0042], [0054]. A POSA would recognize this language as a description of a common method for forming a negative active material layer. EX1019, [0026], [0042], [0054]. Indeed, a POSA would understand this statement to indicate that Guo's cathode membrane is equivalent to a "positive active material layer," and through parallel language, Guo's anode membrane is therefore

equivalent to the claimed “negative active material layer,” especially because a POSA would understand that a negative active material layer is critical to the function of a battery. EX1019, [0026], [0042], [0054].

108. Finally, Guo stating that the cathode membrane contains “active lithium” would provide a POSA with further confidence that the anode membrane is the claimed “negative active material layer.” EX1011, [0003]. A POSA would understand this statement to indicate that Guo’s cathode membrane is equivalent to the “positive active material layer” claimed by the ’686 patent, and through parallel language, Guo’s anode membrane is therefore equivalent to the claimed “negative active material layer.” A POSA would have understood that Guo discloses claim element 1.5.1.

I. [1.5.2] wherein the negative active material layer contains a silicon-based material; and

109. Guo in view of Hu teaches that the recited negative active material layer containing a silicon-based material.

1. Guo

110. As discussed in reference to claim element 1.5.1 above, Guo discloses a negative active material layer. However, aside from disclosing that “the secondary battery may be a lithium-ion battery or a sodium-ion battery,” Guo does not provide detail as to the material composition of its negative active material layer. EX1011, [0079]. In other words, while claim element 1.5.2 is not expressed

in Guo, that is because Guo does not mention this level of detail as it relates to its negative active material layer. As Guo focuses on cell structure information of the secondary battery, it in principle implies that any available negative active materials at state of the arts can be applied in Guo's battery. A POSA would have understood this and used available active materials following the structure disclosed in Guo.

111. However, a lithium-ion battery with a negative electrode comprising a negative active material layer containing a silicon-based material was well known in the prior art, as taught by Hu.

2. Hu

112. First, Hu discloses a “high-energy-density lithium-ion battery” comprising, as one of its components, a “negative electrode active material” that coats a “negative electrode sheet.” EX1005, [0008]. A POSA would recognize from this arrangement that Hu's “negative electrode active material” is the claimed “negative active material layer.”

113. Second, regarding the composition of the negative electrode active material, Hu discloses “[p]referably, the negative electrode active material comprises the following components by mass percentage: sodium carboxymethyl cellulose (CMC) 1.5-1.7%, conductive carbon black 1.4-1.6%, graphite 94.6-95.1%, and styrene-butadiene emulsion 1.9-2.1%.” EX1005, [0014]. This provides

a range of 1.9% to 2.1% mass percentages for the emulsion which contains silicon.

114. Regarding the portion of the styrene-butadiene emulsion which contains a silicon-based material, Hu notes “[p]referably, the styrene-butadiene rubber emulsion also contains 0.6-1.3% by mass percent of nano-SiO₂ and 0.2-0.8% by mass percent of silane coupling agent.” EX1005, [0016]. This gives a minimum mass percentage of silicon-based material within the emulsion of $(0.6\% + 0.2\% =) 0.8\%$, and a maximum mass percentage of silicon-based material within the emulsion of $(1.3\% + 0.8\% =) 2.1\%$. Putting these together produces a calculated weight percentage of the silicon-based material range of $(0.8\% \times 1.9\% =) 0.0152\%$ to $(2.1\% \times 2.1\% =) 0.0441\%$.

115. SiO₂ (silica) is definitionally a silicon-based material. Silane coupling agent contains reactive silicon groups, *i.e.* Si-X, which is a compound of silicon and thus also definitionally a silicon-based material. *See, e.g.*, EX1017, 3-5; EX1020, 1.

116. Thus, Hu’s negative electrode active material is the claimed “negative active material layer,” and Hu’s nano SiO₂ and silane compose the claimed “silicon-based material.”

117. The combination of Hu’s negative active material layer applied to the negative current collector of Guo thus teaches claim element 1.5.2.

3. Motivation to Combine

118. **Analogous Art:** As discussed above, Guo and Hu are analogous art to each other and the claims. Section XI.A.

119. **How to Modify:** It would have been obvious to a POSA to combine the teachings of Guo and Hu because Hu explicitly describes details regarding what material to use in a negative electrode material within a lithium battery. A POSA also would have found it obvious how to add the teachings of Hu to Guo because Hu 1) explicitly describes how to add nano-SiO₂ and the silane coupling agent to its styrene-butadiene rubber emulsion and 2) provides a preferred particle size range for the nano-SiO₂. EX1005, [0017]-[0019], [0040], [0049], [0058].

Given this detailed disclosure, it would have been obvious to a POSA how to make a negative active material layer containing a silicon-based material. Similarly, a POSA also would have understood how to add the *specific weight percentages* of Hu's silicon-based material to Guo's negative active material layer in view of teachings in Hu and a skill set well within those of a POSA.

120. **Why Modify:** Guo lacks information that Hu provides, and a POSA would have expected the combination to produce Guo's battery with improved performance. Specifically, a POSA would have looked to Hu to fill in active layer composition details not expressed in Guo, including to improve "safety performance," a stated goal of Guo. EX1011, [0004], [0007], [0049], [0050]. Hu

describes a negative electrode active material comprising a negative electrode binder that can “reduce internal pressure of the battery” and “improve the battery’s cycling performance” without “swelling, loosening, or powder shedding.”

EX1005, [0014]-[0019], [0004]. A POSA would have understood that those goals in Hu presented enumerated metrics of improved safety performance. Thus, a POSA reading Guo in search of analogous art that described details of a negative active material layer with improved safety performance would have looked to Hu for its teachings.

4. Reasonable Expectation of Success

121. A POSA would have had a reasonable expectation of success in combining Hu with Guo because 1) Hu and Guo both described similar batteries; 2) Hu provides a *clear rationale* for adding its silicon-based material to the negative active material layer (as discussed above); 3) Hu describes in detail *how* a POSA would do so; and 4) Hu describes in detail *why* its specific silicon-based materials would result in the creation of a functional electrochemical apparatus having improved performance.

122. In EX1005, [0019], Hu goes on at length to describe why one such electrochemical apparatus embodiment is beneficial:

The CMC and styrene-butadiene rubber emulsion composite **has good performance as a binder for negative electrode materials.**

However, styrene-butadiene rubber emulsion is prone to

demulsification at a high shear rate, so it cannot be mixed at a high stirring rate, which affects the preparation efficiency and bonding performance of the negative electrode binder. **The present invention can significantly improve the shear stability of styrene-butadiene rubber emulsions by adding nano-SiO₂ and a silane coupling agent into the styrene-butadiene rubber emulsions**, wherein these two agents undergo a grafting reaction with styrene-butadiene rubber macromolecules in the styrene-butadiene emulsion that grafts nano-SiO₂ onto the styrene-butadiene rubber macromolecular chains. Furthermore, by controlling the styrene content in the styrene-butadiene rubber, the grafting rate of nano-SiO₂ can be controlled. An excessively high grafting rate will affect a binder's bonding performance, while an excessively low grafting rate will affect the shear stability. At the same time, the particle size of nano-SiO₂ is controlled within the range of 20-70 nm. An excessively large nano-SiO₂ particle size will affect the flexibility of the grafted chains, leading to a significant decrease in the shear stability of the styrene-butadiene emulsion. **Nano-SiO₂ with the aforementioned particle size also helps to prevent the negative electrode aqueous binder from becoming brittle after dehydration**, while an excessively large particle size will significantly reduce the flexibility of the negative electrode binder, resulting in deteriorated electrode sheet performance.

123. In light of the above, a POSA would have a reasonable expectation of success in combining Hu's silicon-based material with Guo's negative active material layer to produce a functional electrochemical apparatus with improved

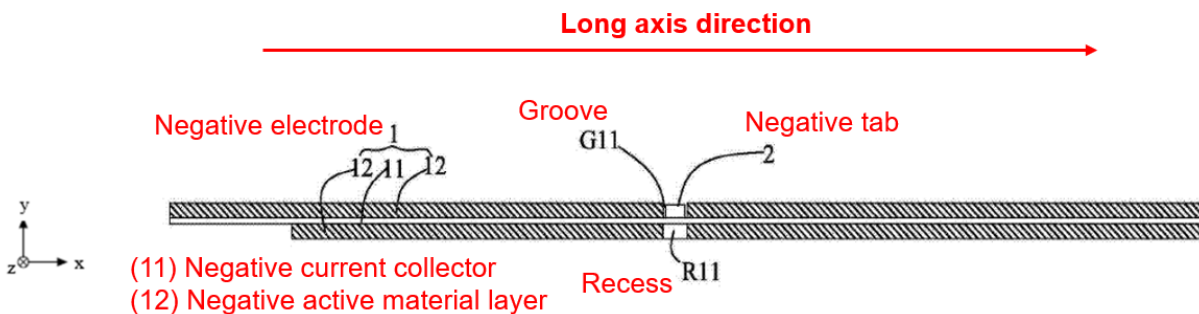
safety performance.

124. As such, a POSA would have understood that Guo in view of Hu discloses claim element 1.5.2.

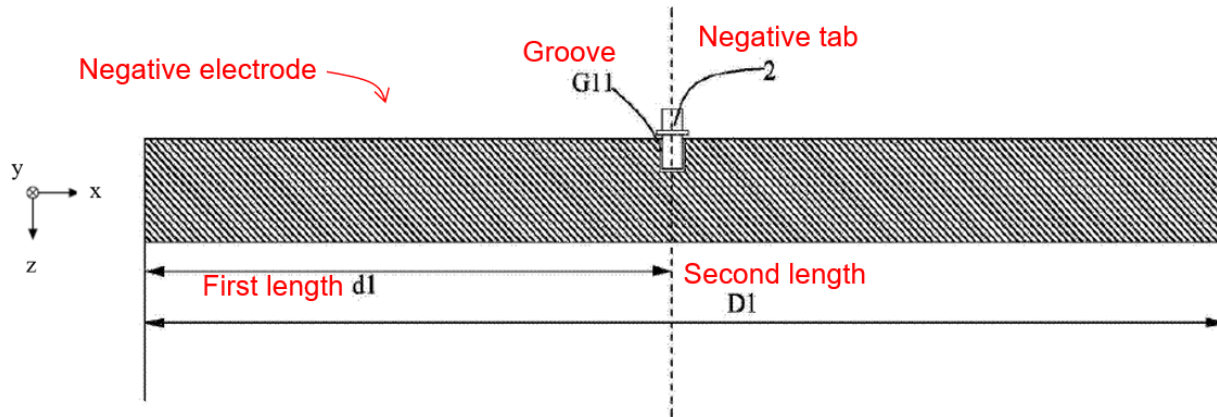
J. [1.6.1] a negative tab,

125. Guo discloses a negative tab.

126. Figures 3a and 3b of Guo disclose an anode sheet formed with “an anode matching recess R11 located on the opposite back side of the anode tab accommodating groove G11, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12.” EX1011, [0066]. The anode current collector is the claimed “negative current collector.” The anode tab is the claimed “negative tab.”



EX1011, FIG. 3a (annotated).



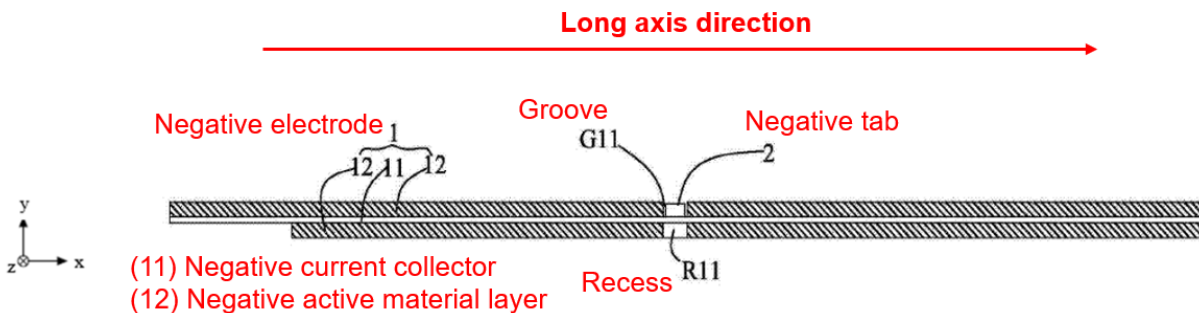
EX1011, FIG. 3b (annotated).

K. [1.6.2] wherein the negative tab is arranged on a side edge of a long axis of the negative current collector,

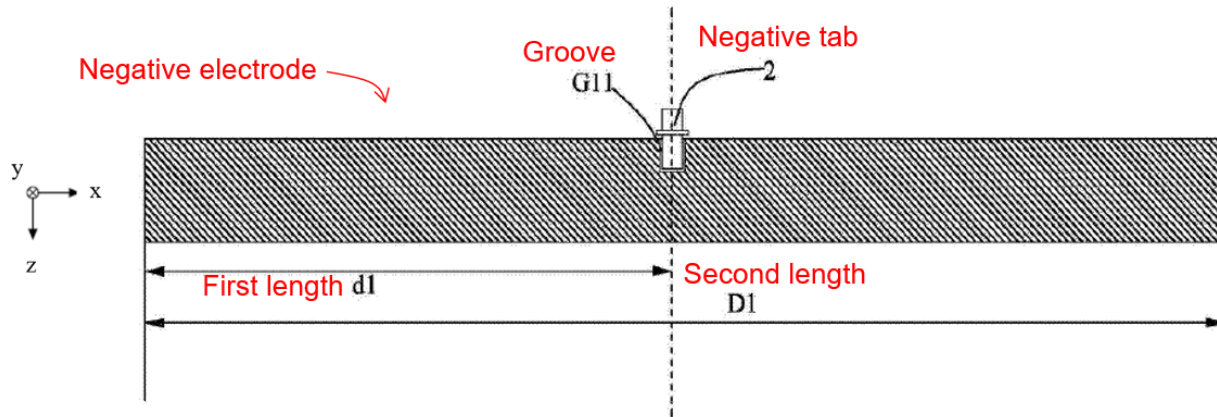
127. Guo discloses a negative tab is arranged on a side edge of a long axis of a negative current collector.

128. As discussed under claim element 1.6.1, the anode current collector of Guo is the claimed “negative current collector,” and the anode tab of Guo is the claimed “negative tab.”

129. As seen in Figures 3a and 3b, a long axis of the negative current collector is aligned with the x-direction.



EX1011, FIG. 3a (annotated).



EX1011, FIG. 3b (annotated).

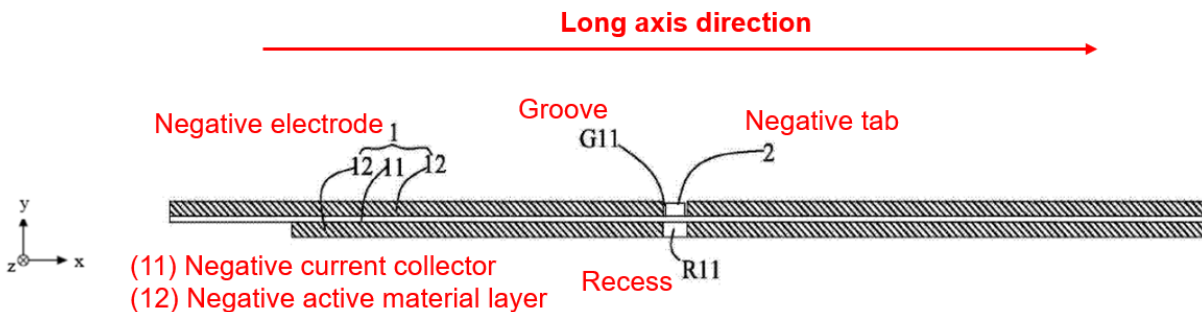
130. Guo thus illustrates a negative current collector with a long axis (i.e. aligned with an x-direction), wherein a negative tab is arranged on a side edge of the long axis (i.e. normal to the x-direction).

- L. [1.6.3] a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length,**

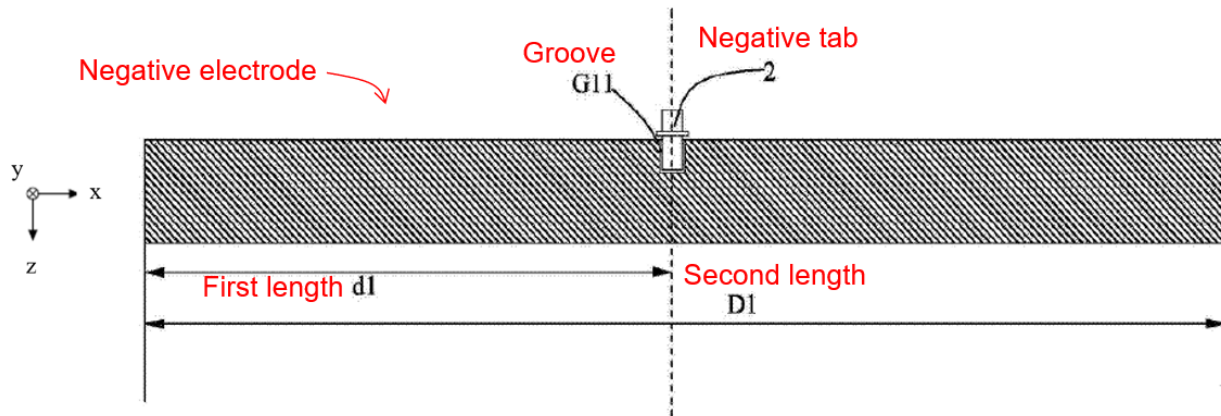
131. Guo discloses a first length which is a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction.

132. Regarding the first length, Guo notes that “the distance between the center line of the anode tab accommodating groove G11 and the head of the anode sheet 1 is defined as d1.” EX1011, [0074]. Guo notes that “anode tab 2 is accommodated within the anode tab accommodating groove G11,” and notes that “anode tab 2 can be electrically connected to the anode current collector 11 at the anode tab accommodating groove G11.” EX1011, [0046], [0049], [0055]. A POSA

would understand the importance of centering anode tab within the anode tab accommodating groove during manufacture. This view is supported by annotated Guo Figure 3b, which clearly illustrates that anode tab 2 (labeled here as “negative tab 2”) is centered within anode tab accommodating groove G11. A POSA would thus understand that the center line of the anode tab 2 is aligned with the center line of the anode tab accommodating groove G11.



EX1011, FIG. 3a (annotated).



EX1011, FIG. 3b (annotated).

133. As a result of this alignment between anode tab 2 and anode tab accommodating groove G11, a POSA would understand “d1” could alternatively

be defined as “the distance between the center line of the anode tab 2 and the head of the anode sheet 1.” Additionally, “the head of anode sheet 1” could alternatively be defined as one “end” of the sheet.

134. Finally, as seen in Figures 3a and 3b, the length of the negative current collector matches the length of the upper layer of anode membrane 12 (labeled here as “negative active material layer 12”) along the long axis in Fig. 3a. Thus, the negative electrode and the upper negative active material layer are aligned and have the same length, so **the distance d1 can alternatively be defined relative to a negative active material layer**. A POSA would thus understand Guo’s d1 definition as equivalent to “the distance between the center line of the negative tab and an end of the negative active material layer.” Because d1 is aligned with the defined long axis direction, a POSA would understand Guo’s definition as equivalent to “the distance between the center line of the negative tab and an end of the negative active material layer in a long axis direction.”

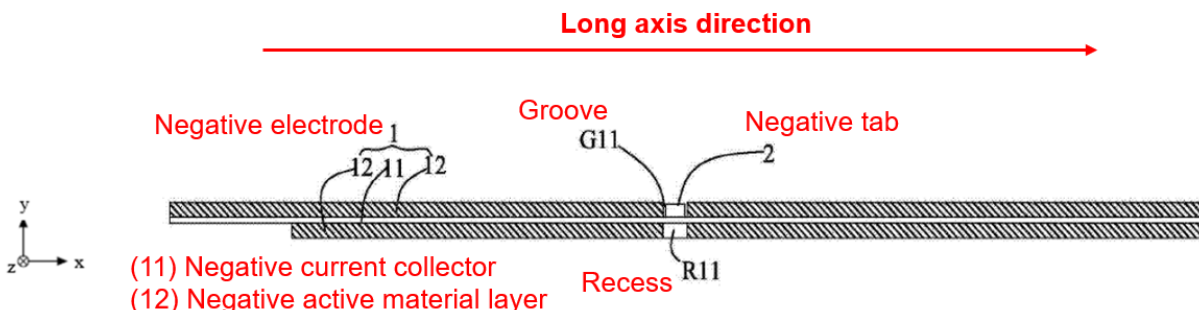
135. Guo thus discloses a first length which is “a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction.”

136. Guo therefore discloses that “a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length.”

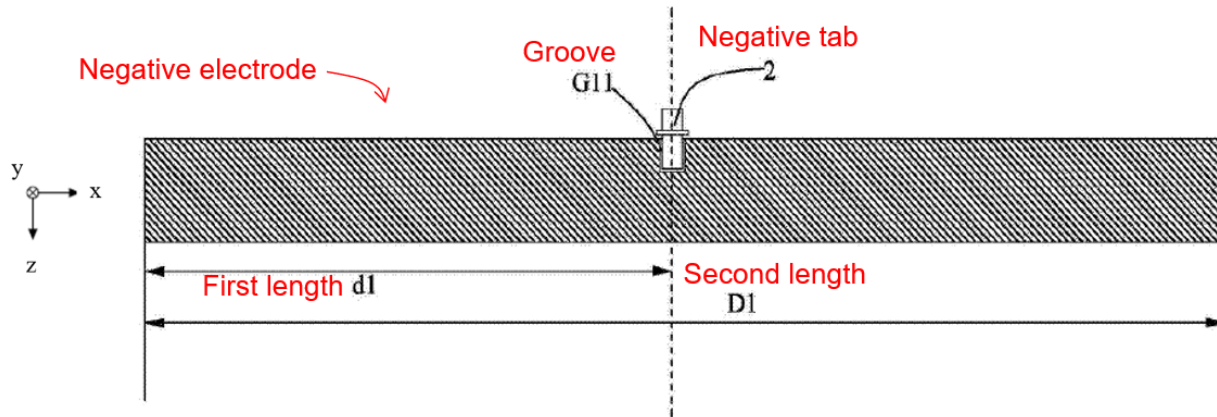
M. [1.6.4] a length of a long axis of the negative active material layer is a second length, and,

137. Guo discloses a second length which is a length of a long axis of the negative active material layer.

138. Regarding the second length, Guo notes that “the distance from the head to the tail of the anode sheet 1 is defined as D1.” EX1011, [0074]. As can be seen in the annotated Guo Figures 3a and 3b, the distance D1 is aligned with the defined long axis direction. Additionally, as seen in Figures 3a and 3b, the length of the negative current collector matches the length of the upper negative active material layer along the long axis in Figure 3a. Thus, the negative electrode and the upper negative active material layer are aligned and have the same length, so **the distance D1 can equivalently be defined relative to the negative active material layer**, i.e. the distance from the head to the tail of the negative active material layer is defined as D1. Thus, a POSA would understand that **D1 is equivalent to a length of a long axis of the negative active material layer.**



EX1011, FIG. 3a (annotated).



EX1011, FIG. 3b (annotated).

139. Guo therefore discloses that “a length of a long axis of the negative active material layer is a second length.”

N. [1.7.1] the negative electrode satisfies the following relationship formula (I): $0.5 \geq D \geq 0.6 \times G$ formula (I)

140. Guo in view of Hu discloses this claim element.

141. As noted above in relation to claim element 1.5.2, Guo does not disclose silicon-based material as part of its negative active material (because Guo does not provide this level of detail), but Hu does.

142. Similarly, “G” in claim element 1.7.1—also in claim elements 1.7.3 and 1.7.4 (discussed below), requiring a weight percentage of the silicon-based material (less than or equal to 70%)—is not taught in Guo, but is taught in Hu.

143. All other elements of claim 1, beyond those directly relating to the silicon-based material, are otherwise taught in Guo.

144. Thus, as discussed below, a negative electrode that satisfies $0.5 \geq D$ is

taught by Guo, a negative electrode that satisfies $0.5 \geq 0.6 \times G$ is taught by Hu, and a negative electrode that satisfies $0.5 \geq D \geq 0.6 \times G$ (formula (I)) is rendered obvious by Guo in view of Hu.

145. Guo discloses a negative electrode which satisfies a first portion of relationship formula (I), specifically, the relationship “ $0.5 \geq D$,” where $D = 0.5$. This disclosure is explained in detail within the discussion of claim element 1.7.2 in Section XI.O below.

146. As discussed below, (see Section XI.P) a negative electrode that satisfies $0.5 \geq 0.6 \times G$ was also well known in the prior art, as taught by Hu.

147. The silicon-based material of Hu would enhance Guo for the reasons presented in the discussion of claim element 1.5.2 above, and Hu’s negative electrode comprising a silicon-based material satisfies a second portion of relationship formula (I): “ $0.5 \geq \dots 0.6 \times G$,” where $0.6 \times G = 0.0000912$ to 0.0002624 . This disclosure is explained in detail within the discussion of claim element 1.7.3 in Section XI.P below.

148. Substitution of $0.6G = 0.0000912$ (as disclosed in Hu) and $D = 0.5$ (as disclosed in Guo) into formula (I) yields:

$$0.5 \geq 0.5 \geq 0.0000912,$$

thus satisfying the conditions of formula (I) and therefore rendering obvious claim element 1.7.1.

149. Substitution of $0.6G = 0.0002624$ (as disclosed in Hu) and $D = 0.5$ (as disclosed in Guo) into formula (I) yields:

$$0.5 \geq 0.5 \geq 0.0002624,$$

thus also satisfying the conditions of formula (I) and therefore also rendering obvious claim element 1.7.1.

150. Thus, Guo in view of Hu discloses claim element 1.7.1.

151. The motivation to combine Guo with Hu with regard to claim elements 1.7.1 through 1.7.4 is provided within the analysis of claim element 1.7.4 below.

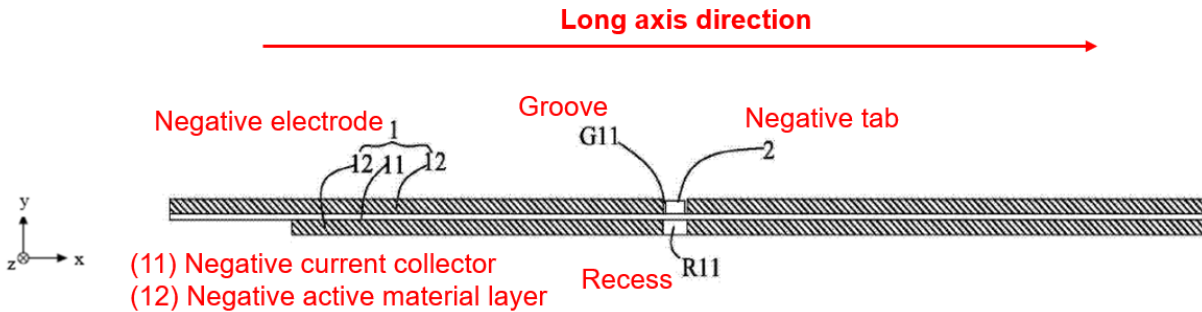
O. [1.7.2] wherein D is a ratio of the first length to the second length,

152. Guo discloses this claim element.

153. As discussed above, Figure 3a of Guo discloses an anode sheet formed with “an anode matching recess R11 located on the opposite back side of the anode tab accommodating groove G11, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12.” EX1011, [0066]. The anode sheet is the claimed “negative electrode.” The anode current collector is the claimed “negative current collector.” The anode membrane is the claimed “negative active material layer.”

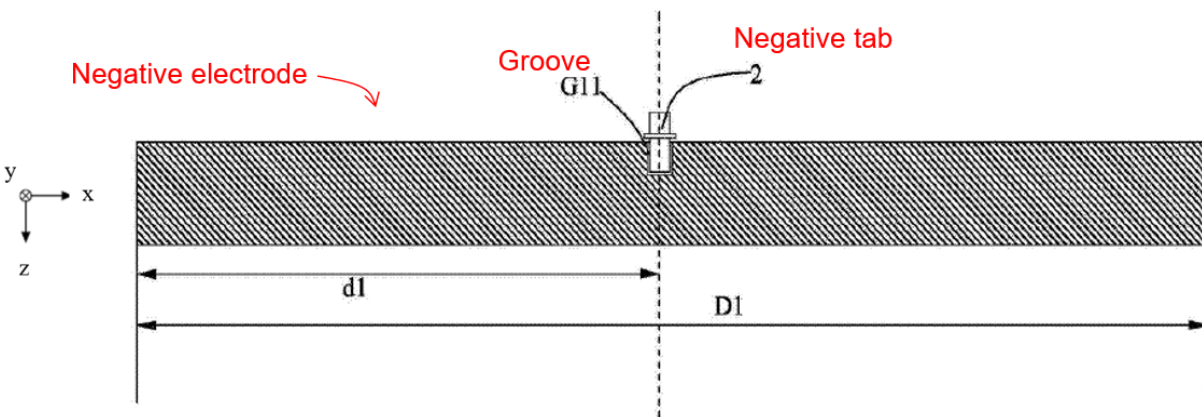
154. Guo discloses that “anode sheet 1 may further be formed with: an anode matching recess R11 located on the opposite back side of the anode tab

accommodating groove G11, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12.” EX1011, [0066]. Furthermore, as disclosed in Guo Claim 1: “the anode tab (2) is accommodated within the anode tab accommodating groove.”



EX1011, FIG. 3a (annotated).

155. As seen in Figures 3a and 3b, the length of the negative current collector matches the length of the upper negative active material layer (i.e. the second length, *see* discussion of claim element 1.6) along a long axis (i.e. the x-axis) in Figure 3a.



EX1011, FIG. 3b (annotated).

156. As seen in Figure 3b, “d1” is defined as “the distance between the center line of the anode tab accommodating groove G11 and the head of the anode sheet,” with “d1 being within the range of $1/10 D1$ to $7/10 D1$ calculated from the head of the anode sheet.” EX1011, [0074]. Doing so helps “to reduce the direct current resistance (DCR) of the secondary battery cell,” where “the closer d1 is to the middle position of the anode sheet 1 (i.e., $1/2 D1$), the smaller the DCR.” EX1011, [0074]. A POSA looking to reduce DCR would thus be motivated to place the anode tab accommodating groove G11 at a position of $d1 = (D1)/2$. Following the same line of reasoning presented under claim element 1.6.3 above, a POSA looking to reduce DCR would similarly be motivated to place *the negative tab* at a position of $d1 = (D1)/2$. Thus, **the “first length” disclosed by Guo is equal to $(D1)/2$.**

157. Considering **the “second length” is equal to $D1$** , the ratio (D) of the first length to the second length is equal to $((D1)/2)/(D1)$. **D is equal to 0.5.**

158. A POSA would understand that Guo discloses “ D is a ratio of the first length to the second length,” where D is used to satisfy formula (I).

P. [1.7.3] G is a weight percentage of the silicon-based material, and

159. Hu discloses this claim element.

160. Regarding G , I refer to the discussion of claim element 1.5.2 above, where the calculated weight percentage of silicon-based material (G) range of

0.0152% to 0.0441% was calculated. The lower of these two values produces a $0.6G$ value of $(0.6 \times 0.0152\% =) 0.00912\%$, or **0.0000912** when expressed as a fraction of 1. The higher of these two values produces a $0.6G$ value of $(0.6 \times 0.0441\% =) 0.02646\%$, or **0.0002646** when expressed as a fraction of 1.

161. A POSA would understand that Hu discloses “ G is a weight percentage of the silicon-based material,” where G is used to satisfy formula (I).

Q. [1.7.4] the weight percentage of the silicon-based material is less than or equal to 70%.

162. Guo in view of Hu teaches a silicon-based material with a weight percentage less than or equal to 70%. As discussed above, “ G ” in claim element 1.7.4 is not taught in Guo (which does not disclose silicon-based material as part of its negative active material, because Guo does not provide this level of detail), but is disclosed on Hu.

1. Guo

163. As discussed in reference to claim element 1.5.1 above, Guo discloses a negative active material layer. However, aside from disclosing that “the secondary battery may be a lithium-ion battery or a sodium-ion battery,” Guo does not provide detail as to the material composition of its negative active material layer. EX1011, [0079].

164. However, a weight percentage of silicon-based material less than or equal to 70% was well known in the prior art, as taught by Hu.

2. Hu

165. As discussed with reference to claim elements 1.5.2 and 1.7.3 above, Hu discloses a weight percentage of silicon-based material (*G*) range of 0.0152% to 0.0441%. These values are less than or equal to 70%, and thus, Hu “discloses the weight percentage of the silicon-based material is less than or equal to 70%.”

3. Motivation to Combine

166. A POSA would have been motivated to combine Hu such that claim elements 1.7.1 through 1.7.4 would have been obvious, for the reasons discussed below.

167. **Analogous Art:** Guo and Hu are analogous art to each other and the claims. Section XI.A.

168. **How to Modify:** A POSA also would have found it obvious how to add the teachings of Hu to Guo for the same reasons detailed above in the Motivation to Combine discussion of claim element 1.5.2. Section XI.I.3. A POSA would understand how to combine these references for *any* specific weight percentage of silicon-based material, including a weight percentage of silicon-based material less than or equal to 70%.

169. **Why Modify:** A POSA would have looked to Hu to fill in active layer composition details missing in Guo for the same reasons detailed above in the Motivation to Combine discussion of claim element 1.5.2. Section XI.I.3.

170. A POSA would be further motivated to combine the *negative tab*

position of Guo with the *silicon-based material weight percentage* of Hu, specifically, to produce an electrochemical apparatus with both reduced direct current resistance and improved safety performance. EX1011, [0004], [0074]; EX1005, [0004], [0019]. With improved safety performance tied to Hu's binder content (as outlined in the discussion of claim element 1.5.2), a POSA would thus be motivated to combine the disclosed silicon-based material weight percentages of Hu with the negative tab position of Guo.

171. Finally, a POSA would recognize that while Hu does not disclose a negative tab position relative to the position of the negative active material layer, Hu **does** disclose a negative tab position relative to the position of the negative electrode, and this teaching of Hu further emphasizes its compatibility with Guo. Specifically, Hu states “the number of the positive electrode tabs is m , the length of the positive electrode sheet is M , the number of the negative electrode tabs is n , the length of the negative electrode sheet is N ” and “the distance between the negative electrode tab near the end of the negative electrode sheet and the end of the electrode sheet is less than or equal to $N/(n+1)$.” EX1005, [0027]. For a number of negative electrode tabs equal to 1, the position of the negative electrode tab on the negative electrode sheet from the end of the electrode sheet is less than or equal to $N/2$.

172. A POSA would recognize that centering a negative active material

layer within a negative electrode is a configuration well-known in the art, and in this known configuration, a negative tab centered within the negative electrode results in the negative tab being centered within the negative active material layer. *See* Section XI.L; EX1011, FIG. 3b. For the centered negative active material layer, this thus results in Hu teaching a first length of $d1 = (D1)/2$ for any second length of $D1$, and thus a D value of $D = 0.5$. A POSA would therefore recognize that for a well-known negative electrode configuration, Hu teaches an identical limitation as Guo and is clearly compatible with Guo.

4. Reasonable Expectation of Success

173. A POSA would have had an expectation of success in combining Hu with Guo because 1) Hu and Guo both described similar batteries; 2) Hu provides a *clear rationale* for adding its silicon-based material to the negative active material layer of a negative electrode with the negative tab position disclosed by Guo; 3) Hu describes in detail *how* a POSA would do so; and 4) Hu describes in detail *why* its specific silicon-based material (and associated silicon-based material weight percentages) would result in the creation of a functional electrochemical apparatus having improved performance.

174. Finally, a POSA would recognize that approximately centering a negative active material layer within a negative electrode is a common configuration, and as a result, Hu's negative electrode tab being positioned at a

distance of $N/2$ from the end of the negative electrode sheet would result in an approximate D value of 0.5. A POSA would recognize that this illustrates the inherent compatibility of Hu's teachings with those of Guo and thus would have a reasonable expectation of success in combining the silicon weight percentage of Hu's silicon-based material with Guo's disclosed ratio of the first length to the second length.

175. A POSA would have thus understood that Guo in view of Hu discloses claim elements 1.7.1 through 1.7.4.

R. Claim 3. The electrochemical apparatus according to claim 1, wherein the silicon-based material contains at least one of an elementary substance of silicon, a compound of silicon, an alloy of silicon, or a silica material.

176. Guo in view of Hu teaches every element of claim 3. Guo and Hu teach or disclose each element of claim 1, from which claim 3 depends, as discussed above in § XI.A-Q. Hu further teaches silicon-based material that contains at least one of an elementary substance of silicon, a compound of silicon, an alloy of silicon, or a silica material, and it would have been obvious to include such silicon-based material in the lithium battery disclosed in Guo.

1. Guo

177. As discussed in reference to claim element 1.5.1 above, Guo discloses a negative active material layer. However, aside from disclosing that "the secondary battery may be a lithium-ion battery or a sodium-ion battery," Guo does

not provide detail as to the material composition of its negative active material layer. EX1011, [0079].

178. However, a silicon-based material that contains at least one of an elementary substance of silicon, a compound of silicon, an alloy of silicon, or a silica material was well known in the prior art, as taught by Hu.

2. Hu

179. As discussed with reference to claim element 1.5.2, Hu discloses a negative active material layer containing a silicon-based material. The silicon-based materials are nano SiO₂ and silane coupling agent. SiO₂ is the chemical formula for silica (the claimed “silica material”), and silane coupling agent contains reactive silicon groups, *i.e.* Si-X, which is the claimed “compound of silicon.” EX1020, 1. Guo in view of Hu thus teaches “[t]he electrochemical apparatus according to claim 1, wherein the silicon-based material contains at least one of an elementary substance of silicon, a compound of silicon, an alloy of silicon, or a silica material.”

3. Motivation to Combine

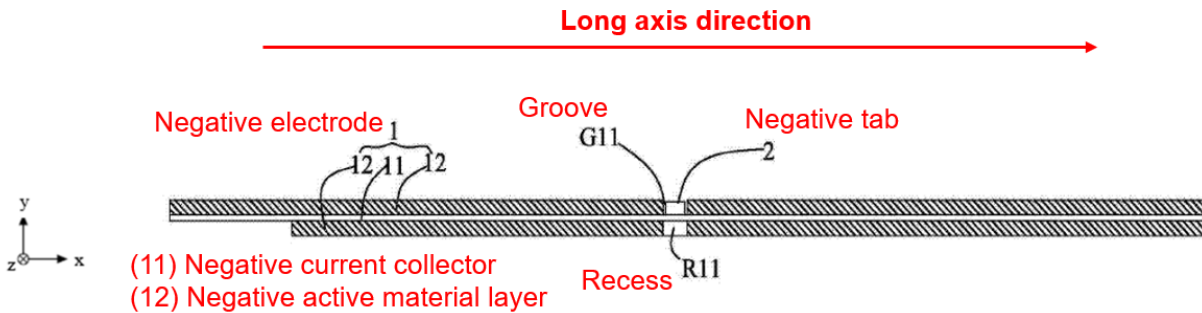
180. A POSA would be motivated to combine Hu with Guo for the same reasons detailed above, under claim elements 1.5.2 and 1.7.3. The motivations to combine discussed under claim elements 1.5.2 and 1.7.3 above hold because 1) claim 3 describes the same “silicon-based material” claim element and 2) the silicon-based material contains said “silica material” and “compound of silicon.”

181. As such, a POSA would have understood that Guo in view of Hu discloses claim 3.

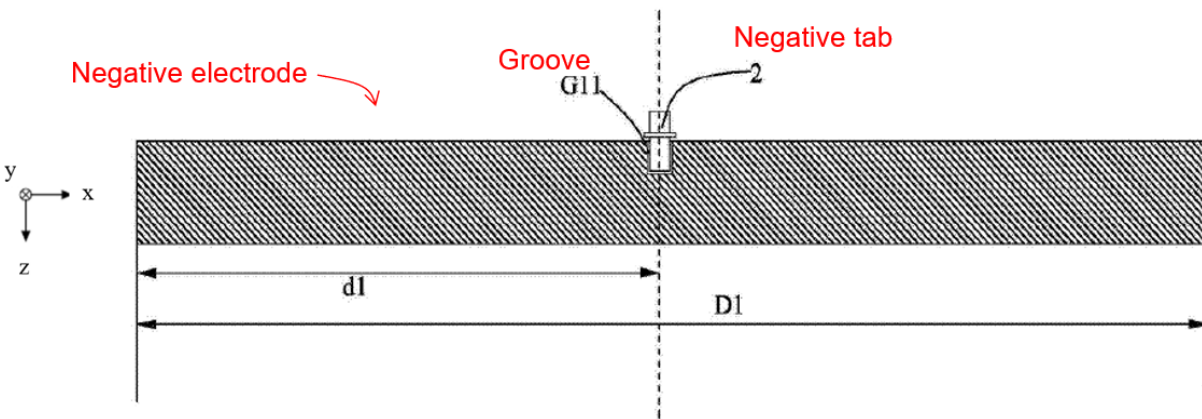
S. Claim 4. The electrochemical apparatus according to claim 1, wherein a ratio of the second length to a length of the long axis of the negative current collector is 0.8 to 1.0.

182. Guo in view of Hu renders claim 4 obvious because a POSA would have been motivated to combine these two references to arrive at the claimed invention of claim 4 with a reasonable expectation of success. Guo and Hu teach or disclose each element of claim 1, from which claim 4 depends, as discussed above in § XI.A-Q. Guo further discloses the additional limitations of claim 4, specifically a ratio of the second length to a length of the long axis of the negative current collector, where the ratio is 0.8 to 1.0.

183. As discussed under claim element 1.7.2, the length of the negative current collector (“D1”) matches the length of the upper negative active material layer (the claimed “second length”) along a long axis (i.e. the x-axis) in Figure 3a, which results in “a ratio of the second length to a length of the long axis of the negative current collector” of 1.



EX1011, FIG. 3a (annotated)



EX1011, FIG. 3b (annotated)

184. Guo in view of Hu thus teaches “[t]he electrochemical apparatus according to claim 4, wherein a ratio of the second length to a length of the long axis of the negative current collector is 0.8 to 1.0.”

185. Guo in view of Hu teaches each and every element of claim 4. A POSA would have been motivated to combine these references with a reasonable expectation of success for the same reasons discussed under claim element 1.7.2. Thus, Guo in view of Hu renders claim 4 obvious.

T. [9.1]. The electrochemical apparatus according to claim 1, wherein the negative electrode is provided with a groove, and

186. Guo in view of Hu renders claim element 9.1 obvious because a POSA would have been motivated to combine these two references to arrive at the claimed invention of claim 9 with a reasonable expectation of success. Guo and Hu teach or disclose each element of claim 1, from which claim 9 depends, as discussed above in § XI.A-Q. Guo further discloses the additional limitations of claim 9.1, specifically a negative electrode provided with a groove.

187. As discussed under claim element 1.7.2, Guo discloses that “**anode sheet 1 may further be formed with:** an anode matching recess R11 located on the opposite back side of the **anode tab accommodating groove G11**, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12.” EX1011, [0066].

Furthermore, as disclosed in Guo Claim 1: “**the anode tab (2) is accommodated within the anode tab accommodating groove.**” The anode tab is the claimed “negative tab,” and the anode tab accommodating groove is the claimed “groove.” EX1011, Claim 1.

188. Guo in view of Hu thus teaches “[t]he electrochemical apparatus according to claim 1, wherein the negative electrode is provided with a groove.”

189. Guo in view of Hu teaches claim element 9.1. For the same reasons discussed under claim element 1.7.1 above, a POSA would have been motivated to

combine these references as described with a reasonable expectation of success.

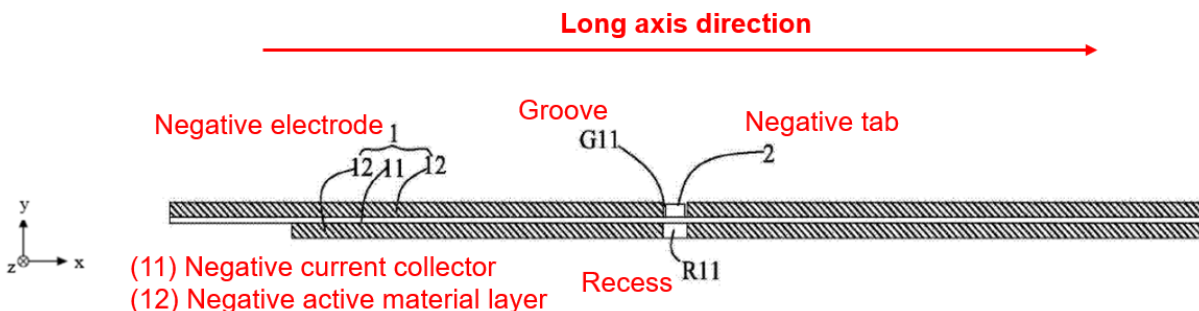
Thus, Guo in view of Hu renders claim element 9.1 obvious.

U. [9.2] the negative tab is arranged in the groove.

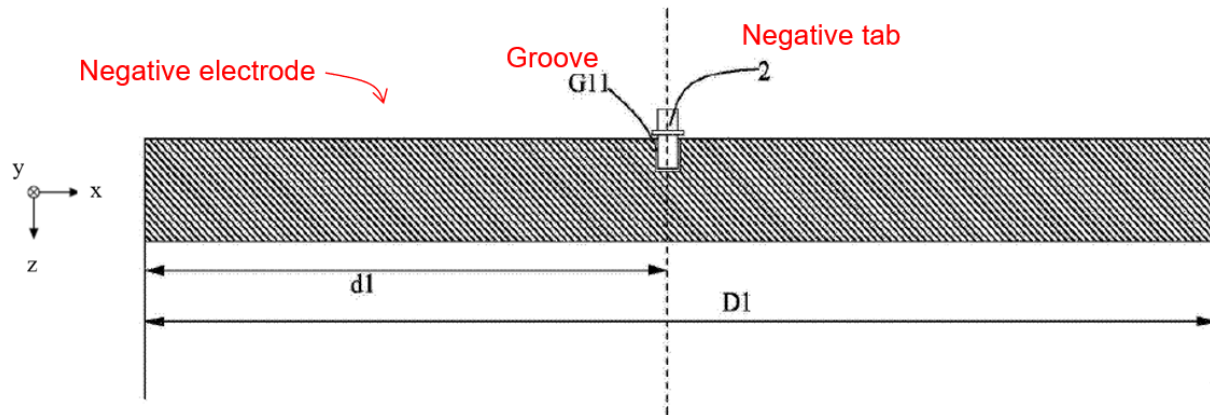
190. Guo in view of Hu render claim element 9.2 obvious because a POSA would have been motivated to combine these two references to arrive at the claimed invention of claim 9 with a reasonable expectation of success. Guo and Hu teach or disclose each element of claim 1, from which claim 9 depends, as discussed above in § XI.A-Q. Guo further discloses the additional limitations of claim 9.2, specifically a negative tab is arranged in a groove.

191. As discussed above in reference to claim element 9.1, Guo's anode tab is the claimed "negative tab," and Guo's anode tab accommodating groove is the claimed "groove." EX1011, Claim 1.

192. As further illustrated in Figures 3a and 3b, the negative tab is arranged in the groove.



EX1011, FIG. 3a (annotated).



EX1011, FIG. 3b (annotated).

193. Guo in view of Hu thus teaches “the negative tab is arranged in the groove.”

194. Guo in view of Hu teaches claim element 9.2. For the same reasons discussed under claim element 1.7.1 above, a POSA would have been motivated to combine these references as described with a reasonable expectation of success.

Thus, Guo in view of Hu render claim element 9.2 obvious.

V. Claim 10: [10.P] An electronic apparatus, comprising an electrochemical apparatus, wherein the electrochemical apparatus comprises:

195. To the extent that the preamble is limiting, Guo discloses this claim element.

196. Guo discloses “lithium-ion batteries” which are “widely used in various electronic products.” EX1011, [0002]. The ’686 patent describes the claimed “electronic apparatus” as an object which “includes the electrochemical apparatus in the embodiments of this application.” EX1001, 10:14-17. The ’686

patent then goes on to list a number of electronic products as examples of the claimed electronic apparatus. EX1001, 10:18-32.

197. As described in the analysis of claim element 1.P above, Guo discloses an electrochemical apparatus.

198. Guo's electronic product is the claimed "electronic apparatus ... comprising an electrochemical apparatus."

W. [10.1] a positive electrode;

199. This claim element is identical to claim element 1.1. *See* § XI.D.

X. [10.2] a separator; and

200. This claim element is identical to claim element 1.2. *See* § XI.E.

Y. [10.3] a negative electrode,

201. This claim element is identical to claim element 1.3. *See* § XI.F.

Z. [10.4] wherein the negative electrode comprises: a negative current collector;

202. This claim element is identical to claim element 1.4. *See* § XI.G.

AA. [10.5.1] a negative active material layer,

203. This claim element is identical to claim element 1.5.1. *See* § XI.H.

BB. [10.5.2] wherein the negative active material layer contains a silicon-based material; and

204. This claim element is identical to claim element 1.5.2. *See* § XI.I.

CC. [10.6.1] a negative tab,

205. This claim element is identical to claim element 1.6.1. *See* § XI.J.

DD. [10.6.2] wherein the negative tab is arranged on a side edge of a long axis of the negative current collector,

206. This claim element is identical to claim element 1.6.2. *See* § XI.K.

EE. [10.6.3] a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length

207. This claim element is identical to claim element 1.6.3. *See* § XI.L.

FF. [10.6.4] a length of a long axis of the negative active material layer is a second length, and

208. This claim element is identical to claim element 1.6.4. *See* § XI.M.

GG. [10.7.1] the negative electrode satisfies the following relationship formula (I): $0.5 \geq D \geq 0.6 \times G$ formula (I)

209. This claim element is identical to claim element 1.7.1. *See* § XI.N.

HH. [10.7.2] wherein D is a ratio of the first length to the second length

210. This claim element is identical to claim element 1.7.2. *See* § XI.O.

II. [10.7.3] G is a weight percentage of the silicon-based material, and

211. This claim element is identical to claim element 1.7.3. *See* § XI.P.

JJ. [10.7.4] the weight percentage of the silicon-based material is less than or equal to 70%.

212. This claim element is identical to claim element 1.7.4. *See* § XI.Q.

213. Similar to claim 1 (and for the same reasons), because Guo in view of Hu teaches or discloses each and every element of claim 10, and because a POSA would have been motivated to modify Guo with the analogous art of Hu to arrive at the claimed invention with a reasonable expectation of success, Guo and Hu render

claim 10 obvious.

KK. Claim 12. The electronic apparatus according to claim 10, wherein the silicon-based material contains at least one of: an elementary substance of silicon, a compound of silicon, or an alloy of silicon.

214. This claim limitation is nearly identical to claim 3. *See* § XI.R. Claim 12 does not recite “a silica material” as one of the options for the silicon based material. But as discussed above in §XI.R, Guo, in view of Hu, teaches a negative active material comprising both SiO₂ and silane, both of which are a “compound of silicon.” Thus, Guo, in view of Hu, teaches each and every element of claim 12.

215. Similar to claim 3 (and for the same reasons), because Guo and Hu teach or disclose each and every element of claim 12, and because a POSA would have been motivated to modify Guo with the analogous art of Hu to arrive at the claimed invention with a reasonable expectation of success, Guo and Hu render claim 12 obvious.

216. Claim 12 is therefore obvious for the reasons discussed above.

LL. Claim 13. The electronic apparatus according to claim 10, wherein a ratio of the second length to a length of the long axis of the negative current collector is 0.8 to 1.0.

217. This claim limitation is identical to claim 4. *See* § XI.S-U.

218. Similar to claim 4 (and for the same reasons), because Guo and Hu teach or disclose each and every element of claim 13, and because a POSA would have been motivated to modify Guo with the analogous art of Hu to arrive at the

claimed invention with a reasonable expectation of success, Guo and Hu render claim 13 obvious.

XII. GROUND 1B: CLAIMS 2 AND 11 WOULD HAVE BEEN OBVIOUS IN VIEW OF GUO IN COMBINATION WITH HU AND KAKINUMA.

A. Guo, Hu, and Kakinuma are analogous art

219. Kakinuma, Guo, and Hu are analogous art to the claims and each other because each reference is directed to the construction of electrochemical apparatuses (“cylindrical battery,” EX1010, Abstract), and all three share a goal of “increased energy density” (see analysis of claim element 1.6.1 above). EX1010, [0003]. A POSA would have been motivated to combine these references to address an art-recognized shortcoming of thick, non-uniform tabs compared to active material layers. EX1007, [0005], [0009].

220. Guo, Hu and Kakinuma have many electrochemical apparatus components in common. Much like Guo and Hu, the electrochemical apparatus (“cylindrical battery,” EX1010, Abstract) of Kakinuma comprises: a positive electrode (“positive electrode plate,” EX1010, [0051]-[0052], [0062]-[0064]), a separator (“separator,” EX1010, [0051], [0073]-[0075]), and a negative electrode (“negative electrode plate,” EX1010, [0051], [0092]-[0094]), wherein the negative electrode comprises a negative current collector (“negative electrode core material,” EX1010, [0053], [0057], [0094]), a negative active material layer (“negative electrode mixture slurry,” EX1010, [0093]-[0094]), and a negative tab

(“negative electrode lead,” EX1010, [0053], [0098]-[0099]).

221. Furthermore, just as the '686 patent describes the need for an electrochemical apparatus “to have higher energy density,” and “higher safety” (EX1001, 1:27-28), and just as Guo and Hu disclose goals of improving energy density and safety (EX1011, [0004], 79; EX1005, Abstract, [0033]), Kakinuma states a need for improved energy density and “enhanced ... safety” (EX1010, Abstract, [0003], [0010], [0011], [0015], [0017], [0020], [0032], [0039]).

B. Application of Guo, Hu, and Kakinuma to claims 2 and 11

222. The combination of Guo with Hu and Kakinuma discloses or renders obvious every element of claims 2 and 11, which depend on claims 1 and 10, respectively.

223. The following explains how each claimed element of claims 2 and 11 is disclosed by Guo in combination with Hu and Kakinuma. In view of Guo's, Hu's, and Kakinuma's disclosures, a POSA would have modified Guo in view of Hu and Kakinuma to arrive at an electrochemical apparatus as claimed in claims 2 and 11 of the '686 patent.

224. The sections below address claims and their limitations individually, but also explain why, as a general matter, a POSA would have started with the battery presented in Guo, knowing that Guo does not teach all relevant details as it relates to certain components and/or aspects of the battery.

225. As it relates to details omitted or easily modified in Guo's battery, a POSA would have looked to Hu and Kakinuma (closely analogous art) to fill in gaps or make modifications, and especially when doing so would improve the performance of Guo's battery, for the reasons taught in Hu and Kakinuma. Thus, each of claims 2 and 11 would have been obvious to a POSA in view of Guo, Hu, and Kakinuma.

C. [2.1.1] The electrochemical apparatus according to claim 1, wherein the negative electrode satisfies the following relationship formula (II): $0.9 \times (S_1 + 2S_3) \leq S_1 + S_2 \leq 1.1 \times (S_1 + 2S_3)$ formula (II)

226. The Guo-Hu combination renders obvious all the elements of claim 1. Section XI.C-XI.Q. Claim element 2.1.1 recites a negative electrode satisfying a relationship formula between the negative current collector, negative tab, and the negative active material, denoted in the claims as S_1 , S_2 , and S_3 , respectively. Although Guo and Hu may not expressly teach a negative electrode satisfying such a relationship, this relationship was taught in the art, as described by Kakinuma. Thus, Guo, in view of Hu and Kakinuma, disclose claim element 2.1.1.

1. Guo-Hu

227. Guo discloses a negative tab ("anode tab") thickness S_2 of 60 μm and a negative active material ("anode membrane) thickness S_3 of 67 μm , but no value is explicitly provided for S_1 . EX1011, [0082]-[0083]. Hu discloses a negative electrode ("negative electrode sheet") thickness of 115 – 125 μm , but no values are explicitly provided for S_1 , S_2 , or S_3 . EX1005, Abstract, Claim 1, [0008], [0039],

[0057]. The Guo-Hu combination thus provides values for S_2 and S_3 , but no value for S_1 .

228. Although Guo-Hu may not expressly disclose what is recited in claim element 2.1.1, a negative electrode satisfying the relationship claimed in formula (II) was well known in the prior art, as taught by Kakinuma.

2. Kakinuma

229. As discussed in more detail below in Sections XII.D-XII.F, Kakinuma teaches S_1 , S_2 , and S_3 values of 20 μm , 120 μm , and 65 μm , respectively. These values result in the recited relationship formula (II), i.e., $0.9 \times (S_1 + 2S_3) \leq S_1 + S_2 \leq 1.1 \times (S_1 + 2S_3)$, being met because $0.9 \times (20 + 2(65)) \leq 20 + 120 \leq 1.1 \times (20 + 2(65)) = 135 \leq 140 \leq 165$.

230. Kakinuma in view of Guo and Hu therefore teaches a relevant electrochemical apparatus “wherein the negative electrode satisfies the following relationship formula (II): $0.9 \times (S_1 + 2S_3) \leq S_1 + S_2 \leq 1.1 \times (S_1 + 2S_3)$, wherein S_1 is a thickness of the negative current collector, S_2 is a thickness of the negative tab, and S_3 is a thickness of the negative active material layer.”

3. Motivation to Combine

231. **Analogous Art:** Kakinuma, Guo, and Hu are analogous art. Section XII.A.

232. **How to Modify:** A POSA would know how to enhance Guo and Hu with the teaching of Kakinuma because the dimensions disclosed in Kakinuma are

straightforward to 1) apply to the teachings of Guo-Hu and 2) implement.

Additionally, Kakinuma details the fabrication of each of its embodiments specifically (*see* EX1010, [0089]-[0099] (“Embodiment 1”), [0100]-[0101] (“Embodiment 2”), etc.). A POSA would understand how to implement these details in order to produce the present combination.

233. **Why Modify:** In response to the Guo-Hu combination providing no value for S_1 , and an understanding of the importance of utilizing compatible dimensions in building a functional device, a POSA would have sought a single reference that included as many parameter dimension ranges as possible.

Additionally, a POSA would have known to look to Kakinuma to enhance Guo and Hu to address an art-recognized shortcoming of thick, non-uniform tabs compared to active material layers (as disclosed in Kakinuma, discussed in the next paragraph). EX1007, [0005], [0009]. Because Guo-Hu is silent on the S_1 value, a POSA would have looked to other prior art that had all thickness values disclosed in a well-performing battery embodiment. One such reference is Kakinuma. As such, POSA thus would have had reason to incorporate the complete set of thickness parameters S_1 , S_2 , and S_3 as taught in Kakinuma, using 20 μm , 120 μm , and 65 μm , respectively.

234. A POSA would have added the teachings of Kakinuma to the electrochemical apparatus of Guo, modified in view of Hu, because Kakinuma

teaches: “[T]here are lithium-ion batteries that use metal-resin laminated sheets instead of battery cases. In this case, by encapsulating *battery components such as positive and negative electrodes*, separators, and electrolytes within such thin sheets, *weight reduction can be achieved along with increased energy density.*” EX1010, [0003]; *see also* EX1010, [00057]. A POSA would thus understand that by incorporating Kakinuma’s teachings, one arrives at a smaller, more energy-dense battery. As Kakinuma teaches, following its disclosure yields a “small cylindrical battery that achieves both improved battery characteristics and enhanced long-term reliability and safety.” EX1010, [0015]. Indeed, Kakinuma independently praises its electrode assembly, disclosing that “[w]ith such an electrode assembly 5, the reaction area is increased, which can achieve strong load characteristics.” EX1010, [0051]. Kakinuma further states that its components, such as the negative electrode plate (i.e., negative electrode including active material), “increase battery capacity.” EX1010, [0052]. A POSA thus would have been motivated to incorporate the electrode component thicknesses disclosed in Kakinuma to the electrochemical apparatus of Guo-Hu.

235. Kakinuma also specifically describes the negative lead (tab) thickness as “preferably” 120 μm or less. EX1010, [0053]. Similarly, Kakinuma describes its current collector thickness as “more preferably” 20 μm or less, EX1010, [0057]. And by using this thickness, Kakinuma teaches that “[a]ccording to the negative

electrode core material with such a thickness, the strength of the negative electrode plate 2 can be maintained, while the negative electrode plate 2 can be made lighter.” EX1010, [0057].

236. As such, a POSA would have arrived at the claimed limitation because they would have understood that battery component thickness is a result effective variable. Through routine optimization of these variables within the prescribed ranges of Kakinuma, a POSA would have arrived at a suitable set of negative electrode thickness values. A POSA would have been motivated to engage in such routine optimization because Kakinuma teaches that such battery component dimensions have superior properties, including strength, size, and energy density. EX1014, Abstract.

4. Reasonable Expectation of Success

237. A POSA would have had a reasonable expectation of success in combining Hu-Guo with Kakinuma because 1) Kakinuma provides a *clear rationale* for its S_1 , S_2 , and S_3 values (as discussed above), 2) Kakinuma describes in detail *how* a POSA would do so for various embodiments, and 3) Kakinuma describes in detail *why* its disclosed dimensions would result in the creation of a functional electrochemical apparatus.

238. Both Kakinuma and Guo are directed to wound battery geometries, and Guo is directed to improved energy density. EX1011, Claim 9, [0074], [0076],

see also [0004] (“the objective of the present utility model is to provide a secondary battery cell ... [w]hen the secondary battery cell forms a secondary battery, it can improve the energy density of the secondary battery.”). Kakinuma teaches that “[a]ccording to the negative electrode core material with such a thickness, the strength of the negative electrode plate 2 can be maintained, while the negative electrode plate 2 can be made lighter.” EX1010, [0057]. A POSA would expect such characteristics to be present in an electrode combining Kakinuma, Guo and Hu, providing a reasonable expectation of success in the art combination.

239. The differences between Guo and Kakinuma’s negative tab thickness (60 μm and 115 μm , respectively) and negative active material thickness (67 and 65 μm , respectively) are similar. Similarly, Hu’s negative electrode is similar in structure to that of Kakinuma, and Hu’s negative electrode thickness of 115-125 μm is close to that of Kakinuma’s negative electrode thickness of 150 μm . EX1005, [0008]. Thus, such a modification would only represent a modification in degree, rather than in kind, and would not have been unpredictable.

D. [2.1.2] wherein S_1 is a thickness of the negative current collector,

240. The Guo-Hu combination renders obvious all the elements of claim 1. Sections XI.C-XI.Q. Claim element 2.1.2 recites thickness of the negative current collector S_1 . Although Guo and Hu may not expressly teach a negative electrode

with a thickness S_1 that satisfies formula (II), this negative electrode was taught in the art, as described by Kakinuma. Thus, Guo, in view of Hu and Kakinuma, disclose claim element 2.1.2.

1. Guo-Hu

241. As discussed under claim element 2.1.1, the Guo-Hu combination thus provides values for S_2 and S_3 , but no value for S_1 .

242. Although Guo-Hu may not expressly disclose claim element 2.1.2, a negative electrode comprising a thickness S_1 that satisfies the relationship claimed in formula (II) was well known in the prior art, as taught by Kakinuma.

2. Kakinuma

243. Kakinuma teaches that the battery according to its invention provides for improved battery thickness characteristics. EX1010, [0015], [0012]. Specifically, Kakinuma teaches that: “The thickness of the negative electrode lead 6 is preferably 10 μm or more and 120 μm or less, more preferably 20 μm or more and 80 μm or less,” EX1010, [0053]; “[t]he thickness of the negative electrode core material is not particularly limited, but it is preferably 1 μm or more and 500 μm or less, more preferably 5 μm or more and 20 μm or less,” EX1010, [0057]; and “[t]hen, by cutting the negative electrode plate into pieces with a width of 29.5 mm and a length of 37.0 mm, to fabricate a negative electrode plate 2 with a thickness of 0.15 mm, a width of 29.5 mm, and a length of 37.0 mm,” EX1010,

[0094]. A POSA would understand that “negative electrode core material” in Kakinuma refers to a negative current collector, as recited in claims 2 and 11.

244. With respect to the current collector thickness, Kakinuma teaches that “[t]he thickness of the negative electrode core material is not particularly limited, but it is preferably 1 μm or more and 500 μm or less, more preferably 5 μm or more and 20 μm or less.” EX1010, [0057]. Kakinuma teaches that following this instruction results in “the strength of the negative electrode plate 2 can be maintained, while the negative electrode plate 2 can be made lighter.” EX1010, [0057]. Thus, Kakinuma discloses a *current collector thickness of $S_1 = 20 \mu\text{m}$* .

3. Motivation to Combine and Reasonable Expectation of Success

245. A POSA would have been motivated to combine Kakinuma with Guo and Hu with a reasonable expectation of success regarding the disclosed current collector thickness (S_1) of Kakinuma for the reasons discussed under claim element 2.1.1.

246. Guo in view of Hu and Kakinuma therefore teaches “ S_1 is a thickness of the negative current collector,” where $S_1 = 20 \mu\text{m}$.

E. [2.1.3] S_2 is a thickness of the negative tab,

247. The Guo-Hu combination renders obvious all the elements of claim 1. Sections XI.C-XI.Q. Claim element 2.1.2 recites a negative tab thickness S_2 . Although Guo and Hu may not expressly teach a negative electrode with a

thickness S_2 that satisfies formula (II), this negative electrode was taught in the art, as described by Kakinuma. Thus, Guo, in view of Hu and Kakinuma, disclose claim element 2.1.3.

1. Guo-Hu

248. As discussed under claim element 2.1.1, the Guo-Hu combination thus provides values for S_2 and S_3 , but no value for S_1 .

249. Although Guo-Hu may not expressly teach claim element 2.1.3, a negative electrode comprising a thickness S_2 that satisfies the relationship claimed in formula (II) was well known in the prior art, as taught by Kakinuma.

2. Kakinuma

250. As discussed under claim element 2.1.2, Kakinuma teaches that the battery according to its invention provides for improved battery thickness characteristics.

251. With respect to the negative tab (lead) thickness, Kakinuma teaches that “[t]he negative electrode lead 6 has the characteristic of bending with small pressure, and its shape is not particularly limited, which may be, for example, a rectangular shape with a welding allowance to the negative electrode core material and a welding allowance to the battery case 1” EX1010, [0053]. Notably, Kakinuma teaches that “the thickness of the negative electrode lead 6 is preferably 10 μm or more and 120 μm or less, more preferably 20 μm or more and 80 μm or less.” EX1010, [0053]. As such, ***Kakinuma teaches the negative tab thickness of***

$S_2 = 120 \mu\text{m}$.

3. Motivation to Combine and Reasonable Expectation of Success

252. A POSA would have been motivated to combine Kakinuma with Guo and Hu with a reasonable expectation of success regarding the disclosed negative tab thickness (S_2) of Kakinuma for the reasons discussed under claim element 2.1.1.

253. Guo in view of Hu and Kakinuma therefore teaches “ S_2 is a thickness of the negative tab,” where $S_2 = 120 \mu\text{m}$.

F. [2.1.4] and S_3 is a thickness of the negative active material layer, and

254. The Guo-Hu combination renders obvious all the elements of claim 1. Sections XI.C-XI.Q. Claim element 2.1.4 recites thickness of the negative active material layer S_3 . Although Guo and Hu may not expressly teach a negative electrode with a thickness S_3 that satisfies formula (II), this negative electrode was taught in the art, as described by Kakinuma. Thus, Guo, in view of Hu and Kakinuma, taught claim element 2.1.4.

1. Guo-Hu

255. As discussed under claim element 2.1.1, the Guo-Hu combination thus provides values for S_2 and S_3 , but no value for S_1 .

256. Although Guo-Hu may not expressly teach claim element 2.1.4, a negative electrode comprising a thickness S_3 that satisfies the relationship claimed

in formula (II) was well known in the prior art, as taught by Kakinuma.

2. Kakinuma

257. As discussed under claim element 2.1.2, Kakinuma teaches that the battery according to its invention provides for improved battery thickness characteristics. As further discussed under claim element 2.1.2, Kakinuma also teaches that following its teachings for negative electrode core material thickness instruction results in “the strength of the negative electrode plate 2 can be maintained, while the negative electrode plate 2 can be made lighter.” EX1010, [0057].

258. Finally, as discussed under claim element 2.1.3, Kakinuma teaches that “[t]he negative electrode lead 6 has the characteristic of bending with small pressure, and its shape is not particularly limited, which may be, for example, a rectangular shape with a welding allowance to the negative electrode core material and a welding allowance to the battery case 1” EX1010, [0053].

259. Reading these passages together, a POSA would appreciate the importance of negative tab and current collector thickness for battery performance, particularly because Kakinuma is directed to the production of batteries of suitable thickness. *See* EX1010, [0003] (“Reducing the thickness of the battery case is particularly effective for increasing the internal volume of small batteries. As another example, there are lithium-ion batteries that use metal-resin laminated

sheets instead of battery cases. In this case, by encapsulating battery components such as positive and negative electrodes, separators, and electrolytes within such thin sheets, weight reduction can be achieved along with increased energy density.”). Thus, a POSA would realize that the thickness of battery components, including tab, active material, and current collector, are result-effective variables for battery weight and energy density.

260. Kakinuma’s total electrode plate thickness is 150 μm . EX1010, [0094]. Thus, the active material can be determined by subtracting the current collector thickness from the total electrode thickness and dividing it by two (because active material is on both sides of the current collector). A POSA would have been motivated to optimize the thickness of the negative current collector, negative tab, and negative active material from the teachings of Kakinuma, particularly within the ranges provided by Kakinuma. Selecting the value of 20 μm from the “most preferred” current collector thickness results in an active material thickness of 65 μm (because $150 - 20 / 2 = 65$). Selecting a negative lead thickness value of 120 μm from the “preferred” range disclosed by Kakinuma results in the *disclosed value of an active material thickness of $S_3 = 65 \mu\text{m}$.*

3. Motivation to Combine and Reasonable Expectation of Success

261. A POSA would have been motivated to combine Kakinuma with Guo and Hu with a reasonable expectation of success regarding the disclosed negative

active material layer thickness (S_3) of Kakinuma for the reasons discussed under claim element 2.1.1.

262. Guo in view of Hu and Kakinuma therefore teaches “ S_3 is a thickness of the negative active material layer,” where $S_3 = 65 \mu\text{m}$.

G. [2.2] wherein the thickness S_1 of the negative current collector is $4 \mu\text{m}$ to $30 \mu\text{m}$.

263. The Guo-Hu combination renders obvious all the elements of claim 1. Sections XI.C-XI.Q. Claim element 2.2 recites an S_1 , thickness of $4 \mu\text{m}$ to $30 \mu\text{m}$. Although Guo and Hu may not expressly teach such an S_1 thickness range, this thickness range was taught in the art, as described by Kakinuma. Thus, Guo, in view of Hu and Kakinuma, disclose each and every element of claim element 2.2.

1. Guo-Hu

264. As discussed under claim element 2.1.1, the Guo-Hu combination thus provides values for S_2 and S_3 , but no value for S_1 .

265. As a result, although Guo-Hu may not expressly teach claim 2.2, a negative electrode with the S_1 range claimed was well known in the prior art, as taught by Kakinuma.

2. Kakinuma

266. As discussed above under element 2.1.2, Kakinuma discloses a current collector thickness of $S_1 = 20 \mu\text{m}$. The *$20 \mu\text{m}$ S_1 thickness of the negative current collector as taught by Kakinuma falls within the claimed range of $4 \mu\text{m}$*

to $30\ \mu\text{m}$, and thus Kakinuma in view of Guo and Hu renders obvious claim element 2.2.

3. Motivation to Combine and Reasonable Expectation of Success

267. A POSA would be motivated to combine Guo with Hu and Kakinuma with a reasonable expectation of success for the same reasons detailed above, under claim element 2.1.1. The motivations to combine discussed under claim element 2.1.1 above hold because 1) claim element 2.2 describes the same negative current collector thickness (S_1) claim element and 2) the $20\ \mu\text{m}$ S_1 thickness disclosed by Kakinuma falls within the claimed S_1 range of claim element 2.2.

268. As such, a POSA would have understood that Guo in view of Hu and Kakinuma discloses claim element 2.2.

H. [11.1.1] The electronic apparatus according to claim 10, wherein the negative electrode satisfies the following relationship formula (II): $0.9 \times (S_1 + 2S_3) \leq S_1 + S_2 \leq 1.1 \times (S_1 + 2S_3)$ formula (II)

269. This additional claim element is identical to claim element 2.1.1. *See* § XII.C.

I. [11.1.2] wherein S_1 is a thickness of the negative current collector,

270. This claim element is identical to claim element 2.1.2. *See* § XII.D.

J. [11.1.3] S_2 is a thickness of the negative tab, and

271. This claim element is identical to claim element 2.1.3. *See* § XII.E.

K. [11.1.4] S₃ is a thickness of the negative active material layer, and

272. This claim element is identical to claim element 2.1.4. *See* § XII.F.

L. [11.2] wherein the thickness S₁ of the negative current collector is 4 μm to 30 μm.

273. This claim element is identical to claim element 2.2. *See* § XII.G.

274. Claim 11 would have been obvious for the same reasons discussed above in relation to claim 2.

XIII. GROUND 1C: CLAIMS 5 AND 14 WOULD HAVE BEEN OBVIOUS IN VIEW OF GUO IN COMBINATION WITH HU AND WANG.

A. Guo, Hu, and Wang are analogous art

275. Guo, Hu, and Wang are analogous art to the claims and each other because all are directed to the construction of electrodes suitable for applications in cylindrical batteries. (*see* Section XI.A for discussion of Guo and Hu). Wang teaches an improvement to a wound battery cell configuration, and teaches that this configuration improves energy density, reduces cost, and reduces the risk of cell deformation. EX1012, [0020].

276. Guo, Hu and Wang have many electrochemical apparatus components in common. Much like Guo and Hu, the electrochemical apparatus (“wound cell,” EX1012, Title, [0008], [0048]) of Wang comprises: a positive electrode (“second electrode plate,” EX1012, Abstract, [0008], [0048]), a separator (“first separator” and “second separator,” EX1012, Abstract, [0008], [0048]), and a negative electrode (“first electrode plate,” EX1012, Abstract, [0008], [0048]), wherein the

negative electrode comprises a negative current collector (“first current collector,” EX1012, [0008], [0049]), a negative active material layer (“first active material layer,” EX1012, Abstract, [0008], [0049]), and a negative tab (“first electrode tab,” EX1012, [0008], [0009], [0049]).

277. Additionally, a POSA would understand that, much like Guo and Hu are analogous because the geometries of their electrochemical apparatuses are compatible (*see* Section XI.A), so too is Wang. A POSA would recognize that the “wound-formed” geometry of Guo is functionally equivalent to Wang’s “wound cell.” EX1011, [0008], [0013], [0074], [0076]; EX1012, Title, [0008], [0048]. Hu is compatible with Wang for the same reasons Hu is compatible with Guo, as discussed above. *See* Section XI.A.

278. Finally, just as the ‘686 patent describes the need for an electrochemical apparatus “to have higher energy density,” and “higher safety” (EX1001, 1:27-28), and just as Guo and Hu disclose goals of improving energy density and safety (EX1011, [0004], [0079]; EX1005, Abstract, [0033]), Wang discloses comparable goals of producing devices that “improve energy density” and “reduce the risk of cell deformation,” which a POSA would recognize as a safety improvement measure. (EX1012, [0020], [0053], [0054], [0058]).

B. Application of Guo, Hu, and Wang to claims 5 and 14

279. Claims 5 and 14 depend on claims 1 and 10, respectively.

280. As discussed below, each claimed element of claim 5 and 14 is disclosed by Guo in combination with Hu and Wang. In view of Guo's, Hu's, and Wang's disclosures, a POSA would have modified the battery in Guo in view of Hu and Wang to arrive at an electrochemical apparatus as claimed in claims 5 and 14 of in the '686 patent.

281. A POSA would have started with the battery presented in Guo, knowing that Guo does not teach all relevant details as it relates to certain components and/or aspects of the battery. As it relates to details omitted or easily modified in Guo's battery, a POSA would have looked to Hu and Wang (closely analogous art) to fill in gaps or make modifications, and especially when doing so would improve the performance of Guo's battery, for the reasons taught in Hu and Wang. Thus, claims 5 and 14 would have been obvious to a POSA in view of Guo, Hu, and Wang.

C. Claim 5. The electrochemical apparatus according to claim 1, wherein the electrochemical apparatus is of a winding structure, and the negative tab is arranged at a position beyond three layers from a center of the winding structure.

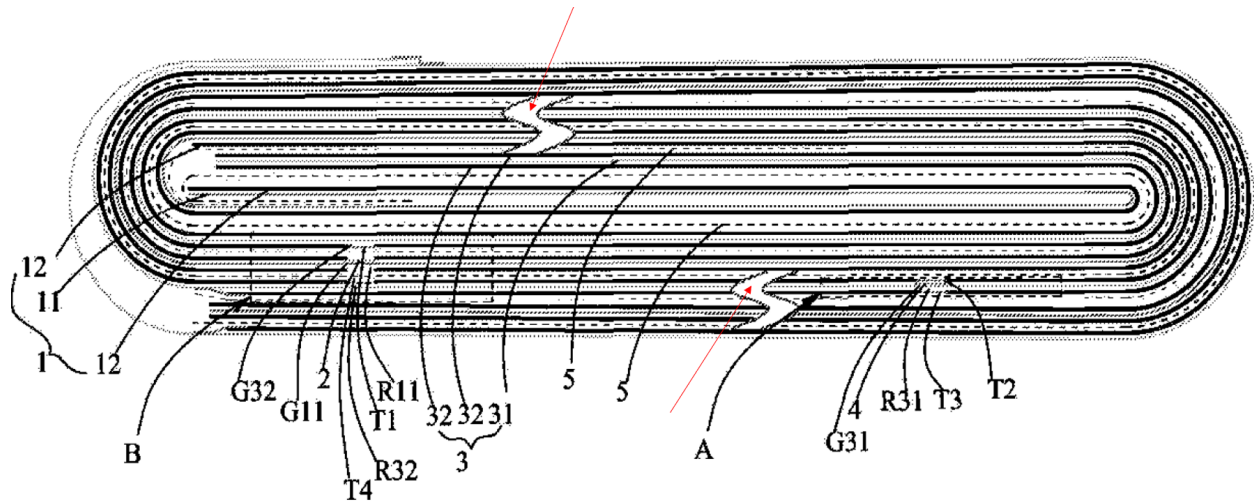
282. As discussed below, Guo in view of Hu and Wang render claim 5 obvious because a POSA would have been motivated to combine these three references to arrive at the claimed invention of claim 5 with a reasonable expectation of success. Guo and Hu teach or disclose each element of claim 1, from which claim 5 depends, as discussed above in § XI.A-Q. Wang further

discloses the additional limitations of claim 5, specifically an electrochemical apparatus of a winding structure, where the negative tab is arranged at a position beyond three layers from a center of the winding structure. Thus, Guo in view of Hu and Wang renders claim 5 obvious.

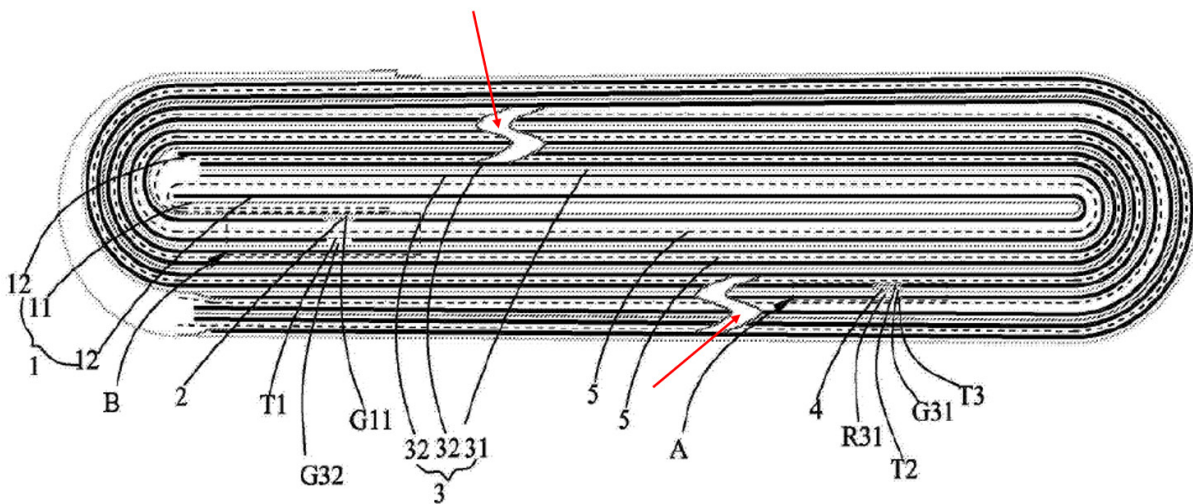
1. Guo-Hu

283. Guo describes an electrochemical apparatus of a winding structure. As described in Guo, “FIG. 1 is a schematic structural diagram of a wound-formed secondary battery cell according to an embodiment of the present utility model.” EX1011, [0008]. The wound-formed secondary battery cell is the claimed “electrochemical apparatus” “of a winding structure.” As described in the analysis of claim element 1.6, the anode tab as described in Guo is the claimed “negative tab.”

284. Regarding the “negative tab ... arranged at a position beyond three layers from a center of the winding structure,” Guo teaches the following structures:



EX1011, FIG. 1 (annotated).



EX1011, FIG. 6 (annotated).

285. The negative tab position from a center of Guo's winding structure is not explicitly disclosed in the specification. Figures 1 and 6 both illustrate winding structures, but a POSA would understand that the "breaks" in the structures shown with red arrows in the annotated Figure 6 above indicate that the total number of winds within each structure can be different from what is shown. The negative tab

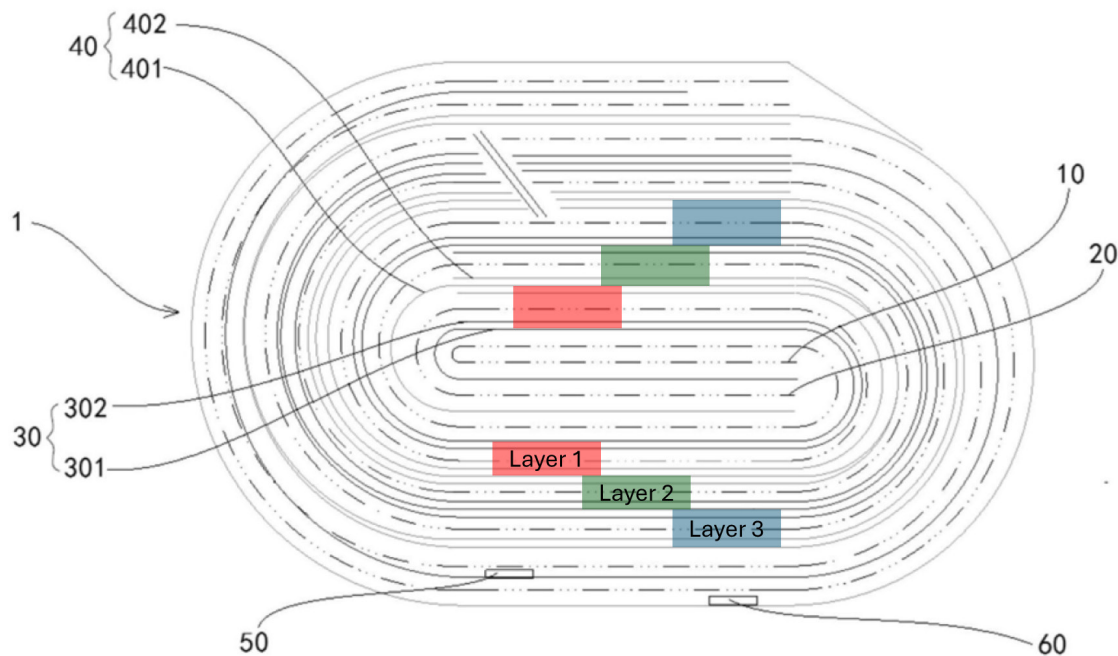
position in varies from $d1 = 1/2 D1$ in Figure 1 to “ $d1 = 3/4 D1$ ” in Figure 6, but with the explicit number of winds not disclosed, *the position of the negative tab relative to a center of the winding structure is not expressed by Guo*. EX1011, [0083], [0087].

286. The negative tab position arrangement relative to the center of a winding structure is also not expressed in Hu.

287. Although Guo-Hu may not expressly disclose a negative tab position relative to a center of the winding structure as recited in claim 5, a negative electrode meeting this limitation was well known in the prior art, as taught by Wang. A POSA would have then looked to Wang to determine the number of layers between the center of the structure and the negative tab.

2. Wang

288. Wang teaches the following structure:



EX1012, FIG. 4 (annotated).

289. As can be seen from this figure, the negative tab 60 is positioned at least four layers from the center of the wound battery (considering each layer containing one cathode, one anode and one separator). Thus, Wang discloses this claim limitation recited in claim 5, and Guo, in view of Hu and Wang, discloses each and every limitation of claim 5.

3. Motivation to Combine

290. **Analogous Art:** Guo, Hu, and Wang are analogous art to each other and the claims. Section XIII.A.

291. **How to Combine:** A POSA would have used at least four layers between the center of the battery and the negative tab, as taught by Wang, in designing the battery of Guo, in view of Hu.

292. **Why Combine:** A POSA would have known to look to Wang to enhance Guo-Hu because given the fact that the position of the negative tab relative to the center of the winding structure is not disclosed in Guo and Hu, and Guo states an express goal of improving “the energy density of the secondary battery” through “accommodating groove” features. EX1011, [0007]. A POSA would understand that implementing Guo’s winding structure within a secondary battery, with the goal of improved energy density in mind, would know to look to analogous art that expressly teaches a *winding structure* geometry which can further “improve energy density” through additional geometric modifications. EX1012, [0020].

293. A POSA would have been motivated to incorporate this claim element because Wang teaches that “the wound cell of the present application can save usage amount of the separator, improve energy density, as well as reduce cost.” EX1012, [0020]. Wang also teaches that “the electrode tab is arranged at the outer side of the cell, which increases the symmetry of the internal structure of the cell, and reduces the risk of cell deformation.” EX1012, [0053]. A POSA would have

been motivated to position electrodes at least 3 layers away from the center of the wound battery to increase the symmetry of the cell, reducing risk of deformation.

4. Reasonable Expectation of Success:

294. A POSA would have had a reasonable expectation of success in creating a battery as taught by Guo, Hu, and Wang, because the primary reference Guo taught a wound battery just as taught by Wang. And Wang specifically praises its wound battery configuration, making it one of a finite set of options that would have been obvious to try in view of Wang. A POSA would have understand that the wound battery of Guo-Hu would have been compatible with Wang's design choice because both disclosures are directed to the same type of wound batteries with comparable electrode structures. Section XIII.A.

295. Guo in view of Hu and Wang therefore teaches "The electrochemical apparatus according to claim 1, wherein the electrochemical apparatus is of a winding structure, and the negative tab is arranged at a position beyond three layers from a center of the winding structure," as recited in dependent claim 5.

296. A POSA would have been motivated to combine Hu and Wang with Guo as described above with a reasonable expectation of success. Thus, Guo in view of Hu and Wang render claim 5 obvious.

D. Claim 14. The electronic apparatus according to claim 10, wherein the electrochemical apparatus is of a winding structure,

and the negative tab is arranged at a position beyond three layers from a center of the winding structure.

297. Dependent claim 14's additional limitation is identical to that of claim 5. *See* § XIII.A-C. Guo in view of Hu and Wang render claim 14 obvious for the same reasons discussed above in relation to claim 5.

XIV. GROUND 1D: CLAIM 7 WOULD HAVE BEEN OBVIOUS IN VIEW OF GUO IN COMBINATION WITH HU AND KUSAGAWA.

A. Guo, Hu, and Kusagawa are analogous art

298. Guo, Hu, and Kusagawa are analogous art to the claims and each other because all are directed to the construction of electrodes suitable for applications in similar cylindrical batteries. Kusagawa discloses a silicon-graphite-based negative active material layer and teaches that its embodiments can improve battery capacity and safety. (EX1008, [0002]-[0003]).

299. Guo, Hu and Kusagawa have many electrochemical apparatus components in common. Much like Guo and Hu, the electrochemical apparatus (“non-aqueous electrolyte secondary battery,” EX1008, Abstract, [0001]-[0004]) of Kusagawa comprises: a positive electrode (“positive electrode plate,” EX1008, Abstract, [0016], [0032]), a separator (“separator,” EX1008, Abstract, [0016], [0034]), and a negative electrode (“negative electrode plate,” EX1008, Abstract, [0016], [0027]-[0028]), wherein the negative electrode comprises a negative current collector (“negative electrode current collector,” EX1008, Abstract, [0016], [0028]), a negative active material layer (“negative electrode mixture layer,”

EX1008, Abstract, [0016], [0028]), and a negative tab (“negative electrode tab,” EX1008, Abstract, [0016], [0028]).

300. Furthermore, Guo and Kusagawa describe very similar battery geometries. For example, just as Guo discloses a “wound-type cell,” Kusagawa discloses “an electrode body formed by winding,” and a negative electrode plate with a “winding start end” and a “winding finish end.” EX1011, Claims 9, 10, [0074], [0076]; EX1008, Abstract, [0016].

301. Finally, just as the ’686 patent describes the need for an electrochemical apparatus “to have higher energy density,” and “higher safety” (EX1001, 1:27-28), and just as Guo and Hu disclose goals of improving energy density and safety (EX1011, [0004], [0079]; EX1005, Abstract, [0033]), Kusagawa discloses a comparable goals of producing batteries that have “higher capacity and output more power” and have “a high level of safety” (EX1008, [0002]-[0003]).

B. Application of Guo, Hu, and Kusagawa to claim 7

302. Claim 7 depends on claim 1. As discussed below, each claimed element of claim 7 is disclosed by Guo in combination with Hu and in further combination with Kusagawa.

303. The following explains how each claimed element of the ’686 patent is disclosed by Guo, Hu, and/or Kusagawa. In view of Guo’s, Hu’s, and Kusagawa’s disclosures, a POSA would have modified Guo in view of Hu and

further in view of Kusagawa to arrive at an electrochemical apparatus as recited in claim 7 in the '686 patent. Also discussed below, a POSA would have been motivated to modify Guo with the teachings in Hu and Kusagawa to arrive at the claims with a reasonable expectation of success. The sections below address claims and their limitations individually, but also explain why, as a general matter, a POSA would have started with the battery presented in Guo, knowing that Guo does not teach all relevant details as it relates to certain components and/or aspects of the battery. As it relates to details omitted or easily modified in Guo's battery, a POSA would have looked to Hu and then Kusagawa (closely analogous art) to fill in gaps or make modifications, and especially when doing so would improve the performance of Guo's battery, for the reasons taught in Hu and the performance of Guo-Hu for the reasons taught in Kusagawa. Thus, each of claims 1 and 7 would have been obvious to a POSA in view of Guo, Hu, and Kusagawa.

304. As discussed below, a POSA would have been understood that Kusagawa discloses a negative active material layer containing a silicon-based material, wherein the silicon-based material contains a material layer, the material layer is arranged on at least a part of a surface of the silicon-based material, and the material layer contains amorphous carbon. Kusagawa thus discloses all elements from claim 7.

305. Upon reading Kusagawa, *a POSA seeking to enhance Guo-Hu would be motivated to apply Kusagawa's teachings to those of Guo-Hu*. As further explained below, a POSA would have been motivated to modify the negative active material layer taught by Guo-Hu, specifically, with Kusagawa's teachings regarding negative active material layer composition. The resultant combination of Guo, Hu, and Kusagawa renders claim 7 obvious.

C. [7.1] The electrochemical apparatus according to claim 1, wherein the silicon-based material further contains a material layer,

306. The Guo-Hu combination renders obvious all the elements of claim 1. Sections XI.C-XI.Q. Claim element 7.1 recites that the silicon-based material contains a material layer. To the extent missing from Guo-Hu, this material layer was taught in the art, as described by Kusagawa. Thus, Guo, in view of Hu and further in view of Kusagawa, discloses claim element 7.1.

1. Guo-Hu

307. As discussed above, the Guo-Hu combination teaches a silicon-based material as claimed by the '686 patent. Section XI.I.

308. Although Guo-Hu may not expressly teach a material layer as recited dependent claim 7, a negative active material layer comprising a silicon-based material containing a material layer was well known in the prior art, as taught by Kusagawa.

2. Kusagawa

309. Kusagawa Example 1 describes a “negative electrode mixture layer” formed from a dried “negative electrode mixture slurry,” wherein the negative electrode mixture slurry comprises a “negative electrode active material,” and the negative electrode active material comprises “SiO coated with carbon.” EX1008, [0027]-[0028].

310. In Example 15, Kusagawa discloses a modification of Example 1 as follows:

Graphite particles and carbon pitch were added to the silicon-containing slurry and mixed to carbonize carbon pitch. The product was classified so as to obtain a particle size in a predetermined range, and carbon pitch was added to the obtained product. **The carbon pitch was carbonized to produce a silicon-graphite composite in which Si particles and graphite particles were bonded to each other with amorphous carbon.** The amount of silicon in this composite was 20.9% by mass.

A non-aqueous electrolyte secondary battery 10 in Example 15 was produced in the same manner as in Example 1 except that the silicon-graphite composite produced as described above was used instead of SiO coated with carbon.

EX1008, [0043]-[0044]. Thus, through the modification of Example 15, Kusagawa discloses a negative electrode mixture layer formed from a dried negative electrode mixture slurry, wherein the negative electrode mixture slurry comprises a negative

electrode active material, and the negative electrode active material comprises the aforementioned silicon-graphite composite. Additionally, a POSA would understand that Example 15 being produced “in the same manner as in Example 1 except that the silicon-graphite composite ... was used instead of SiO coated with carbon” (*Id.* at [0043]) indicates that the silicon-graphite composite of Kusagawa Example 15—with a Si mass percentage of 20.9% (*Id.* at [0043])—replaces the “4% by mass” SiO of Example 1 (*Id.* at [0043]). The resultant negative electrode mixture layer of Example 15 thus comprises *4% by mass of silicon-graphite composite*. A POSA would further recognize Kusagawa’s Si particles as the claimed “silicon-based material,” and thus, a POSA would understand that **the weight percentage of the silicon-based material of the negative electrode mixture layer of Kusagawa Example 15 is 0.836%**, because 20.9% of 4% is 0.836%.

311. The negative electrode mixture layer in Kusagawa corresponds to a “negative active material layer” as recited in claims 1 and 7; the “Si particles” correspond to “silicon-based material” as claimed; and the “amorphous carbon” corresponds to a “material layer” as recited in claim 7. EX1008, [0043]-[0044]. Additionally, a POSA would have understood that Kusagawa’s disclosed negative active material layer, including its silicon-based material and material layer, taught a modification of the Guo-Hu negative active material layer that can be used to

improve battery performance. Finally, the 0.836% weight percentage of the silicon-based material “Si particles”) of Kusagawa Example 15 results in a G value of 0.00836 (EX1008, [0042]-[0044]) and satisfies Formula (I) when used in place of the G value range of 0.0000912 to 0.0002646 as taught by Hu. Substitution of $0.6G = 0.6 \times 0.00836 = 0.005016$ and $D = 0.5$ (as disclosed in Guo, *see* Section XI.O) into formula (I) yields $0.5 \geq 0.5 \geq 0.005016$, thus satisfying the conditions of formula (I) and therefore rendering obvious claim elements 1.7.1 through 1.7.3. As the 0.836% weight percentage of the silicon-based material is less than or equal to 70%, claim element 1.7.4 is also rendered obvious by the Guo-Hu-Kusagawa combination.

312. Thus, the combination of Guo in view of Hu and further view of Kusagawa teaches claim element 7.1.

3. Motivation to Combine

313. **Analogous Art:** Guo, Hu, and Kusagawa are analogous art to each other and the claims. Section XIV.A.

314. **How to Modify:** A POSA would have known how to enhance Guo and Hu with the teaching of Kusagawa because Kusagawa spells out explicitly the “production of negative electrode active material” and the “production of negative electrode plate,” where the latter describes drying a slurry comprising the negative electrode active material “to both sides of a negative electrode current collector.”

EX1008, [0025]-[0028]. A POSA would have understood that this method is compatible with the structure of Guo's anode sheet, which "comprises an anode current collector and an anode membrane disposed on the surface of the anode current collector." EX1011, [0005].

315. Kusagawa Example 15 describes the "production of silicon-graphite composite" containing the aforementioned silicon-based material, and a material layer containing amorphous carbon on the surface of that silicon-based material. EX1008, [0042]-[0044]. Kusagawa Example 15 teaches that "the amount of silicon in this composite was 20.9% by mass." EX1008, [0043]. The reference goes on to note that the battery produced via this example "was produced in the same manner as in Example 1 except that the silicon-graphite composite produced as described above was used instead of SiO coated with carbon." EX1008, [0043], [0025]-[0038]. A POSA would understand how to apply these teachings to those of Guo-Hu, including applying Kusagawa's silicon-graphite composite (comprising a silicon-containing negative active material layer and an amorphous carbon material layer arranged on its surface) to the negative current collector taught by Guo-Hu.

316. Through the descriptions of Examples 1 and 15, a POSA would thus have understood how to enhance the teachings of Guo-Hu with Kusagawa's negative active material layer comprising a silicon-based material with a weight percentage of 0.836% (*See* Section XIV.C.2), which had a material layer (of

amorphous carbon) arranged on its surface.

317. **Why Modify:** A POSA would have found it obvious to modify the electrochemical apparatus of Guo-Hu with Kusagawa's disclosed negative active material layer comprising a silicon-based material containing a material layer. While the Guo and Hu teach improved energy density, safety performance, and shear stability (EX1011, [0004]-[0007]; EX1005, [0014]-[0019], [0023]-[0028]), Guo and Hu are silent as to the performance of their disclosed electrochemical apparatuses with respect to active material capacity, specifically. A POSA seeking to improve capacity would thus look to analogous art that teaches enhanced active material capacity, and Kusagawa taught a POSA how to do so.

318. A POSA would have recognized the benefit of using an amorphous carbon material layer arranged on at least part of a surface of a silicon-based material, as taught in Kusagawa, as an additional component incorporated into the apparatus taught by Guo-Hu, discussed above in relation to claim 1. A POSA further would have recognized the benefit of incorporating a weight percentage of silicon-based material of 0.836% to the electrochemical apparatus of Guo-Hu (*see* Section XIV.C.2). This is because Kusagawa demonstrates that silicon-based active materials were known in the art to improve electrode capacity, and this reference goes on to explicitly provide multiple Examples detailing how to incorporate its teachings, including an Example having a negative active material

layer with 0.836% silicon-based material by mass (*see* Section XIV.C.2).

Kusagawa, [0043]. A POSA would have known to use Kusagawa's negative active material layer because the reference disclosed why this type of active material layer improves capacity while overcoming known challenges regarding cycling characteristics. *See* EX1008, [0004], [0005], [0015], [0017], [0066]-[0068].

319. A POSA would then have been motivated to add the claimed material layer (amorphous carbon) on at least a part of a surface of the silicon-based material, because Kusagawa teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Kusagawa further notes that “in a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon”, as is the case in Example 15. EX1008, [0070].

320. A POSA would have understood that amorphous carbon, specifically, is a suitable choice of conductive coating (i.e., material layer) in this application, as is known in the art. EX1015, 11454-56; EX1016, Abstract, 21-26.

4. Reasonable Expectation of Success

321. A POSA would have had a reasonable expectation of success in combining the teachings of Hu-Guo with Kusagawa because 1) Kusagawa provides a *clear rationale* for use of a negative active material layer comprising a

silicon-based material containing a carbon material layer (as discussed above), 2) Kusagawa describes in detail *how* a POSA would do so, and 3) Kusagawa teaches *why* its disclosed material layer would result in the creation of a functional electrochemical apparatus.

322. A POSA would recognize that Kusagawa's disclosed negative active material layer, comprising a silicon-based material containing a material layer, would result in a successful combination with Guo-Hu because Kusagawa teaches that "any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention." EX1008, [0058]. A POSA would have understood that Kusagawa's silicon material allows for reversible intercalation of Li ions and thus is compatible with the lithium-ion-based electrochemical apparatus of Guo-Hu as described in Ground 1A. Section XI.A-XI.Q.

323. Finally, Kusagawa also teaches that "[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples." EX1008, [0065]. Indeed, *each Example of Kusagawa includes this additional carbon layer*, meaning that Kusagawa valued the feature of the carbon layer being arranged on top of the SiO material. A POSA would have understood from the art that amorphous carbon, specifically, is often used in similar applications (EX1015, 11454-56; EX1016,

Abstract, 21-26), and thus would have a reasonable expectation of success in employing teachings in Kusagawa's Example 15 of a silicon-graphite composition (with the amorphous carbon layer) in Guo's apparatus.

324. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Guo and Hu to form a better-performing battery.

D. [7.2] the material layer is arranged on at least a part of a surface of the silicon-based material, and

325. The Guo-Hu combination renders obvious all the elements of claim 1. Sections XI.C-XI.Q. Claim element 7.2 recites a material layer arranged on at least a part of a surface of a silicon-based material. This material layer was taught in the art, as described by Kusagawa (discussed above). Thus, Guo, in view of Hu and Kusagawa, disclose claim element 7.2.

1. Guo-Hu

326. As discussed above, the Guo-Hu combination teaches a silicon-based material as claimed by the '686 patent. Section XI.I.

327. Although Guo-Hu may not teach the material layer recited in dependent claim 7.2, a material layer, such one made of carbon, arranged on at least a part of a surface of a silicon-based material was well known in the prior art, as taught by Kusagawa.

2. Kusagawa

328. As discussed above, in Example 15, Kusagawa discloses the following:

Graphite particles and carbon pitch were added to the silicon-containing slurry and mixed to carbonize carbon pitch. The product was classified so as to obtain a particle size in a predetermined range, and carbon pitch was added to the obtained product. **The carbon pitch was carbonized to produce a silicon-graphite composite in which Si particles and graphite particles were bonded to each other with amorphous carbon.** The amount of silicon in this composite was 20.9% by mass.

EX1008, [0043]-[0044].

329. Additionally, Kusagawa discloses that “[s]ince silicon materials have lower electron conductivity than graphite, **the surface of the silicon material is preferably coated with carbon** as described in Examples.” EX1008, [0065].

330. The “Si particles” in Kusagawa correspond to the claimed “silicon-based material,” and the amorphous carbon “bonded to” the Si particles correspond to the claimed “material layer arranged on at least a part of a surface of the silicon-based material.” EX1008, [0065].

3. Motivation to Combine

331. **Analogous Art:** Guo, Hu, and Kusagawa are analogous art to each other and the claims. Section XIV.A.

332. **How to Modify:** A POSA would have known how to enhance Guo and Hu with the teaching of Kusagawa for the same reasons outlined under discussion of claim element 7.1 above. Section XIV.C.3. The arrangement of the material layer, as claimed in claim element 7.2, has been discussed under claim element 7.1.

333. **Why Modify:** A POSA would have found it obvious to look to Kusagawa's disclosures to combine with Guo-Hu's electrochemical apparatus for the same reasons outlined under discussion of claim element 7.1 above. Section XIV.C.3. The arrangement of the material layer, as claimed in claim element 7.2, has been discussed under claim element 7.1.

4. Reasonable Expectation of Success

334. A POSA would have had a reasonable expectation of success in combining the teachings of Guo-Hu with Kusagawa for the same reasons outlined under discussion of claim element 7.1 above. Section XIV.C.4. The arrangement of the material layer, as claimed in claim element 7.2, has been discussed under claim element 7.1.

335. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Guo and Hu to form a better-performing battery.

E. [7.3] the material layer contains at least one of a polymer, inorganic particles, amorphous carbon or carbon nanotubes.

336. The Guo-Hu combination renders obvious all the elements of claim 1. Sections XI.C-XI.Q. Claim element 7.3 recites a material layer containing at least one of a polymer, inorganic particles, amorphous carbon or carbon nanotubes. This material layer was taught in the art, as described by Kusagawa. Thus, Guo, in view of Hu and Kusagawa, disclose claim element 7.3.

1. Guo-Hu

337. As discussed above, the Guo-Hu combination teaches a silicon-based material as claimed by the '686 patent. Section XI.I.

338. Although Guo-Hu may not expressly teach the material layer recited in dependent claim 7.3, a material layer containing amorphous carbon was well known in the prior art, as taught by Kusagawa.

2. Kusagawa

339. As discussed above, in Example 15, Kusagawa discloses the following:

Graphite particles and carbon pitch were added to the silicon-containing slurry and mixed to carbonize carbon pitch. The product was classified so as to obtain a particle size in a predetermined range, and carbon pitch was added to the obtained product. **The carbon pitch was carbonized to produce a silicon-graphite composite in which Si particles and graphite particles were bonded to each**

other with amorphous carbon. The amount of silicon in this composite was 20.9% by mass.
EX1008, [0043]-[0044].

340. The “Si particles” in the above-quoted passage in Kusagawa correspond to a “silicon-based material” as recited in claims 1 and 7, and the graphite particles “bonded to” the Si particles correspond to a “material layer arranged on at least a part of a surface of the silicon-based material” as recited in claim 7. EX1008, [0043]-[0044]. In addition, the amorphous carbon discussed in Kusagawa corresponds to the “amorphous carbon” in recited in claim 7.

3. Motivation to Combine

341. **Analogous Art:** Guo, Hu, and Kusagawa are analogous art to each other and the claims. Section XIV.A.

342. **How to Modify:** A POSA would know how to enhance Guo and Hu with the teaching of Kusagawa for the same reasons outlined under discussion of claim element 7.1 above. Section XIV.C.3. The material layer containing amorphous carbon, as claimed in claim element 7.3, has been discussed under claim element 7.1.

343. **Why Modify:** A POSA would have found it obvious to look to Kusagawa’s disclosures to combine with Guo-Hu’s electrochemical apparatus for the same reasons outlined under discussion of claim element 7.1 above. Section

XIV.C.3. The material layer containing amorphous carbon, as claimed in claim element 7.3, has been discussed under claim element 7.1.

4. Reasonable Expectation of Success

344. A POSA would have had a reasonable expectation of success in combining Hu-Guo with Kusagawa for the same reasons outlined under discussion of claim element 7.1 above. Section XIV.C.4. The material layer containing amorphous carbon, as claimed in claim element 7.3, has been discussed under claim element 7.1.

345. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Guo and Hu to form a better-performing battery.

XV. GROUND 2A: CLAIMS 1, 3, 7, 9, 10, AND 12 WOULD HAVE BEEN OBVIOUS IN VIEW OF TAO AND KUSAGAWA.

A. Analogous art

346. Tao and Kusagawa are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes. Kusagawa teaches an improvement to a graphite-based negative active material layer like the one in Tao, mitigating the expansion and shrinkage of silicon by adding graphite to the active material layer.

347. As described in more detail below, claims 1, 3, 7, 10, and 12 would have been obvious in view of Tao and Kusagawa before the effective filing date of

the '686 patent. Specifically, Tao teaches an electrochemical apparatus comprising positive and negative electrodes, as well as a separator. The negative electrode of Tao contains components arranged in a way that satisfies each and every element of claims 1, 3, 7, 10, and 12, except that Tao does not explicitly disclose a specific silicon concentration value as required by claims 1 and 10 (i.e., a negative electrode comprising a negative active material layer containing a “weight percentage of [a] silicon-based material [of] less than or equal to 70%.” However, Kusagawa discloses an electrode with a weight percentage of silicon-based material that satisfies this claim limitation.

348. A POSA would have been motivated to combine the electrochemical apparatus, including the graphite-based negative electrode, of Tao, with the silicon concentration of Kusagawa (in Tao’s negative active material layer in its negative electrode). In doing so, a POSA would have arrived at the claimed invention of claims 1, 3, 7, 10, and 12. And as described below, a POSA would have been motivated to modify Tao in this way because both Tao and Kusagawa teach, in the context of lithium-ion batteries, the drawbacks of purely graphite-based electrodes, as well as the benefits of silicon-containing electrodes. And as discussed in more detail below, a POSA would have had a reasonable expectation of success in making the silicon modification in Tao’s battery in view of Kusagawa because Kusagawa teaches that its electrode compositions display the positive aspects of

both silicon- and graphite-containing electrodes. Further, Tao teaches that its electrodes are compatible with silicon materials. As such, it is my opinion that claims 1, 3, 7, 10, and 12 would have been obvious in view of Tao and Kusagawa.

B. Claims 1 and 10

349. As discussed in more detail below, the combination of Tao and Kusagawa render claims 1 and 10 obvious.

1. Tao and Kusagawa teach or disclose each and every element of claims 1 and 10.

350. Tao discloses an electrochemical apparatus that includes each and every element of claims 1 and 10, except it does not explicitly describe a negative electrode silicon satisfying the “relationship formula (I) equation” because it does not describe a weight percentage of silicon-based material that satisfies Formula (I), nor does it describe a silicon weight percentage of “less than or equal to 70%” recited as “G” in claims 1 and 10. Nevertheless, these aspects of claims 1 and 10 were known in the art in view of Kusagawa, which disclosed the recited weight percentage of silicon-based material. As discussed below, a negative electrode satisfying the formula (I) equation in claims 1 and 10 would have been obvious over Tao in view of Kusagawa.

a. Claim 1: [1.P] “An electrochemical apparatus, comprising:”

351. Tao discloses element [1.P]. Specifically, Tao describes that “[t]he present invention generally relates to lithium ion batteries and, more particularly,

relates to a *lithium ion battery* having desirable safety performance.” EX1007, [0002], *see also* EX1007, [0008] (“According to one embodiment of the present invention, a *lithium ion battery* having desirable safety performance is provided”). A POSA would understand that lithium-ion batteries are an “electrochemical apparatus.” A POSA would understand that lithium-ion batteries function through the movement of lithium ions during charging and discharging cycles. This movement of lithium ions is an electrochemical process. As such, a lithium-ion battery is an “electrochemical apparatus.”

b. [1.1] “a positive electrode;”

352. Tao discloses element [1.1]: “The lithium ion battery includes: a *positive plate*, including a positive current collector, a positive film formed on the positive current collector and a positive lead coupled to the positive current collector” EX1007, [0008]. A POSA would understand that this positive plate is a “positive electrode.”

c. [1.2] “a separator; and”

353. Tao discloses element [1.2]: “a *separator* disposed between the positive plate and the negative plate” EX1007, [0008].

d. [1.3] “a negative electrode;”

354. Tao discloses element [1.3]: “a *negative plate*, including a negative current collector, a negative film formed on the negative current collector and a

negative lead coupled to the negative current collector” EX1007, [0008]. A

POSA would understand that this negative plate is a “negative electrode.”

e. [1.4] “wherein the negative electrode comprises a negative current collector;”

355. Tao discloses element [1.4]. Specifically, Tao teaches that its lithium ion battery comprises “a negative plate, including a ***negative current collector***, a negative film formed on the negative current collector and a negative lead coupled to the negative current collector” EX1007, [0008]. As discussed above, the “negative plate” of Tao is an electrode. Thus, the negative electrode of Tao comprises a negative current collector.

f. [1.5.1] “a negative active material layer,”

356. Tao discloses element [1.5.1]. Specifically, one embodiment disclosed in Tao teaches: “a negative plate, including a negative current collector, ***a negative film formed on the negative current collector*** and a negative lead coupled to the negative current collector” EX1007, [0008]. A POSA would understand that this negative film is the negative active material.

g. [1.5.2] “wherein the negative active material layer contains a silicon-based material; and”

357. Both Tao and Kusagawa disclose element [1.5.2].

i. Tao

358. Tao discloses this element. Specifically, Tao teaches an embodiment where “Example 2 is almost the same as Example 1, except that ... [t]he ***negative***

active material is silicon.” EX1007, [0041], [0047]; *see also* EX1007, Example 3, [0056] (describing for Example 3 that “[t]he *negative active material is silicon*”).

Tao also teaches negative active material that does not contain silicon, such as described in Example 1: “Preparation of the Negative Plate: 1) adding 95 wt % *negative active material graphite*, 2 wt % bonding agent SBR, 1 wt % thickener CMC and 2 wt % conductive agent graphite in solvent deionized water, and obtaining negative slurry having a viscosity of 1000-3000 pa~S after fully stirring” EX1007, [0038].

ii. Kusagawa

359. As discussed above, Tao’s teaching of silicon as the negative active material satisfies the “silicon-based material” limitation. Kusagawa likewise teaches this limitation, but also specifically identifies other silicon-based materials that overcome known shortcomings of silicon in a battery such as the battery described in Tao. For example, Kusagawa teaches “silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008, [0005]. Kusagawa then explains how to balance silicon with carbon materials (like graphite) in a negative electrode active material to achieve “a high capacity and a good load characteristic.” EX1008, [0015]. In pursuit of this goal, Kusagawa discloses that “[t]he negative electrode mixture layer contains a silicon material and graphite as negative electrode active materials.” EX1008,

[0016]. An embodiment disclosed by Kusagawa is described as such: “(Production of *Negative Electrode Active Material*)” and “By chemical vacuum deposition (CVD) where *silicon oxide* having a composition of SiO (corresponding to general formula SiO_x where $x=1$) was heated in an argon atmosphere containing a hydrocarbon gas so that the hydrocarbon gas was thermally decomposed, *the surface of SiO was coated with carbon*. The amount of carbon that covered the surface of SiO was 10% by mass relative to the mass of SiO.” EX1008, [0025]-[0026]. Thus, Kusagawa also discloses negative electrode active material, wherein the negative active material contains a silicon-based material (silicon oxide). Kusagawa also discloses an example, Example 15, using elemental silicon, or a “silicon-graphite composite” as a negative active material. EX1008, [0042]-[0043]. Specifically, Kusagawa teaches formation of a “silicon-based slurry” from “monocrystalline Si particles” which is then added to graphite and carbon pitch to produce a “silicon-graphite composite in which Si particles and graphite particles were bonded to each other with amorphous carbon.” *Id.* Kusagawa teaches incorporating this silicon-graphite composite in a battery, disclosing that such a battery was produced “in the same manner as in Example 1 except that the silicon-graphite composite ... was used instead of SiO coated with carbon.” *Id.* at [0044]. A POSA would have thus understood that the negative active material of Kusagawa Example 15 was thus replacing the 4% (by mass) SiO of Example 1

with 4% (by mass) silicon-graphite composite of Example 15. Kusagawa further teaches that “[t]he amount of silicon in this composite was 20.9 % by mass.” *Id.* at [0043]. A POSA thus would further understand that the negative active material of Kusagawa Example 15 was 0.836% silicon by mass (and thus, a weight percentage of silicon-based material of 0.836%), because 20.9% of 4% is 0.836%.

h. [1.6.1] “a negative tab,”

360. Tao teaches the recited structure. Specifically, Tao Figure 4 discloses a “negative lead,” which is also known as a “negative tab.” EX1007, FIG. 4. This tab is located on negative current collector 21 in a central location.

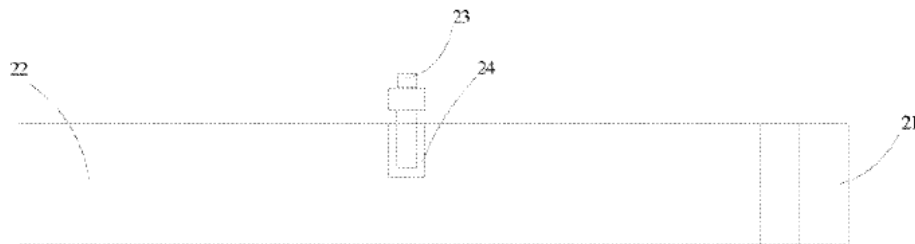


Fig. 4

EX1007, FIG. 4.

i. [1.6.2] “wherein the negative tab is arranged on a side edge of a long axis of the negative current collector,”

361. Tao teaches element [1.6.2]. Specifically, Figure 4 in Tao shows its negative tab arranged on the side of the long axis of the negative current collector

21, as shown below:

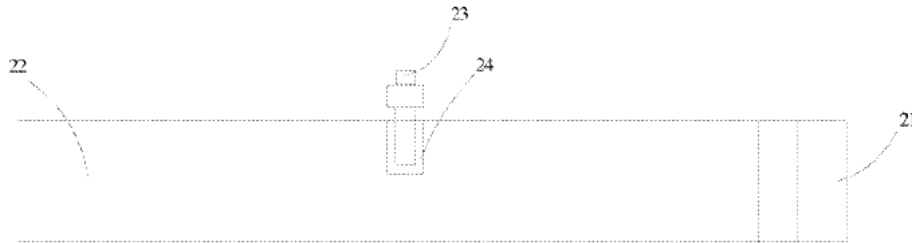


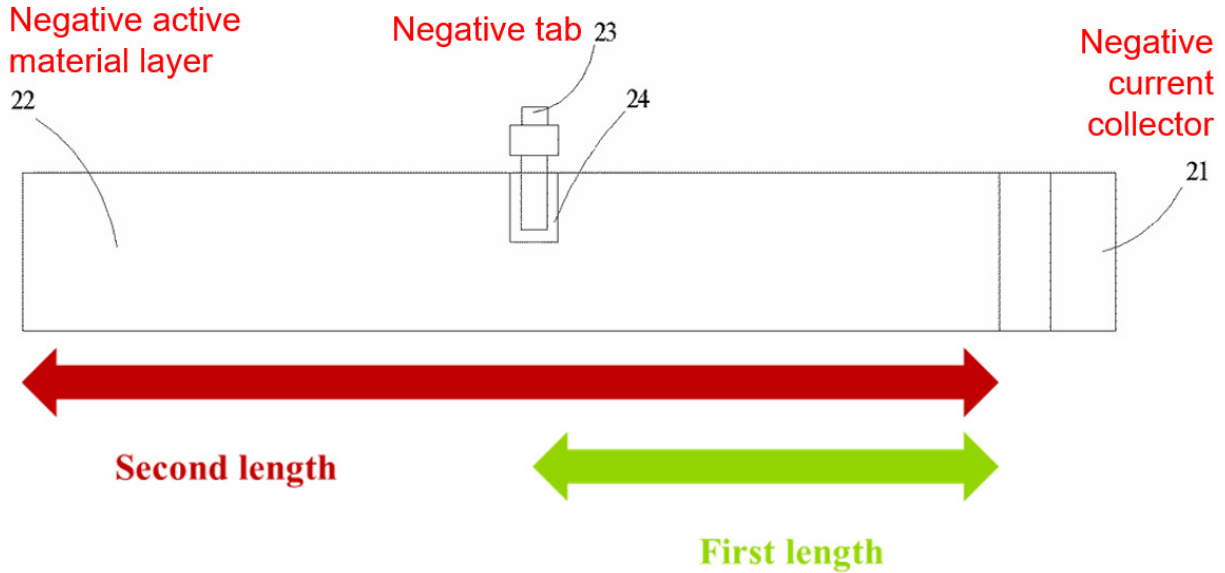
Fig. 4

EX1007, FIG. 4

362. In this figure, 21 is described as a negative current collector; 22 is the negative film (negative active material); 23 is the negative lead (negative tab); and 24 is a second recess. EX1007, [0028]. A POSA would have readily understood that a “negative lead” is a “negative tab” as recited in claim 1. Further, Figure 4 in Tao shows that this negative tab is positioned on the side edge of the long axis of the current collector 21.

j. [1.6.3] “a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length,”

363. As discussed for claim elements [1.6.1] and [1.6.2], Figure 4 in Tao shows the arrangement of the negative tab and the negative active material layer. The distances recited in this claim limitation can also be readily measured in terms of their relationship (e.g., ratio) to each other, as shown below:

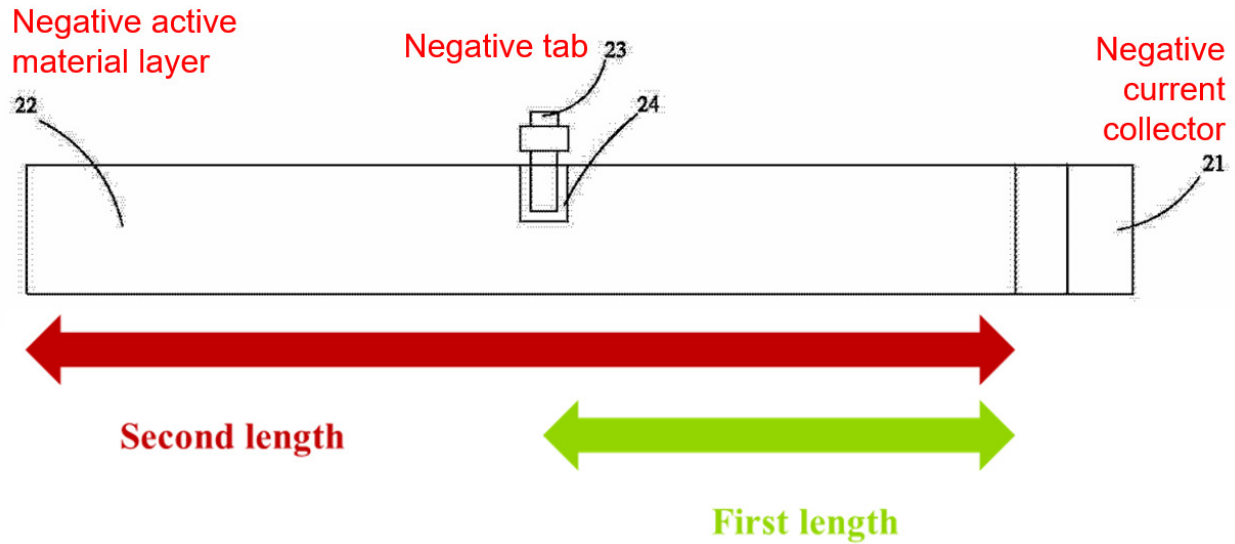


EX1007/EX1022, FIG. 4 (annotated).

As such, Tao discloses claim element [1.6].

k. [1.6.4] “a length of a long axis of the negative active material layer is a second length, and”

364. As discussed for claim elements [1.6.1] and [1.6.2], Figure 4 in Tao shows the arrangement of the negative tab and the negative active material layer. The distances recited in this claim limitation can also be readily measured in terms of their relationship (e.g., ratio) to each other, as shown below:



EX1007/EX1022, FIG. 4 (annotated).

As such, Tao discloses claim element [1.6].

l. [1.7.1] “the negative electrode satisfies the following relationship formula (I): $0.5 \geq D \geq 0.6 \times G$ ”

365. Tao, in view of Kusagawa, teaches this element. To determine whether this element is met, values for both “D” and “G” must be determined. As discussed below, Tao’s lithium battery satisfies “D,” while the negative electrode in Kusagawa comprises a negative active material layer containing a weight percentage of a silicon-based material of “less than or equal to 70%,” meaning it satisfies “G.” As also discussed below, it would have been obvious to a POSA to combine these teachings, i.e., use the weight percentage of a silicon-based material as disclosed in Kusagawa in the negative active material layer of Tao, and that combination meets the “formula (I) $0.5 \geq D \geq 0.6 \times G$ ” in claims 1 and 10.

366. Specifically, and as described in more detail below, Tao teaches the value of $D = 0.5$, and Kusagawa teaches the value of $G = 0.836\%$, or 0.00836 . When the 0.5 value taught by Tao is combined with the “G” value of 0.00836 (i.e., weight percentage of 0.836%) taught by Kusagawa, the recited claim limitation is met. Inputting these values into the recited formula of $0.5 \geq D \geq 0.6 \times G$ (formula (I)) yields $0.5 \geq (0.5) \geq 0.6 \times (0.00836)$. Here, $0.5 \geq 0.5 \geq 0.005016$ is true. Thus, Tao in view of Kusagawa discloses this element.

m. [1.7.2] “wherein D is a ratio of the first length to the second length,”

367. As noted above, Tao teaches a “D” value of 0.5 . Specifically, Tao teaches that “[t]he distance between the center of the second recess 24 and one end of the negative film 22, i.e. one end of the negative film 12 perpendicular to a length direction of the negative current collector 21 and formed no blank negative current collector 21, is half of a length of the negative film 22.” EX1007, [0031]. In explaining this design choice, Tao explains that “[a]ccording to one aspect of the present invention, a distance between a center of the first recess and one end of the positive film is half of a length of the positive film, and a distance between a center of the second recess and one end of the negative film is half of a length of the negative film.” EX1007, [0015].

368. A POSA would have understood that a tab that is located in a recess at “half the length” of the negative film is located in the middle of the negative film.

EX1007, [0031]. Thus, the “first length” as measured from the middle of the tab to the edge of the current collector is half of the distance of the “second length.” Thus, because Tao teaches a recess in the middle of an active material film, Tao teaches a “D” value equal to 0.5.

n. [1.7.3] “G is a weight percentage of the silicon-based material,”

369. Kusagawa teaches a “G” value of 0.836%. Specifically, Kusagawa teaches a weight percentage of 0.836% relative to the total mass of silicon-graphite composite and graphite. EX1008, [0026]. In Example 1, Kusagawa teaches that “SiO and graphite were mixed such that the mass of SiO was 4% by mass relative to the total mass of SiO and graphite, whereby a negative electrode active material was produced.” EX1008, [0026]. And in Example 15, a Kusagawa teaches that “non-aqueous electrolyte secondary battery 10 in Example 15 was produced in the same manner as in Example 1 except that the silicon-graphite composite produced as described above was used instead of SiO coated with carbon.” EX1008, [0044]. Kusagawa further teaches that “[t]he amount of silicon in this composite was 20.9 % by mass.” *Id.* at [0043]. A POSA thus would further understand that the negative active material of Kusagawa Example 15 was 0.836% silicon by mass (and thus, a weight percentage of silicon-based material of 0.836%), because 20.9% of 4% is 0.836%.

o. [1.7.4] “and the weight percentage of the silicon-based material is less than or equal to 70%.”

370. Tao in view of Kusagawa teaches this element. As discussed below, a POSA would have been motivated to combine the “G” silicon concentration of 0.836% in Kusagawa with the electrode negative active material of Tao. The motivation to combine and reasonable expectation of success for this modification are described in § XV.B.1.g and XV.B.2-3. Since 0.836% is “less than or equal to 70%,” the modification described in for limitation [1.7.1] also meets this claim limitation. Thus, Tao in view of Kusagawa teaches this limitation.

2. Motivation to Combine

371. **Analogous Art:** Tao and Kusagawa are analogous art to each other and the claims. Section XV.A.

372. **How to combine:** In combining Kusagawa’s teachings with Tao, a POSA would have looked to Kusagawa’s disclosure of amounts of silicon-based materials to use in addition to graphite-based active material. Those amounts achieve the balance that Kusagawa praises between the higher capacity of silicon and the improved load characteristics of carbon. As such, a POSA would have been motivated to modify the electrode of Tao Example 1 by reducing the amount of graphite in the negative active material from 95% to 91%, and adding 4% silicon-graphite composite, as described in Kusagawa Example 15. A POSA also would have been motivated to modify the electrode of Tao Examples 2 and 3 by

replacing the 95% silicon in with 4% silicon-graphite composite, and replacing all but the 4% silicon-graphite with 91% graphite.

373. **Why to combine:** Kusagawa teaches an improvement to a graphite-based negative active material layer like the one in Tao, mitigating the expansion and shrinkage of silicon by adding graphite to the active material layer, as discussed below.

374. A POSA would have known to enhance the electrode composition of Tao with the silicon concentration taught in Kusagawa because Kusagawa expressly teaches that its electrode compositions perform well, describing that “[s]ilicon materials, such as silicon and silicon oxide, having a higher capacity than carbon materials have recently attracted more attention as negative electrode active materials of non-aqueous electrolyte.” EX1008, [0004]. Kusagawa also warns that “[h]owever, silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008, [0005]. Kusagawa then explains how to balance silicon with carbon materials (like graphite) in a negative electrode active material to achieve “a high capacity and a good load characteristic.” EX1008, [0015]. Kusagawa thus motivated a POSA to modify Tao and combine it with Kusagawa because the POSA would have (1) identified a shortcoming in silicon active material layers like Tao’s, and (2) looked for a proposed solution to that shortcoming. A POSA would have understood that both

graphite and silicon have respective benefits and drawbacks, and that a careful balance between the two materials was beneficial.

375. In addition, Kusagawa describes that “[i]n light of the aforementioned circumstances, the present invention is directed to a non-aqueous electrolyte secondary battery in which a silicon material and graphite are used as negative electrode active materials and which has a high capacity and a good load characteristic.” EX1008, [0015]. Indeed, Kusagawa teaches that “[t]he results of Examples 15 and 16 indicate that the use of the silicon-graphite composite or the silicon-lithium silicate composite instead of SiO as a silicon material still provides the advantageous effects of the present invention.” EX1008, [0059]. As such, a POSA would have been motivated to use a mixture of graphite and silicon-graphite composite as active material components when constructing a negative electrode. A POSA would have understood that routine optimization of these components, as taught by Kusagawa, would have been advantageous for the development of a lithium-ion battery.

3. Reasonable expectation of success

376. A POSA would have had a reasonable expectation of success in combining these references because Kusagawa teaches that “any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008,

[0058]. A POSA would have understood that Kusagawa's silicon-graphite composite material allows for reversible intercalation of Li ions. Indeed, Kusagawa teaches that "[t]he results of Examples 15 and 16 indicate that the use of the silicon-graphite composite or the silicon-lithium silicate composite instead of SiO as a silicon material still provides the advantageous effects of the present invention." EX1008, [0059]. And a POSA would have understood that Kusagawa's 4% Si-graphite composite / 96% graphite compositions would have been compatible with the battery described in Tao, which has embodiments of both 95% graphite and 95% silicon. EX1008, Table 1; EX1007, Example 1, Example 2.

377. A POSA also would have understood that Tao's graphite active material could tolerate the incorporation of silicon-graphite composite because Tao discloses the use of silicon in other embodiments. For example, Tao teaches an Example 2, which "is almost the same as Example 1, except that ... [T]he negative active material is silicon." EX1007, [0041], [0047]. Thus, a POSA would have understood that silicon could have been readily incorporated into the graphite active material of Tao Example 1, and that such an active material would perform favorably.

378. Because Tao and Kusagawa teach or disclose each and every element of claim 1, and because a POSA would have been motivated to modify Tao with

the analogous art of Kusagawa to arrive at the claimed invention with a reasonable expectation of success, Tao and Kusagawa render claim 1 obvious.

a. Claim 10: [10.P] An electronic apparatus, comprising an electrochemical apparatus, wherein the electrochemical apparatus comprises:

379. To the extent that the preamble is limiting, Tao discloses this element. Specifically, Tao discloses that “[t]he present invention generally relates to lithium ion batteries and, more particularly, relates to a *lithium ion battery* having desirable safety performance.” EX1007, [0002], *see also* EX1007, [0008] (“According to one embodiment of the present invention, a *lithium ion battery* having desirable safety performance is provided”). A POSA would understand that lithium ion batteries are an “electronic apparatus.” And as discussed above in § XI.V, these lithium ion batteries comprise an electrochemical apparatus.

380. Kusagawa also discloses this element. Specifically, Kusagawa teaches that non-aqueous electrolyte secondary batteries “have been used as power supplies” of a variety of electronic apparatuses, including “smart phones, tablet computers, laptop computers, and portable music players.” EX1008, [0002]. Thus, Kusagawa also independently teaches “an electrochemical apparatus.”

b. [10.1] a positive electrode;

381. This limitation is identical to limitation [1.1]. *See* § XV.B.1.b.

c. [10.2] a separator; and

382. This limitation is identical to limitation [1.2]. *See* § XV.B.1.c.

d. [10.3] a negative electrode,

383. This limitation is identical to limitation [1.3]. See § XV.B.1.d.

e. [10.4] wherein the negative electrode comprises: a negative current collector;

384. This limitation is identical to limitation [1.4]. See § XV.B.1.e.

f. [10.5.1] a negative active material layer,

385. This limitation is identical to limitation [1.5.1]. See § XV.B.1.f.

g. [10.5.2] wherein the negative active material layer contains a silicon-based material; and

386. This limitation is identical to limitation [1.5.2]. See § XV.B.1.g.

h. [10.6.1] a negative tab,

387. This limitation is identical to limitation [1.6.1]. See § XV.B.1.h.

i. [10.6.2] wherein the negative tab is arranged on a side edge of a long axis of the negative current collector,

388. This limitation is identical to limitation [1.6.2]. See § XV.B.1.i.

j. [10.6.3] a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length,

389. This limitation is identical to limitation [1.6.3]. See § XV.B.1.j.

k. [10.6.4] a length of a long axis of the negative active material layer is a second length, and

390. This limitation is identical to limitation [1.6.4]. See § XV.B.1.k.

l. [10.7.1] the negative electrode satisfies the following relationship formula (I): $0.5 \geq D \geq 0.6 \times G$ formula (I)

391. This limitation is identical to limitation [1.7.1]. See § XV.B.1.l.

m. [10.7.2] wherein D is a ratio of the first length to the second length,

392. This limitation is identical to limitation [1.7.2]. *See* § XV.B.1.m.

n. [10.7.3] G is a weight percentage of the silicon-based material,

393. This limitation is identical to limitation [1.7.3]. *See* § XV.B.1.n.

o. [10.7.4] and the weight percentage of the silicon-based material is less than or equal to 70%.

394. This limitation is identical to limitation [1.7.4]. *See* § XV.B.1.o.

395. Similar to claim 1 (and for the same reasons), because Tao and Kusagawa teach or disclose each and every element of claim 10, and because a POSA would have been motivated to modify Tao with the analogous art of Kusagawa to arrive at the claimed invention with a reasonable expectation of success, Tao and Kusagawa render claim 10 obvious. *See* § XV.A, XV.B.2-3.

C. Claims 3 and 12

396. As explained above, Tao and Kusagawa teach or disclose each element of claims 1 and 10. As discussed in more detail below, Tao and Kusagawa render claims 3 and 12, which depend on claims 1 and 10, respectively, obvious because Tao and Kusagawa also teach or disclose each and every element of claims 3 and 12. Further, as discussed in more detail below, a POSA would have been motivated to modify Tao in view of Kusagawa to arrive at the claimed invention with a reasonable expectation of success.

1. Tao and Kusagawa teach or disclose each and every element of claims 3 and 12.

397. Tao in view of Kusagawa teaches each and every element of claims 3 and 12.

a. Claim 3: [3] *The electrochemical apparatus according to claim 1, wherein the silicon-based material contains at least one of an elementary substance of silicon, a compound of silicon, an alloy of silicon, or a silica material.*

i. Tao

398. Tao discloses this claim element. Specifically, Tao discloses a negative active material layer. Tao discloses an embodiment of its battery comprising a negative active material with a silicon-based material that is elementary silicon. Tao teaches: “a negative plate, including a negative current collector, ***a negative film formed on the negative current collector*** and a negative lead coupled to the negative current collector” EX1007, [0008]. A POSA would understand that this negative film is the negative active material. Tao also teaches, in an embodiment that “Example 2 is almost the same as Example 1, except that ... [T]he negative active material is ***silicon***.” EX1007, [0041], [0047], *see also* EX1007, Example 3, [0056] (describing for Example 3 that “[t]he negative active material is ***silicon***”). A POSA would understand that “silicon” is an elementary substance of silicon.

399. Tao also teaches negative active materials that do not contain silicon, that a POSA would have readily modified to incorporate silicon, as taught by Kusagawa and explained in more detail below. Specifically, Tao teaches negative active material that does not contain silicon, such as that described in Example 1: “Preparation of the Negative Plate: 1) adding 95 wt % negative active material graphite, 2 wt % bonding agent SBR, 1 wt % thickener CMC and 2 wt % conductive agent graphite in solvent deionized water, and obtaining negative slurry having a viscosity of 1000-3000 pa~S after fully stirring” EX1007, [0038]. And as described below, a POSA would have been able to modify this 95% graphite negative active material in view of Kusagawa to arrive at claim limitation [3].

ii. Kusagawa

400. As discussed above, Tao’s teaching of silicon as the negative active material satisfies the “elementary silicon” limitation. Kusagawa likewise teaches this limitation, but and also specifically identifies other silicon-based materials that overcome shortcomings of silicon in a battery such as the battery described in Tao. For example, Kusagawa teaches “silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008, [0005]. Kusagawa then explains how to balance silicon with carbon materials (like graphite) in a negative electrode active material to achieve “a high capacity and a

good load characteristic.” EX1008, [0015]. In pursuit of this goal, Kusagawa discloses that “[t]he negative electrode mixture layer contains a silicon material and graphite as negative electrode active materials.” EX1008, [0016]. An embodiment disclosed by Kusagawa is described as such: “(Production of *Negative Electrode Active Material*) By chemical vacuum deposition (CVD) where *silicon oxide* having a composition of SiO (corresponding to general formula SiO_x where $x=1$) was heated in an argon atmosphere containing a hydrocarbon gas so that the hydrocarbon gas was thermally decomposed, *the surface of SiO was coated with carbon*. The amount of carbon that covered *the surface of SiO* was 10% by mass relative to the *mass of SiO*.” EX1008, [0025]-[0026]. Thus, Kusagawa also discloses negative electrode active material, wherein the negative active material contains various silicon oxides. Kusagawa also discloses an example, Example 15, using elemental silicon, or a “silicon-graphite composite” as a negative active material. EX1008, [0042]-[0043]. Specifically, Kusagawa teaches formation of a “silicon-based slurry” from “monocrystalline Si particles” which is then added to graphite and carbon pitch to produce a “silicon-graphite composite in which Si particles and graphite particles were bonded to each other with amorphous carbon.” *Id.* Kusagawa teaches incorporating this silicon-graphite composite in a battery, disclosing that such a battery was produced “in the same manner as in Example 1 except that the silicon-graphite composite ...

was used instead of SiO coated with carbon.” *Id.* at [0044]. A POSA would have thus understood that the negative active material of Kusagawa Example 15 was thus replacing the 4% SiO of Example 1 with 4% silicon-graphite composite of Example 15. Kusagawa further teaches that “[t]he amount of silicon in this composite was 20.9 % by mass.” *Id.* at [0043]. A POSA thus would further understand that the negative active material of Kusagawa Example 15 was 0.836% silicon by mass (and thus, a weight percentage of silicon-based material of 0.836%), because 20.9% of 4% is 0.836%.

401. When Tao is modified in view of Kusagawa as discussed above in Section XV.B.1.g, the silicon-based material is a composition of 0.836% Si. A POSA would have known that Si particles, which comprise the silicon-graphite composite, are an elementary substance of silicon. Thus, Tao in view of Kusagawa teaches each element of claim 3.

iii. Motivation to Combine

402. **Analogous Art:** Kusagawa and Tao are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes. Kusagawa teaches an improvement to a graphite-based negative active material layer like the one in Tao, mitigating the expansion and shrinkage of silicon by adding graphite to the active material layer.

403. **How to combine:** In combining Kusagawa's teachings with Tao, a POSA would look to Kusagawa's disclosure of the amounts of graphite to mix into the silicon layer. Those amounts achieve the balance that Kusagawa praises between the higher capacity of silicon and the improved load characteristics of carbon. A POSA would thus have combined Tao's electrochemical apparatus with Kusagawa's recited silicon concentration of 0.836% SiO.

404. **Why to combine:** A POSA would have been motivated to make this modification to Tao because Kusagawa praises its active material composition, describing that "Silicon materials, such as silicon and silicon oxide, having a higher capacity than carbon materials have recently attracted more attention as negative electrode active materials of non-aqueous electrolyte." EX1008, [0004]. Kusagawa also warns that "[h]owever, silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials." EX1008, [0005]. Thus, a POSA would have understood that both graphite and silicon have respective benefits and drawbacks, and that a careful balance between the two materials is beneficial. Kusagawa then describes that "[i]n light of the aforementioned circumstances, the present invention is directed to a non-aqueous electrolyte secondary battery in which a silicon material and graphite are used as negative electrode active materials and which has a high capacity and a good load characteristic." EX1008, [0015]. Kusagawa explains that its particular electrode

composition of 0.836% Si by mass (Example 15) performed favorably with respect to comparative examples that did not have any silicon material by mass. EX1008, [0059], Table 1. Thus, a POSA would have been motivated to use a mixture of graphite and silicon as active material components when constructing a negative electrode.

iv. Reasonable Expectation of Success

405. A POSA would have had a reasonable expectation of success in combining these references because Kusagawa teaches that “any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008, [0058]. A POSA would have understood that Kusagawa’s silicon material allows for reversible intercalation of Li ions. And a POSA would have understood that Kusagawa’s 4% Si-graphite composite / 96% graphite compositions would have been compatible with the battery described in Tao, which has embodiments of both 90% graphite and 90% silicon. EX1008, Table 1; EX1007, Example 1, Example 2.

406. A POSA would have understood that routine optimization of these components, as taught by Kusagawa, would have been advantageous for the development of a lithium ion battery, and would have done so with a reasonable expectation of success. Thus, Tao, in view of Kusagawa, renders claim 3 obvious.

b. Claim 12: [12] The electronic apparatus according to claim 10, wherein the silicon-based material contains

at least one of: an elementary substance of silicon, a compound of silicon, or an alloy of silicon.

407. This limitation in claim 12 is nearly identical to that of claim 3. *See* § XV.C.1.a. Claim 12 does not recite “a silica material” as one of the options for the silicon based material. But as discussed above in §XV.C.1.a, Tao, in view of Kusagawa, teaches a negative active material comprising a silicon-graphite composite, which contains an “elementary substance of silicon.” Thus, Guo, in view of Hu, teaches each and every element of claim 12. Thus, Tao in view of Kusagawa renders claim 12 obvious for the same reasons discussed above for claim 3.

D. Claim 7

408. Claim 7 depends on claim 1. As discussed in more detail below, Tao and Kusagawa render claim 7 obvious because a POSA would have been motivated to combine these references to arrive at the claimed invention with a reasonable expectation of success.

1. Tao and Kusagawa teach or disclose each and every element of claim 7.

409. Tao and Kusagawa teach or disclose each and every element of claim 7, as explained below.

a. [7.1] The electrochemical apparatus according to claim 1, wherein the silicon-based material further contains a material layer,

i. Kusagawa

410. Tao, in view of Kusagawa, teaches this element. Although Tao may not expressly disclose a “further” “material layer,” such a layer was known in the art, as is taught by Kusagawa. Kusagawa teaches a second layer containing amorphous carbon. Specifically, the negative active material of Kusagawa Example 15 teaches an electrode active material wherein “Si particles and graphite particles were bonded to each other with amorphous carbon.” EX1008, [0043]. A POSA would understand that this carbon coating is a material layer, as recited by this claim element.

ii. Motivation to Combine

411. **Analogous references:** As discussed above, Kusagawa and Tao are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes. Kusagawa teaches an improvement to a graphite-based negative active material layer like the one in Tao, mitigating the expansion and shrinkage of silicon by adding carbon to the active material layer, as discussed below.

412. **How to combine:** A POSA would have combined Tao’s electrochemical apparatus with Kusagawa’s recited silicon concentration of 4% Si-

graphite composite. A POSA further would have added an amorphous carbon layer to the negative silicon based material of Kusagawa.

413. **Why to combine:** In combining Kusagawa's teachings with Tao, a POSA would understand the benefit of an additional layer on top of the active material, because Kusagawa teaches that "[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples." EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional graphite layer. A POSA would further have been motivated to make this modification to Tao because Kusagawa praises its active material composition, describing that "[s]ilicon materials, such as silicon and silicon oxide, having a higher capacity than carbon materials have recently attracted more attention as negative electrode active materials of non-aqueous electrolyte." EX1008, [0004]. These carbon layers are arranged on top of the SiO material layers. Further, Kusagawa teaches an amorphous carbon layer specifically: "[t]he carbon pitch was carbonized to produce a silicon - graphite composite in which Si particles and graphite particles were bonded to each other with amorphous carbon. The amount of silicon in this composite was 20.9% by mass." EX1008, [0043] (Example 15).

414. Thus, Kusagawa provides an art-recognized improvement to electrodes such as those described in Tao. A POSA would have been motivated to

add an amorphous carbon layer, such as that taught by Kusagawa (EX1008, [0043]), on top of the silicon-containing negative active material layer taught by Tao in view of Kusagawa, to solve the art-recognized problem of low conductivity in silicon-containing active materials, as discussed below. Indeed, Kusagawa stresses the importance of such a carbon layer, describing that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Thus, a POSA would have been motivated to incorporate such a structure. Indeed, Kusagawa teaches that “In a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

415. With respect to the addition of silicon to the electrode of Tao, Kusagawa also warns that “[h]owever, silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008, [0005]. Thus, a POSA would have understood that both graphite and silicon have respective benefits and drawbacks, and that a careful balance between the two materials is beneficial. Kusagawa then describes that “[i]n light of the aforementioned circumstances, the present invention is directed to a non-aqueous

electrolyte secondary battery in which a silicon material and graphite are used as negative electrode active materials and which has a high capacity and a good load characteristic.” EX1008, [0015]. Kusagawa explains that its particular electrode composition of Si-graphite composite of 4% by mass (Example 15) performed favorably with respect to comparative examples that did not have any silicon material by mass. EX1008, [0059], Table 1. Thus, a POSA would have been motivated to use a mixture of graphite and silicon as active material components when constructing a negative electrode.

iii. Reasonable Expectation of Success

416. A POSA would have had a reasonable expectation of success in combining these references because Kusagawa teaches that “any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008, [0058]. A POSA would have understood that Kusagawa’s silicon material allows for reversible intercalation of Li ions. And a POSA would have understood that Kusagawa’s 4% Si-graphite composite / 96% graphite compositions would have been compatible with the battery described in Tao, which has embodiments of both 90% graphite and 90% silicon. EX1008, Table 1; EX1007, Example 1, Example 2. Kusagawa also teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated

with carbon as described in Examples.” EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer, meaning that Kusagawa valued the feature of the carbon layer being arranged on top of the SiO material. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Tao to form a better-performing battery.

b. [7.2] the material layer is arranged on at least a part of a surface of the silicon-based material, and

i. Kusagawa

417. Tao, in view of Kusagawa, teaches this element. Although Tao may not expressly disclose a material layer arranged on at least a part of the silicon-based material, it would have been obvious to add such a second material layer on top of the silicon-based material because such layers were known in the art, as taught by Kusagawa. Kusagawa teaches a second layer arranged on at least a part of the silicon-based surface. Specifically, Kusagawa teaches an electrode active material wherein during the “production of negative electrode active material,” that “silicon oxide” was “coated with carbon” using a hydrocarbon gas that was “thermally decomposed” so that “the surface of SiO was coated with carbon.” EX1008, [0026]. A POSA would understand that this coating is a material layer” and that when SiO is “coated” with carbon, the carbon material layer is arranged on at least a part of the surface of the silicon-based material. Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and

graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that “In a silicon-graphite composite , silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

ii. Motivation to Combine

418. **Analogous references:** As discussed above, Kusagawa and Tao are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes. Kusagawa teaches an improvement to a graphite-based negative active material layer like the one in Tao, mitigating the expansion and shrinkage of silicon by adding carbon to the active material layer.

419. **How to combine:** A POSA would have combined Tao’s electrochemical apparatus with Kusagawa’s recited silicon concentration of 4% Si-graphite composite. A POSA further would have added an amorphous carbon layer to the negative active material of Kusagawa.

420. **Why to combine:** In combining Kusagawa’s teachings with Tao, a POSA would understand the benefit of an additional layer on top of the active material, because Kusagawa teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably

coated with carbon as described in Examples.” EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer. A POSA would further have been motivated to make this modification to Tao because Kusagawa praises its active material composition, describing that “[s]ilicon materials, such as silicon and silicon oxide, having a higher capacity than carbon materials have recently attracted more attention as negative electrode active materials of non-aqueous electrolyte.” EX1008, [0004]. These carbon layers are arranged on top of the SiO material layers. Indeed, the benefits of the additional layer of carbon do not occur unless the silicon material is “coated” with carbon, as described in Kusagawa. EX1008, [0004]. As discussed above, a deposited carbon layer constitutes “amorphous carbon.”

421. Thus, Kusagawa provides an art-recognized improvement to electrodes such as those described in Tao. A POSA would have been motivated to add an amorphous carbon layer, such as that taught by Kusagawa, on top of the silicon-containing negative active material layer taught by Tao in view of Kusagawa, to solve the art-recognized problem of low conductivity in silicon-containing active materials.

422. With respect to the addition of silicon to the electrode of Tao, Kusagawa also warns that “[h]owever, silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008,

[0005]. Thus, a POSA would have understood that both graphite and silicon have respective benefits and drawbacks, and that a careful balance between the two materials is beneficial. Kusagawa then describes that “[i]n light of the aforementioned circumstances, the present invention is directed to a non-aqueous electrolyte secondary battery in which a silicon material and graphite are used as negative electrode active materials and which has a high capacity and a good load characteristic.” EX1008, [0015]. Kusagawa explains that its particular electrode composition of Si-graphite composite of 4% by mass (Example 15) performed favorably with respect to comparative examples that did not have any silicon material by mass. EX1008, [0058], Table 1. Thus, a POSA would have been motivated to use a mixture of graphite and silicon as active material components when constructing a negative electrode.

iii. Reasonable Expectation of Success

423. A POSA would have had a reasonable expectation of success in combining these references because Kusagawa teaches that “any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008, [0058]. A POSA would have understood that Kusagawa’s silicon material allows for reversible intercalation of Li ions. And a POSA would have understood that Kusagawa’s 4% Si-graphite composite / 96% graphite compositions would have

been compatible with the battery described in Tao, which has embodiments of both 90% graphite and 90% silicon. EX1008, Table 1; EX1007, Example 1, Example 2. Kusagawa also teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer, meaning that Kusagawa valued the feature of the carbon layer being arranged on top of the SiO material. And the active material of Kusagawa explicitly contains an amorphous carbon layer. EX1008, [0043]. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Tao to form a better-performing battery.

c. [7.3] the material layer contains at least one of a polymer, inorganic particles, amorphous carbon or carbon nanotubes.

i. Kusagawa

424. Tao, in view of Kusagawa, teaches this element. Although Tao may not expressly disclose an additional material layer containing at least one of a polymer, inorganic particles, amorphous carbon or carbon nanotubes, it would have been obvious to add such a material layer because such layers were known in the art, as taught by Kusagawa.

425. Kusagawa teaches a second layer containing amorphous carbon. Specifically, Kusagawa teaches an electrode active material wherein during the

“production of negative electrode active material,” that “silicon oxide” was “coated with carbon” using a hydrocarbon gas that was “thermally decomposed” so that “the surface of SiO was coated with carbon.” EX1008, [0026]. And the active material of Kusagawa explicitly contains an amorphous carbon layer. EX1008, [0043]. Indeed, Kusagawa teaches that “In a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

ii. Motivation to Combine

426. **Analogous references:** As discussed above, Kusagawa and Tao are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes. Kusagawa teaches an improvement to a graphite-based negative active material layer like the one in Tao, mitigating the expansion and shrinkage of silicon by adding carbon to the active material layer.

427. **How to combine:** A POSA would have combined Tao’s electrochemical apparatus with Kusagawa’s recited silicon concentration of 4% Si-graphite composite. A POSA further would have added an amorphous carbon layer to the negative active material of Kusagawa.

428. **Why to combine:** In combining Kusagawa's teachings with Tao, a POSA would understand the benefit of an additional layer on top of the active material, because Kusagawa teaches that "[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples." EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer. A POSA would further have been motivated to make this modification to Tao because Kusagawa praises its active material composition, describing that "[s]ilicon materials, such as silicon and silicon oxide, having a higher capacity than carbon materials have recently attracted more attention as negative electrode active materials of non-aqueous electrolyte." EX1008, [0004]. These carbon layers are arranged on top of the SiO material layers. Indeed, the benefits of the additional layer of carbon do not occur unless the silicon material is "coated" with carbon, as described in Kusagawa. EX1008, [0004]. And the active material of Kusagawa explicitly contains an amorphous carbon layer. EX1008, [0043]. Indeed, Kusagawa teaches that "In a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]" EX1008, [0070]. Thus, a POSA would have recognized that this "preferable" material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

429. Thus, Kusagawa provides an art-recognized improvement to electrodes such as those described in Tao. A POSA would have been motivated to add an amorphous carbon layer, such as that taught by Kusagawa, on top of the silicon-containing negative active material layer taught by Tao in view of Kusagawa, to solve the art-recognized problem of low conductivity in silicon-containing active materials.

430. With respect to the addition of silicon to the electrode of Tao, Kusagawa also warns that “[h]owever, silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008, [0005]. Thus, a POSA would have understood that both graphite and silicon have respective benefits and drawbacks, and that a careful balance between the two materials is beneficial. Kusagawa then describes that “[i]n light of the aforementioned circumstances, the present invention is directed to a non-aqueous electrolyte secondary battery in which a silicon material and graphite are used as negative electrode active materials and which has a high capacity and a good load characteristic.” EX1008, [0015]. Kusagawa explains that its particular electrode composition of Si-graphite composite of 4% by mass (Example 15) performed favorably with respect to comparative examples that did not have any silicon material by mass. EX1008, [0059], Table 1. Thus, a POSA would have been

motivated to use a mixture of graphite and silicon as active material components when constructing a negative electrode.

iii. Reasonable Expectation of Success

431. A POSA would have had a reasonable expectation of success in combining these references because Kusagawa teaches that “any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008, [0058]. A POSA would have understood that Kusagawa’s silicon material allows for reversible intercalation of Li ions. And a POSA would have understood that Kusagawa’s 4% Si-graphite composite / 96% graphite compositions would have been compatible with the battery described in Tao, which has embodiments of both 90% graphite and 90% silicon. EX1008, Table 1; EX1007, Example 1, Example 2. Kusagawa also teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer, meaning that Kusagawa valued the feature of the carbon layer being arranged on top of the SiO material. And the active material of Kusagawa explicitly contains an amorphous carbon layer. EX1008, [0043]. Indeed, Kusagawa teaches that “In a silicon-graphite composite , silicon particles and graphite particles are preferably bonded to each other with

amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Tao to form a better-performing battery.

E. Claim 9

432. Claim 9 depends on claim 1. As discussed in more detail below, Tao in view of Kusagawa render claim 9 obvious because a POSA would have been motivated to combine these two references to arrive at the claimed invention of claim 9 with a reasonable expectation of success.

1. Tao and Kusagawa teach or disclose each and every element of claim 9.

433. Tao and Kusagawa teach or disclose each element of claim 1, from which claim 9 depends, as discussed above in § XV.B.1.a-o. Tao further discloses the additional limitations of claim 9. Thus, Tao in view of Kusagawa renders claim 9 obvious.

a. [9.1] The electrochemical apparatus according to claim 1, wherein the negative electrode is provided with a groove, and

434. Tao describes that its electrochemical apparatus contains a “recess” and that the negative tab (or lead) is positioned in the “recess.” EX1007, [0009]. A

POSA would understand that a “recess” is the same as a “groove” and that the negative lead is the same as a negative tab.

b. [9.2] the negative tab is arranged in the groove.

435. Tao describes that “[a]ccording to one aspect of the present invention, the positive lead is entirely seated in the first recess and the *negative lead is entirely seated in the second recess*. Due to the arrangement of the first recess on the positive plate and the second recess on the negative plate, the positive lead and the negative lead can be received in the first recess and the second recess respectively.” EX1007, [0009]. A POSA would understand that the negative tab is the same as a negative lead.

436. Tao in view of Kusagawa disclose each and every element of claim 9. And as discussed above, a POSA would have been motivated to combine these references as described above with a reasonable expectation of success. Thus, Tao in view of Kusagawa render claim 9 obvious.

XVI. GROUND 2B: CLAIMS 2 AND 11 WOULD HAVE BEEN OBVIOUS IN VIEW OF TAO AND KUSAGAWA, FURTHER IN VIEW OF KAKINUMA.

A. Analogous Art

437. Kakinuma, Kusagawa, and Tao are analogous art because each of these references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes. As discussed below, a POSA would have been motivated to combine these references to address an art-

recognized shortcoming of thick, non-uniform tabs compared to active material layers. EX1007, [0005], [0009].

438. A battery comprising a negative electrode satisfying relationship formula (II) as recited in claim 2 and 11 was known in the art, as taught by Kakinuma, as discussed below. Further, a POSA would have been motivated to combine the teachings of Kakinuma with the electrochemical apparatus of Tao, modified in view of Kusagawa, with a reasonable expectation of success, to arrive at the claimed invention of claims 2 and 11. Thus, Tao, in view of Kusagawa and Kakinuma, render claims 2 and 11 obvious.

B. Tao, Kusagawa, and Kakinuma teach or disclose each and every element of claims 2 and 11.

439. As discussed above, Tao and Kusagawa teach or disclose each element of claims 1 and 10. Claims 2 and 11, which depend on claims 1 and 10, respectively, recite a relationship between the negative current collector, negative tab (or electrode) and the negative active material, denoted in the claims as S_1 , S_2 , and S_3 , respectively. Although Tao and Kusagawa may not expressly discuss such the relationship as presented in formula (II), a battery with relevant components satisfying that relationship was taught in the art, as described by Kakinuma. Thus, Tao, in view of Kusagawa and Kakinuma, disclose each and every element of claims 2 and 11.

1. **[2.1.1] The electrochemical apparatus according to claim 1, wherein the negative electrode satisfies the following relationship formula (II): $0.9 \times (S_1 + 2 S_3) \leq S_1 + S_2 \leq 1.1 \times (S_1 + 2 S_3)$ formula (II)**

440. A POSA would have been motivated to further modify the current collector thickness, tab thickness, and active material thickness of Tao-Kusagawa further in view of Kakinuma, all of which are addressed separately below. In modifying Tao-Kusagawa in view of Kakinuma, a POSA would have satisfied the relationship formula (II) of claim element 2.1.1.

441. Specifically, as discussed in more detail below in Sections XVI.B.4-XVI.B.6, Kakinuma teaches S_1 , S_2 , and S_3 values of 20 μm , 120 μm , and 65 μm , respectively. These values result in the recited relationship formula (II), i.e., $0.9 \times (S_1 + 2S_3) \leq S_1 + S_2 \leq 1.1 \times (S_1 + 2S_3)$, being met because $0.9 \times (20 + 2 (65)) \leq 20 + 120 \leq 1.1 \times (20 + 2 (65)) = 135 \leq 140 \leq 165$. Thus, Kakinuma discloses this claim limitation.

2. Motivation to Combine

442. **How to combine:** A POSA would have taken the tab thickness, active material thickness, and current collector thickness of Tao and modified them to be 120 μm , 65 μm , and 20 μm , respectively.

443. **Why to combine:** A POSA would have added the teachings of Kakinuma to the electrochemical apparatus of Tao, modified in view of Kusagawa, because Kakinuma teaches: “[T]here are lithium-ion batteries that use metal-resin

laminated sheets instead of battery cases. In this case, by encapsulating ***battery components such as positive and negative electrodes***, separators, and electrolytes within such thin sheets, ***weight reduction can be achieved along with increased energy density***.” EX1010, ¶3; *see also* EX1010, ¶57. A POSA would thus understand that by incorporating Kakinuma’s teachings, one arrives at a smaller, more energy-dense battery. As Kakinuma teaches, following its disclosure yields a “small cylindrical battery that achieves both improved battery characteristics and enhanced long-term reliability and safety.” EX1010, [0015]. Indeed, Kakinuma independently praises its electrode assembly, disclosing that “[w]ith such an electrode assembly 5, the reaction area is increased, which can achieve strong load characteristics.” EX1010, [0051]. Kakinuma further states that its components, such as the negative electrode plate (i.e., negative electrode including active material), “increase battery capacity.” EX1010, [0052]. A POSA thus would have been motivated to incorporate the electrode component thicknesses disclosed in Kakinuma to the electrochemical apparatus of Tao-Kusagawa.

444. Kakinuma also specifically describes the negative lead (tab) thickness as “preferably” 120 μm or less, EX1010, [0053]. Similarly, Kakinuma describes its current collector thickness as “more preferably” 20 μm or less, EX1010, [0057]. And by using this thickness, Kakinuma teaches that “[a]ccording to the negative electrode core material with such a thickness, the strength of the negative electrode

plate 2 can be maintained, while the negative electrode plate 2 can be made lighter.” EX1010, [0057].

445. Through routine optimization of these variables within the prescribed ranges of Kakinuma, a POSA would have arrived at a suitable set of negative electrode thickness values. A POSA would have been motivated to engage in such routine optimization because Kakinuma teaches that such battery component dimensions have superior properties, including strength, weight, and energy density. EX1010, [0003], [0010].

446. Tao-Kusagawa also suggests the importance of battery smoothness in its disclosure, teaching that “the thickness of the positive lead (negative lead) is less than the thickness of the positive plate (negative plate). Therefore, the lead will not induce thickness increase of the positive lead or the negative lead.” EX1007, [0009]. Thus, a POSA would have been motivated to make such changes to the components of Tao-Kusagawa according to Kakinuma.

3. Reasonable Expectation of Success

447. A POSA would have had a reasonable expectation of success in combining the electrode dimensions of Kakinuma with the electrochemical apparatus taught by Tao and Kusagawa because both Kakinuma and Tao-Kusagawa are directed to wound batteries, and Tao teaches that “[a]t present, lithium ion batteries are required to be thinner and thinner as well as have higher

and higher energy density, which demands a lithium ion battery has as much energy as possible in a volume as small as possible.” EX1007, [0003], *see also* EX1007, [0007] (“One object of the present invention is to provide a lithium ion battery which has high energy density and desirable safety performance.”). And Kakinuma teaches that “[a]ccording to the negative electrode core material with such a thickness, the strength of the negative electrode plate 2 can be maintained, while the negative electrode plate 2 can be made lighter.” EX1010, [0057]. A POSA would expect such characteristics to be present in an electrode combining Kakinuma, Kusagawa and Tao, providing a reasonable expectation of success in the art combination.

448. Further, Tao-Kusagawa’s electrode thickness is similar in structure to that of Kakinuma. In addition to the wound structures present in both electrodes, Tao-Kusagawa’s electrode thickness of 115 μm is close to that of Kakinuma’s thickness of 150 μm . Similarly, Tao-Kusagawa and Kakinuma both teach a current collector thickness of 20 μm . The differences between Tao-Kusagawa and Kakinuma’s tab thickness (80 μm and 120 μm , respectively) and active material thickness (115 and 65 μm , respectively) are also similar. Thus, such a modification would only represent a modification in degree, rather than in kind, and would not have been unpredictable.

4. [2.1.2] wherein S₁ is a thickness of the negative current collector,

a. Kakinuma

449. Although Tao-Kusagawa may not expressly satisfy this element, a POSA would have been motivated to further modify the current collector thickness, tab thickness, and active material thickness of Tao-Kusagawa further in view of Kakinuma.

450. Kakinuma teaches that the battery according to its invention provides for improved battery thickness characteristics. EX1010, [0015], [0012]. Specifically, Kakinuma teaches that: “The thickness of the negative electrode lead 6 is preferably 10 μm or more and 120 μm or less, more preferably 20 μm or more and 80 μm or less,” EX1010, [0053]; “[t]he thickness of the negative electrode core material is not particularly limited, but it is preferably 1 μm or more and 500 μm or less, more preferably 5 μm or more and 20 μm or less,” EX1010, [0057]; and “[t]hen, by cutting the negative electrode plate into pieces with a width of 29.5 mm and a length of 37.0 mm, to fabricate a negative electrode plate 2 with a thickness of 0.15 mm, a width of 29.5 mm, and a length of 37.0 mm,” EX1010, [0094]. A POSA would understand that “negative electrode core material” in Kakinuma refers to a negative current collector, as recited in claims 2 and 11.

451. With respect to the current collector thickness, Kakinuma teaches that “[t]he thickness of the negative electrode core material is not particularly limited,

but it is preferably 1 μm or more and 500 μm or less, more preferably 5 μm or more and 20 μm or less.” EX1010, [0057]. Kakinuma teaches that following this instruction results in “the strength of the negative electrode plate 2 can be maintained, while the negative electrode plate 2 can be made lighter.” EX1010, [0057]. Thus, Kakinuma discloses a current collector thickness (S_1) of 20 μm .

5. [2.1.3] S_2 is a thickness of the negative tab,

a. Kakinuma

452. Although Tao-Kusagawa may not expressly teach this element, a POSA would have been motivated to further modify the current collector thickness, tab thickness, and active material thickness of Tao-Kusagawa further in view of Kakinuma.

453. Kakinuma teaches that the battery according to its invention provides for improved battery thickness characteristics. EX1010, [0015], [0012]. Specifically, Kakinuma teaches that: “[t]he thickness of the negative electrode lead 6 is preferably 10 μm or more and 120 μm or less, more preferably 20 μm or more and 80 μm or less,” EX1010, [0053]; “[t]he thickness of the negative electrode core material is not particularly limited, but it is preferably 1 μm or more and 500 μm or less, more preferably 5 μm or more and 20 μm or less,” EX1010, [0057]; and “[t]hen, by cutting the negative electrode plate into pieces with a width of 29.5 mm and a length of 37.0 mm, to fabricate a negative electrode plate 2 with a thickness of 0.15 mm, a width of 29.5 mm, and a length of 37.0 mm,” EX1010,

[0094]. A POSA would understand that “negative electrode core material” in Kakinuma refers to a negative current collector, as recited in claims 2 and 11.

454. With respect to the negative tab (lead) thickness, Kakinuma teaches that “[t]he negative electrode lead 6 has the characteristic of bending with small pressure, and its shape is not particularly limited, which may be, for example, a rectangular shape with a welding allowance to the negative electrode core material and a welding allowance to the battery case 1” EX1010, [0053]. Notably, Kakinuma teaches that “the thickness of the negative electrode lead 6 is preferably 10 μm or more and 120 μm or less, more preferably 20 μm or more and 80 μm or less.” EX1010, [0053]. As such, Kakinuma teaches the negative tab thickness (S_2) of 120 μm .

6. [2.1.4] and S_3 is a thickness of the negative active material layer, and

a. Kakinuma

455. Although Tao-Kusagawa may not expressly teach this element, a POSA would have been motivated to further modify the current collector thickness, tab thickness, and active material thickness of Tao-Kusagawa further in view of Kakinuma.

456. Kakinuma teaches that the battery according to its invention provides for improved battery thickness characteristics. EX1010, [0015], [0012]. Specifically, Kakinuma teaches that: “[t]he thickness of the negative electrode lead

6 is preferably 10 μm or more and 120 μm or less, more preferably 20 μm or more and 80 μm or less,” EX1010, [0053]; “[t]he thickness of the negative electrode core material is not particularly limited, but it is preferably 1 μm or more and 500 μm or less, more preferably 5 μm or more and 20 μm or less,” EX1010, [0057]; and “[t]hen, by cutting the negative electrode plate into pieces with a width of 29.5 mm and a length of 37.0 mm, to fabricate a negative electrode plate 2 with a thickness of 0.15 mm, a width of 29.5 mm, and a length of 37.0 mm,” EX1010, [0094]. A POSA would understand that “negative electrode core material” in Kakinuma refers to a negative current collector, as recited in claims 2 and 11.

457. With respect to the negative tab (lead) thickness, Kakinuma teaches that “[t]he negative electrode lead 6 has the characteristic of bending with small pressure, and its shape is not particularly limited, which may be, for example, a rectangular shape with a welding allowance to the negative electrode core material and a welding allowance to the battery case 1” EX1010, [0053]. Notably, Kakinuma teaches that “the thickness of the negative electrode lead 6 is preferably 10 μm or more and 120 μm or less, more preferably 20 μm or more and 80 μm or less.” EX1010, [0053].

458. Reading these passages together, a POSA would appreciate the importance of negative tab and current collector thickness for battery performance, particularly because Kakinuma is directed to the production of batteries of suitable

thickness. *See* EX1010, [0003] (“Reducing the thickness of the battery case is particularly effective for increasing the internal volume of small batteries. As another example, there are lithium-ion batteries that use metal-resin laminated sheets instead of battery cases. In this case, by encapsulating battery components such as positive and negative electrodes, separators, and electrolytes within such thin sheets, weight reduction can be achieved along with increased energy density.”). Thus, a POSA would realize that the thickness of battery components, including tab, active material, and current collector, are result-effective variables for battery weight and energy density.

459. Kakinuma’s total electrode plate thickness is 150 μm . EX1010, [0094]. Thus, the active material can be determined by subtracting the current collector thickness from the total electrode thickness and dividing it by two (because active material is on both sides of the current collector). A POSA would have been motivated to optimize the thickness of the negative current collector, negative tab, and negative active material from the teachings of Kakinuma, particularly within the ranges provided by Kakinuma. Selecting the value of 20 μm from the “most preferred” current collector thickness results in an active material thickness of 65 (because $(150 - 20) / 2 = 65$). Selecting a negative lead thickness value of 120 μm from the “preferred” value disclosed by Kakinuma results in the disclosed value of an active material thickness of 65 μm .

7. [2.2] wherein the thickness S_1 of the negative current collector is 4 μm to 30 μm .

a. Kakinuma

460. Although Tao-Kusagawa may not expressly teach this element, a POSA would have been motivated to further modify the current collector thickness, tab thickness, and active material thickness of Tao-Kusagawa further in view of Kakinuma.

461. As discussed above, the thickness of these three elements must be considered in conjunction, rather than in a vacuum. Kakinuma teaches that the battery according to its invention provides for improved battery thickness characteristics. EX1010, [0015], [0012]. Specifically, Kakinuma teaches that: “[t]he thickness of the negative electrode lead 6 is preferably 10 μm or more and 120 μm or less, more preferably 20 μm or more and 80 μm or less,” EX1010, [0053]; “[t]he thickness of the negative electrode core material is not particularly limited, but it is preferably 1 μm or more and 500 μm or less, more preferably 5 μm or more and 20 μm or less,” EX1010, [0057]; and “[t]hen, by cutting the negative electrode plate into pieces with a width of 29.5 mm and a length of 37.0 mm, to fabricate a negative electrode plate 2 with a thickness of 0.15 mm, a width of 29.5 mm, and a length of 37.0 mm,” EX1010, [0094]. A POSA would understand that “negative electrode core material” in Kakinuma refers to a negative current collector, as recited in claims 2 and 11.

462. With respect to the current collector thickness, Kakinuma teaches that “[t]he thickness of the negative electrode core material is not particularly limited, but it is preferably 1 μm or more and 500 μm or less, more preferably 5 μm or more and 20 μm or less.” EX1010, [0057]. Kakinuma teaches that following this instruction results in “the strength of the negative electrode plate 2 can be maintained, while the negative electrode plate 2 can be made lighter.” EX1010, [0057].

463. Reading these passages together, a POSA would appreciate the importance of negative tab and current collector thickness for battery performance, particularly because Kakinuma is directed to the production of batteries of suitable thickness. *See* EX1010, [0003] (“***Reducing the thickness of the battery case*** is particularly effective for increasing the internal volume of small batteries. As another example, there are lithium-ion batteries that use metal-resin laminated sheets instead of battery cases. In this case, by encapsulating ***battery components such as positive and negative electrodes***, separators, and electrolytes within such thin sheets, ***weight reduction can be achieved along with increased energy density.***”). Thus, a POSA would realize that the thickness of battery components, including tab, active material, and current collector, are result-effective variables for battery weight and energy density.

464. Kakinuma's total electrode plate thickness is 150 μm . EX1010, [0094]. Thus, the active material can be determined by subtracting the current collector thickness from the total electrode thickness and dividing it by two (because active material is on both sides of the current collector). A POSA would have been motivated to optimize the thickness of the negative current collector, negative tab, and negative active material from the teachings of Kakinuma, particularly within the ranges provided by Kakinuma. Selecting the value of 20 μm from the "most preferred" current collector thickness results in an active material thickness of 65 (because $(150 - 20) / 2 = 65$). The value of 20 μm falls within the 4 μm to 30 μm range, satisfying this claim element. Thus, Tao, in view of Kusagawa and Kakinuma, discloses this claim element.

465. The modification discussed above for claim elements [2.1.1], [2.1.2], and [2.1.3] thus results in meeting claim limitation [2.2]. And the motivation to combine and reasonable expectation of success that a POSA would have had are the same for claim element [2.2] as discussed above for claim element [2.1.1]. *See* Section XVI.B.1.

8. [11.1.1] The electronic apparatus according to claim 10, wherein the negative electrode satisfies the following relationship formula (II): $0.9 \times (S_1 + 2 S_3) \leq S_1 + S_2 \leq 1.1 \times (S_1 + 2 S_3)$ formula (II)

466. This additional limitation of claim 11 is identical to claim limitation [2.1.1]. *See* § XVI.B.1.

9. [11.1.2] wherein S_1 is a thickness of the negative current collector,

467. This additional limitation of claim 11 is identical to claim limitation [2.1.2]. *See* § XVI.B.4.

10. [11.1.3] S_2 is a thickness of the negative tab, and

468. This additional limitation of claim 11 is identical to claim limitation [2.1.3]. *See* § XVI.B.5.

11. [11.1.4] S_3 is a thickness of the negative active material layer, and

469. This additional limitation of claim 11 is identical to claim limitation [2.1.4]. *See* § XVI.B.6.

12. [11.2] wherein the thickness S_1 of the negative current collector is 4 μm to 30 μm .

470. This limitation of claim 11 is identical to limitation [2.2]. *See* § XVI.B.7.

471. Similar to claim 2 (and for the same reasons), because Tao, Kusagawa, and Kakinuma teach or disclose each and every element of claim 11, and because a POSA would have been motivated to modify Tao with the analogous art of Kusagawa and Kakinuma to arrive at the claimed invention with a reasonable expectation of success, Tao and Kusagawa render claim 11 obvious. *See* § XVI.A, XVI.B.2-3.

**XVII.GROUND 2C: CLAIMS 4 AND 13 WOULD HAVE BEEN OBVIOUS
IN VIEW OF TAO AND KUSAGAWA, FURTHER IN VIEW OF
GUO.**

472. Although Tao and Kusagawa may not expressly teach the elements of claims 4 and 13, such elements were known in the art, as was taught by Guo, and explained in more detail below. Further, a POSA would have been motivated to combine the teachings of Guo with the electrochemical apparatus of Tao, modified in view of Kusagawa, with a reasonable expectation of success, to arrive at the claimed invention of claims 4 and 13. Thus, Tao, in view of Kusagawa and Guo, render claims 4 and 13 obvious.

**A. Tao, Kusagawa, and Guo teach or disclose each and every element
of claims 4 and 13.**

473. As discussed above, Tao and Kusagawa teach or disclose each element of claims 1 and 10. Claims 4 and 13, which depend on claims 1 and 10 respectively, recite a relationship between the negative electrode tab placement and the length of the negative active material layer on both sides of the tab. Although Tao and Kusagawa are silent on this limitation, the limitation was known in the art, as taught by Guo. Thus, Tao, in view of Kusagawa and Guo, teach or disclose each and every element of claims 4 and 13.

1. **[4] The electrochemical apparatus according to claim 1, wherein a ratio of the second length to a length of the long axis of the negative current collector is 0.8 to 1.0.**

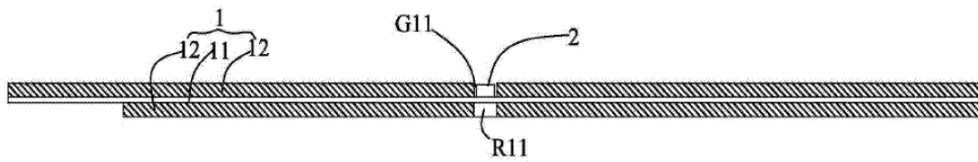
a. Guo

474. Although Tao-Kusagawa may not expressly teach element, a POSA would have been motivated to further modify the location of the negative electrode of Tao-Kusagawa further in view of Guo.

475. Figure 3a of Guo discloses an anode sheet formed with “an anode matching recess R11 located on the opposite back side of the anode tab accommodating groove G11, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12.” EX1011, [0066]. Anode current collector 11 is the claimed “negative current collector.” Anode membrane 12 is the claimed “negative active material layer.”

476. As seen in Figure 3a, the length of the negative current collector matches the length of the negative active material layer (i.e. the second length) along a long axis (i.e. the x-axis) in Figure 3a, which results in “a ratio of the second length to a length of the long axis of the negative current collector” of 1.0.

477. Guo thus teaches “[t]he electrochemical apparatus according to claim 1, wherein a ratio of the second length to a length of the long axis of the negative current collector is 0.8 to 1.0.” A figure illustrating this point is shown below.



EX1011, FIG. 3a.

478. In this figure, the labels are defined as such: anode sheet (1); anode membrane (12); anode current collector (11); anode tab accommodating groove (G11); anode tab (2); anode matching recess (R11). As can be clearly seen from this figure, the anode current collector 11 and the anode active material 12 overlap, meaning that they are the same length.

479. Guo further describes that “[i]n one embodiment of the secondary battery cell according to the present utility model, referring to FIG. 1, FIG. 3, and FIG. 4, the anode sheet 1 may further be formed with: an anode matching recess R11 located on the opposite back side of the anode tab accommodating groove G11, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12. The provision of the anode matching recess R11 facilitates the ultrasonic welding of the anode tab 2 within the anode tab accommodating groove G11.” EX1011, [0066]. As such, a POSA would understand that this electrode setup meets the claim limitation recited in claim 4, because the length of the negative active material is the same as the underlying current collector, yielding a ratio of the second length to a length of the long axis of the negative current collector of 1.0.

b. Motivation to Combine

480. **Analogous Art:** Guo, Kusagawa, and Tao are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes.

481. **How to Modify:** A POSA would have modified the length of the negative current collector as disclosed in Tao, in view of Kusagawa, to match the length of the negative active material layer (i.e. the second length) along a long axis (i.e. the x-axis) in Figure 3a, which results in “a ratio of the second length to a length of the long axis of the negative current collector” of 1.0.

482. **Why Modify:** A POSA starting with the battery of Tao-Kusagawa would have had a similar goal, and it would have been routine optimization to take advantage of Guo’s teaching in relation to that goal. *See* EX1021, FIG. 4.² To

² Guo’s active material layer configuration, wherein a ratio of the second length to a length of the long axis of the negative current collector is 1.0, was well-known in the art. EX1021, [0035], discloses a “paste” which is formed when “an active material is thoroughly mixed with a conductive agent and a binder in a predetermined ratio,” wherein the paste “is coated onto a current collector by roll coating, blade coating, spray coating, or the like.” A POSA would recognize this “paste” as an active material layer, and EX1021, Figure 4 illustrates this active

further this goal, a POSA would have been motivated to use the negative electrode of Guo in the battery of Tao-Kusagawa to maximize the coverage of the amount of negative active material per unit volume within the negative electrode, as such an optimization will reduce the total weight of nonactive materials in the lithium ion batteries, improving energy density. *See* EX1021, FIG. 8.³

483. Thus, a POSA would have had reason to set the length of at least one negative active material layer equal to that of the negative current collector, as shown in Figure 3a in Guo (see above), resulting in a ratio of 1.0.

484. **Reasonable Expectation of Success:** A POSA would have expected the combination to work as intended because Guo explicitly discloses a configuration in which the ratio is equal to 1.0, and the negative electrode configuration as illustrated in Figures 3a and 3b is used to produce a "secondary

material layer ("paste 42") disposed along the entire length of a "negative electrode plate."

³ EX1021, Figure 8 illustrates "negative electrode plate ... after tab formation" (EX1021, [0029]) wherein the entire negative electrode plate is coated with an active material layer, aside from tabs 81. A POSA would recognize this configuration as maximizing the amount of negative active material per unit volume within the negative electrode.

battery cell" with improved energy density. EX1011, [0010], [0007]. A POSA thus would have understood this configuration to maximize negative material volume and thus energy density of a given electrode.

2. **[13] The electronic apparatus according to claim 10, wherein a ratio of the second length to a length of the long axis of the negative current collector is 0.8 to 1.0.**

485. This additional limitation is identical to that of claim 4. *See* § XVII.A.1.

XVIII. GROUND 2D: CLAIMS 5 AND 14 WOULD HAVE BEEN OBVIOUS OF TAO AND KUSAGAWA, FURTHER IN VIEW OF WANG.

486. Although Tao and Kusagawa may not expressly teach the elements of claims 5 and 14, such elements were known in the art, as was taught by Wang and explained in more detail below. Further, a POSA would have been motivated to combine the teachings of Wang with the electrochemical apparatus of Tao, modified in view of Kusagawa, with a reasonable expectation of success, to arrive at the claimed invention of claims 2 and 11. Thus, Wang, in view of Kusagawa and Guo, render claims 5 and 14 obvious.

- A. Tao, Kusagawa, and Wang teach or disclose each and every element of claims 5 and 14.**

487. As discussed above, Tao and Kusagawa teach or disclose each element of claims 1 and 10. Claims 5 and 14, which depend on claims 1 and 10, respectively, recite a minimum number of three layers between the center of a

wound electrochemical apparatus and the negative tab. Although Tao and Kusagawa are silent on this limitation, such a limitation was known in the art, as taught by Wang. Thus, Tao, in view of Kusagawa and Wang, teach or disclose each and every element of claims 4 and 13.

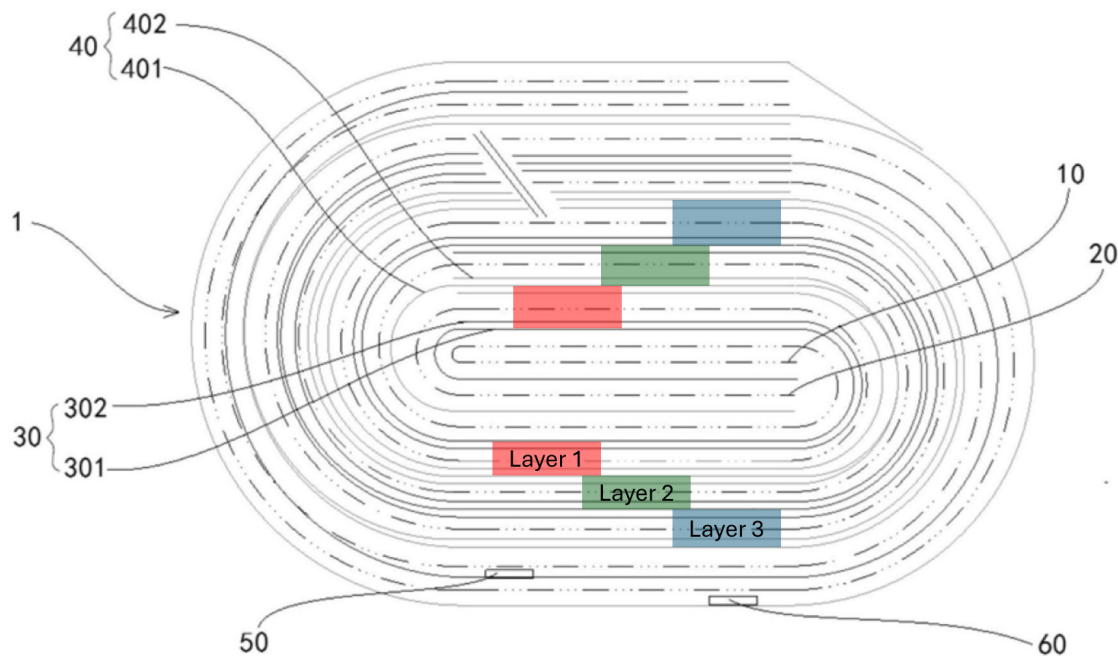
1. **[5] The electrochemical apparatus according to claim 1, wherein the electrochemical apparatus is of a winding structure, and the negative tab is arranged at a position beyond three layers from a center of the winding structure.**

a. Wang

488. Tao-Kusagawa describes a wound electrochemical apparatus, but is silent on the number of layers between the center of the winding structure and the negative tab.

489. Tao-Kusagawa may not expressly teach the limitation wherein the negative tab is arranged at a position beyond three layers from a center of the winding structure. However, a POSA would have then looked to Wang to determine the number of layers between the center of the structure and the negative tab.

490. Wang teaches the following structure:



EX1012, FIG. 4 (annotated).

As can be seen from this figure, the negative tab 60 is positioned at least four layers from the center of the wound battery (considering each layer containing one cathode, one anode and one separator). Thus, Wang discloses this claim limitation, and Tao, in view of Kusagawa and Wang, discloses each and every limitation of claim 5.

b. Motivation to Combine

491. **Analogous Art:** Wang, Kusagawa, and Tao are analogous art because all three references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes.

492. **How to Combine:** A POSA would have used at least four layers between the center of the battery and the negative tab, as taught by Wang, in designing the battery of Tao, in view of Kusagawa.

493. **Why Combine:** A POSA would have been motivated to incorporate this design element because Wang teaches that “the wound cell of the present application can save usage amount of the separator, improve energy density, as well as reduce cost.” EX1012, [0020]. Wang also teaches that “the electrode tab is arranged at the outer side of the cell, which increases the symmetry of the internal structure of the cell, and reduces the risk of cell deformation.” EX1012, [0053]. A POSA would have been motivated to position electrodes at least 3 layers away from the center of the wound battery to increase the symmetry of the cell, reducing risk of deformation.

494. **Reasonable Expectation of Success:** A POSA would have had a reasonable expectation of success in creating a battery as taught by Tao, Kusagawa, and Wang, because the primary reference Tao teaches a wound battery just as that taught by Wang. And Wang specifically praises its wound battery configuration, making it one of a finite set of options that would have been obvious to try when making a battery of the type taught in Tao and Kusagawa. A POSA would have understood that the wound battery of Tao-Kusagawa would have been

compatible with Wang's design choice because the disclosures are directed to the same type of wound, nonaqueous electrolyte batteries with graphite electrodes.

2. **[14] The electronic apparatus according to claim 10, wherein the electrochemical apparatus is of a winding structure, and the negative tab is arranged at a position beyond three layers from a center of the winding structure.**

495. The additional limitation present in claim 14 is identical to that of claim 4. *See* § XVIII.A.1.

XIX. GROUND 3: CLAIMS 1, 7, AND 10 WOULD HAVE BEEN OBVIOUS IN VIEW OF GUO AND KUSAGAWA.

A. Analogous art

496. Guo and Kusagawa are analogous art to the claims and each other because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes. Kusagawa teaches an improvement to a negative active material layer and teaches that coating such an active material with carbon improves battery performance.

497. As described in more detail below, claims 1, 7, and 10 would have been obvious in view of Guo and Kusagawa before the effective filing date of the '686 patent. Specifically, a POSA would have started with the electrochemical apparatus of Guo and modified it in view of Kusagawa, knowing that Guo does not teach all relevant details as it relates to certain components or aspects of the battery. Thus, A POSA would have readily looked to the analogous art of Kusagawa to fill in gaps or modify Guo's electrochemical apparatus, particularly

when doing so would improve the performance of Guo's battery. And in doing so, a POSA would have arrived at the claimed invention with a reasonable expectation of success. Thus, claims 1, 7, and 10 would have been obvious in view of Guo and Kusagawa.

B. Claims 1 and 10

498. As discussed in more detail below, the combination of Guo and Kusagawa render claims 1 and 10 obvious.

1. Guo and Kusagawa teach or disclose each and every element of claims 1 and 10.

499. As discussed in more detail below, Guo and Kusagawa disclose each and every element of claims 1 and 10.

a. Claim 1: [1.P] An electrochemical apparatus, comprising:

500. Guo discloses element [1.P]. Guo teaches that its disclosure is directed towards “*electrochemical energy storage devices*, and more particularly to a secondary battery cell.” EX1011, [0001].

b. [1.1] a positive electrode;

501. Guo discloses element [1.1]: Guo teaches “a secondary battery cell, comprising an anode sheet, an anode tab, *a cathode sheet*, a cathode tab, and a separator.” EX1011, [0005]. This cathode sheet comprises a “cathode current collector and a cathode membrane disposed on the surface of the cathode current collector” (EX1011, [0005]), all of which a POSA would realize are the elements

of a positive electrode. Thus, a POSA would understand that this cathode sheet is a “positive electrode.”

c. [1.2] a separator; and

502. Guo discloses element [1.2]. Guo teaches “a secondary battery cell, comprising an anode sheet, an anode tab, a cathode sheet, a cathode tab, and a *separator*.” EX1011, [0005]. Guo teaches that “[t]he separator is placed between the anode sheet and the cathode sheet.” EX1011, [0005]. Thus, this separator is the separator disclosed in claim element [1.2].

d. [1.3] a negative electrode;

503. Guo discloses element [1.3]: “a secondary battery cell, comprising an *anode sheet, an anode tab*, a cathode sheet, a cathode tab, and a separator.” EX1011, [0005]. Guo also teaches that “[t]he anode sheet comprises an anode current collector and an anode membrane disposed on the surface of the anode current collector,” all of which are elements a POSA would recognize as composing a negative electrode. EX1011, [0005].

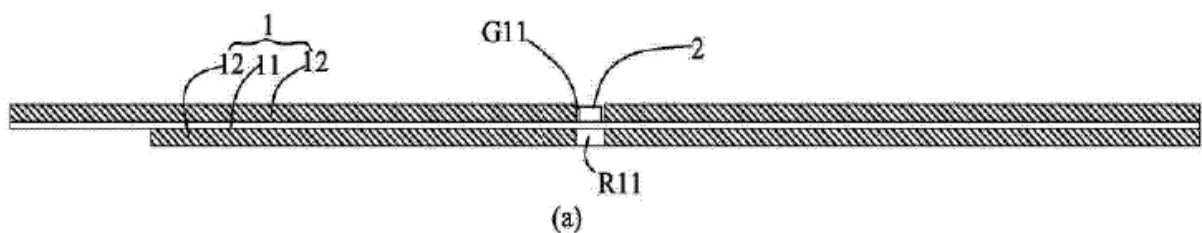
e. [1.4] wherein the negative electrode comprises a negative current collector;

504. Guo discloses element [1.4]. Specifically, Guo discloses a negative electrode which comprises “an *anode current collector*.” EX1011, [0005]. Additionally, Guo states that “the anode sheet is formed with an anode tab accommodating groove, the bottom of which is an *anode current collector* and the

peripheral side of which is an anode membrane, and the anode tab is accommodated within the anode tab accommodating groove and is electrically connected to the anode current collector at the anode tab accommodating groove.” EX1011, [0005]. A POSA would interpret this description as disclosing a negative electrode comprising a negative current collector.

f. [1.5.1] a negative active material layer,

505. Guo discloses element [1.5.1]. Specifically, Guo discloses a negative electrode comprising a negative current collector and an “anode membrane disposed on the surface of” the negative current collector. EX1011, [0005]. A POSA would recognize the arrangement of elements within Guo Figure 3a as teaching a negative electrode comprising a negative current collector with a negative active material layer disposed on the negative current collector. Thus, Guo’s anode membrane is the claimed “negative active material layer.”



506. A POSA would understand that this arrangement discloses a negative active layer, (12), above.

507. Beyond the arrangement of components comprising the negative electrode, a POSA would further look towards Guo’s description forming the

electrochemical apparatus to understand the anode membrane. Guo (in [0057] and [0069]) describes forming an anode membrane by “applying and drying the anode membrane slurry.” EX1011, [0057]. A POSA would recognize this language as a description of a common method for forming a negative active material layer. EX1018, Abstract, 1.

508. Finally, Guo stating that the cathode membrane contains “active lithium” would provide a POSA with further confidence that the anode membrane is the claimed “negative active material layer.” EX1011, [0003]. A POSA would understand this statement to indicate that Guo’s cathode membrane is equivalent to a “positive active material layer” as claimed by the ‘686 patent, and through parallel language, Guo’s anode membrane is therefore equivalent to the claimed “negative active material layer.” Thus, Guo discloses claim element [1.5.1].

g. [1.5.2] wherein the negative active material layer contains a silicon-based material; and

509. Guo in view of Kusagawa teaches this claim element.

i. Guo

510. As discussed above, Guo discloses a negative active material layer. *See* claim element [1.5.1]. Guo is silent on the composition of its negative active material layer. However, a negative active material containing a silicon-based material was known in the art, as discussed by Kusagawa.

ii. Kusagawa

511. Kusagawa teaches “silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008, [0005]. Kusagawa then explains how to balance silicon with carbon materials (like graphite) in a negative electrode active material to achieve “a high capacity and a good load characteristic.” EX1008, [0015]. In pursuit of this goal, Kusagawa discloses that “[t]he negative electrode mixture layer contains a silicon material and graphite as negative electrode active materials.” EX1008, [0016]. An embodiment disclosed by Kusagawa is described as such: “(Production of *Negative Electrode Active Material*)” and “By chemical vacuum deposition (CVD) where *silicon oxide* having a composition of SiO (corresponding to general formula SiO_x where $x=1$) was heated in an argon atmosphere containing a hydrocarbon gas so that the hydrocarbon gas was thermally decomposed, *the surface of SiO was coated with carbon*. The amount of carbon that covered the surface of SiO was 10% by mass relative to the mass of SiO.” eEX1008, [0025]-[0026]. Thus, Kusagawa also discloses negative electrode active material, wherein the negative active material contains a silicon-based material (silicon oxide). Kusagawa also discloses an example, Example 15, using elemental silicon, or a “silicon-graphite composite” as a negative active material. EX1008, [0042]-[0043]. Specifically, Kusagawa teaches formation of a “silicon-based slurry” from

“monocrystalline Si particles” which is then added to graphite and carbon pitch to produce a “silicon-graphite composite in which Si particles and graphite particles were bonded to each other with amorphous carbon.” *Id.* Kusagawa teaches incorporating this silicon-graphite composite in a battery, disclosing that such a battery was produced “in the same manner as in Example 1 except that the silicon-graphite composite ... was used instead of SiO coated with carbon.” *Id.* at [0044]. A POSA would have thus understood that the negative active material of Kusagawa Example 15 was thus replacing the 4% SiO of Example 1 with 4% silicon-graphite composite of Example 15. Kusagawa further teaches that “[t]he amount of silicon in this composite was 20.9 % by mass.” *Id.* at [0043]. A POSA thus would further understand that the negative active material of Kusagawa Example 15 was 0.836% silicon by mass (and thus, a weight percentage of silicon-based material of 0.836%), because 20.9% of 4% is 0.836%.

iii. Motivation to Combine

512. **Analogous art:** Guo and Kusagawa are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes.

513. **How to modify:** A POSA would have modified Guo in view of Kusagawa by incorporating the negative active material taught by Kusagawa to the negative electrode taught by Guo. Specifically, a POSA would combine the

“negative active material” of 4% Si-graphite composite by mass and with an amorphous carbon coating binding the Si to the graphite particles to the negative electrode of Guo. EX1008, [0026]. Kusagawa Example 1 spells out explicitly the “production of negative electrode active material” which includes the aforementioned silicon-based material. EX1008, [0025]-[0026]. Example 1 makes explicit the production of nearly every battery component beyond the negative active material layer, including the negative electrode, the positive electrode, the electrode body, and the electrolyte. EX1008, [0025]-[0038]. A POSA would understand how to combine this detailed method disclosure with the analogous art of Guo.

514. **Why to modify:** A POSA would enhance Guo with the teaching of Kusagawa because Kusagawa Example 1 spells out explicitly the “production of negative electrode active material” which includes the aforementioned silicon-based material. EX1008, [0025]-[0026]. Example 1 makes explicit the production of nearly every battery component beyond the negative active material layer, including the negative electrode, the positive electrode, the electrode body, and the electrolyte. EX1008, [0025]-[0038]. A POSA would understand why to combine this detailed method disclosure with the analogous art of Guo.

515. A POSA would have found it obvious to modify the electrochemical apparatus of Guo with Kusagawa’s disclosed negative active material layer

comprising a silicon-based material containing a material layer. While Guo teaches improved energy density, safety performance, and shear stability (EX1011, [0004]-[0007]), Guo is silent as to the performance of their disclosed electrochemical apparatuses with respect to active material capacity, specifically. A POSA seeking to improve capacity would thus look to analogous art that teaches enhanced active material capacity, and Kusagawa taught a POSA how to do so.

516. A POSA would have recognized the benefit of using an amorphous carbon material layer arranged on at least part of a surface of a silicon-based material, as taught in Kusagawa, as an additional component incorporated into the apparatus taught by Guo, discussed above in relation to claim 1. A POSA further would have recognized the benefit of incorporating 4% silicon-graphite composite (*see* Section XIV.C.2) to the electrochemical apparatus of Guo. This is because Kusagawa demonstrates that silicon-based active materials were known in the art to improve electrode capacity, and this reference goes on to explicitly provide multiple Examples detailing how to incorporate its teachings, including an Example having a negative active material layer with 4% silicon-graphite composite by mass (*see* Section XIV.C.2). EX1008, [0043]. A POSA would have known to use Kusagawa's negative active material layer because the reference disclosed why this type of active material layer improves capacity while overcoming known challenges regarding cycling characteristics. *See* EX1008,

[0004], [0005], [0015], [0017], [0066]-[0068].

517. A POSA would then have been motivated to add the claimed material layer (amorphous carbon) on at least a part of a surface of the silicon-based material, because Kusagawa teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer, i.e. the claimed “material layer.”

518. A POSA would have understood that amorphous carbon, specifically, is a suitable choice of conductive coating (i.e., material layer) in this application, as is known in the art. EX1015, 11454-11456; EX1016, Abstract, 21-26.

iv. Reasonable Expectation of Success

519. A POSA would have had a reasonable expectation of success in combining Guo with Kusagawa because 1) Kusagawa provides a *clear rationale* for use of a silicon-based material in a negative active material layer (as discussed above), 2) Kusagawa describes in detail *how* a POSA would do so, and 3) Kusagawa teaches *why* its disclosed silicon-based material when combined with Guo would result in the creation of a functional electrochemical apparatus.

520. A POSA would recognize that the disclosed silicon-based material of Kusagawa would result in a successful combination because 1) Guo and Kusagawa

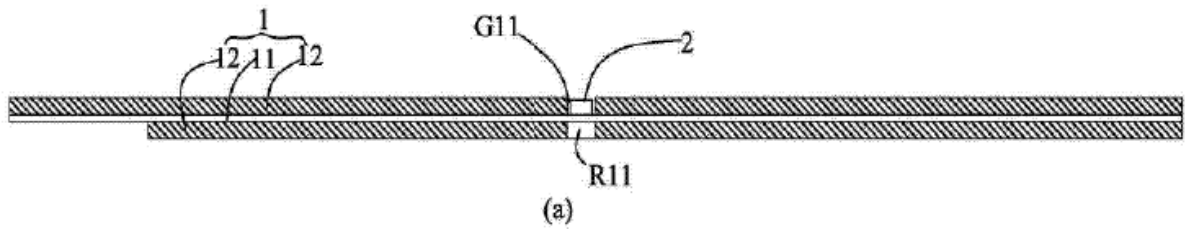
are directed to the same wound battery geometry, and Kusagawa is analogous to Guo, and 2) Kusagawa teaches that “any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008, [0058]. A POSA would have understood that Kusagawa’s silicon-graphite composite material allows for reversible intercalation of Li ions, and thus is compatible with the “lithium-ion battery” disclosed by Guo. EX1008, [0002]-[0003], [0079].

521. In light of this, a POSA would have a reasonable expectation of success in combining Kusagawa’s silicon-based material with Guo’s negative active material layer to produce a functional electrochemical apparatus with improved performance.

522. As such, Guo in view of Kusagawa discloses claim element [1.5.2].

h. [1.6.1] a negative tab,

523. Guo discloses claim element [1.6.1]. Specifically, Figures 3a and 3b of Guo disclose an anode sheet formed with “an anode matching recess R11 located on the opposite back side of the anode tab accommodating groove G11, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12.” EX1011, [0066]. The anode current collector is the claimed negative current collector and the anode tab is the claimed negative tab.

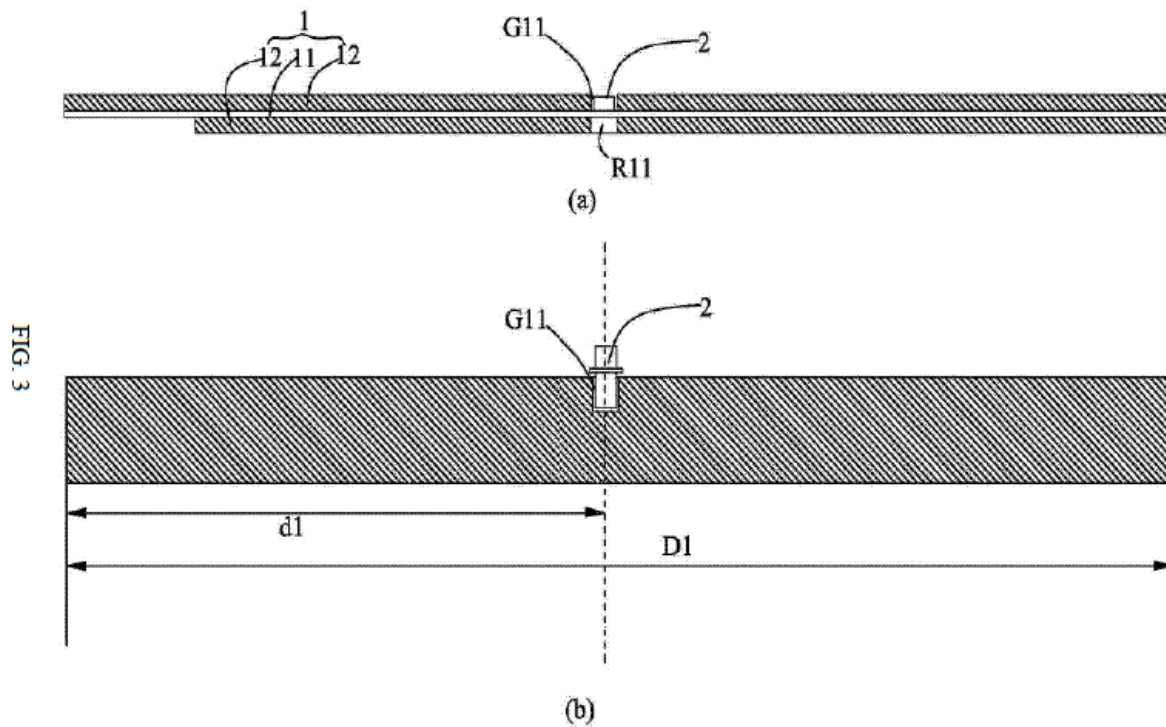


i. [1.6.2] wherein the negative tab is arranged on a side edge of a long axis of the negative current collector,

524. Guo discloses a negative tab is arranged on a side edge of a long axis of a negative current collector.

525. Specifically, as discussed under claim element [1.6.1], the anode current collector of Guo is the claimed “negative current collector,” and the anode tab of Guo is the claimed “negative tab.”

526. As seen in Figures 3a and 3b, a long axis of the negative current collector is aligned with the x-direction.



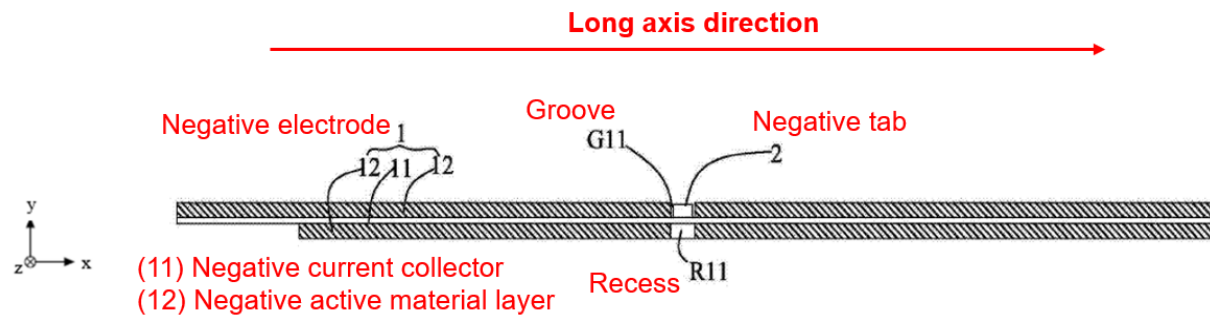
527. Guo thus discloses a negative current collector with a long axis (i.e. aligned with an x-direction), wherein a negative tab is arranged on a side edge of the long axis (i.e. normal to the x-direction).

j. ***[1.6.3] a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length,***

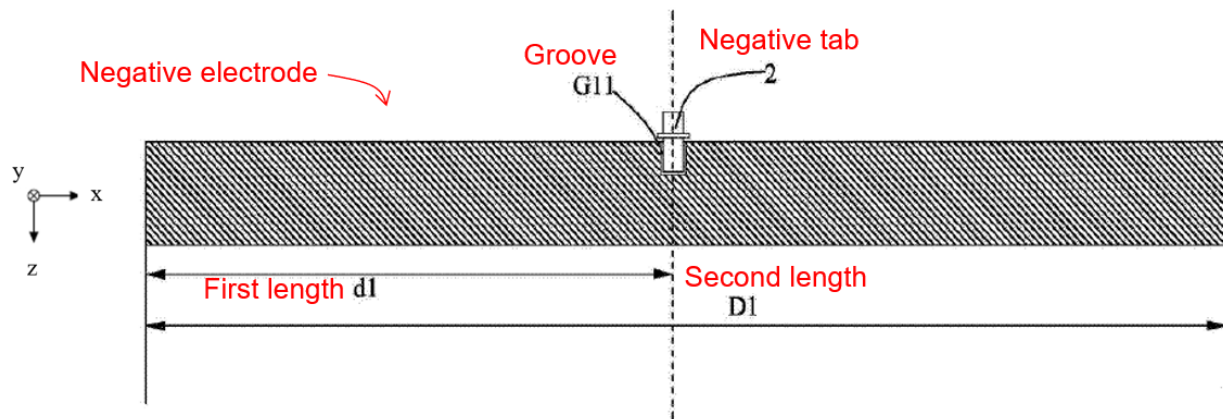
528. Guo discloses this claim element Specifically, regarding the first length, Guo notes that ***“the distance between the center line of the anode tab accommodating groove G11 and the head of the anode sheet 1 is defined as d1.”***

EX1011, [0074]. Guo notes that “anode tab 2 is accommodated within the anode tab accommodating groove G11,” and notes that “anode tab 2 can be electrically connected to the anode current collector 11 at the anode tab accommodating

groove G11.” EX1011, [0046], [0049], [0055]. A POSA would understand the importance of centering anode tab within the anode tab accommodating groove during manufacture. This view is supported by annotated Guo Figure 3b, which clearly illustrates that anode tab 2 (labeled here as “negative tab 2”) is centered within anode tab accommodating groove G11. A POSA would thus understand that the center line of the anode tab 2 is aligned with the center line of the anode tab accommodating groove G11.



Guo FIG. 3a (annotated).



EX1011, FIG. 3b (annotated).

529. As a result of this alignment between anode tab 2 and anode tab accommodating groove G11, a POSA would understand “d1” could alternatively be defined as “the distance between the center line of the anode tab 2 and the head of the anode sheet 1.” Additionally, “the head of anode sheet 1” could alternatively be defined as one “end” of the sheet.

530. When viewed in combination with the previously discussed claim element mappings of the claimed “negative tab” and “negative active material layer,” a POSA would thus understand Guo’s d1 definition as equivalent to “the distance between the center line of the negative tab and an end of the negative active material layer.”

531. Finally, because d1 is aligned with the defined long axis direction, a POSA would understand Guo’s definition as equivalent to “the distance between the center line of the negative tab and an end of the negative active material layer in a long axis direction.”

532. Guo thus discloses a first length which is “a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction.” Guo therefore discloses that “a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length.”

k. [1.6.4] a length of a long axis of the negative active material layer is a second length, and

533. Guo discloses this claim element. Specifically, Guo teaches that “the distance from the head to the tail of the anode sheet 1 is defined as D1.” And as discussed above, D1 is aligned with the defined long axis direction. Thus, a POSA would understand that D1, as defined by Guo, is equivalent to the recited “second length” of this claim element.

l. [1.7.1] the negative electrode satisfies the following relationship formula (I) $0.5 \geq D \geq 0.6 \times G$

534. Guo in view of Kusagawa discloses this claim element.

535. As noted above in relation to claim element 1.5.2, Guo does not disclose silicon-based material as part of its negative active material (because Guo does not provide this level of detail), but Kusagawa does.

536. Similarly, “G” in claim element 1.7.1—also in claim elements 1.7.3 and 1.7.4 (discussed below), requiring a weight percentage of the silicon-based material (less than or equal to 70%)—is not taught in Guo, but is taught in Kusagawa.

537. All other elements of claim 1, beyond those directly relating to the silicon-based material, are otherwise taught in Guo.

538. Thus, as discussed below, a negative electrode that satisfies $0.5 \geq D$ is taught by Guo, a negative electrode that satisfies $0.5 \geq 0.6 \times G$ is taught by

Kusagawa, and a negative electrode that satisfies $0.5 \geq D \geq 0.6 \times G$ (formula (I)) is rendered obvious by Guo in view of Kusagawa.

539. Guo discloses a negative electrode which satisfies a first portion of relationship formula (I), specifically, the relationship “ $0.5 \geq D$,” where $D = 0.5$. This disclosure is explained in detail within the discussion of claim element 1.7.2 below.

540. A negative electrode that satisfies $0.5 \geq 0.6 \times G$ was also well known in the prior art, as taught by Kusagawa.

541. The silicon-based material of Kusagawa would enhance Guo for the reasons presented in the discussion of claim element 1.5.2 above, and Kusagawa’s negative electrode comprising a silicon-based material satisfies a second portion of relationship formula (I): “ $0.5 \geq \dots 0.6 \times G$,” where $0.6 \times G = 0.836\%$, or 0.00836. This disclosure is explained in detail within the discussion of claim element 1.7.3 in Section XIX.B.1.n. below.

542. Substitution of $0.6G = 0.00386$ (as disclosed in Kusagawa) and $D = 0.5$ (as disclosed in Guo) into formula (I) yields $0.5 \geq 0.5 \geq 0.05016$, thus satisfying the conditions of formula (I) and therefore rendering obvious claim element 1.7.1.

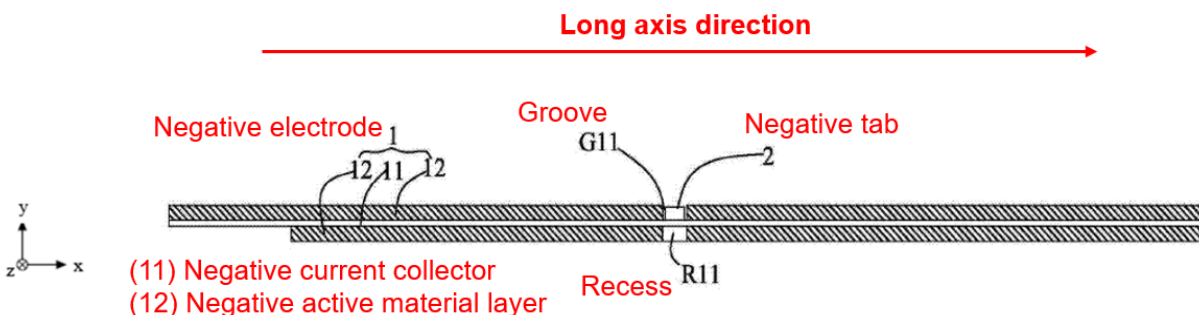
543. Thus, Guo in view of Kusagawa discloses claim element 1.7.1. The motivation to combine Guo with Kusagawa with regard to claim elements 1.7.1 through 1.7.4 is provided within the analysis of claim element 1.7.4 below.

m. [1.7.2] wherein D is a ratio of the first length to the second length,

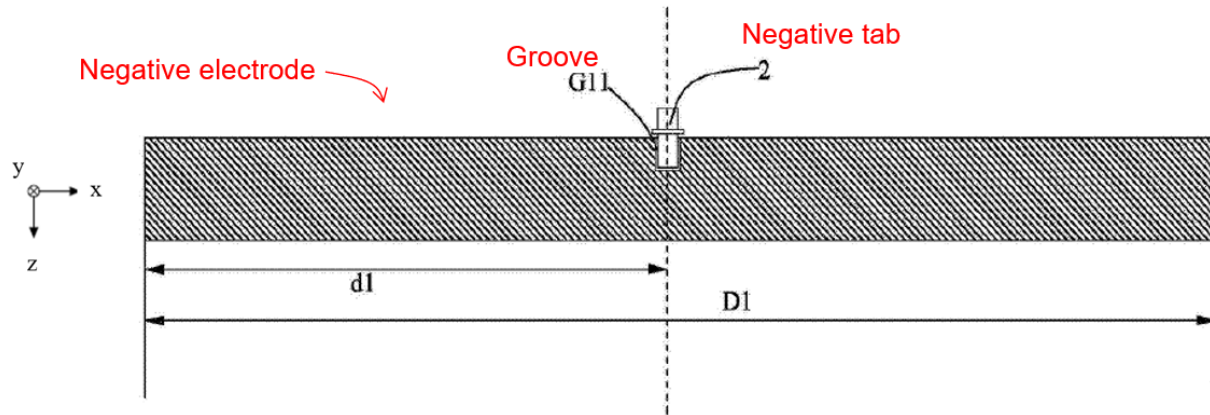
544. Guo discloses this claim element.

545. As discussed above, Figure 3a of Guo discloses an anode sheet formed with “an anode matching recess R11 located on the opposite back side of the anode tab accommodating groove G11, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12.” EX1011, [0066]. The anode sheet is the claimed “negative electrode.” The anode current collector is the claimed “negative current collector.” The anode membrane is the claimed “negative active material layer.”

546. Guo discloses that “anode sheet 1 may further be formed with: an anode matching recess R11 located on the opposite back side of the anode tab accommodating groove G11, the bottom of the anode matching recess being an anode current collector 11, and the peripheral side thereof being an anode membrane 12.” EX1011, [0066]. Furthermore, as disclosed in Guo Claim 1: “the anode tab (2) is accommodated within the anode tab accommodating groove.”



547. As seen in Figures 3a and 3b, the length of the negative current collector matches the length of the upper negative active material layer (i.e. the second length, *see* discussion of claim element 1.6) along a long axis (i.e. the x-axis) in Figure 3a.



548. As seen in Figure 3b, “d1” is defined as “the distance between the center line of the anode tab accommodating groove G11 and the head of the anode sheet,” with “d1 being within the range of 1/10 D1 to 7/10 D1 calculated from the head of the anode sheet.” EX1011, [0074]. Doing so helps “to reduce the direct current resistance (DCR) of the secondary battery cell,” where “the closer d1 is to the middle position of the anode sheet 1 (i.e., 1/2 D1), the smaller the DCR.” EX1011, [0074]. A POSA looking to reduce DCR would thus be motivated to place the anode tab accommodating groove G11 at a position of $d1 = (D1)/2$. Following the same line of reasoning presented under claim element 1.6.3 above, a POSA looking to reduce DCR would similarly be motivated to place *the negative*

tab at a position of $d1 = (D1)/2$. Thus, the **“first length” disclosed by Guo is equal to $(D1)/2$.**

549. Considering the **“second length” is equal to $D1$** , the ratio (D) of the first length to the second length is equal to $((D1)/2)/(D1)$. **D is equal to 0.5.**

550. A POSA would understand that Guo discloses “ D is a ratio of the first length to the second length,” where D is used to satisfy formula (I).

n. [1.7.3] G is a weight percentage of the silicon-based material, and

551. Kusagawa discloses this claim element.

552. Kusagawa teaches a “ G ” value of 0.00836. Specifically, Kusagawa teaches a weight percentage of 4% silicon-graphite composite relative to the total mass of silicon-graphite composite and graphite. EX1008, [0026], [0044].

Kusagawa teaches that “[t]his SiO and graphite were mixed such that the mass of SiO was 4% by mass relative to the total mass of SiO and graphite, whereby a negative electrode active material was produced.” EX1008, [0026]. And in Example 15, a Kusagawa teaches that “non-aqueous electrolyte secondary battery 10 in Example 15 was produced in the same manner as in Example 1 except that the silicon-graphite composite produced as described above was used instead of SiO coated with carbon.” EX1008, [0044]. Kusagawa further teaches that “[t]he amount of silicon in this composite was 20.9 % by mass.” *Id.* at [0043]. A POSA thus would further understand that the negative active material of Kusagawa

Example 15 was 0.836% silicon by mass (and thus, a weight percentage of silicon-based material of 0.836%), because 20.9% of 4% is 0.836%.

553. This results in a $0.6G$ value of $(0.6 \times 0.836\% =) 0.5016\%$, or **0.005016** when expressed as a fraction of 1.

554. A POSA would understand that Kusagawa discloses “ G is a weight percentage of the silicon-based material,” where G is used to satisfy formula (I).

o. [1.7.4] the weight percentage of the silicon-based material is less than or equal to 70%.

555. Guo in view of Kusagawa teaches a silicon-based material with a weight percentage less than or equal to 70%. As discussed above, “ G ” in claim element 1.7.4 is not taught in Guo (which does not disclose silicon-based material as part of its negative active material, because Guo does not provide this level of detail), but is disclosed in Kusagawa.

556. As discussed in reference to claim element 1.5.1 above, Guo discloses a negative active material layer. However, aside from disclosing that “the secondary battery may be a lithium-ion battery or a sodium-ion battery,” Guo does not provide detail as to the material composition of its negative active material layer. EX1011, [0079].

557. However, a weight percentage of silicon-based material less than or equal to 70% was well known in the prior art, as taught by Kusagawa.

558. As discussed with reference to claim elements 1.5.2 and 1.7.3, Kusagawa discloses a weight percentage of silicon-based material (*G*) of 0.836%, or 0.00836 when expressed as a fraction of 1. These values are less than or equal to 70%, and thus, Kusagawa “discloses the weight percentage of the silicon-based material is less than or equal to 70%.”

2. Motivation to Combine

559. A POSA would have been motivated to combine Guo and Kusagawa such that claim elements 1.7.1 through 1.7.4 would have been obvious, for the reasons discussed below.

560. **Analogous Art:** Guo and Kusagawa are analogous art to each other and the claims. *See* Section XIX.A.

561. **How to Modify:** A POSA also would have found it obvious how to add the teachings of Kusagawa to Guo for the same reasons detailed above in the Motivation to Combine discussion of claim element 1.5.2. A POSA would understand how to combine these references for *any* specific weight percentage of silicon-based material, including a weight percentage of silicon-based material less than or equal to 70%.

562. **Why Modify:** A POSA would have looked to Kusagawa to fill in active layer composition details missing in Guo for the same reasons detailed

above in the Motivation to Combine discussion of claim element 1.5.2. Section XIX.B.1.g.iii.

563. A POSA would be further motivated to combine the *negative tab position* of Guo with the *silicon-based material weight percentage* of Kusagawa, specifically, to produce an electrochemical apparatus with both reduced direct current resistance and improved safety performance. EX1011, [0004], [0074], [0076]; EX1008, [0003]. With improved safety performance explicitly tied to Kusagawa's negative active material layer content (EX1008, [0003]), a POSA would thus be motivated to combine the disclosed silicon-based material weight percentages of Kusagawa with the negative tab position of Guo.

564. Kusagawa explains that its particular electrode composition of Si-graphite composite of 4% by mass (Example 15) performed favorably with respect to comparative examples that did not have any silicon material by mass. EX1008, [0059], Table 1.

565. Thus, a POSA would have been motivated to use a mixture of graphite and silicon as active material components, ***with the specific silicon-based material weight percentage disclosed in Kusagawa***, when constructing a negative electrode. A POSA would have understood that routine optimization of these components, as taught by Kusagawa, would have been advantageous for the development of a lithium-ion battery.

3. Reasonable Expectation of Success

566. A POSA would have had an expectation of success in combining Kusagawa with Guo for the same reasons explained under claim element 1.5.2 above. Kusagawa provides a *clear rationale* for use of a silicon-based material in a negative active material layer *for a specific weight-based percentage*, 2) Kusagawa describes in detail *how* a POSA would do so, and 3) Kusagawa teaches *why* its disclosed silicon-based material when combined with Guo would result in the creation of a functional electrochemical apparatus. Section XIX.B.1.o.2.

567. A POSA would have thus understood that Guo in view of Kusagawa discloses claim elements 1.7.1 through 1.7.

p. Claim 10: [10.P] An electronic apparatus, comprising an electrochemical apparatus, wherein the electrochemical apparatus comprises:

568. To the extent that the preamble is limiting, Guo discloses this element. Guo teaches: “[t]he present utility model relates to electrochemical energy storage devices, and more particularly to a secondary battery cell.” EX1011, [0001]. More specifically, Guo teaches that the “objective of the present utility model is to provide a secondary battery cell.” EX1011, [0004]. A POSA would understand that a battery cell is an electronic apparatus. Thus, Guo discloses claim element [10.P].

q. [10.1] a positive electrode;

569. This limitation is identical to limitation [1.1]. *See* § XIX.B.1.b.

r. [10.2] a separator; and

570. This limitation is identical to limitation [1.2]. See § XIX.B.1.c.

s. [10.3] a negative electrode,

571. This limitation is identical to limitation [1.3]. See § XIX.B.1.d.

t. [10.4] wherein the negative electrode comprises: a negative current collector;

572. This limitation is identical to limitation [1.4]. See § XIX.B.1.e.

u. [10.5.1] a negative active material layer,

573. This limitation is identical to limitation [1.5.1]. See § XIX.B.1.f.

v. [10.5.2] wherein the negative active material layer contains a silicon-based material; and

574. This limitation is identical to limitation [1.5.2]. See § XIX.B.1.g.

w. [10.6.1] a negative tab,

575. This limitation is identical to limitation [1.6.1]. See § XIX.B.1.h.

x. [10.6.2] wherein the negative tab is arranged on a side edge of a long axis of the negative current collector,

576. This limitation is identical to limitation [1.6.2]. See § XIX.B.1.i.

y. [10.6.3] a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length,

577. This limitation is identical to limitation [1.6.3]. See § XIX.B.1.j.

z. [10.6.4] a length of a long axis of the negative active material layer is a second length, and

578. This limitation is identical to limitation [1.6.4]. See § XIX.B.1.k.

aa. [10.7.1] the negative electrode satisfies the following relationship formula (I): $0.5 \geq D \geq 0.6 \times G$ formula (I)

579. This limitation is identical to limitation [1.7.1]. See § XIX.B.1.l.

bb. [10.7.2] wherein D is a ratio of the first length to the second length,

580. This limitation is identical to limitation [1.7.2]. See § XIX.B.1.m.

cc. [10.7.3] G is a weight percentage of the silicon-based material,

581. This limitation is identical to limitation [1.7.3]. See § XIX.B.1.n.

dd. [10.7.4] and the weight percentage of the silicon-based material is less than or equal to 70%.

582. This limitation is identical to limitation [1.7.4]. See § XIX.B.1.o.

583. Similar to claim 1 (and for the same reasons), because Guo and Kusagawa teach or disclose each and every element of claim 10, and because a POSA would have been motivated to modify Guo with the analogous art of Kusagawa to arrive at the claimed invention with a reasonable expectation of success, Guo and Kusagawa render claim 10 obvious.

C. Claim 7

584. Claim 7 depends on claim 1. As discussed in more detail below, Guo and Kusagawa render claim 7 obvious because a POSA would have been motivated to combine these references to arrive at the claimed invention with a reasonable expectation of success.

1. Guo and Kusagawa teach or disclose each and every element of claim 7.

585. Guo and Kusagawa teach or disclose each and every element of claim 7, as explained below.

a. [7.1] *The electrochemical apparatus according to claim 1, wherein the silicon-based material further contains a material layer,*

i. *Guo-Kusagawa*

586. Guo, in view of Kusagawa, teaches this element.

587. Although Guo may not expressly disclose a “further” “material layer,” such a layer was known in the art, as is taught by Kusagawa.

588. Kusagawa teaches a second layer containing amorphous carbon. Specifically, Kusagawa teaches an electrode active material wherein during the “production of negative electrode active material,” that “silicon oxide” was “coated with carbon” using a hydrocarbon gas that was “thermally decomposed” so that “the surface of SiO was coated with carbon.” EX1008, [0026]. A POSA would understand that this carbon coating is a material layer, as recited by this claim element.

ii. *Motivation to Combine*

589. **Analogous references:** As discussed above, Kusagawa and Guo are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes.

Kusagawa teaches an improvement to a graphite-based negative active material layer like the one in Guo, mitigating the expansion and shrinkage of silicon by adding carbon to the active material layer, as discussed below.

590. **How to combine:** A POSA would have known how to combine Guo's electrochemical apparatus with Kusagawa's recited silicon concentration of 4% SiO. A POSA further would have added an amorphous carbon layer, as also described in Kusagawa, to the negative active material of Kusagawa because, as discussed in more detail below, an amorphous carbon layer provides a benefit to silicon-containing negative active materials. A POSA would thus have been motivated to add both the silicon content of Kusagawa, and its amorphous carbon layer, to the electrochemical apparatus of Guo.

591. **Why to combine:** In combining Kusagawa's teachings with Guo, a POSA would understand the benefit of an additional layer on top of the active material, because Kusagawa teaches that "[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples." EX1008, [0065]. Indeed, each of the relied upon Examples of Kusagawa includes this additional graphite layer. Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that "In a silicon-graphite composite, silicon particles and graphite particles are

preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

592. A POSA would further have been motivated to make this modification to Guo because Kusagawa praises its active material composition, describing that “[s]ilicon materials, such as silicon and silicon oxide, having a higher capacity than carbon materials have recently attracted more attention as negative electrode active materials of non-aqueous electrolyte.” EX1008, [0004]Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that “In a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

593. Thus, Kusagawa provides an art-recognized improvement to electrodes such as those described in Guo. A POSA would have been motivated to add an amorphous carbon layer, such as that taught by Kusagawa ([0043]), on top of the silicon-containing negative active material layer taught by Guo in view of Kusagawa, to solve the art-recognized problem of low conductivity in silicon-

containing active materials, as discussed below. Indeed, Kusagawa stresses the importance of such a carbon layer, describing that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Thus, a POSA would have been motivated to incorporate such a structure.

594. In modifying this structure, A POSA would have found it obvious to modify the electrochemical apparatus of Guo-Hu with Kusagawa’s disclosed negative active material layer comprising a silicon-based material containing a material layer. While the Guo and Hu teach improved energy density, safety performance, and shear stability (EX1011, [0004]-[0007]; EX1005, [0014]-[0019], [0023]-[0028]), Guo and Hu are silent as to the performance of their disclosed electrochemical apparatuses with respect to active material capacity, specifically. A POSA seeking to improve capacity would thus look to analogous art that teaches enhanced active material capacity, and Kusagawa taught a POSA how to do so.

595. Further, a POSA would have recognized the benefit of using an amorphous carbon material layer arranged on at least part of a surface of a silicon-based material, as taught in Kusagawa, as an additional component incorporated into the apparatus taught by Guo, discussed above in relation to claim 1. A POSA further would have recognized the benefit of incorporating a weight percentage of silicon-based material of 4% Si-graphite composite (*see* Section XIV.C.2) to the

electrochemical apparatus of Guo. This is because Kusagawa demonstrates that silicon-based active materials were known in the art to improve electrode capacity, and this reference goes on to explicitly provide multiple Examples detailing how to incorporate its teachings, including an Example having a negative active material layer with 4% Si-graphite composite silicon by mass (*see* Section XIV.C.2).

EX1008, [0043]. A POSA would have known to use Kusagawa's negative active material layer because the reference disclosed why this type of active material layer improves capacity while overcoming known challenges regarding cycling characteristics. *See* EX1008, [0004], [0005], [0015], [0017], [0066]-[0068].

596. Thus, a POSA would then have been motivated to add the claimed material layer (amorphous carbon) on at least a part of a surface of the silicon-based material, because Kusagawa teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer, i.e. the claimed “material layer.”

597. A POSA would have understood that amorphous carbon, specifically, is a suitable choice of conductive coating (i.e., material layer) in this application, as is known in the art. EX1015, 11454-11456; EX1016, Abstract, 21-26.

598. With respect to the addition of the silicon-based active material to the electrode of Guo, Kusagawa also warns that “[h]owever, silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008, [0005]. Thus, a POSA would have understood that both graphite and silicon have respective benefits and drawbacks, and that a careful balance between the two materials is beneficial.

599. Kusagawa then describes that “[i]n light of the aforementioned circumstances, the present invention is directed to a non-aqueous electrolyte secondary battery in which a silicon material and graphite are used as negative electrode active materials and which has a high capacity and a good load characteristic.” EX1008, [0015]. Kusagawa explains that its particular electrode composition of Si-graphite composite of 4% by mass (Example 1) performed favorably with respect to comparative examples that did not have any silicon material by mass. EX1008, [0054]-[0058], Table 1.

600. Thus, a POSA would have been motivated to use a mixture of graphite and silicon as active material components for the active material of Guo when constructing a negative electrode.

iii. Reasonable Expectation of Success

601. A POSA would have had a reasonable expectation of success in combining these references because Kusagawa teaches that “any silicon material

that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008, [0058]. A POSA would have understood that Kusagawa’s silicon material allows for reversible intercalation of Li ions. And a POSA would have understood that Kusagawa’s 4% Si-graphite composite / 96% graphite compositions would have been compatible with the battery described in Guo, which is silent on its active material layer composition. Kusagawa also teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer, meaning that Kusagawa valued the feature of the carbon layer being arranged on top of the SiO material. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Guo to form a better-performing battery.

b. [7.2] the material layer is arranged on at least a part of a surface of the silicon-based material, and

i. Guo-Kusagawa

602. Guo, in view of Kusagawa, teaches this element.

603. Although Guo may not expressly disclose a material layer arranged on at least a part of the silicon-based material, it would have been obvious to add such a second material layer on top of the silicon-based material because such layers were known in the art, as taught by Kusagawa.

604. Kusagawa teaches a second layer arranged on at least a part of the silicon-based surface. Specifically, Kusagawa teaches an electrode active material wherein during the “production of negative electrode active material,” that “silicon oxide” was “coated with carbon” using a hydrocarbon gas that was “thermally decomposed” so that “the surface of SiO was coated with carbon.” EX1008, [0026]. Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that “In a silicon-graphite composite , silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

605. A POSA would understand that this coating is a material layer” and that when Si-graphite composite is “coated” with carbon, the carbon material layer is arranged on at least a part of the surface of the silicon-based material.

ii. Motivation to Combine

606. **Analogous references:** As discussed above, Kusagawa and Guo are analogous art because both references are directed to the construction of electrodes suitable for applications in wound batteries with non-aqueous electrodes. Kusagawa teaches an active material layer composition suitable to be used in Tao.

607. **How to combine:** A POSA would have combined Guo's electrochemical apparatus with Kusagawa's recited silicon concentration of 4% Si-graphite composite. A POSA further would have added an amorphous carbon layer to the negative active material of Kusagawa.

608. **Why to combine:** In combining Kusagawa's teachings with Guo, a POSA would understand the benefit of an additional layer on top of the active material, because Kusagawa teaches that "[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples." EX1008, [0065]. Indeed, each of the relied upon Examples of Kusagawa includes this additional graphite layer. Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that "In a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]" EX1008, [0070]. Thus, a POSA would have recognized that this "preferable" material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

609. A POSA would further have been motivated to make this modification to Guo because Kusagawa praises its active material composition, describing that "[s]ilicon materials, such as silicon and silicon oxide, having a higher capacity than

carbon materials have recently attracted more attention as negative electrode active materials of non-aqueous electrolyte.” EX1008, [0004]. These carbon layers are arranged on top of the Si-containing material layers. Indeed, the benefits of the additional layer of carbon do not occur unless the silicon material is “coated” with carbon, as described in Kusagawa. EX1008, [0004]. As discussed above, a deposited carbon layer constitutes “amorphous carbon.” Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that “In a silicon-graphite composite , silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

610. Thus, Kusagawa provides an art-recognized improvement to electrodes such as those described in Guo. A POSA would have been motivated to add an amorphous carbon layer, such as that taught by Kusagawa, on top of the silicon-containing negative active material layer taught by Kusagawa, to solve the art-recognized problem of low conductivity in silicon-containing active materials.

611. With respect to the addition of silicon to the electrode of Guo, Kusagawa also warns that “[h]owever, silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008,

[0005]. Thus, a POSA would have understood that both graphite and silicon have respective benefits and drawbacks, and that a careful balance between the two materials is beneficial. Kusagawa then describes that “[i]n light of the aforementioned circumstances, the present invention is directed to a non-aqueous electrolyte secondary battery in which a silicon material and graphite are used as negative electrode active materials and which has a high capacity and a good load characteristic.” EX1008, [0015]. Kusagawa explains that its particular electrode composition of Si-graphite composite of 4% by mass (Example 15) performed favorably with respect to comparative examples that did not have any silicon material by mass. EX1008, [0059], Table 1.

612. Thus, a POSA would have been motivated to use a mixture of graphite and silicon as active material components when constructing a negative electrode.

iii. Reasonable Expectation of Success

613. A POSA would have had a reasonable expectation of success in combining these references because Kusagawa teaches that “any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008, [0058]. A POSA would have understood that Kusagawa’s silicon material allows for reversible intercalation of Li ions. And a POSA would have understood that

Kusagawa's 4% Si-graphite composite / 96% graphite compositions would have been compatible with the battery described in Guo, which has embodiments of both 90% graphite and 90% silicon. EX1008, Table 1. Kusagawa also teaches that "[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples." EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer, meaning that Kusagawa valued the feature of the carbon layer being arranged on top of the SiO material. Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that "In a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]" EX1008, [0070]. Thus, a POSA would have recognized that this "preferable" material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Guo to form a better-performing battery.

c. [7.3] the material layer contains at least one of a polymer, inorganic particles, amorphous carbon or carbon nanotubes.

i. Guo-Kusagawa

614. Guo, in view of Kusagawa, teaches this element.

615. Although Guo may not expressly disclose an additional material layer containing at least one of a polymer, inorganic particles, amorphous carbon or carbon nanotubes, it would have been obvious to add such a material layer because such layers were known in the art, as taught by Kusagawa.

616. Kusagawa teaches a second layer containing amorphous carbon. Specifically, Kusagawa teaches an electrode active material wherein during the “production of negative electrode active material,” that “silicon oxide” was “coated with carbon” using a hydrocarbon gas that was “thermally decomposed” so that “the surface of SiO was coated with carbon.” EX1008, [0026]. A POSA would understand that this carbon coating is “amorphous carbon” in contrast to crystalline carbon, such as graphite. Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that “In a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material.

ii. Motivation to Combine

617. **Analogous references:** As discussed above, Kusagawa and Guo are analogous art because both references are directed to the construction of electrodes

suitable for applications in wound batteries with non-aqueous electrodes.

Kusagawa teaches composition for a negative active material layer suitable for the electrochemical apparatus of Guo, mitigating the expansion and shrinkage of silicon by adding carbon to the active material layer.

618. **How to combine:** A POSA would have combined Guo's electrochemical apparatus with Kusagawa's recited silicon concentration of 4% Si-graphite composite. A POSA further would have added an amorphous carbon layer to the negative active material of Kusagawa.

619. **Why to combine:** In combining Kusagawa's teachings with Guo, a POSA would understand the benefit of an additional layer on top of the active material, because Kusagawa teaches that "[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples." EX1008, [0065]. Indeed, each Example of Kusagawa includes this additional carbon layer. Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that "In a silicon-graphite composite, silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]" EX1008, [0070]. Thus, a POSA would have recognized that this "preferable" material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material. A

POSA would further have been motivated to make this modification to Guo because Kusagawa praises its active material composition, describing that “[s]ilicon materials, such as silicon and silicon oxide, having a higher capacity than carbon materials have recently attracted more attention as negative electrode active materials of non-aqueous electrolyte.” EX1008, [0004]. These carbon layers are arranged on top of the SiO material layers. Indeed, the benefits of the additional layer of carbon do not occur unless the silicon material is “coated” with carbon, as described in Kusagawa. EX1008, [0004].

620. Thus, Kusagawa provides an art-recognized improvement to electrodes such as those described in Guo. A POSA would have been motivated to add an amorphous carbon layer, such as that taught by Kusagawa, on top of the silicon-containing negative active material layer taught by Kusagawa, to solve the art-recognized problem of low conductivity in silicon-containing active materials.

621. With respect to the addition of silicon to the electrode of Guo, Kusagawa also warns that “[h]owever, silicon materials undergo larger expansion and shrinkage with charging and discharging than carbon materials.” EX1008, [0005]. Thus, a POSA would have understood that both graphite and silicon have respective benefits and drawbacks, and that a careful balance between the two materials is beneficial. Kusagawa then describes that “[i]n light of the aforementioned circumstances, the present invention is directed to a non-aqueous

electrolyte secondary battery in which a silicon material and graphite are used as negative electrode active materials and which has a high capacity and a good load characteristic.” EX1008, [0015]. Kusagawa explains that its particular electrode composition of Si-graphite composite of 4% by mass (Example 15) performed favorably with respect to comparative examples that did not have any silicon material by mass. EX1008, [0059], Table 1. Thus, a POSA would have been motivated to use a mixture of graphite and silicon as active material components when constructing a negative electrode.

iii. Reasonable Expectation of Success

622. A POSA would have had a reasonable expectation of success in combining these references because Kusagawa teaches that “any silicon material that contains Si and can reversibly intercalate and deintercalate lithium ions is expected to exert the advantageous effects of the present invention.” EX1008, [0058]. A POSA would have understood that Kusagawa’s silicon material allows for reversible intercalation of Li ions. And a POSA would have understood that Kusagawa’s 4% Si-graphite composite / 96% graphite compositions would have been compatible with the battery described in Guo. Kusagawa also teaches that “[s]ince silicon materials have lower electron conductivity than graphite, the surface of the silicon material is preferably coated with carbon as described in Examples.” EX1008, [0065]. Indeed, each Example of Kusagawa includes this

additional carbon layer, meaning that Kusagawa valued the feature of the carbon layer being arranged on top of the SiO material. And Kusagawa Example 15 specifically discloses an amorphous carbon layer between the Si particles and graphite particles. EX1008, [0043]. Indeed, Kusagawa teaches that “In a silicon-graphite composite , silicon particles and graphite particles are preferably bonded to each other with amorphous carbon[.]” EX1008, [0070]. Thus, a POSA would have recognized that this “preferable” material was an art-recognized feature suitable for inclusion in a silicon-composite containing negative active material. As such, a POSA would have understood that the teachings of Kusagawa could be readily combined with Guo to form a better-performing battery.

XX. CONCLUSION

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

Executed on this 20th day of July in Akron, Ohio.

A handwritten signature in cursive script, appearing to read "Yu Zhu".

Yu Zhu, Ph.D.