

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHUHAI COSMX BATTERY CO., LTD.,

Petitioner

v.

NINGDE AMPEREX TECHNOLOGY LTD.,

Patent Owner

Case: IPR2025-00385

U.S. Patent No. 10,964,927

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

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I, Dean R. Wheeler, Ph.D., do hereby declare and say as follows:

I. INTRODUCTION

1. I have personal knowledge of the facts contained in this Declaration, am of legal age, and am otherwise competent to testify.

2. I have been retained by Ningde Amperex Technology Ltd. (“ATL” or “Patent Owner”) as an independent technical expert in this proceeding before the United States Patent and Trademark Office (“PTO”) Patent Trial and Appeal Board (“PTAB”) regarding U.S. Patent No. 10,964,927 (the “’927 Patent”).

3. I understand that Zhuhai CosMX Battery Co., Ltd. (“Petitioner”) filed a petition for *Inter Partes* Review (“IPR”) of the ’927 Patent (“Petition”), in which Petitioner asserts that:

- Claims 1-10 are anticipated by U.S. Patent Application Publication No. 2015/0180002 to Nishikawa et al. (“Nishikawa” or “Ex. 1004”) (Ground 1);
- Claims 1-10 are obvious over Nishikawa (Ground 2A);
- Claims 1-10 are obvious over Nishikawa and Chen et al., “Deformation and fracture behaviors of microporous polymer separators for lithium ion batteries” RSC Advances (March 2014) (“Chen” or Ex. 1005) (Ground 2B); and

- Claims 1-10 are obvious over Chen and U.S. Patent No. 10,559,802 to Zhang et al. (“Zhang” or “Ex. 1006”) (Ground 3).

4. I have been asked, for purposes of Patent Owner’s Preliminary Response, to analyze and respond to particular assertions in the Petition. I reserve the right to analyze and respond to other alleged patentability challenges if this proceeding is instituted.

5. As explained below, in my opinion, the Petition fails to show that Claims 1-10 of the ’927 Patent are anticipated or rendered obvious.

6. I am being compensated for my time spent on the present matter at my customary consulting rate of \$350 per hour for preparatory work and at my customary consulting rate of \$450 per hour for depositions/trial work. I am also being compensated for expenses incurred as a result of activities performed as an expert. My compensation is in no way contingent on the nature of my opinions, the outcome of this or any other proceeding, or any of the issues involved therein. I have no other interest in this proceeding.

II. BASIS FOR OPINIONS

A. Qualifications

7. My qualifications and professional experience are described in my *curriculum vitae*, a copy of which is provided with this Declaration as Ex. 2016. The following is a brief summary of my qualifications and professional experience.

8. I am a university professor and consultant with 28 years of experience in the fields of electrochemical engineering, materials science, and manufacturing of battery materials. I received a B.S. in Chemical Engineering from Brigham Young University in 1996, and a Ph.D. in Chemical Engineering from the University of California, Berkeley, in 2002. My Ph.D. advisor was Professor John Newman, arguably the world's foremost leader in understanding battery materials through computer simulations. Under his direction, I acquired a deep understanding of the physics and chemistry of battery materials.

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

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

11. I have also authored or co-authored 63 peer-reviewed scientific publications. My most influential paper, "Quantifying tortuosity in porous Li-ion battery materials," published in the Journal of Power Sources in 2009, has been cited

more than 600 times, and describes the movement of ions through various types of battery materials, including separator and electrode materials. I have also published papers on the subjects of electrode structures and compaction, interactions of solids, binders, and electrolytes, interfaces between electrodes and electrolytes, and how all these factors relate to battery longevity.¹

12. I have received more than \$7 million in government research grants to study batteries and related materials. Current research grants from NASA and the U.S. Army deal with understanding and improving electrolyte formulations and

¹ See, e.g., Amir-Sina Hamed, Fezzeh Pouraghajan, Fei Sun, Mojdeh Nikpour, & Dean R. Wheeler, *Interplay of Electrode Heterogeneity and Lithium Plating*, 169 020551 J. Electrochem. Soc. (2022)); Fei Sun and Dean R. Wheeler, *The Effects of Lithium Ions and pH on the Function of Polyacrylic Acid Binder for Silicon Anodes*, 170 080502 J. Electrochem. Soc. (2023)); and Fezzeh Pouraghajan, Andrea I. Thompson, Emilee E. Hunter, Brian Mazzeo, Jake Christensen, Ram Subbaraman, Michael Wray, & Dean Wheeler, *The Effects of Cycling on Ionic and Electronic Conductivities of Li-ion Battery Electrodes*, 492 229636 J. of Power Sources (2021)), 2031 (Amir-Sina Hamed, Edmund M. Shumway, & Dean R. Wheeler, *Electrode-Level Modeling of Silicon Anodes for Improved Cell Design*, 171 120539 J. Electrochem. Soc. (2024)).

interactions between separators, anodes, and cathodes. My student assistants and I regularly fabricate and analyze battery materials in the laboratory, using techniques comparable to those described in the '927 Patent and cited prior art references. In particular, we routinely mix up custom-formulated electrolyte solutions, fabricate separators, anodes, and cathodes, and construct and test full lithium-based batteries. My research group is among the top users of electron microscopy at the university, which we use to analyze and understand battery electrode and separator structures. We also routinely measure the properties of battery materials and develop new diagnostic tools for making such measurements. Such training in my laboratory has allowed the students graduating from my program to go on to employment at numerous battery manufacturers and battery-related startup companies across the United States.

13. In 2016, I led the Gordon Research Conference on Batteries,² as conference chair, having been nominated and voted into that position at a previous conference. This biennial international conference is attended by around two hundred of the world's thought leaders in the field of batteries. Furthermore, on three occasions I was selected to be a member of the technical review team for an ongoing

² See Ex. 2025 (2016 Batteries Conference GRC, <https://www.grc.org/batteries-conference/2016/> (last visited on May 12, 2025)).

\$25 million/year “Battery Hub” program funded by the U.S. Department of Energy.³

I believe my experience in such positions of leadership and responsibility, among others, reflects the stature with which I am viewed by my peers in the academic, industrial, and government battery research communities.

B. Materials Considered

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

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

³ See Ex. 2026 (*Hubs – Department of Energy*, <https://www.energy.gov/hubs> (last visited on May 12, 2025)); Ex. 2027 (*DOE Energy Innovation Hubs*, <https://science.osti.gov/bes/Research/DOE-Energy-Innovation-Hubs> (last visited on May 12, 2025)).

16. As I discuss below, I disagree with Dr. Pecht's conclusions that the subject matter of any of Claims 1-10 of the '927 patent would have been anticipated or obvious.

III. LEGAL STANDARDS

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

A. Claim Construction

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

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

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

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

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

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

B. Prior Art Status

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

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

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

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

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

C. Anticipation

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

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

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

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

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

32. Understanding that there are not any issues with respect to anticipation in this *inter partes* review, I focus my attention on obviousness.

D. Obviousness

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

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

35. I understand that a person of ordinary skill in the art provides a reference point from which the prior art and claimed invention should be viewed.

This reference point prevents one from using his or her own insight or hindsight in deciding whether a claim is obvious.

36. I have been informed and understand that an invention composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known or in the prior art, but that there must be an apparent reason or motivation to combine the known elements in the fashion claimed by the patents at issue.

37. I understand that in order to show obviousness based on a single reference or a combination of references, a particular motivation to modify the reference or combine the teachings in the references, and a reasonable expectation of success must be shown. I further understand that whether a proposed modification or combination of the prior art has a reasonable expectation of success is determined at the time the invention was made.

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

39. I am informed that objective factors indicating non-obviousness, also known as secondary considerations, may include (1) a long felt but unmet need in

the prior art that was satisfied by the alleged invention of the patent; (2) commercial success or lack of commercial success of processes covered by the patent; (3) unexpected results achieved by the alleged invention; (4) praise of the alleged invention by others skilled in the art; (5) taking of licenses under the patent by others; and (6) deliberate copying of the alleged invention. I also understand that there must be a relationship or nexus between any such secondary indicia and the alleged invention.

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

IV. TECHNOLOGY OVERVIEW

A. Separators in Lithium-Ion Batteries

41. Lithium-ion batteries are commonly used in portable electronic devices like laptops and cellphones, as well as in electric vehicles. These types of batteries

are known to have high energy density and good performance characteristics, including battery life.

42. Each lithium-ion battery has an anode, a cathode, an electrolyte, and a separator. When in a charging state, the lithium ions move from the cathode to the anode, where they are stored. When in a discharging state (i.e. when the battery is being used), the lithium ions move back to the cathode. That movement of lithium ions from the anode to the cathode releases energy that powers the device. The electrolyte is the solution in the battery that allows the lithium ions to move between the two electrodes.

43. A separator is a membrane placed between the cathode and the anode to prevent direct contact between electrodes, while still allowing lithium ions to pass through from one electrode to the other. Preventing contact between electrodes is important, not only because contact between the cathode and anode can cause a short circuit, but because a short circuit could result in a fire or explosion. Given its safety function, the separator must be strong enough to withstand outside forces that could puncture the separator and lead to contact between electrodes.

44. At the same time, the separator must allow for high ion flow between the electrodes (i.e. high ionic conductivity) and must not react to the electrolyte solution in a way that negatively affects ionic conductivity.

45. The various design considerations for separators require an extremely delicate balance of elements in the composition of the separator and its components, as well as the separator's physical properties. Experts in the field, associated with both research organizations and manufacturers, have been working on that balance for decades. *See, e.g.*, Ex. 1015 (summarizing such efforts).

46. One workable design for a separator involves using a porous substrate, on its own, as the separator. Examples include polyolefin-based films such as those made of polypropylene and polyethylene that can be extruded into a thin sheet. The sheet can have one layer or multiple layers. Subsequent processing steps can create desired porosity in the separator, for instance through thermal and stretching operations that effectively create micro-tears that act as pores. Another common separator example is to use nonconducting fibers that are formed into a mat or nonwoven sheet (i.e. like a dryer sheet) that acts as a highly porous layer. The fibers can be interlocked or networked to increase strength of the separator. Ex. 2028; *see also, e.g.*, Ex. 1007 at 26-28; Ex. 1015 at 4421-4426.

47. Another technique is to use a separator that is made up of a porous substrate with an additional porous layer applied, either on one side or both sides. *See, e.g.*, Ex. 1006. This porous layer may be made up of many types of materials, including different types of resins, organic particles, and/or inorganic particles. *See e.g., id.* at 8:27-60.

48. One way of quantitatively analyzing the safety efficacy of a lithium-ion battery is to subject a lithium-ion battery to a nail penetration test. Ex. 2029; *see also, e.g.*, Ex. 1015 at 4436-39. The purpose of this test is to simulate the worst-case mechanical abuse scenario, where the battery is severely damaged by a penetrating object. In the test one inserts a conductive metal nail that punctures the outer protective packaging and some or all of the internal layers of a battery, leading to a hard-short (meaning a strong electrical connection between the two electrodes leading to release of battery energy in the form of heat) and a possible pathway for battery materials to be released or other outside materials to intrude. The ideal scenario in this test is that the battery heats or swells up but is mostly stable and does not ignite. If you can achieve this outcome, then the battery passes the test. Alternatively, thermal runaway ensues, which is a series of cascading failures causing the battery to ignite or explode. Note that in scientific tests (e.g. Ex. 2029) it has been shown that the speed or rate at which the nail penetrates the battery layers influences the outcome. Testing a battery with a nail penetration test is different than testing puncture resistance of a separator. A nail penetration test studies the entire battery after some or all layers of the battery have been punctured, whereas testing puncture resistance is a test of just the separator to measure how much force that separator can withstand before being punctured. For example, the puncture resistance mentioned in Nishikawa refers to the amount of force a separator can

withstand before the nail penetrates the separator, measured in units of N or g. This is puncture resistance and is different than the unitless absolute plastic deformation rate in the '927 Patent, which is characterized in that the separator can retain sufficient plastic deformation **after being punctured** by a nail to prevent the possibility of contact between cathode and anode.

49. Based on nail penetration testing, one problem with prior art separators was that they did not do a great job of effectively preventing safety issues related to the catastrophic ignition of batteries caused by external forces puncturing the battery, causing manufacturers to attempt to rely on other mechanisms to maintain thermomechanical safety. *See, e.g.*, Ex. 1015 at 4439.

B. The '927 Patent

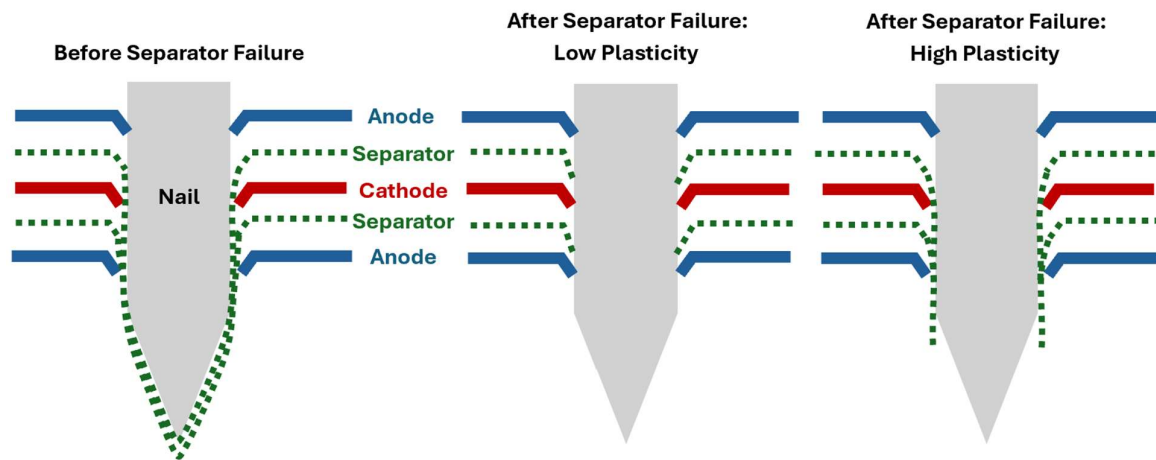
50. The '927 Patent solves the safety problems in the prior art by proposing a separator having a porous substrate with certain characteristics or properties. Ex. 1001 at 1:37-44. In particular, the '927 Patent describes and claims a porous substrate with a “high plastic deformation rate, such that when pierced by a hard object such as a steel nail, the separator around the steel nail will extend together with the steel nail, and eventually create a wrapping effect around the steel nail, thereby reducing the probability of an internal short circuit and effectively preventing fire caused by large-area short circuit inside an electrochemical device (for example, a lithium ion battery).” *Id.* This idea of plastic deformation relating to

the separator extending together with the steel nail and eventually creating a wrapping effect is different from how puncture resistance was understood and studied in the prior art.

51. The '927 Patent describes subjecting a porous substrate to a tensile test to determine its physical properties, such as plastic deformation rate. It explains that “[t]he porous substrate is subjected to both elastic deformation and plastic deformation during the tensile test.” *Id.* at 4:22-23. Consistent with a POSITA’s knowledge, the '927 Patent explains that “[p]lastic deformation is a permanent deformation that does not bounce back.” *Id.* at 4:27-28. This contrasts with elastic deformation, which is temporary deformation representing a zone in which a material will bounce back to its original state when no longer subjected to force.

52. The inventors of the '927 Patent discovered that, “[i]n the nail penetration test of a lithium ion battery, the greater the amount of plastic deformation of the porous substrate is, the greater the extent that the separator extends with the nail and produces permanent deformation will be, and the better the wrapping effect around the nail will be, thereby maintaining the effect of the separator in isolating the cathode and the anode, and reducing the probability of failure of lithium ion batteries.” *Id.* at 4:28-35. On the other hand, “if the amount of elastic deformation is relatively large, even if the separator is extended during the piercing process, the separator will be greatly retracted after puncture, thereby weakening the effect of the

separator in isolating the cathode and the anode.” *Id.* at 4:36-40. This can be seen in the conceptual diagrams below, which show how a large absolute plastic deformation rate allows the separator to better shield the electrode from the nail. These diagrams illustrate the difference between separator failures with a separator with low plasticity versus a separator with high plasticity. In both instances, if we look at the diagram just before separator failure, we see that the separator is extended to provide a protective sheath around the nail (which would ideally prevent a short circuit). But when the separator breaks, for the separator with low plasticity (and high elasticity), the separator retracts significantly, leaving the nail exposed to possible short circuit. In contrast, when the separator with high plasticity (and low elasticity) breaks, the separator will remain more elongated after failure and will not retract as significantly—thus leaving more of the elongated separator to serve as a protective sheath around the nail.



53. In the tensile test of the '927 Patent, “[t]he length before stretching is recorded as L_0 ; the porous substrate of a certain length and width is stretched to break at a certain rate, and the maximum length reached by the stretching is recorded as L_1 ; and then the broken porous substrates are docked along the fracture and flattened to test the length L_2 in a natural state.” *Id.* at 4:15-21. The patent explains that “elastic deformation= L_1-L_2 ,” “plastic deformation= L_2-L_0 ,” and “the total amount of deformation=the amount of elastic deformation + the amount of plastic deformation.” *Id.* at 4:23-27.

54. The patent further explains that “[t]he absolute plastic deformation rate ϵ_1 and the relative plastic deformation rate ϵ_2 of the porous substrate are calculated by the following equation[s]:

$$\epsilon_1 = (L_2 - L_0) / L_0 \times 100\%$$

$$\epsilon_2 = (L_2 - L_0) / (L_1 - L_0) \times 100\%.”$$

Id. at 4:48-54.

55. The '927 Patent goes on to describe various embodiments, including examples where “the porous substrate has an absolute plastic deformation rate in a first direction (e.g. a longitudinal direction) ranging from about 40% to about 1800%.” *Id.* at 4:55-58. According to the '927 Patent, a “porous substrate having the above properties exhibits a high plastic deformation rate, and also exhibits a high plastic deformation rate when a porous layer is provided on the surface of the porous substrate.” *Id.* at 5:14-17.

56. Throughout these tensile tests and nail penetration tests, the inventors of the '927 Patent discovered that it is the properties of the *porous substrate* that dictate nail penetration test passing rate (and thus the safety effectiveness of the separator), *not* the porous layer. *Id.* at 22:65-23:5 (concluding “different types of porous layers have no significant influence on the nail penetration test passing rate.”).

V. LEVEL OF ORDINARY SKILL IN THE ART

57. I understand that Petitioner provides the following definition of a POSITA:

A person of ordinary skill in the relevant art would typically hold an advanced degree in chemistry, material science, and/or a related discipline, and have at least two years of experience with designing and/or fabricating battery separators or have an equivalent level of education, training, and experience. EX1003, ¶48. Of course, additional years of experience might compensate for fewer years of education in the relevant field, and vice versa.

Pet., p. 5.

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

59. Each of the arguments below should be considered from the perspective of a POSITA in the field of the '927 Patent and during the relevant time frame (e.g., June 2018). During that time frame, I possessed at least the qualifications of a POSITA, as defined above.

VI. CLAIM CONSTRUCTION

60. The Petition states "all claim terms should receive their plain and ordinary meaning in the context of the Specification, with the exception of terms that are expressly defined by equations." Pet. at 22; *see also* Ex. 1003 ¶ 38. For terms

defined by equations, Petitioner argues those “terms should be construed as extending to the physical properties they denote, even though those properties may also be expressed by other equations.” Pet. at 22. I disagree and believe that these terms should have their plain and ordinary meaning.

61. The terms expressly defined by equations in the claim language should be construed as defined by those equations. For example, “absolute plastic deformation rate” is defined in the claim language as “ $(L2-L0)/L0 \times 100\%$, where L0 refers to a length of the porous substrate before stretching and L2 refers to a length of the porous substrate after the porous substrate is stretched to breakage and docked along the fracture caused by the breakage and flattened.” Ex. 1001 at Claim 1. This claim language is clear, and a POSITA would have understood this to require the equation and variables set forth in the claim to calculate absolute plastic deformation rate.

62. The Petition cites to the specification, which states that “[p]lastic deformation is a permanent deformation that does not bounce back” for its conclusion that absolute plastic deformation may be “expressed by other equations.” Pet. at 22. This conclusion is incorrect for multiple reasons, not least of which that it equates “plastic deformation” as a general phrase with the claimed term, “absolute plastic deformation rate.” Moreover, this argument ignores the fact that the claims

expressly define “absolute plastic deformation rate” in terms of a specific equation. Petitioner’s approach to this term would read out that claim language entirely.

VII. THE BOARD SHOULD NOT INSTITUTE INTER PARTES REVIEW

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

A. Ground 1: Nishikawa Does Not Anticipate Claims 1-10

64. Petitioner contends that Nishikawa anticipates Claims 1-10 of the ’927 Patent. These claims recite:

1. An electrochemical device, comprising:
a cathode;
an anode; and
a separator;
wherein, the separator comprises a porous substrate and a porous layer;
wherein the porous layer is disposed on a surface of the porous substrate and comprises inorganic particles and a binder; and
the porous substrate has an absolute plastic deformation rate in a first direction ranging from about 40% to about 1800%, and
wherein the absolute plastic deformation rate is calculated according to an equation $(L2-L0)/L0 \times 100\%$, where $L0$

refers to a length of the porous substrate before stretching and L2 refers to a length of the porous substrate after the porous substrate is stretched to breakage and docked along the fracture caused by the breakage and flattened.

2. The electrochemical device according to claim 1, wherein the porous substrate has an absolute plastic deformation rate in a second direction ranging from about 60% to about 1800%.

3. The electrochemical device according to claim 1, wherein the porous substrate has at least one of the following properties:

an absolute plastic deformation rate in the first direction ranging from about 40% to about 1600%; and

an absolute plastic deformation rate in the second direction ranging from about 70% to about 1600%.

4. The electrochemical device according to claim 1, wherein the porous substrate has at least one of the following properties:

a relative plastic deformation rate in the first direction ranging from about 50% to about 100%; and

a relative plastic deformation rate in the second direction ranging from about 60% to about 100%.

5. The electrochemical device according to claim 4, wherein the porous substrate has at least one of the following properties:

a relative plastic deformation rate in the first direction ranging from about 65% to about 90%; and

a relative plastic deformation rate in the second direction ranging from about 75% to about 90%.

6. The electrochemical device according to claim 1, wherein the binder comprises at least one selected from

the group consisting of a vinylidene fluoride-hexafluoropropylene copolymer, a vinylidene fluoride-trichloroethylene copolymer, polymethyl methacrylate, polyacrylic acid, polyacrylate, polyacrylonitrile, polyvinyl pyrrolidone, polyvinyl acetate, an ethylene-vinyl acetate copolymer, polyimide, polyethylene oxide, cellulose acetate, cellulose acetate butyrate, cellulose acetate propionate, cyanoethyl amylopectin, cyanoethyl polyvinyl alcohol, cyanoethyl cellulose, cyanoethyl sucrose, amylopectin, sodium carboxymethyl cellulose, lithium carboxymethyl cellulose, an acrylonitrile-styrene-butadiene copolymer, polyvinyl alcohol, polyvinyl ether, polytetrafluoroethylene, polyhexafluoropropylene, a styrene-butadiene copolymer, and polyvinylidene fluoride.

a relative plastic deformation rate in the first direction ranging from about 65% to about 90%; and

a relative plastic deformation rate in the second direction ranging from about 75% to about 90%.

7. The electrochemical device according to claim 1, wherein the inorganic particles comprise at least one selected from the group consisting of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zinc oxide, calcium oxide, zirconia, yttria, silicon carbide, eboehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide and barium sulfate.

8. The electrochemical device according to claim 1, wherein the porous substrate comprises a polymer film, a multilayer polymer film or a nonwoven fabric, wherein the polymer film, the multilayer polymer film or the nonwoven fabric is formed by any one or more of the following polymers: polyethylene, polypropylene, polyethylene terephthalate, polybutylene terephthalate, polyphenylene terephthamide, polyester, polyacetal, polyamide, polycarbonate, polyimide,

polyetheretherketone, polyaryletherketone, polyetherimide, polyamideimide, polybenzimidazole, polyethersulfone, polyphenylene ether, a cyclic olefin copolymer, polyphenylene sulfide or polyethylene naphthalene.

9. The electrochemical device according to claim 1, wherein the porous substrate has a thickness ranging from about 1 to about 40 μm .

10. The electrochemical device according to claim 1, wherein the electrochemical device comprises lithium ion batteries.

65. I disagree that Nishikawa expressly or inherently anticipates any of Claims 1-10 for at least the following reasons.

1. Nishikawa is Directed to a Different Problem and a Different Solution

66. First, Nishikawa and the '927 Patent are directed to two very different problems. Unlike the '927 Patent, which is directed to increased battery safety, Nishikawa is directed to the problem of a gap formed between the electrode and separator. Ex. 1004 ¶ [0004]. This gap is not related to safety but rather to battery life. *Id.*

67. Nishikawa and the '927 Patent also solve their different problems by focusing on entirely different aspects of the separator. The '927 Patent is focused on the properties of the porous substrate and concludes that “different types of porous layers have no significant influence on the nail penetration test passing rate.” Ex. 1001 at 22:65-23:5. In contrast, Nishikawa is not focused on the properties of the

porous substrate at all but instead is focused on the adhesive porous layer. *See, e.g.*, Ex. 1004 at Abstract (“The ratio of the standard deviation of the areal weight of the adhesive porous layer to the mean of the areal weight of the adhesive porous layer (g/m^2) (standard deviation/mean) is 0.3 or less.”). To the extent Nishikawa reports properties of the porous substrate, it is in the context of how the properties of the substrate will affect the target properties of the adhesive porous layer. *See, e.g.*, Ex. 1004 ¶ [0028] (“In the invention, the method for adjusting the ratio of the standard deviation to mean of the areal weight of an adhesive porous layer to be within a range of 0.3 or less may be a method that selects the physical properties of a porous substrate, such as variations in the thickness of the porous substrate, or selects a porous substrate having suitable physical properties such as elongation, puncture resistance, tensile strength, and Young's modulus.”). It is my opinion that a POSITA would not have considered disclosures regarding an adhesive porous layer when considering the porous substrate.

2. Nishikawa Does Not Disclose the Claimed Absolute Plastic Deformation Rate

68. Dr. Pecht opines that because “Nishikawa discloses the numeric values for several properties of the porous substrate that teach a plastic deformation rate as defined in the patent” that “[t]his disclosure can be considered an express (albeit indirect) disclosure of the plastic deformation rate via other metrics, as well as an

inherent disclosure of the plastic deformation rate.” Ex. 1001 ¶ 95. I disagree. Nishikawa does not expressly or inherently disclose the claimed absolute plastic deformation rate for at least the reasons below.

a. Nishikawa Does Not Disclose or Suggest “Absolute Plastic Deformation Rate” as Defined in the Claims

69. The claims of the ’927 Patent require that “absolute plastic deformation rate is calculated according to an equation $(\underline{L2}-L0)/L0 \times 100\%$, where $L0$ refers to a length of the porous substrate before stretching and $\underline{L2}$ refers to a length of the porous substrate after the porous substrate is stretched to breakage and docked along the fracture caused by the breakage and flattened.” *See, e.g.*, Ex. 1001 at Claim 1.

70. Dr. Pecht does not opine, and the Petition does not argue, that Nishikawa explicitly discloses $\underline{L2}$. Nor could they, because nowhere in Nishikawa does it say to measure “a length of the porous substrate after the porous substrate is stretched to breakage and docked along the fracture caused by the breakage and flattened.”

71. Indeed, Dr. Pecht admits that Nishikawa does not directly disclose absolute plastic deformation rate, $(L2-L0)/L0 \times 100\%$. *See* Ex. 1003 ¶ 97 (“[I]t [Nishikawa] does not directly provide a value for plastic deformation rates of its porous substrates.”); *id.* ¶ 120 (“Once again, Nishikawa does not provide numeric values for the percentage of elastic or plastic deformation . . .”).

72. Instead of identifying any explicit disclosure of **L2** or absolute plastic deformation rate, Dr. Pecht opines that a POSITA could use other values in Nishikawa to “*approximate* the claimed absolute plastic deformation rate $((L2-L0)/L0 \times 100\%)$.” *Id.* ¶ 97. But Dr. Pecht and Petitioner have failed to show that the “*approximated*” or “*estimated* plastic strain values” (*id.* ¶ 111) anticipate the claimed absolute plastic deformation rate for the reasons discussed below. Because the claims expressly require **L2** as part of the equation for absolute plastic deformation rate, and because Nishikawa does not disclose L2 nor provide sufficient information to calculate it, Nishikawa cannot anticipate the claims. Dr. Pecht attempts only to approximate or estimate the claimed absolute plastic deformation rate using hindsight, and fails to meet the burden to prove unpatentability.

b. The Petition and Dr. Pecht Rely on Incorrect Assumptions and Estimates

73. Dr. Pecht opines that a POSITA could “estimate” or “approximate” the claimed absolute plastic deformation rate based on three parameters disclosed in Table 1 of Nishikawa: (1) elongation, (2) tensile strength, and (3) Young’s modulus. *Id.* ¶ 97. In doing so, not only does Dr. Pecht overlook Nishikawa’s express disclosure of “elongation” without any explanation, but more importantly, he makes the incorrect assumption that his “estimate” of plastic deformation also accurately represents absolute plastic deformation rate, as claimed in the ’927 Patent.

(i) Dr. Pecht Ignores Nishikawa’s Definition of “Elongation”

74. **First**, Dr. Pecht overlooks Nishikawa’s expressly stated definition of “elongation” by stating that, in Nishikawa, “elongation . . . reflects $L1 - L0$, as those lengths are defined in the ’927 Patent.” Ex. 1003 ¶ 96. This conflicts with Nishikawa’s disclosure that elongation as used in that reference is actually the *quotient* of $L1/L0$, not the *difference* of $L1-L0$. Ex. 1004 ¶ [0134]. This fundamental error taints all of Dr. Pecht’s calculations.

75. Nishikawa discloses “[u]sing a tensile tester (RTC-1225A manufactured by A&D Company)” to stretch “a sample adjusted to 10 mm x 100 mm . . . under the following conditions: load cell load: 5 kgf, chuck-to-chuck distance: 50 mm, tensile rate:100 mm/min.” Ex. 1004 ¶ [0133]. A POSITA would have understood that the initial “chuck-to-chuck distance” of 50 mm is, at best, akin to $L0$ in the ’927 Patent, which is “[t]he length before stretching.” Ex. 1001 at 4:15-21. This is because the “chucks” are the clamps (i.e. opposing flat pieces of metal to grip the sample) by which the machine stretches the sample. Because the chuck is firmly grasping the sample, the assumption is that there will be negligible amount of sample stretching between the clamps themselves and that all the stretching will occur in the distance between the two chucks. Thus, the distance between the two chucks is the effective length of the sample before stretching. In the literature on

stress-strain testing this distance is also called the “gauge length” or “gauge distance.” *See, e.g.*, Ex. 1007 p. 120. A POSITA would have further understood that the “chuck-to-chuck distance at break” in Nishikawa is, at best, like L1 in the ’927 Patent, which is defined as “the maximum length L1 reached by stretching.” *Id.* Nishikawa expressly defines what it means when using the term “elongation”: “[t]he chuck-to-chuck distance at break was ***divided by*** the initial chuck-to-chuck distance of 50 mm, and ***the quotient*** was taken as elongation.” Ex. 1004 ¶ [0134] (emphasis added). Thus, if a POSITA were to represent elongation in Nishikawa in the terms of the ’927 Patent, a POSITA would have understood this disclosure to mean that Nishikawa defines “elongation” as $L1/L0$ —*not* $L1-L0$, which is what Dr. Pecht assumes. *Id.* Indeed, if “elongation” was really the difference ($L1 - L0$) that Dr. Pecht claims, then it would be represented with units of length (mm) and would not be represented as a unitless percentage. *See e.g.*, Table 1.

76. Further undercutting the analysis of Dr. Pecht and undercutting the viability of Nishikawa itself, is that the neither of these characterizations of “elongation” is consistent with the data in Table 1 of Nishikawa.

TABLE 1

	Porous Substrate						Adhesive Porous Layer				
	Thickness	Standard Deviation/ Mean of	Elongation	Puncture	Tensile	Young's	Adhesive Resin		Filler	Areal	Standard
	[μm]	Thickness	MD/TD	[g]	MD/TD	MD/TD	Kind	Mw	Ratio	[g/m ²]	Deviation/ Mean of Areal
Example 1	9	0.01	82/113	411	20/14	2.4/1.3	PVDF	1,950,000	0.01	2.3	0.13
Example 2	9	0.01	82/113	411	20/14	2.4/1.3	PVDF	1,950,000	0.03	2.4	0.28
Example 3	9	0.01	82/113	411	20/14	2.4/1.3	PVDF	1,950,000	0.05	2.4	0.20
Example 4	9	0.03	81/110	405	21/14	2.4/1.3	PVDF	1,950,000	0.01	2.3	0.25
Example 5	9	0.02	100/150	420	22/16	2.3/1.2	PVDF	1,950,000	0.5	2.5	0.30
Example 6	9	0.02	150/115	380	19/13	2.0/1.0	PVDF	1,950,000	0.5	2.4	0.29
Example 7	9	0.01	82/113	411	20/14	2.4/1.3	PVDF	600,000	0.01	2.3	0.28
Example 8	9	0.01	82/113	411	20/14	2.4/1.3	PVDF	3,000,000	0.01	2.3	0.29
Comparative Example 1	9	0.01	82/113	411	20/14	2.4/1.3	PVDF	1,950,000	0.10	2.4	0.40
Comparative Example 2	12	0.05	210/250	305	19/15	1.1/0.7	PVDF	1,950,000	0.01	2.3	0.39
Comparative Example 3	9	0.03	45/120	320	22/10	3.1/0.9	PVDF	1,950,000	0.01	2.3	0.35
Comparative Example 4	30	0.04	70/100	850	60/44	2.2/1.2	PVDF	1,950,000	0.01	2.3	0.41
Comparative Example 5	12	0.03	110/6	190	26/2	3.0/0.5	PVDF	1,950,000	0.01	2.3	0.33

Separator

77. If “elongation” as measured by Nishikawa were really the quotient (L1 divided by L0) that Dr. Pecht claims, then a POSITA would expect all the reported elongation values to be greater than 100% (because L1, the maximum length of stretching, will always be greater than L0, the initial length). But the data reported in Table 1 of Nishikawa includes multiple “elongation” values that are less than 100%. See Table 1 (elongation [%] column reported above; showing percentages of 82 and 81 in the MD direction, for example). Thus, and in addition to Dr. Pecht being incorrect, a POSITA would have to conclude either: (1) the definition of elongation in Paragraph 134 of Nishikawa is a typographical error, or (2) the reported data is incorrect.

78. It is more likely that a POSITA would conclude that there is some sort of typographical error in Nishikawa's Paragraph 134 because there are so many values in Table 1 that are less than 100%. *See, e.g.*, Table 1 (Examples 1-4, 7-8). Then, the POSITA would need to determine what Nishikawa *meant to say* elongation means. At best, a POSITA would assume Nishikawa meant to say that elongation is the difference between L1 and L0, divided by L0 (times 100, to arrive at a percentage as reported in Nishikawa). This definition would give weight to the "quotient" language in the definition (by dividing by L0) but also give weight to the fact that many of the reported elongation values are less than 100% (by using the difference between L1 and L0 as the numerator, rather than just L1 as the numerator). *See* Ex. 1004 ¶ [0134] ("The chuck-to-chuck distance at break was divided by the initial chuck-to-chuck distance of 50 mm, and *the quotient* was taken as elongation.") (emphasis added).

79. Given the unknowns related to the meaning of "elongation" in Nishikawa, Dr. Pecht's analysis and opinions regarding Nishikawa are unreliable. Dr. Pecht never acknowledges the express disclosure of Nishikawa that elongation is the quotient ($L1/L0$) *not* the difference ($L1-L0$). Dr. Pecht was therefore relying on assumptions that contradict the express disclosure of the prior art reference itself.

80. This failure to address the express disclosure of Nishikawa regarding the term "elongation" is significant because it illustrates Dr. Pecht's fundamental

misunderstanding of stress-strain behavior and, in my opinion undercut his ultimate conclusion that the POSITA could approximate the claimed absolute plastic deformation rate *Id.* ¶ 97 (“The ***total elongation of a material (L1 – L0)*** in combination with its tensile strength (stress at breakage) and Young’s modulus (a proxy for L1 – L2 as those lengths are defined in the ’927 patent) are inputs from which a POSA could approximate the claimed absolute plastic deformation rate ((L2 – L0)/L0 x 100%).”).

(ii) Dr. Pecht’s Estimation Calculations Do Not Accurately Reproduce Absolute Plastic Deformation Rate

81. ***Second***, Dr. Pecht’s analysis fails to show how the claimed absolute plastic deformation rate is disclosed because he incorrectly assumes that his other approximations for arriving at “estimated” plastic deformation are an accurate approximation of the claimed absolute plastic deformation rate. Dr. Pecht uses two alternative estimation calculations to reach his results. Both fail to accurately reproduce or measure the claimed absolute plastic deformation rate.

82. Dr. Pecht’s **first estimation calculation** works like this:

- He notes that total strain = plastic strain + elastic strain. *Id.* ¶ 106.
 - Thus, he concludes plastic strain (which Dr. Pecht equates to absolute plastic deformation rate) = total strain – elastic strain. *Id.*

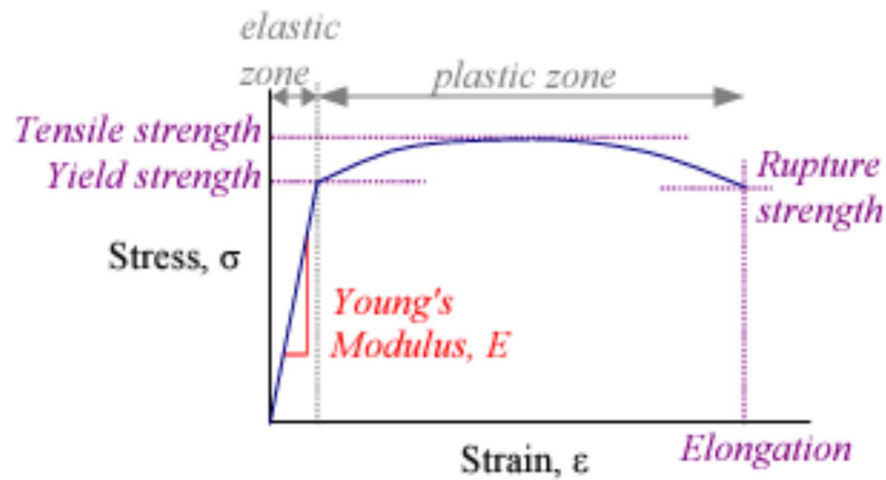
- Dr. Pecht assumes that elastic strain can be estimated as ($\approx$) tensile strength/Young's modulus. *Id.*
 - Thus, he concludes plastic strain $\approx$ total strain – (tensile strength/Young's modulus). *Id.*
 - Or, in terms of percentage: plastic strain % $\approx$ total strain % - ((tensile strength/Young's modulus)*100%). *Id.* ¶ 107.
- Dr. Pecht assumes that total strain % = elongation. *Id.* ¶ 108.
 - Thus, he estimates that **plastic strain $\approx$ elongation – ((tensile strength/Young's modulus)*100%).** *Id.*

In sum – Dr. Pecht takes the reported elongation, tensile strength, and Young's modulus parameters from Nishikawa Table 1; converts them to the same units so that they are consistent; and uses them in the bolded and underlined equation above to estimate “plastic strain,” which he, without support or evidence, claims is the same as “absolute plastic deformation rate.” *Id.* ¶¶ 104-108.

83. Dr. Pecht's first approximation (plastic strain $\approx$ elongation – ((tensile strength/Young's modulus)*100%)) is unreliable at least because it relies on the critical assumption that elastic strain can be estimated with reasonable accuracy as tensile strength/Young's modulus. *Id.* ¶ 106. This estimation is key to Petitioner's calculation of absolute plastic deformation rate. *See* Pet. at 32 (“Elastic strain for Example 1 MD can be approximated as follows: elastic strain = 0.222 GPa (breaking

strength) / 2.4 GPa (Young's Modulus) *100% = 9.25%. EX1003, ¶107. The elongation at break is 82%. Thus, the APD is approximated as follows: APD = 82% (strain at break) - 9.25% (elastic strain) = 72.75%. *Id.*”). However, as explained below, this estimation is incorrect.

84. Dr. Pecht does not clearly explain how he arrives at this assumption that elastic strain $\approx$ tensile strength/Young's Modulus in the claim-specific section of his report (Ex. 1003 ¶¶ 106-114), but he provides the below conceptual (not actual) drawing from a textbook in his technology background section and explains his assumption further in that section. I refer to it as a conceptual drawing because it does not contain any actual measurements or values and does not provide any identification of the relevant material, and because it represents an idealized and academic approximation of certain characteristics for an idealized material that differ from the stress-strain plots that a POSITA would expect and observe when testing actual physical materials.



Id. ¶ 62 (citing Ex. 1020, 18).

85. In my experience, this conceptual drawing illustrates an academic and idealized approximation of stress-strain behavior of a metal material. The conceptual drawing and others like it serve the same function as training wheels on a bicycle, in this case allowing materials scientists and engineers to learn beginning principles that apply to a few common metal alloys. These scientists and engineers, however, must later learn how most real materials including a variety of metals, ceramics, polymers, and composites depart from such idealized behavior. While this progressive introduction of ideas makes sense pedagogically, if interrupted at the

superficial stage it can lead to unfortunately incorrect ideas about how real materials behave.⁴

86. A POSITA analyzing a stress-strain plot would understand that the x-axis represents the strain on the material and the y-axis represents the stress that is put on the material. A POSITA would have also understood from the conceptual drawing that there is a distinct and specific point at which the curve changes abruptly from a diagonal straight line to a curved line. This point is called the yield strength. The section before the yield strength is called the elastic zone, and the point after the yield strength (up until breakage at rupture strength), is called the plastic zone. Young's modulus or modulus of elasticity is the slope of the diagonal line in the elastic zone.

87. A POSITA would have understood that there are many problems with using Dr. Pecht's method founded on such an idealized stress-strain plot to estimate the plastic strain of a porous substrate or a separator. In my opinion, the most glaring

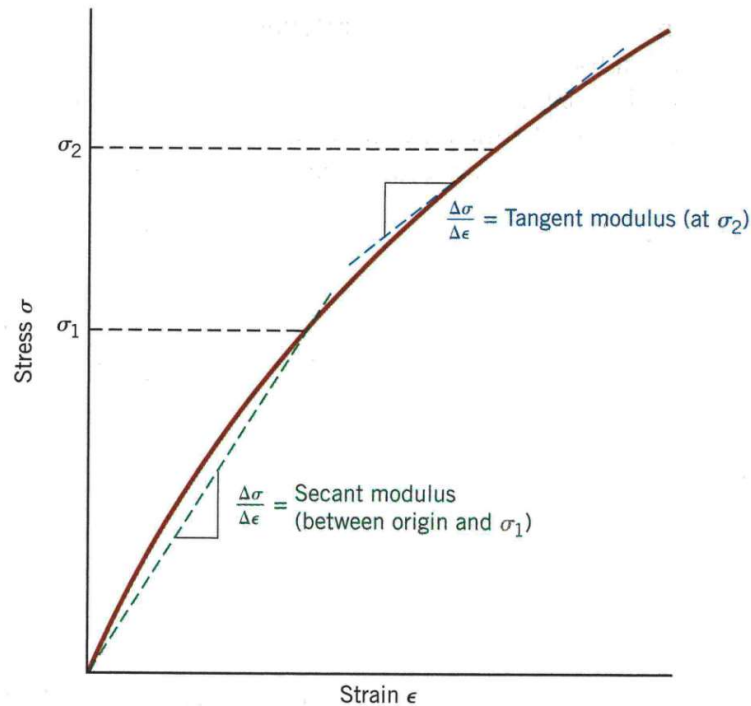
⁴ Callister and Rethwisch, Materials Science and Engineering: An Introduction, 9th ed., Wiley, 2014, for example is a widely used textbook that follows this teaching approach. I have excerpted several relevant pages as Ex. 2030. While the 9th edition is featured here, earlier related editions of the textbook have been in publication since 2000.

problem is that porous substrates and separators, particularly when based on polymeric constituents, depart in numerous substantive respects from the perfectly ideal behavior represented in this conceptual drawing, which I shall now enumerate.

88. In a real-world stress-strain plot for a polymer-based separator material, the stress-strain curve would not have an unambiguously linear (i.e. straight-line) elastic region whose slope remains constant. While Dr. Pecht claims that Young's modulus is "easily calculated" due to it being the slope of the linear portion of the stress-strain curve (Ex. 1003 ¶ 57), this is not the case for the majority of polymeric materials in use. Instead, the curve has a continuously changing slope, which means the value of Young's modulus is also changing as the material is elongated and is therefore ambiguous. Materials scientists deal with this problem by various means or conventions for producing a single value of Young's modulus, but each requires assumptions and arbitrary decisions and no single approach is universally accepted. For instance, the Callister and Rethwisch textbook teaches:

[t]here are some materials (i.e., gray cast iron, concrete, and many polymers) for which this elastic portion of the stress-strain curve is not linear (Figure 6.6); hence, it is not possible to determine a modulus of elasticity as described previously. For this nonlinear behavior, either the *tangent* or *secant modulus* is normally used.

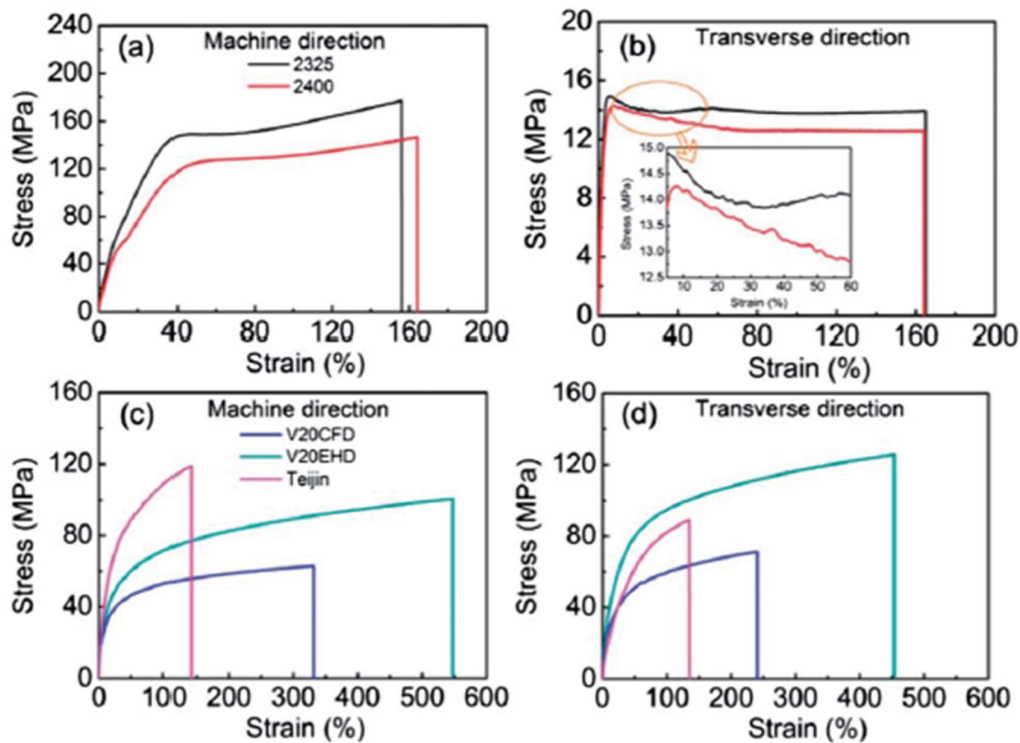
Ex. 2030, p. 175. The referenced textbook figure is shown below. Even if one decides to use the tangent or secant approach, the practitioner must make arbitrarily and potentially consequential decisions on what limit values (i.e. σ_1 or σ_2 as shown in the figure) to use to estimate Young's modulus from the full stress-strain curve.



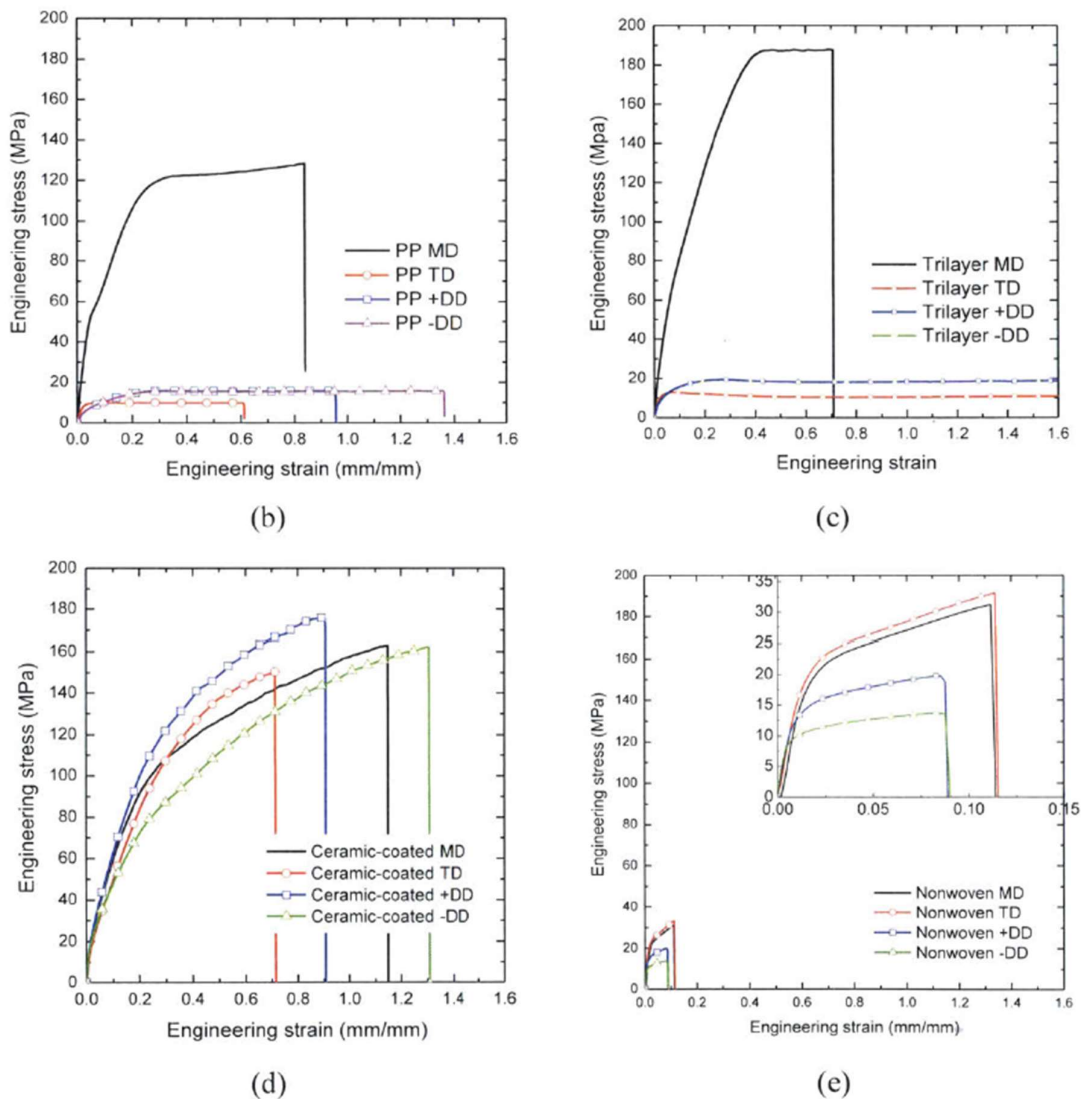
Ex. 2030 Figure 6.6, “Schematic stress-strain diagram showing nonlinear elastic behavior and how secant and tangent moduli are determined”

89. It would be difficult enough if a separator mechanically behaved in the manner of Ex. 2030 Figure 6.6, but the illustrative stress-strain plots given in the references Petitioner and Dr. Pecht themselves rely on present even more challenging cases far different than Dr Pecht’s conceptual drawing and approach.

Some example stress-strain plots from Chen and the Zhang Thesis, which Petitioner cited but does not appear to take into account when analyzing this claim element, are reproduced below.



Ex. 1005 at Fig. 3



Ex. 1007 at Fig. 3-1

90. As a POSITA would readily understand from these plots of porous substrates and separators, the materials at issue here do not necessarily behave in the same way as Dr. Pecht's idealized conceptual drawing. A POSITA would not and cannot assume that there is a clear demarcation between elastic strain and plastic

strain, or that Young's modulus can be unambiguously and exactly calculated for each material using a linear slope. Instead, the plots from Chen and Zhang confirm that there is elastic strain interwoven with the plastic strain and that there is significant elastic strain after the yield point, as further elaborated in Paragraph 97 below.

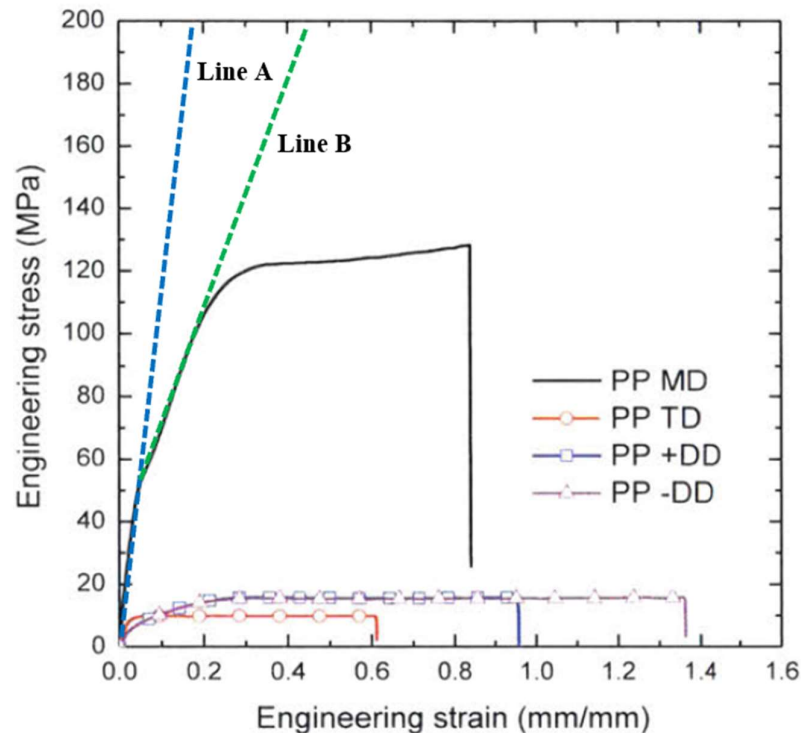
91. It is important in attempting to estimate the Young's modulus to ensure that it is determined only from the elastic region of the stress-strain curve, meaning it is obtained for the portion of the curve to the left of the so-called yield point (Ex. 2030, p. 181). Otherwise a Young's modulus incorporating information past the yield point would be incorrectly contaminated by initiation of plastic deformation. However, the stress-strain curve in a real-world stress-strain plot for a polymer-based separator has an ill-defined transition between elastic and plastic behavior (i.e. in contrast to the well-defined kink in Dr. Pecht's conceptual drawing indicating the yield stress point). This means one cannot be sure as to exactly where the yield point is, that is, where plastic behavior begins. Even for relatively ideal metals it can be hard to find the yield point, and various methods have been proposed.

92. The "offset method" that Dr. Pecht relies on (Ex. 1003 ¶ 59) is one such method used to estimate yield strength for metals. However, this is not an appropriate method for polymer-based materials, as pointed out by Callister and Rethwisch: "For materials having a nonlinear elastic region (Figure 6.6) *use of the*

strain offset method is not possible, and the usual practice is to define the yield strength as the stress required to produce some amount of strain (e.g., $\epsilon=0.005$).” Ex. 2030, p. 181. I would add that while this might be a favored alternative for estimating the yield *strength* (i.e. stress value) in a polymer, it nevertheless requires yet another consequential arbitrary choice, in this case determining a yield *strain* value at which one believes plastic behavior has begun. For instance, there is no reason to believe that strain $\epsilon=0.005$ is the correct start of plastic behavior for the polymer in question. We hereby have a bootstrapping problem: to determine where plastic behavior begins, one must start by choosing where plastic behavior begins. Dr. Pecht suggests no remedy to this circular logic because the question is not even in the ambit of his incorrect reliance on a procedure, namely the 0.2% strain offset method described below (explicitly incorporated into Dr. Pecht’s second estimation method, but also implicitly included in his first estimation method due to its reliance on determination of a single Young’s modulus) (Ex. 1003 ¶ 59), which is only appropriate to certain metals (and not polymers), as established above. In my opinion a POSITA would not rely on this erroneous approach in any consideration of Nishikawa’s separators.

93. Moreover, even if a POSITA could pick a point on a battery separator stress-strain plot as the yield strength and take the slope of a tangent or secant line at a second point to arrive at Young’s modulus, the resulting Young’s modulus value

would vary significantly depending on which second point is chosen. To illustrate this principle, I have drawn in two diagonal lines that a POSITA might pick to calculate slope (i.e. Young's modulus) from the separator data provided in the Zhang thesis. As can be seen, the result would vary widely depending on if a POSITA picks Line A or Line B (i.e. compare the slope of Line A to the slope of Line B). And, as a POSITA would have understood, there is no indication based on the plot alone as to which diagonal line is correct or should be chosen as "the" correct slope.

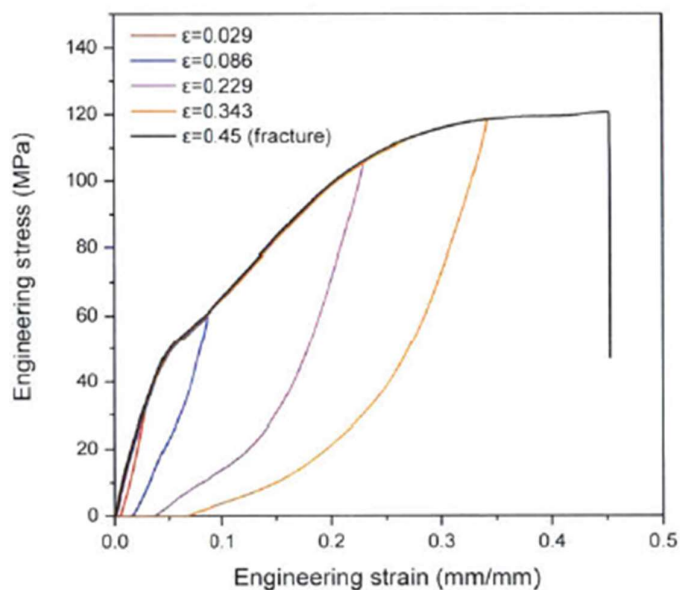


Ex. 1007 Fig. 3-1(b), modified to illustrate possible tangent or secant lines labeled Line A and Line B, in an ill-conceived attempt to determine a single Young's modulus for this material.

94. Thus, Dr. Pecht provides no actionable method for determining Young's modulus that would work for polymer-based separators, particularly for the stress-strain curves shown above that he and Petitioner rely on. These separator materials show no linear elastic behavior and no clear demarcation between elastic and plastic behavior and one's only option is essentially to make at least two arbitrary decisions controlling the determination of Young's modulus, which Dr. Pecht and cited prior art provide no guidance on. Instead, the plots from Chen and Zhang confirm that there is elastic strain interwoven with the plastic strain in a complex fashion.

95. Even if a POSITA had some measure of confidence in the Young's modulus determined in some fashion for a particular separator specimen, there is no guarantee that this simplified value would be valid in the unique context that Dr. Pecht's first estimation formula requires. **Dr. Pecht's formula assumes and therefore requires that the Young's modulus is constant across all possible stress values**, namely from zero stress all the way to the maximum stress the specimen can withstand, i.e. the tensile strength. However, as already established above there is every expectation that the Young's modulus for a polymeric separator would vary strongly across such a wide range of stresses. There is ample evidence of this in the stress-strain curves presented above from Chen and the Zhang thesis.

96. To see an elastic part of the stress-strain curve that has a widely varying slope and hence Young's modulus, we can also examine the colored stress relaxation curves shown below from another portion of the Zhang thesis (reproduced below). A POSITA would understand that the first four curves in this plot are obtained by partially elongating a specimen but not to the point of fracture and then stopping the elongation and instead allowing the specimen to relax back to zero stress. A POSITA would further understand that the downward stress-strain path (colored curve) followed during this relaxation is largely elastic. However in the plot we see that the colored relaxation curves are far from straight diagonal lines (constant slope), thus showing that Young's modulus is varying strongly along that path and violating a central assumption of Dr. Pecht's first estimation formula. It should also be pointed out that the orange curve (labeled " $\epsilon=0.343$ ") comes very close to the region in which Dr. Pecht wishes to apply his formula, namely at the tensile stress.



Ex. 1007 Fig. 4-12, showing “Force-displacement curves of interrupted test along MD”

97. This figure from the Zhang Thesis further shows that there is significant elastic deformation after Petitioner’s alleged yield point, even though a yield point cannot be precisely located for the reasons given above. It can be seen that Zhang’s colored “interrupted test” stress-strain curves of the PP separator exceed the alleged yield point at their as-labeled points of maximum strain because, as a POSITA would observe, there is permanent deformation following the relaxation/interruption process (i.e. because the engineering strain values at the final zero-stress relaxed points along the horizontal axis are not zero). For the curves labeled “ $\epsilon = 0.086$,” “ $\epsilon = 0.229$,” and “ $\epsilon = 0.343$,” the respective final relaxed strain values are approximately 0.017, 0.037, and 0.067. Although not done by Dr. Pecht, by taking

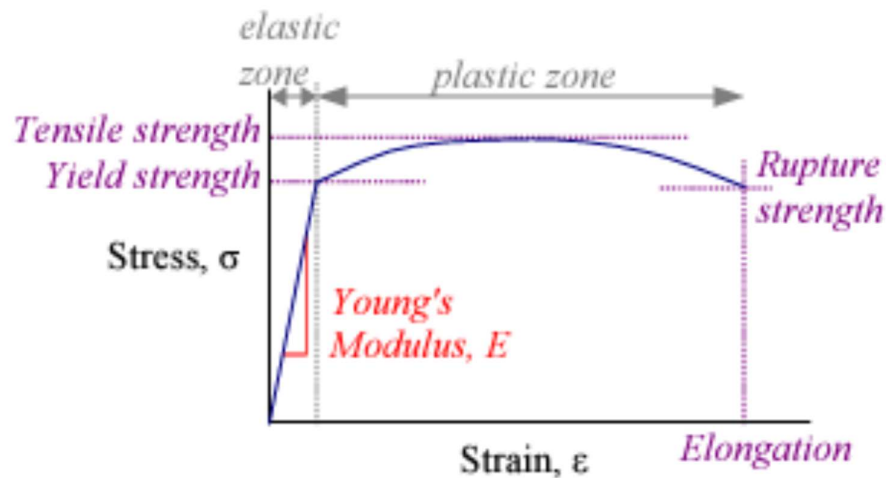
the difference between the maximum strain before relaxation and the final strain after relaxation, a POSITA could estimate the amount of elastic strain that occurred in each of the three curves. Specifically, this calculation results in respectively $0.086 - 0.017 = 0.069 = 6.9\%$, $0.229 - 0.037 = 0.192 = 19.2\%$, and $0.343 - 0.067 = 0.276 = 27.6\%$. Dr. Pecht's procedure would have us assume that the three curves have the same elastic strain because each exceeds or traverses the yield point, and that the amount of elastic strain is exactly equal to the yield strain. Instead, what a POSITA observes in the Zhang FIG. 4-12 data is each interruption and relaxation experiment shows a distinct and widely dissimilar value of elastic strain even though each test did exceed Petitioner's alleged yield point. Furthermore, a POSITA observes during the stretching process of Zhang's PP separator in the MD direction, the greater the deformation beyond the yield point, the greater the amount of elastic deformation involved. It can be seen from this example that the elastic deformation that happens within the so-called "plastic zone" is not zero as Dr. Pecht assumes and can far exceed the elastic deformation that happens within the so-called "elastic zone" of the stress-strain curve. For example, Zhang's curve labeled " $\epsilon = 0.343$ " has about 27.6% elastic strain, most of which occurs in the "plastic zone," as compared to about 6.7% plastic strain. Finally, a POSITA would also see in this example that the alleged yield point, even if it could be determined with any exactness for a polymer-based separator, cannot be used simply as the boundary point between mutually

exclusive elastic deformation (on the one side) and plastic deformation (on the other side) along the stress-strain curve.

98. Moreover, Dr. Pecht's first estimation formula fails for another reason. The formula explicitly uses **tensile strength and not rupture strength** to estimate the amount of elastic relaxation that would occur upon failure of the specimen (Ex. 1003 ¶¶ 106-108).⁵ This is perhaps understandable on Dr. Pecht's part as tensile strength would be required to apply his formula to Nishikawa's data. Nishikawa only reports tensile strength and not rupture strength in Table 1 (Ex. 1004). Tensile strength, also known as ultimate strength, is the maximum stress the specimen experiences in the stress-strain path. As shown even in Dr. Pecht's conceptual drawing from Ex. 1020 (reproduced below), tensile strength is not necessarily the same as rupture strength, also known as fracture or breaking strength, which is the stress value at which the specimen fails.⁶

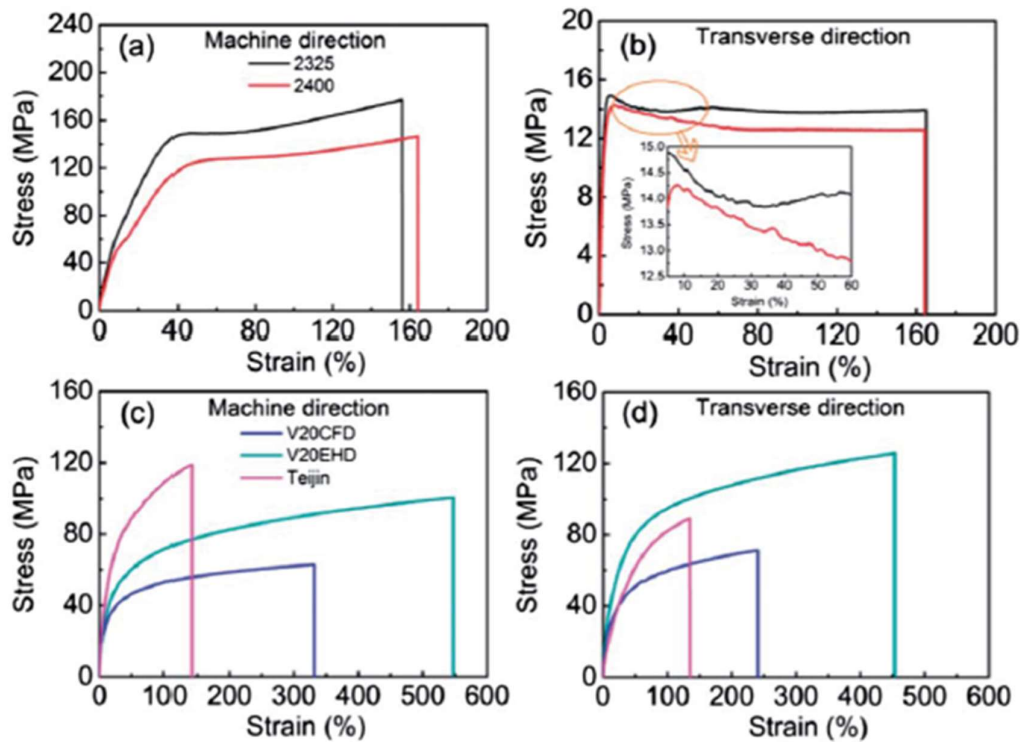
⁵ Note that Pecht in Ex. 1003 paragraph 61 uses "stress at breakage" when developing his formula but when it comes to Nishikawa and paragraphs 106-108 starts using tensile stress instead.

⁶ The text portion of Ex. 1020 also provides no reason to assume that tensile strength and rupture strength will be equal.



That tensile strength and rupture strength are distinct values would be well understood by a POSITA trained in strength of materials (Ex. 2030 p. 182; Ex. 1018 p. 60; Ex. 1019 p. 8). For Dr. Pecht's formula to be able to correctly estimate the elastic relaxation that would occur following failure of the specimen, and thereby match the claimed absolute plastic deformation rate, Dr. Pecht's first estimation formula (plastic strain $\approx$ elongation – ((tensile strength/Young's modulus)*100%)) would have to be based on the **rupture or fracture strength**, not the tensile strength. This is because the claimed formula for absolute plastic deformation rate ("absolute plastic deformation rate is calculated according to an equation $(L_2 - L_0)/L_0 \times 100\%$, where L_0 refers to a length of the porous substrate before stretching and L_2 refers to a length of the porous substrate after the porous substrate is stretched to **breakage** and docked along the fracture caused by the breakage and flattened") and associated experimental method ("The length before stretching is recorded as L_0 ; the porous

substrate of a certain length and width is *stretched to break* at a certain rate, and the maximum length reached by the stretching is recorded as L1; and then the broken porous substrates are docked along the *fracture* and flattened to test the length L2 in a natural state.”) rely on the elastic recovery of the specimen from the stress that existed at the point of failure or breakage, not from the maximum stress that existed at the potentially earlier tensile strength point. ’927 Patent at claim 1, 4:14-21, Fig. 1. A POSITA would know that for some especially more brittle samples, that the tensile and rupture strength may be the same, but such is not the case for all polymeric samples, including in many of the below examples. For example, in Figure 3 of Ex. 1005, subpart (a) shows a rupture strength that is higher than the yield strength, whereas subpart (b) shows a rupture strength that is lower than the yield strength.



Ex. 1005 at Fig. 3

99. Therefore a POSITA would have understood that Dr. Pecht's first estimation formula that uses tensile strength fails to estimate or approximate the claimed absolute plastic deformation rate because it uses tensile strength rather than rupture, fracture, or breaking strength that is necessary to calculate the claimed absolute plastic deformation rate.

100. Furthermore, Nishikawa does not in fact provide stress-strain curves for its embodiments.⁷ This means that a POSITA cannot be certain of the reliability and appropriateness of the Nishikawa's reported values for tensile strength and Young's modulus (Nishikawa Table 1 for the embodiments) without such a strain curve, which would be necessary but not sufficient for a POSITA following Dr. Pecht's procedure to determine whether Nishikawa meets the claim requirements. These values in Nishikawa for one test at one point may have some utility to the practitioner, but certainly they are not fit for the purpose of Dr. Pecht's uniquely calculated estimate of plastic strain, a purpose and approach not taught in Nishikawa or other cited prior art.

101. Thus, for at least these reasons, Dr. Pecht's method of estimating plastic strain is based on a series of unreliable assumptions that do not reflect the real-world behavior of the porous substrates and separators that are recited in Nishikawa.

⁷ Dr. Pecht later tries to cure this deficiency in Nishikawa by combining with Chen which purportedly provides stress-strain curves for the same Teijin separators as Nishikawa (*E.g.* Ex. 1003 ¶¶ 141, 148-55). However, as shown in Paragraphs 130-131, 164-71 below, the substantial differences in materials and/or experimental methods between Chen and Nishikawa do not in fact allow Chen to cure Nishikawa.

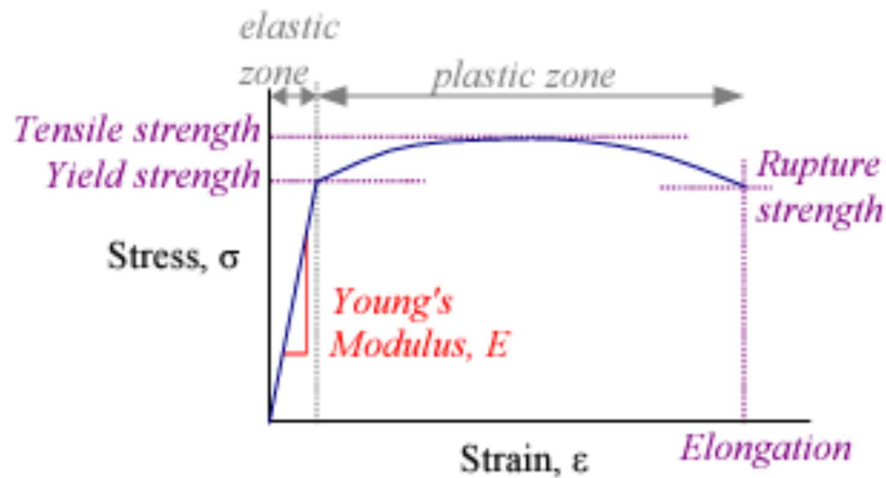
Therefore, a POSITA would not and cannot rely on Dr. Pecht's calculation to disclose or teach the claimed absolute plastic deformation rate.

102. Dr. Pecht's **second, alternative estimation calculation** is what he calls the "0.2% offset method." *Id.* ¶ 109. This estimation approach is even less scientific and fails for many of the same reasons.

103. Dr. Pecht states that "[i]f the yield strength is equal to the tensile strength (and the separator deforms plastically at a stress equal to the tensile strength until breakage), the 0.2% offset line will intersect the stress st[r]ain curve at a strain 0.2% greater than the elastic strain." *Id.* This estimation method is flawed for the same reasons stated above with respect to the first estimation method—it relies on the stress-strain curve of a metal material following the perfect idealized form.

104. It also adds other assumptions to the mix that are unsupported: (1) that the yield strength is equal to the tensile strength, and (2) the separator deforms plastically—and only plastically—beginning at a stress equal to the tensile strength and continuing until failure occurs. *Id.* In other words, Dr. Pecht already incorrectly assumed for the first calculation that tensile strength and rupture strength are the same, but now he is making the additional assumption that all three (tensile strength, rupture strength, and yield strength) are the same. If this were true, the stress-strain curve would be perfectly horizontal throughout the plastic zone starting at a well-defined yield strength point, rather than having any curvature. None of the example

stress-strain curves Dr. Pecht has cited shows that, not even the conceptual drawing of what would be expected in an ideal world for a metal material.



Ex. 1020

105. Dr. Pecht gives no reason why these assumptions for his second estimation formula are likely to be true for the porous substrates in Nishikawa. He recites that “[a]s described above, elastic strain **at any stress value** (such as the stress at breakage) can be estimated by dividing the **tensile strength** by Young’s modulus. EX1018, 63-65”. Ex. 1003 ¶ 106, emphases added. This statement by Dr. Pecht is manifestly incorrect, even if one assumes that Young’s modulus is constant and unambiguous (which it is not, as discussed above). The correct approach within Dr. Pecht’s assumptions would be to calculate the elastic strain at a given stress value by dividing the given stress value (not the tensile strength) by the Young’s modulus.

This fundamental misunderstanding by Dr. Pecht may explain why he further confounds tensile strength with rupture strength as discussed in Paragraph 98 above.

106. Dr. Pecht further recites in his justification for the second estimation formula that “[t]he elastic strain can be estimated using a 0.2% offset. EX1018, 61; EX1019, 8; E1021, 87.” Ex. 1003 ¶ 106. When one examines these purported sources for this teaching, one finds the following. Ex. 1018 and Ex. 1021 are both “mechanics of materials” textbooks and on respectively cited pages 61 and 87 they recommend the 0.2% offset method as appropriate for *estimating the yield strength of aluminum* due to its ductility, with no mention of its appropriateness for polymers. Indeed Ex. 1021 at p. 88 instead warns a POSITA that polymers (such as natural rubber) must be treated differently due to the stress and strain not being proportional, meaning they exhibit nonlinear elastic behavior. This would be true of Nishikawa’s polymers. As for Ex. 1019 at p. 8 as cited by Dr. Pecht, it in turn refers to Ex. 1015 as its source and cites using a “2% offset yield” method in order to estimate tensile strength for polymeric separators. While this method is not well-explained in either Ex. 1019 p. 8 or the primary source Ex. 1015 p. 4428, it is important to note that 2% offset is not the same as Dr. Pecht’s 0.2% offset value, and the method is clearly posed as a method to estimate tensile strength, not yield strength as claimed by Dr. Pecht. In other words, there is no cited teaching that the 0.2% offset method is appropriate for analyzing polymeric materials such as

separators. And in fact, as I showed in Paragraph 92 above, a widely used textbook teaches expressly against such a practice being appropriate (Ex. 2030). Moreover, the stress-strain curves provided in Chen and Zhang further confirm that these type of assumptions are incorrect for polymeric materials. Again, it is my opinion that such conclusory and unsupported assumptions cannot be relied upon.

(iii) Dr. Pecht's Conclusory Statements and Analogies Fail

107. *Finally*, Dr. Pecht makes the conclusory statement that “the values disclosed in the prior art are so comfortably within the claimed range, a POSA would know that any differences in the method of measurement can be disregarded.” Ex. 1003 ¶ 103. Dr. Pecht cites no support for this baseless speculation, such as a standard deviation or other means of adjusting for error. A POSITA would not have relied on such unsupported and unscientific statements.

108. In making his argument, Dr. Pecht relies on an analogy of a mercury thermometer and an alcohol thermometer in his attempts to invalidate the precise claim language. *Id.* ¶¶ 98-103. He equates the patented calculation for absolute plastic deformation rate to measuring a composition's temperature with a mercury thermometer. *Id.* ¶¶ 99-100. In this analogy, the estimation calculations are akin to measuring the same composition but with an alcohol thermometer, which will not necessarily give the same reading. *Id.* He reasons that “[t]he difference in accuracy

of an alcohol thermometer is not enough to risk bringing the measured value . . . outside the claimed range.” *Id.* ¶ 100.

109. I disagree with this logic, especially given that Dr. Pecht is relying on an unrelated series of calculation steps, not just pure measurements as claimed in the thermometer analogy, in an attempt to render a previously recited formula unpatentable. Even if the analogy were correct, which it is not, Dr. Pecht provides no reported data showing how far off his approach would be from the ’927 claimed method for determining an absolute plastic deformation rate.

110. The same lack of comparison is true with Dr. Pecht’s estimations based on a subset of Nishikawa’s examples that share common mechanical properties. Ex. 1003 ¶¶ 104-08. He provides no data or explanation to quantify the difference between plastic strain values using his estimation calculations and the claimed absolute plastic deformation rate values using the claim language’s calculation. Without providing that difference, Dr. Pecht is left to simply wave his hands and assume that the difference would not be big enough to make Nishikawa’s plastic strain fall outside the claimed range. There is no support for this unscientific assumption. In contrast, as shown above, the errors in Dr. Pecht’s calculation approach are so significant and substantial that a POSITA would never have attempted it, in contrast to Dr. Pecht, to potentially assess and disregard “any differences in the method of measurement.” Ex. 1003 ¶ 103.

111. Dr. Pecht's other analogy, regarding density, is also misplaced. Given the incorrect assumptions and estimations Dr. Pecht makes for both the first and second estimation calculations, Dr. Pecht is incorrect that "[e]ven though [Nishikawa] does not directly provide a value for the plastic deformation rates of its porous substrates, Nishikawa nonetheless discloses these values in the same way that a reference discloses, for example, the density of an object by providing its mass and volume." Ex. 1003 ¶ 97. Using this same analogy, Dr. Pecht's proposal would estimate density (absolute plastic deformation rate) based on the wrong mass (elongation) and the wrong volume (tensile strength and Young's Modulus). His resulting approximations therefore remain incorrect because they use incorrect inputs, as well as being the wrong calculations entirely.

c. The Petition and Dr. Pecht Ignore Different Parameters that Affect Stress-Strain Behavior

112. In his estimations, Dr. Pecht relies extensively on data that a POSITA would expect to obtain from a stress-strain plot, such as elongation at failure, tensile strength, and Young's Modulus. *See, e.g.*, Ex. 1003 ¶¶ 104-11. But the deformation and failure properties of a material, and therefore its stress-strain behavior, may be affected by factors that Dr. Pecht entirely failed to consider, such as stretching rate, chuck-to-chuck distance, and sample size.

113. **First**, the rate at which one stretches a material necessarily impacts the deformation properties of that material, and thus its stress-strain behavior. It is well-known for thermoplastic polymer materials that they act as a visco-elastic material. That means that, if you stretch them slowly or quickly, as quantified by the strain rate, it changes their mechanical response. If you stretch a specimen slowly, it yields more readily and can stretch a longer distance. But if you stretch it quickly, it will generally fail more readily and therefore snap, i.e. demonstrate brittle fracture. *See, e.g.,* Ex. 2030 at p. 581 which states “[t]he mechanical characteristics of polymers, for the most part, are highly sensitive to the rate of deformation (strain rate)...” among other factors. One can also observe strain-rate dependence of the failure of commercial battery separators as recorded in the figures from Kalnaus (Ex. 2028) reproduced below in Paragraph 123.

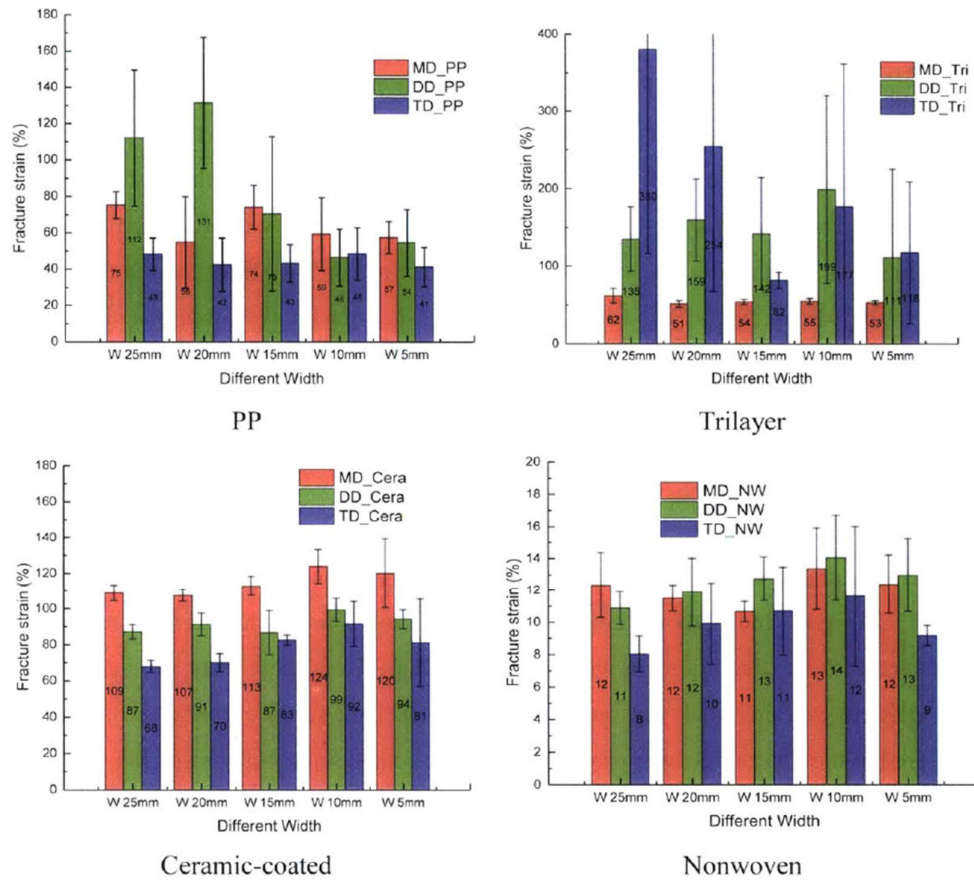
114. **Second**, a POSITA would have understood that, in the case where a sample is stretched all the way to breakage, sample geometry may impact the failure point of the sample and thus its stress-strain behavior. In classical mechanics, a POSITA would expect sample geometry (including chuck-to-chuck distance and sample width) to be normalized such that a stress-strain curve is not affected by changes in sample geometry. **However**, when stretching a sample all the way to the point of breakage, as is the case here, chuck-to-chuck distance may impact the failure point of the sample, and thus its stress-strain behavior. Sample thickness, width, and

total length also may impact the deformation properties of the material when stretching that material to breakage, and thus impact its failure point on the stress-strain plot. Ex. 2030, p. 588.

115. That chuck-to-chuck distance may impact the failure point of a sample is illustrated by the Lund and Byrne paper. Ex. 2031. In observations of material failure going even back to Leonardo da Vinci, the failure point of a sample of a material is partially determined by the presence of defects, sometimes microscopic and difficult to detect, in the sample. Any one of these defects under the action of tensile stress can grow and become the source of failure of the entire specimen. A specimen with greater volume, such as greater chuck-to-chuck distance, will have more defects present and therefore more likelihood of producing failure at an earlier point in the elongation process. This can be related to the principle that a chain is only as strong as its weakest link, and any defect present can act as this point of weakness. The higher the number of links, the more likely that one of those links will have a defect. Nevertheless, material failure is a complex process and there could be other geometry-related effects that are important. In some instances, a wider specimen might be less likely to fail. Such instances are akin to having multiple chains in parallel, such that any one chain that is strong can carry the load for weaker chains, leading to less likelihood of failure for the material as a whole. These principles mean that specimen geometry must be considered in addition to the

identity of the material when stress-strain data are taken to the point of failure, in contrast to a naïve assumption that geometry is not important.

116. That sample width may impact the failure point of a sample is illustrated by Dr. Pecht's cited art, the Zhang Thesis (Ex. 1007). Figure 3-2 of the Zhang Thesis (reproduced below) illustrates how samples with different widths exhibit different deformation properties. Notwithstanding statistical uncertainties shown in the plot, the wider PP and trilayer samples in Zhang's data tend to experience failure less readily, i.e. fail at a greater elongation distance as given by fracture strain (%) in the vertical axis. On the other hand, the ceramic-coated and nonwoven separators appear to show a modest reverse trend. In either case, the data show the complex interactions of both geometry and material identity on testing to the point of failure.



Zhang at Fig. 3-2

117. Despite the substantial impact these parameters have on stress-strain behavior, Dr. Pecht fails to acknowledge that all of them—stretching rate, chuck-to-chuck distance, and sample width—are different in Nishikawa than in the '927 Patent. In Nishikawa, the stretching rate is 100 mm/min, whereas in the '927 Patent the stretching rate used in its embodiment is 50 mm/min. *Compare* Ex. 1004 at [0133]-[0135] *with* Ex. 1001 at 10:31-33.

118. Similarly, in Nishikawa the initial chuck-to-chuck distance of the sample tested is 50 mm. Ex. 1004 ¶¶ [0133]-[0135]. In the '927 Patent's embodiment, however, the initial distance of the sample is 40 mm. Ex. 1001 at 10:26-28. Moreover, in Nishikawa the sample dimensions are 100 mm by 10 mm, whereas the sample dimensions in the '927 Patent's embodiment are 100 mm by 20 mm, meaning the respective widths differ by a factor of 2. Ex. 1004 ¶¶ [0133]-[0135]; Ex. 1001 at 10:26-28.

119. Dr. Pecht failed to consider and account for the effects of any of these three parameters on the stress-strain plot values reported in Nishikawa, let alone all three. This is yet another reason why his analysis is unreliable and does not show the claimed absolute plastic deformation rate is present or disclosed in Nishikawa.

d. Nishikawa Does Not *Inherently* Disclose the Claimed Absolute Plastic Deformation Rate

120. Dr. Pecht relies on the same opinions addressed above as grounds for inherent anticipation, and I disagree for the same reasons listed above. For at least those reasons, Dr. Pecht and Petitioner have not shown that his estimated plastic strain discloses the claimed absolute plastic deformation rate—even inherently.

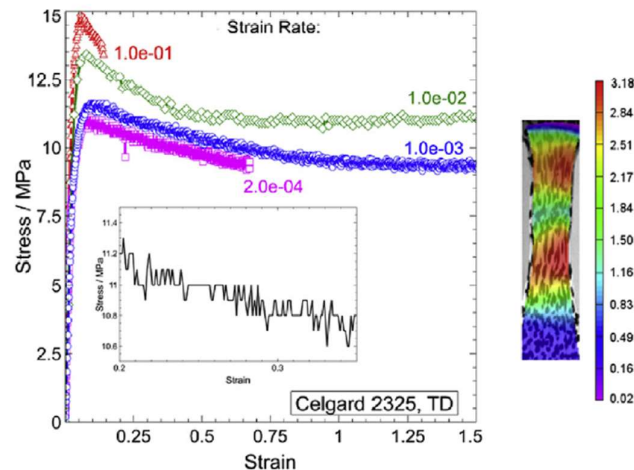
121. In addition, Dr. Pecht argues that “even without performing the calculations, a POSA would understand the plastic deformation rate of Nishikawa's porous substrate to be within the claimed range.” *Id.* ¶ 112. He reasons that “[a]

thermoplastic resin with a high elongation at break will *necessarily* exhibit a large degree of plastic deformation, because the elongation for these materials come from the plasticity and not elasticity.” *Id.* Dr. Pecht cites to images from the Zhang Thesis to support this argument, without explaining how those images show support for the particular claimed range in the claims of the ’927 Patent. *Id.* ¶ 113.

122. I disagree with Dr. Pecht’s conclusory and unsupported opinion that Nishikawa’s separator necessarily discloses the claimed absolute plastic deformation rate because (1) the claimed range is high, (2) thermoplastic resins typically have high plastic deformation rates, and (3) Nishikawa uses a thermoplastic resin. Not all thermoplastic resins are created equal.

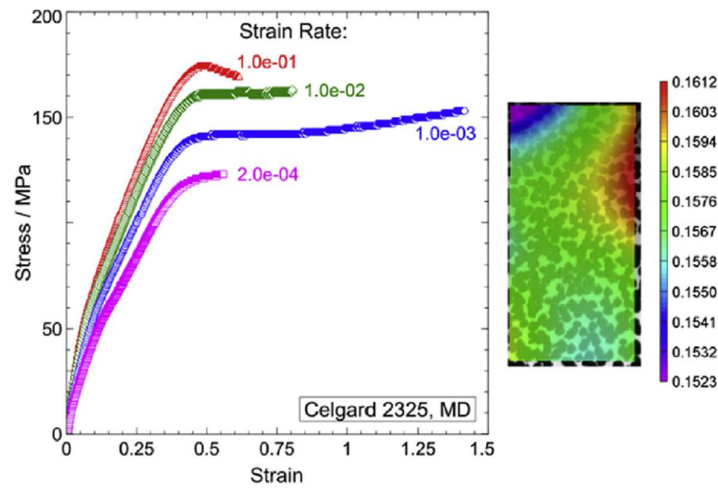
123. Indeed, even using Dr. Pecht’s rough estimation calculations, there are multiple examples of thermoplastic resin samples that have less than 40% plastic strain. Some examples are shown in the Kalnaus reference (Ex. 2028) and reproduced below. Each figure shows stress-strain results for samples of commercially available battery separators, meaning common thermoplastic materials that would be known and available to a POSITA, which are tested under different strain rates (thus reinforcing the point made in Paragraph 113 above). In each figure one or more of the samples shows a strain at failure of less than 0.4, meaning that total strain or deformation was less than 40%. For instance, in Kalnaus Figure 8(b) all four samples failed at 15% or less total strain. Because total strain

includes both elastic and plastic contributions, as Dr. Pecht correctly identifies, even when a sample fails at total strain greater than 40%, some portion of that strain is elastic and so the absolute plastic deformation, as defined by the '927 Patent, could have nevertheless been less than 40% for that sample. For instance, in Kalnaus Figure 6(a) all four samples appear to have failed with little to no plastic deformation, though as pointed out above it is difficult to quantify this without doing the specific testing and calculation as taught by the '927 Patent.



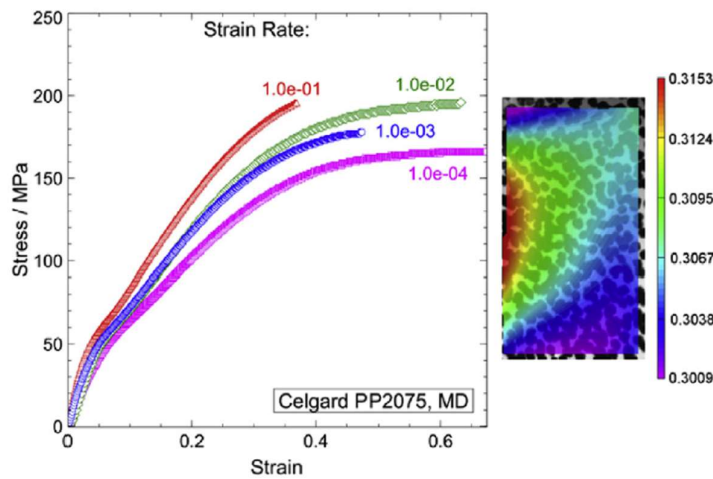
(a)

Ex. 2028 at Fig. 3(a)



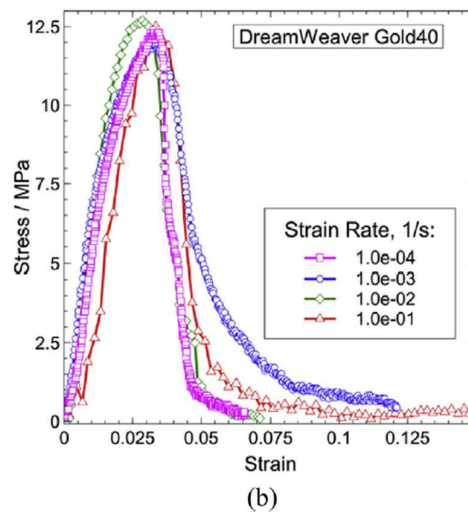
(a)

Ex. 2028 at Fig. 5(a)



(a)

Ex. 2028 at Fig. 6(a)



Ex. 2028 at 8(b)

124. Nothing about these facts, without appropriate experiments and calculations, indicates what the plastic strain of the Nishikawa thermoplastic resin actually is. Thus, Dr. Pecht has not shown that Nishikawa discloses, even inherently, the claimed range.

3. Claims 2-10 Are Not Unpatentable

125. Claims 2-10 are not unpatentable for the same reasons as discussed above with respect to independent claim 1. I reserve the right to address Claims 2-10 individually if this proceeding is instituted.

B. Ground 2A: Nishikawa Does Not Render Obvious Claims 1-10

126. Petitioner and its expert contend that Nishikawa renders obvious Claims 1-10 of the '927 Patent, which are reproduced above with respect to Ground

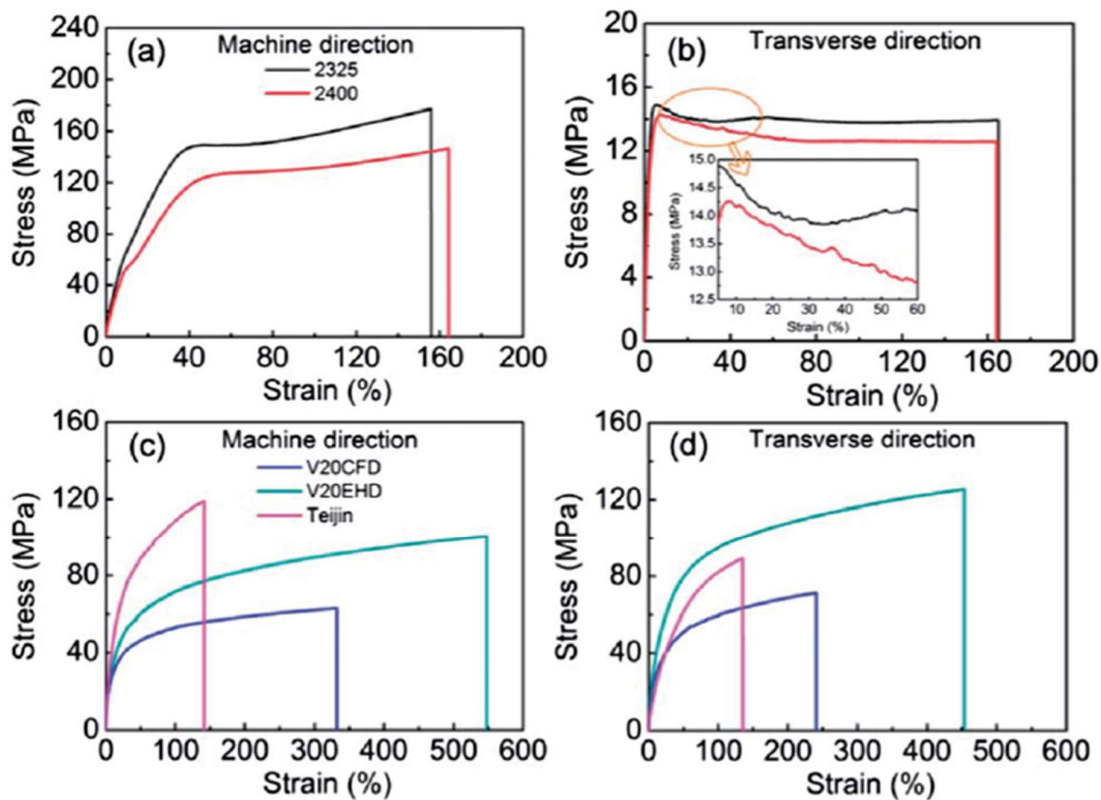
1. I disagree for at least the following reasons, in addition to the reasons I raised with respect to Ground 1.

127. Dr. Pecht opines that, even if Nishikawa does not expressly or inherently anticipate the claims of the '927 Patent, Nishikawa still renders them obvious because (1) absolute plastic deformation rate is an “inherent” property of porous substrate materials and Nishikawa’s substrates “necessarily” have absolute plastic deformation rates within the claimed ranges, (2) Table 1 of the '927 Patent found no significant difference in absolute plastic deformation rates between separators with and without porous layers, and (3) Nishikawa describes the materials, molecular weight, and preparation process for its porous substrate and thus a POSITA could “obtain an absolute plastic deformation rate within the claimed range for any of Nishikawa’s example substrates, at least by manipulating the stretching ratio.” Ex. 1003 ¶¶ 136-40. I disagree on all three fronts.

128. First, while absolute plastic deformation rate is a value at least in part related to the porous substrate materials used, I disagree that Nishikawa’s substrates *necessarily* have absolute plastic deformation rates within the claimed ranges. Dr. Pecht provides no support for this opinion, and as stated above in Paragraphs 120-24, I disagree that Nishikawa inherently discloses the claimed ranges.

129. Moreover, a POSITA would have understood that deformation properties of porous substrates are not all the same and can vary widely. Indeed, the

Chen reference Dr. Pecht cites would underscore this point to a POSITA. Chen shows various separators and the differences in how their stress-strain curves and deformation properties:



Ex. 1005 at Fig. 3

130. Dr. Pecht's own calculations also show the extreme differences in plastic strain, which Dr. Pecht (incorrectly) equates to absolute plastic deformation rate. In conjunction with Ground 2B, Dr. Pecht opines that the Teijin separator in Chen "is the same PE substrate disclosed in Nishikawa, made by the same company

as the applicant and assignee of the Nishikawa patent.” Ex. 1003 ¶ 160. Despite the unsupported opinion that Nishikawa substrate and the Chen substrate are the same material, Dr. Pecht’s own calculations for the plastic strain of these two separators vary widely. He opines that the Nishikawa substrate has a plastic strain of 72.55-72.75% in the MD direction (*id.* ¶ 110), whereas the Chen separator has a plastic strain of 137.2-141.57% in the MD direction (*id.* ¶ 155). This significant difference, especially given Dr. Pecht’s opinion that both use the allegedly *same* material, underscores the complexity of calculating plastic strain and the unreliability of Dr. Pecht’s method of calculating that plastic strain.

131. This large difference in Dr. Pecht’s calculations only confirms that (a) plastic deformation properties are not necessarily the same across porous substrates—or even the same porous substrate; and/or (b) Dr. Pecht’s stress-strain plot-dependent approximations and estimations are not reliable.

132. Thus, a POSITA could not simply assume that the Nishikawa porous substrate has the same absolute plastic deformation rate as the claims of the ’927 Patent simply because it is also a porous substrate—which is what Dr. Pecht assumes and concludes.

133. Second, the fact that Table 1 of the ’927 Patent found no significant difference in absolute plastic deformation rates between separators with and without porous layers does not dictate that the claimed ranges would have been obvious. As

the '927 Patent states, the conclusion to be drawn from the fact that there is no significant difference in absolute plastic deformation rates between separators is that differences in the porous substrate—not the porous layer—is what matters for absolute plastic deformation rate. Ex. 1001 at 22:65-23:5. Other factors, such as the stretching ratio, would impact the absolute plastic deformation rate. Nothing about this conclusion would lead a POSITA to believe that the claimed ranges would be obvious. Dr. Pecht's opinion to the contrary is conclusory, unscientific, and lacks any explanation.

134. Third, Dr. Pecht's opinion that a POSITA *could* “obtain an absolute plastic deformation rate within the claimed range for any of Nishikawa's example substrates, at least by manipulating the stretching ratio” does not render the claimed ranges for absolute plastic deformation rate obvious. Even if this were true, just because a POSITA *could* experiment and manipulate the absolute plastic deformation rate of a porous substrate does not mean that a POSITA *would* do so and arrive at the claimed ranges. Without the teachings of the '927 Patent, which explains why the claimed ranges are valuable and critical, there is no reason a POSITA would have been motivated to manipulate the absolute plastic deformation rate of a porous substrate in order to arrive at the claimed rates.

135. That there is no motivation to arrive at the claimed ranges is clear from the fact that Nishikawa has both a different problem and solution. As I explain above

in Paragraphs 66-67, Nishikawa is directed to increasing battery life by achieving certain properties of the porous layer, thereby preventing a gap from being formed between the separator and electrode. Thus, a POSITA following Nishikawa's teaching would be focused on adjusting the properties of the porous layer—not the porous substrate. And as explained above in Paragraphs 50-57 and 66-67, the '927 patent teaches that it is the porous substrate that affects absolute plastic deformation rate. In other words, a POSITA working from Nishikawa would not be motivated to adjust the properties of the porous substrate layer or to adjust the absolute plastic deformation rate. Even if they would, Dr. Pecht gives no reason why a POSITA would have a reasonable expectation of success in arriving at the claimed ranges, and fails to identify any material or combination of materials from Nishikawa or any other reference that would meet the claimed ranges.

1. Claims 2-10 Are Not Unpatentable

136. Claims 2-10 are not unpatentable for the same reasons as discussed above with respect to independent claim 1. I reserve the right to address Claims 2-10 individually if this proceeding is instituted.

C. Ground 2B: Nishikawa and Chen Do Not Render Obvious Claims 1-10

137. Petitioner and its expert contend that the combination of Nishikawa and Chen renders obvious Claims 1-10 of the '927 Patent, which are reproduced above

with respect to Ground 1. In addition to the issues I raise above with respect to Grounds 1 and 2A, I disagree for at least the following additional reasons.

1. Chen

138. The Chen reference “report[s] the deformation behaviors of five commercially available microporous polymer separators investigated by conventional tensile testing coupled with *in situ* tensile testing under an atomic force microscope.” Ex. 1005 at Abstract. Two of the separators tested are Celgard separators (Celgard 2325 and 2400) made by a dry process. *Id.* Chen concludes that “[f]or anisotropic separators (Celgard 2325 and 2400) made by the dry process, material direction dictates the significant diversity in overall mechanical integrity of the separator,” in that “they have limited mechanical properties when stretched in the transverse direction (TD)” but are “rather robust when pulled in the machine direction (MD).” *Id.*

139. The other three separators tested in Chen are “[s]eparators manufactured by the wet technique (Toray V20CFD and V20EHD, and the Teijin Lielsort.” *Id.* According to Chen, these separators “behaved more biaxially – all mechanical properties were nearly identical in both MD and TD.” *Id.*

140. Some of the properties of these separators are published in Chen and are reproduced below.

Table 1 Technical data for commercial Li-ion battery polymer separators used in this study^a

Manufacturer	Celgard	Celgard	Toray	Toray	Teijin
Product name	2325	2400	V20EHD	V20CFD	Lielsort
Material	PP-PE-PP	PP	Unknown polyolefin	Unknown polyolefin	PE substrate coated with fluorine-based compound
Process ^b	Dry	Dry	Wet	Wet	Wet (substrate) and proprietary coating technique
Thickness (μm)	25	25	20	20	15 ^c
Porosity (%)	39	41	42	43	
Puncture strength (g)	380	450	470	310	

141. As shown in Table 1, the Celgard 2235 separator is a polypropylene (PP)-polyethylene (PE)-polypropylene (PP) separator. *Id.* at 14905. This means that it has two sheets of PP with one sheet of PE in between. It does not have a porous layer.

142. In contrast, the Celgard 2400 is a PP porous substrate with no polyethylene (also no porous layer). *Id.*

143. The two Toray separators, for their part, are made of “unknown polyolefins.” *Id.*

144. The fifth separator tested, the Teijin Lielsort, is a polyethylene (PE) porous substrate coated with a fluorine-based compound as a porous layer. *Id.*

145. In addition to tensile testing of these five separators, Chen dedicates pages to testing the separators with the essential work of fracture (EWF) method. Because EWF is unrelated to the '927 Patent or the other references cited by Dr. Pecht, I do not go into the details here and instead focus my attention on the tensile testing portions of Chen (as did Dr. Pecht).

146. I understand that Chen's thesis was cited in the prosecution of the Chinese Application and has the same data as is reported in Chen.

2. Like Nishikawa, Chen Does Not Disclose the Claimed Absolute Plastic Deformation Rate

147. In this combination, Dr. Pecht relies on the Teijin separator in Chen to disclose the claimed "absolute plastic deformation rate." Ex. 1003 ¶¶ 148-55. I disagree. In my opinion, Chen does not disclose or suggest the claimed absolute plastic deformation rate, either expressly or inherently, for many of the same reasons as Nishikawa.

a. Chen Does Not Disclose the Claimed Absolute Plastic Deformation Rate

148. As explained above with respect to Ground 1, all claims of the '927 Patent require that "absolute plastic deformation rate is calculated according to an equation $(\underline{L2}-L0)/L0 \times 100\%$, where $L0$ refers to a length of the porous substrate before stretching and $\underline{L2}$ refers to a length of the porous substrate after the porous substrate is stretched to breakage and docked along the fracture caused by the breakage and flattened." *See, e.g.*, Ex. 1001 at Claim 1. Dr. Pecht does not opine, and the Petition does not argue, that explicitly Chen discloses $\underline{L2}$. Nor could they, because nowhere in Chen does it say to measure "the porous substrate after the porous substrate is stretched to breakage and docked along the fracture caused by the breakage and flattened."

149. Like with Nishikawa, Dr. Pecht opines that a POSITA could use other values in Chen to “estimate” plastic strain, which Dr. Pecht wrong equates to absolute plastic deformation rate. Ex. 1003 ¶ 154. But Dr. Pecht and Petitioner have failed to show that estimated plastic strain values meet the claimed absolute plastic deformation rate values for the reasons discussed below.

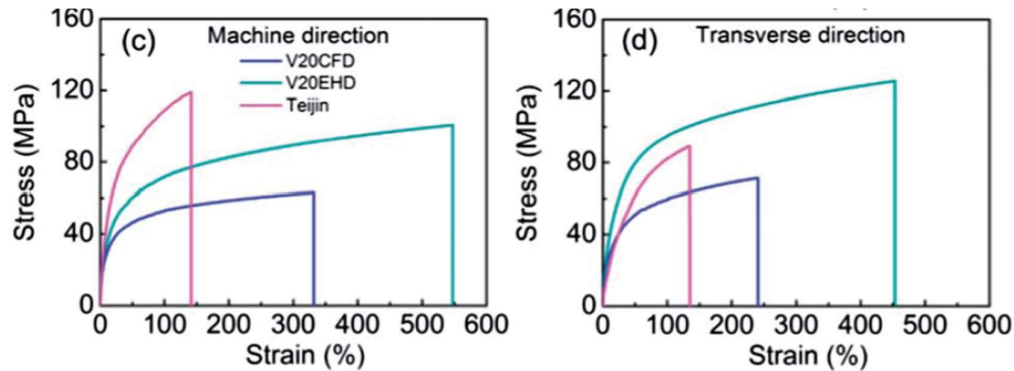
b. The Petition and Dr. Pecht Rely on Incorrect Assumptions and Estimates

150. The same failures that applied to Nishikawa and are discussed in Paragraphs 68-135 above also apply to Chen.

151. Like with Nishikawa, Dr. Pecht relies on both the first estimation calculation method (total strain = plastic strain + elastic strain) and the second estimation calculation method (the 0.2% offset method) to estimate plastic strain. *Id.* ¶¶ 151-55. Regardless of which of the two estimation methods used, Dr. Pecht fails to show how the estimated plastic strain accurately reflects the claimed range of absolute plastic deformation.

152. In the **first method**, Dr. Pecht relies on the reported “strain that non-linearity occurred (%)” as estimated elastic strain and “strain at break” as estimated total strain. *Id.* ¶¶ 151, 153. As explained below, these estimates are plagued by the same assumptions Dr. Pecht made with respect to Nishikawa.

153. First, the accuracy of the calculation depends on choosing the correct point where non-linearity occurred. But as shown below, this point is not clear because the line is non-linear throughout, an expected condition of many polymeric materials.



Ex. 1005, Fig. 3 (excerpted).

154. Second, the accuracy of the calculation depends on an assumption that there is no elastic strain after this subjective point of non-linearity. But again, the plots in Chen do not follow the idealized conceptual stress-strain behavior Dr. Pecht relies on. In the plots above, for example, one could identify more than one characteristic slope of the stress-strain curve in the initial presumably elastic region, meaning that more than one value is possible for Young's modulus and yield strength. Furthermore, even if one could identify an end point for elastic behavior, the stress-strain curve exhibits a complex mix of elastic and plastic behavior after this point and up to the point of failure.

155. In the **second method**, Dr. Pecht's estimation relies on "[a] line with a slope equal to Young's modulus and a 0.2% offset" that "can be plotted and overlaid onto the stress-strain curve provided by Chen." Ex. 1003 ¶ 155. This type of estimate is not accurate or appropriate for polymeric materials. The proposed method not only relies on picking the correct slope of the line, but it adds in the additional assumptions discussed above with respect to Nishikawa: 1) that the yield strength is equal to the tensile strength, and (2) the separator deforms only plastically at a stress equal to the tensile strength until breakage. *See* Paragraphs 103-106. Dr. Pecht gives no reason why these assumptions are likely to be true for the Teijin separator in Chen. Again, such conclusory and unsupported assumptions cannot be relied upon.

156. Finally, like for Nishikawa, Dr. Pecht provides no margin of error for either of his estimations. While he does not make the same arguments that any differences in these methods are not enough to make the calculated values fall outside the claimed range, such arguments would fail for the same reasons set forth above in Paragraphs 107-111.

c. The Petition and Dr. Pecht Ignore Different Parameters that Affect Stress-Strain Behavior

157. As he did with Nishikawa, Dr. Pecht does not account for the parameters that affect stress-strain behavior in Chen.

158. As explained above in Paragraphs 112-19 and incorporated by reference herein, the stretching or strain rate, initial chuck-to-chuck distance, and sample dimensions all have an impact on the deformation and failure properties of a separator and thus its stress-strain plot.

159. Dr. Pecht fails to account for the differences in stretching rate, initial chuck-to-chuck distance, and sample dimensions between Chen and the '927 Patent. While the stretching rate in Chen is 6 mm/min, the stretching rate in the '927 Patent's embodiment is 50 mm/min. *Compare* Ex. 1005 at 14906 with Ex. 1001 at 10:31-33. Similarly, the initial chuck-to-chuck distance in Chen is 30 mm, but it is 40 mm in the '927 Patent's embodiment. *Compare* Ex. 1005 at 14906 with Ex. 1001 at 10:28-31. And the sample dimension in Chen is 50 mm by 10 mm, whereas it is 100 mm by 20 mm in the '927 Patent's embodiment. *Compare* Ex. 1005 at 14906 with Ex. 1001 at 10:26-28.

160. For the same reasons discussed above in Paragraphs 112-19, these are significant differences in experimental conditions and a POSITA would expect them to have a significant impact on the deformation and properties of the separator and the stress-strain plot, which Dr. Pecht relies on for his calculations.

161. Dr. Pecht's failure to account for the differences in these variables is yet another reason why his analysis and conclusory opinions are unreliable.

d. Chen Does Not *Inherently* Disclose the Claimed Absolute Plastic Deformation Rate

162. Unlike for Nishikawa, Dr. Pecht does not specify that Chen expressly *and* inherently discloses the claimed absolute plastic deformation rate. Because he does not specify an inherency argument, I can only assume that he claims this limitation is only expressly disclosed. It is not for the reasons explained above.

163. Moreover, if Dr. Pecht were to make the same inherency arguments he made with Nishikawa but for Chen, those arguments fail for the same reasons set forth in Paragraphs 120-24.

3. Petitioner Has Not Shown a Motivation to Combine Nishikawa and Chen to Arrive at the Claimed Invention

164. Ground 2B fails to render the claims obvious for the additional reason that a POSITA would not have been motivated to combine Nishikawa and Chen to arrive at the claimed invention.

165. Dr. Pecht's primary opinion as to motivation to combine appears to be that a POSITA would have been motivated to combine Nishikawa and Chen with a reasonable expectation of success because "both references disclose a Teijin separator—i.e., both references describe the properties of separators made by the same company for the same purpose." *Id.* ¶ 157; *see also id.* ¶ 158 ("A POSA would therefore look to Chen to learn more detail about the elastic and plastic deformation properties of the kind of separators described in Nishikawa."); *id.* ¶ 159 ("This is the

same kind of separator disclosed in Nishikawa for the exact purpose the '927 Patent discloses for its claimed separator."); *id.* ¶ 160 ("This is the same PE substrate disclosed in Nishikawa.").

166. I disagree that a POSITA would have been motivated to combine these two references with a reasonable expectation of success.

167. First, contrary to Dr. Pecht's conclusory opinions otherwise, Nishikawa and Chen are not directed to the same problem or purpose but rather are directed to different, unrelated problems and solutions. As explained in Paragraphs 66-67, the Nishikawa reference is directed to the problem of a gap that forms between the separator and electrode during battery operation, thereby decreasing battery life. Nishikawa suggests solving this problem by focusing on the properties of the porous layer in the separator. *See* above in Paragraphs 66-67. In contrast, the Chen reference is directed to the problem of "mechanical failure of polymer separators in Li-ion battery cells can result in internal shorting and initiate thermal runaway." Ex. 1005 at 14904-14905. Chen proposes addressing that problem by "reveal[ing] the underlying structural change in membranes during mechanical deformation." *Id.* at 14905.

168. Second, Dr. Pecht provides no explanation as to why a POSITA would look outside of Nishikawa's separators. If anything, the fact that Nishikawa and Chen presumably both describe Teijin separators means that, by Dr. Pecht's and

Petitioner's logic, a POSITA would not think they need to look outside Nishikawa to Chen because they would assume the two would provide the same disclosure.

169. Third, even if a POSITA were to look to combine Chen and Nishikawa, there is not a reasonable expectation of success. Despite opining that the Nishikawa and Chen separators are essentially interchangeable, Dr. Pecht separately opines that these separators have wildly different plastic strains. Dr. Pecht opines that the Nishikawa separator has a plastic strain of 72.55-72.75% in the MD direction. Ex. 1003 ¶ 110. In contrast, Dr. Pecht opines that the Chen Teijin separator has a plastic strain of 137.2-141.57% in the MD direction. This is more than 89% greater (almost twice as much) plastic strain as the Nishikawa separator.

170. A POSITA would not be able to reconcile these two vastly different numbers for plastic strain, and Dr. Pecht provides no explanation as to how a POSITA would do so.

171. Fourth, the only thing Chen adds to the disclosure of Nishikawa is that Chen provides stress-strain plots that are absent in Nishikawa. But as explained above, using stress-strain plots to estimate plastic strain does not accurately reflect the claimed absolute plastic deformation rate. Thus, Chen's addition of these plots does nothing to overcome the failures of Nishikawa discussed at length above.

4. Claims 2-10 Are Not Unpatentable

172. Claims 2-10 are not unpatentable for the same reasons as discussed above with respect to independent claim 1. I reserve the right to address Claims 2-10 individually if this proceeding is instituted.

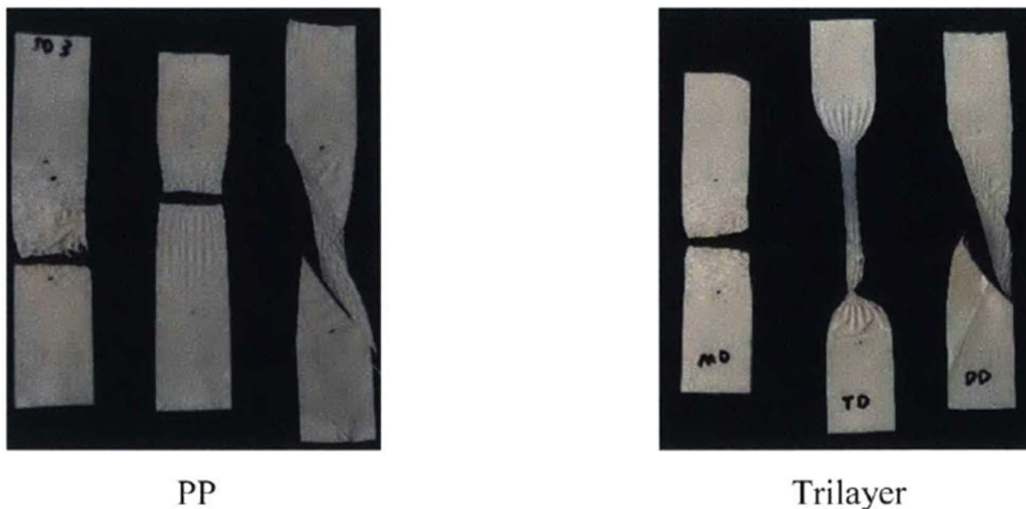
D. Ground 3: Chen and Zhang Do Not Render Obvious Claims 1-10

173. Petitioner and its expert contend that the combination of Chen and Zhang renders obvious Claims 1-10 of the '927 Patent, which are reproduced above with respect to Ground 1. In additions to the reasons I have identified with respect to Ground 2B with respect to Chen, I disagree for at least the following additional reasons.

1. Chen Does Not Disclose the Claimed Absolute Plastic Deformation Rate

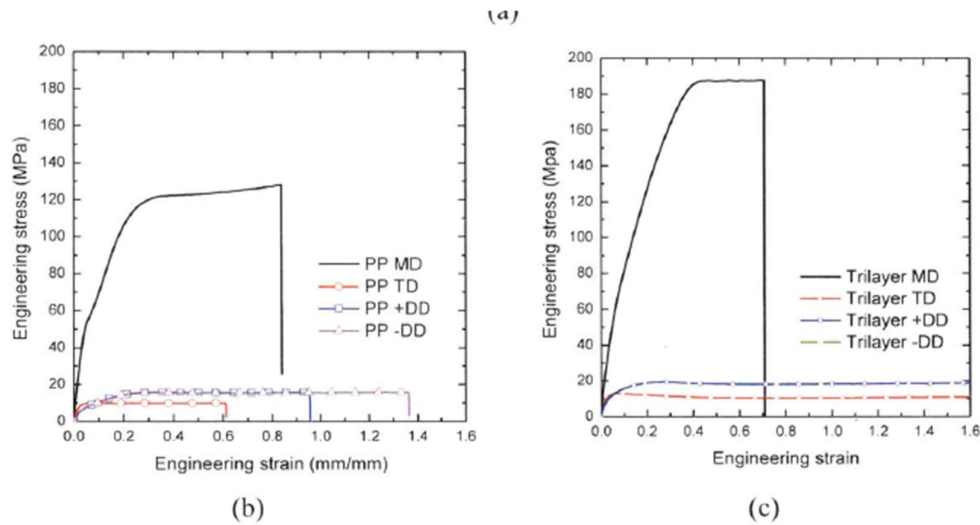
174. Ground 3 relies on Chen for the limitation “the porous substrate has an absolute plastic deformation rate in a first direction ranging from about 40% to about 1800%, and wherein the absolute plastic deformation rate is calculated according to an equation $(L2-L0)/L0 \times 100\%$, where L0 refers to a length of the porous substrate before stretching and L2 refers to a length of the porous substrate after the porous substrate is stretched to breakage and docked along the fracture caused by the breakage and flattened.” For the reasons discussed above in Paragraphs 147-63, I disagree that Chen discloses or suggests this limitation. Those paragraphs are incorporated by reference herein.

175. Dr. Pecht does not (and cannot) argue that Zhang discloses this limitation. In fact, the Zhang Thesis (background art relied on by Dr. Pecht) teaches away from this limitation because it teaches stretching until breakage and then *not* measuring L2. The Zhang Thesis performs tensile stretching where various separators are stretched to the point of breakage and then proximately docked solely to take photos.



Ex. 1007 at 71.

176. But notably, Zhang never *measures* L2 (the length of the porous substrate after the porous substrate is stretched to breakage and docked along the fracture caused by the breakage and flattened). Instead, the Zhang thesis plots stress/strain plots like Chen.



Ex. 1007 at Fig. 3-1

177. Thus, a POSITA would have been discouraged from measuring L2 and arriving at the claimed absolute plastic deformation rate because even the reference that appears to dock the separators at the end (the Zhang reference) does not measure L2 and instead uses the stress-strain plot method to look at plastic strain. And as explained at length throughout this declaration, the stress/strain plot estimation methods do not reliably reflect the claimed absolute plastic deformation rate.

2. Petitioner Has Not Shown a Motivation to Combine Chen and Zhang to Arrive at the Claimed Invention

178. Ground 3 fails to render the claims obvious for the additional reason that a POSITA would not have been motivated to combine Chen and Zhang to arrive at the claimed invention.

179. Like with Ground 2B, Dr. Pecht's primary opinion as to motivation to combine is that a POSITA would have been motivated to combine Zhang with Chen with a reasonable expectation of success because both references describe Celgard separators. Ex. 1003 ¶ 191-94. Once combined, Dr. Pecht argues there is a reasonable expectation of success because (1) "Zhang teaches that its porous layer would be an improvement to the Celgard separator," and (2) "Chen and Zhang both have the same purpose and objectives." Ex. 1003 ¶ 195-96.

180. I disagree that a POSITA would have been motivated to combine Chen and Zhang with a reasonable expectation of success.

181. While Chen and Zhang both discuss separator safety concerns, the two references are directed to very different proposed solutions. The Chen reference suggests analyzing and reporting "the mechanical behavior of the polymer separators (tensile and fracture)." Ex. 1005 at 14905. In contrast, Zhang is focused solely on the properties of the *porous layer*, claiming layers that "include one or more particles having an average particle size ranging from 0.01 μm to 5 μm and/or binders that include poly (sodium acrylate-acrylamide-acrylonitrile copolymer." Ex. 1006 at Abstract.

182. The claims of the '927 patent are directed to the absolute plastic deformation rate of the *porous substrate*. Thus, a POSITA would not look to a reference like Zhang that is focused on the properties of the *porous layer*.

3. Claims 2-10 Are Not Unpatentable

183. Claims 2-10 are not unpatentable for the same reasons as discussed above with respect to independent claim 1. I reserve the right to address Claims 2-10 individually if this proceeding is instituted.

VIII. CONCLUSION

184. In sum, it is my opinion that Grounds 1, 2A, 2B, and 3 of the Petition do not render any of Claims 1-10 of the '927 Patent unpatentable as anticipated or obvious for the reasons I discuss above.

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

Executed on June 9, 2025, in Provo, Utah.

A handwritten signature in black ink, appearing to read "Dean R. Wheeler". The signature is fluid and cursive, with the first name "Dean" and last name "Wheeler" clearly distinguishable.

Dean R. Wheeler