

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Caihong Display Devices Co., Ltd.,

Petitioner,

v.

Corning Incorporated

Patent Owner.

Case No.: IPR2025-00439
U.S. Patent No. 7,851,394

DECLARATION OF DR. ~~ASHUTOSH GOEL~~FRANK ERNST¹

¹ In this comparison document, additions are shown in red underline, deletions are shown in red strikethrough. All black text (including black underline) is original. The creation of this comparison has changed the pagination of the document.

Petitioner Ex-1003 (Substitute)

Corning Inc. EX2001
IPR2025-00439
U.S. Patent No. 7,851,394

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I. INTRODUCTION

1. I have been retained by Caihong Display Devices Co., Ltd. (“Caihong” or “Petitioner”), as an independent expert in this proceeding before the Patent Trial and Appeal Board (“PTAB” or “Board”). I understand that Caihong is requesting that the Board institute an *inter partes* review (“IPR”) proceeding of U.S. Patent No. 7,851,394 (“the ‘394 Patent”) (EX1001), currently assigned to Corning Inc (“Patent Owner” or “PO”).

2. I am not and have never been an employee of Caihong. I am being compensated at my usual and customary rate of \$~~400~~280 per hour. No part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I have been asked to provide my independent analysis of the ‘394 Patent in light of the prior art publications cited below. I have also been asked to consider the state of the art and prior art available as of June 28, 2005. Based on the prior art discussed in this declaration, it is my opinion that Claims 1-16 of the 394 Patent are unpatentable for the reasons provided below.

A. Qualifications

4. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth herein. I understand that a copy of my current curriculum vitae, which details my education and professional and academic

experience, is being submitted by Petitioner as ~~EX1008~~EX1011. The following provides an overview of some of my experience that is relevant to the matters set forth in this declaration.

5. I am currently a ~~Professor~~(full) professor in the Department Chair of Materials Science and Engineering ~~at Rutgers, The State~~in the School of Engineering at Case Western Reserve University ~~of New Jersey. Before joining Rutgers-~~
~~University as a faculty member in January 2014. For 9 years, until October 2024, I~~
~~served as a Senior Scientist at Pacific Northwest National Laboratory, Richland, WA~~
~~(March 2011—April 2012) and Senior Scientist at Sterlite Technologies Ltd., India~~
~~(May 2012—December 2013). My area of expertise is glass science, with emphasis~~
~~on design, synthesis and characterization of silicate, borosilicate, aluminosilicate and~~
~~boroaluminosilicate glasses and glass-ceramics. I have published more than 100~~
~~research articles in scientific journals in the field of glasses and glass-ceramics and~~
~~listed as co-inventor on two US patents and two US patent applications. Additionally, I~~
~~have delivered more than 30 invited/keynote lectures at international conferences and~~
~~workshops. Owing to my expertise in glass science, I serve as an Associate Editor for~~
~~Journal of the American Ceramic Society and International Journal of Applied Glass~~
~~Science~~been leading this department as department chair.

~~1. ——— Based on my contribution to the field of glass science, I was~~
~~awarded the 2017 Vittorio Gottardi Prize by the International Commission on Glass,~~
~~2019 Outstanding Reviewer Award by the journal Acta Biomaterialia, 2021 W.H.~~

~~Zachariasen Award by the Journal of Non-Crystalline Solids, and 2023 Tadashi-Kokubo Award by the American Ceramic Society.~~

6. I have more than 40 years of experience in materials science and engineering, physics, mathematics, and computation. My scientific work contributed to several areas of material science, including ceramics. I have substantial expertise in microcharacterization of materials, including atomic-resolution imaging, diffractometry, and spectrometry using state-of-the-art sophisticated methodology and major instrumentation. I have served as the director of a microscopy center at Case Western Reserve University for about 10 years.

7. My scientific work involves ceramic/ceramic interfaces, especially grain boundaries in ceramics, as well as ceramic/metal- and ceramic/semiconductor interfaces. The list of materials my group and I researched and published on includes perovskite ceramics, oxides, carbides, nitrides, and metallic glasses. I also have expertise with the methodology and application of some of the sophisticated experimental methods that are in use to analyze the composition and microstructure of glasses, e.g. TEM, XEDS, EELS, SEM, FIB, AFM, XPS, AES, XRD, ToF-SIMS. My research group has advanced the frontier of research across a great variety of materials classes and phenomena, focusing on processing–composition–crystal/micro-structure–property relationships and with ceramic materials playing a significant role. I have extensive expertise with (and developed) advanced experimental methods of microcharacterization, which serve to determine the

microscopic structure and composition of materials, including borosilicate glasses. I am knowledgeable on glass composition and its impact on microscopic structure and glass properties.

8. Based on my experience and education, I believe that I am qualified to opine as to the knowledge and level of skill of one of ordinary skill in the art at the time of the alleged invention of the '394 Patent, as well as the state of the art at that time.

B. Materials Considered

9. In forming my opinions, I have reviewed the following documents:

EX1001	U.S. Patent No. 7,851,394 (the "'394 Patent")
EX1002	Prosecution History of the '394 Patent
EX1004	JP2004-189535A ("Miwa) certified translation
EX1005	US5824127 ("Bange")
EX1006	W. Vogel, Glass Chemistry, 2 nd Ed., Chapter 4: Classical Theories of Glass Structure, Springer-Verlag (1994)
EX1007	A.K. Varshneya, Fundamentals of Inorganic Glasses, Chapter 5: Glass Compositions and Structures, Academic Press (1994)

II. LEGAL STANDARDS

22. In forming my opinions and considering the subject matter of the '394 Patent and its claim considering the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is summarized below.

23. I understand that earlier publications and patents may act to render a patent unpatentable for one of two reasons: (1) anticipation, and (2) obviousness.

A. Anticipation

24. It is my understanding that the claims of a patent are anticipated by a prior art reference if each and every element of the claim is found either explicitly or inherently in the reference. I understand that inherency requires a showing that the missing descriptive matter in the claim is necessarily present in the allegedly anticipating reference, and that it would have been so recognized by a person of ordinary skill in the art (“POSITA”).

25. I understand that when a challenged claim covers several structures, either generically or as alternatives, the claim is deemed anticipated if any of the structures within the scope of the claim is found in the prior art reference.

26. Although anticipation typically involves the analysis of a single prior art reference, I understand that additional references may be used to show that the prior art reference has enabling disclosure (i.e., allows a POSITA to make the invention without undue experimentation), to explain the meaning of a term used in the prior art reference, and/or to show that a characteristic is inherent in the prior art reference.

B. Obviousness

27. I understand that a claim is invalid as obvious if it would have been obvious to a person of ordinary skill in the art at the time the alleged invention was made. This means that even if all of the elements of the claim cannot be found in a single prior art reference that would anticipate the claim, a person of ordinary skill in

the art who was aware of the prior art would have been able to come up with the claimed invention. This may be the case, for example, where the missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system. I understand that in an obviousness determination, the person of ordinary skill in the art is presumed to have knowledge of all material prior art.

28. I understand that an obviousness analysis requires an understanding of the scope and content of the prior art, any differences between the alleged invention and the prior art, and the level of ordinary skill in evaluating the pertinent art.

29. I understand that when a product is available, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation, obviousness likely bars its patentability. For the same reason, if a technique has been used to improve one device and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

30. I understand that whether a prior art reference renders a patent claim unpatentable as obvious is determined from the perspective of a person of ordinary skill in the art at the time of the alleged invention. I have been told that there is not a requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, but a suggestion to combine known elements to achieve the claimed invention may come from the prior art, as filtered

through the knowledge of one skilled in the art. In addition, I have been told that the inferences and creative steps a person of ordinary skill in the art would employ are relevant to the determination of obviousness.

31. I understand that one may consider, e.g., whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; (3) the claimed innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results; or (7) known work in one field of endeavor may have prompted variations of it for use in either the same field or a different one based on design incentives or other market forces that would have been predictable to a person of ordinary skill in the art.

32. I further understand that certain factors may support or rebut the obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the patented invention, skepticism of

those having ordinary skill in the art at the time of the invention, unexpected results of the invention, any long-felt but unsolved need in the art that was satisfied by the alleged invention, the failure of others to make the alleged invention, praise of the alleged invention by those having ordinary skill in the art, and copying of the alleged invention by others in the field. I understand that there must be a nexus—that is, a connection—between any such secondary considerations and the alleged invention. I also understand that contemporaneous and independent invention by others is a secondary consideration tending to show obviousness.

33. Additionally, I understand that in considering obviousness, it is important not to use the benefit of hindsight derived from the patent under consideration.

C. Level of Ordinary Skill in the Art

34. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to that patent, as well as the level of ordinary skill in that art at the time of the claimed invention. The “art” is the field of technology to which the patent is related.

35. I am informed and understand that the POSITA is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor’s skill is not determinative of the level of ordinary skill. I further understand that factors that may be considered in determining level of skill include: (i) the types

of problems encountered in the art; (ii) prior art solutions to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

36. I understand that a POSITA is one who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity. A POSITA would have ~~had~~comprehensive knowledge ~~of~~ and ~~experience~~ ~~with deep understanding of~~ the ~~concepts of glass materials~~ science aspects and the underlying physical, chemical, and mathematical concepts of the science of glasses, as relevant to the '394 patent, ~~for~~ For example, this would include (but is not limited to, the concepts of liquidus temperature, viscosity, coefficient of thermal expansion (CTE), strain point, density, ~~and~~ Further, a POSITA would have ~~5-10-~~ years considerable understanding of and experience with design, synthesis, and characterization of silicate, borosilicate, aluminosilicate and boroaluminosilicate glasses, ~~demonstrable in the form of peer-reviewed publications and/or patents.~~

37. Based on my education and experience, I meet the criteria for a POSITA.

D. Claim Construction

38. I understand that the United States Patent and Trademark Office interprets claim terms in an *inter partes* review proceeding under the same claim construction standard that is used in a United States federal court. I understand that

under this standard, the meaning of claim terms is considered from the viewpoint of a POSITA at the time of the alleged invention.

39. I have been informed that claim terms are generally given their ordinary and customary meaning as understood by one of ordinary skill in the art in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claims terms are generally not limited by the embodiments described in the specification.

40. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I have been informed that this other evidence is often less significant and less reliable than the claims, specification, and prosecution history.

41. I have thus interpreted each of the terms in the claims as would be understood by one of ordinary skill in the art in light of the specification and the prosecution history pertaining to the patent.

III. SUMMARY OF GROUNDS

42. I understand that Petitioner challenges the validity of Claims 1-16 of the '394 Patent. In particular, I understand that Petitioner asserts the following grounds for challenging the claims of the '394 Patent:

Ground	Challenged Claims	Asserted Prior Art
1	1-16	Miwa in view of Bange
2	1 and 3	Miwa
3	2, 4-16	Miwa

IV. THE '394 PATENT

A. Overview of the '394 Patent

43. The '394 patent focuses on the development of alkali-free boroaluminosilicate glasses intended for use as substrates in flat panel displays, such as AMLCDs. EX1001, Abstract. The Applicant alleges that the invention has improved the fining (or refining) process of these glasses to achieve desirable physical and chemical properties suitable for high-quality display manufacturing. *Id*, at 1:14-20. Specifically, the Applicant claims that the specified glass composition is tailored for low thermal expansion, high liquidus viscosity, high strain point, and low density. *Id*, at 3:53-67.

44. Traditionally, As_2O_3 and Sb_2O_3 ~~are~~have been used as fining agents during glass ~~finning process~~manufacturing. *Id*, at 12:7-31. However, since both fining agents are toxic, special handling is needed. *Id*. To solve this issue, the '394 Patent proposes to use SnO_2 as the fining agent.

45. Further, the '394 patent requires the liquidus temperature of the glass to be lower than 1170 °C and the liquidus viscosity to be no less than 100,000 poise. *Id*,

at 14:36-50.

46. ~~To make the fining process easier and more effective~~Further, the Applicant indicates that ~~the MgO content and $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$ ratio, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\Sigma[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO, are critical to the glass performance and, in particular, with regard to meltability and fining.~~ *Id.*, at 7:28-33, 12:46-55. ~~As,~~ as described in the '394 Patent, the MgO mole percentage fraction X_{MgO} of ~~MgO~~ should be within ~~1% to 3%~~the range $X_{\text{MgO}} = 1$ to 3 mol%, in order to reduce the liquidus temperature, thus ~~increasing~~increase the liquidus viscosity. *Id.*, at 10:19-44. In addition, ~~the~~ $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$ ~~ratio~~ should be ~~higher~~greater than 1.00 to avoid inclusions (blisters) in the glasses and maintain high viscosity during the fining process. *Id.*, Abstract, FIG. 3 as reproduced below.

B. Prosecution History of the '394 Patent

47. I understand the '394 Patent was filed on June 28, 2006 and claims priority to a U.S. provisional application with the serial number of 60/694,478 that was filed on June 28, 2005.

48. I understand the prior art relied on in this Declaration was before the USPTO during prosecution of the '394 Patent. However, my analysis takes into consideration the fact that the USPTO did not fully appreciate the relevance of the teachings of Miwa and/or Bange, despite having been cited in the prosecution

history. In fact, my review of the prosecution history (EX1002) did not find any discussion of these references in the manner that is discussed below. As clearly explained below Miwa, considered by itself or with the other citations (e.g., EX1005, EX1006 and EX1007), is relevant to Claims 1-16 of the '394 patent.

49. As such, I understand that this Declaration presents substantially new arguments that were not properly considered during prosecution in the UPSTO.

V. TECHNOLOGY BACKGROUND AND INTERPRETATIONS

50. As I will describe below from a high-level functional perspective, in the next section based on specific prior art, and then in subsequent sections on a limitation-by- limitation basis, all of these technologies and techniques were well-known to those of ordinary skill in the art at the time of the alleged invention claimed in the '394 Patent, and a POSITA would have readily understood these relevant disclosures.

VI. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS

A. Miwa (EX1004)

51. Miwa was filed on December 11, 2002, and published on July 8, 2004. Therefore, it is a prior art at least under 35 U.S.C. § 102(a) (pre-AIA). EX1004, cover page. Similar to the '394 Patent, Miwa also relates to alkali-freeboroaluminosilicate glass compositions primarily suitable for application as a substrate flat-panel display and thin-film photovoltaic technologies. *Id.*, at summary, [0001]-[0008]. More specifically, this Japanese patent, filed by Nippon Electric-

Glass Co Ltd (a Japanese glass manufacturer of glass for flat panel displays), concerns an alkali-free glass substrate used in various flat panel displays such as liquid crystal displays (LCDs), electroluminescence displays (ELDs), field emission displays (FEDs), sensors, and cover glass for solid-state imaging devices. *Id.* It addresses the need for glass substrates that do not contain alkali metal oxides to prevent diffusion of alkali ions into semiconductor materials during heat treatments, which can degrade film properties. *Id.* Miwa also aims to provide glass with high resistance to chemicals used in photoetching processes, high strain points to prevent pattern misalignment during heat treatments, excellent meltability to avoid melting defects, and low thermal expansion coefficients to reduce thermal shock damage. *Id.*

52. Additionally, Miwa emphasizes the necessity for high transmittance in the ultraviolet to visible spectrum, crucial for device performance in displays and sensors. *Id.*, at [0001]-[0017]. Miwa proposes adding SnO₂ to achieve the desired transmittance rates without significantly increasing costs, meeting all required characteristics such as chemical durability, heat shrinkage resistance, meltability, high strain points, and minimal thermal expansion while maintaining high clarity and free of alkali metal oxides. *Id.* Unlike conventional glass substrates but similar to the '394 patent, Miwa incorporates a specific amount of SnO₂ (between 0.01%-0.3% by mass) without increasing the cost. *Id.* This composition effectively improves the substrate's transmittance rates in both the UV and visible light ranges while satisfying all required characteristics such as chemical durability, minimal thermal

expansion, and high strain points without including any alkali metal oxides. *Id.*

53. Similar to the '394 Patent, Miwa ~~also describes the specified specifics~~
~~a continuous range of~~ glass compositions, ~~including that achieve favorable~~
~~properties. Different from the '394 Patent, however, Miwa indicates the respective~~
~~glass compositions by providing ranges for the mass (or weight – not mole) fractions~~
~~of SiO₂, B₂O₃, Al₂O₃, MgO, CaO, SrO, and BaO. *Id.* at [0022]., in certain weight~~
~~percentages~~ Glasses within the specified range of compositions are shown to ~~achieve~~
~~properties such as~~ possess high thermal shock resistance, high chemical resistance,
high transparency across visible and ultraviolet spectral regions, low density, and a
thermal expansion coefficient ~~matched to~~ matching that of silicon substrates. They
~~demonstrate~~ For example, the glass disclosed by Miwa demonstrates excellent
mechanical stability and resistance to hydrochloric acid, making ~~it~~ them ideal for ~~Thin-~~
~~Film Transistor (“TFT”)~~ (thin-film transistor) displays, thin-film photovoltaics, and
hard-disk substrates, while addressing disadvantages found in prior art related to
mechanical stability and meltability. *Id.* at [0055]. In summary, Miwa teaches ~~similar~~
alkali-free glass substrates with similar compositions and similar physical and
chemical properties as the '394 patent, ~~which,~~ Miwa's glass compositions are also
suitable for flat panel display applications.

54. For example, Miwa's ~~e~~Embodiment 15 teaches that the glass has the
following alkali-free compositions in weight percentages as shown below:

	Embodiment				
	11	12	13	14	15
Composition (mass percent)					
SiO ₂	61.0	62.0	63.0	62.0	62.0
Al ₂ O ₃	16.0	15.0	16.0	16.0	16.0
B ₂ O ₃	12.0	9.4	12.0	11.0	11.0
MgO	–	0.5	–	–	1.3
CaO	7.0	7.0	7.0	8.0	8.0
SrO	1.9	4.0	1.0	0.5	1.0
BaO	1.0	0.05	0.3	1.5	0.5
ZnO	0.5	0.5	–	0.5	–
ZrO ₂	–	0.4	–	0.15	–
SnO ₂	0.1	0.25	0.15	0.15	0.1
As ₂ O ₃	–	0.1	–	–	–
Sb ₂ O ₃	0.5	0.7	0.5	–	0.1
Cl	–	0.1	0.05	0.2	–
All Fe ₂ O ₃	0.015	0.015	0.015	0.010	0.010
Transmittance (%)					
300 nm	65	72	70	74	70
400 nm	91	91	91	92	91
600 nm	92	92	92	92	92
800 nm	92	92	92	92	92
Density (g/cm ³)	2.40	2.44	2.35	2.40	2.39
Coefficient of thermal expansion [30-380°C] (×10 ⁻⁷ /°C)	34	33	31	33	34
Strain point (°C)	665	671	668	669	673
Logn at 10 ^{2.5} (°C)	1555	1560	1605	1565	1560
Liquid phase temperature (°C)	1105	1055	1090	1085	1120
Acid resistance	○	○	○	○	○
Buffered hydrofluoric acid resistance	○	○	○	○	○

EX1004, Table 4

55. Converting the weight percentages in Miwa's Embodiment 15 to the mole percentage, Miwa teaches that the glass has the following alkali-free compositions in mole percentages as shown below:

SiO₂: ~~67.19 mole~~ 2 mol%

Al₂O₃: ~~10.22 mole~~ 2 mol%

B₂O₃: ~~10.29 mole~~ 3 mol%

MgO: ~~2.10 mole~~ 1 mol%

CaO: ~~9.29 mole~~ 3 mol%

SrO: 0.63 ~~mole~~ mol%

BaO: 0.21 ~~mole~~ mol%

SnO₂: 0.04 ~~mole~~mol%

As₂O₃: 0.0 ~~mole~~mol%

Sb₂O₃: 0.02 ~~mole~~mol%

Fe₂O₃: 0.00 ~~mole~~mol%

$\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3] = 1.$ ~~21~~20

A. Bange (EX1005)

56. Bange was filed on October 28, 1996 and published on October 20, 1998. Therefore, it is a prior art at least under 35 U.S.C. § 102(b) (pre-AIA). EX1005, cover page. Bange, assigned to Corning Incorporated, also describes alkali-free glasses developed primarily for use as a substrate in flat panel displays, such as LCDs. *Id.*, Field of Invention.

57. Similar to the '394 Patent, Bange also describes ~~the a continuous range~~ of glass compositions by specifying ranges of mole fractions X_i , including for SiO₂, B₂O₃, Al₂O₃, MgO, CaO, SrO, and BaO, ~~in certain mole percentages to.~~ Glass compositions within the specified range achieve properties such as low density, high strain point, low CTE, low liquidus temperature, high liquidus viscosity, and high chemical durability. *Id.*, 4:65-5:37.

58. Similar to the '394 Patent, Bange ~~also~~ describes using SnO₂ and Sb₂O₃ as the fining agents among others. *Id.*, 6:37-41; 4:35-41.

B. Motivation to combine Miwa in view of Bange

59. As set forth below in more detail in the specific relevant limitations, a

POSITA would have found it obvious to combine Miwa with Bange. In particular, both references are in the same technical field: alkali-free glasses developed primarily for use as substrates in flat panel display technologies. Thus, Miwa and Bange are analogous references, and a POSITA would have found combining two references to be one of a finite number of identified means for desired non-alkali low-density glass applicable to substrates in display technologies and would have had a reasonable expectation of success of their combination. Additionally, given the low ionic field strengths ($F = \frac{Z}{(r_c + r_o)^2}$, where Z is the charge on cation, r_c is the ionic radius of cation, and r_o is the ionic radius of oxide anion) of Sr^{2+} ($0.28 \text{ \AA}^{-2}$) and Ba^{2+} ($0.24 \text{ \AA}^{-2}$), both these cations play a similar role of network modifier in the silicate glass structure. EX1006. This information was well known at the time the '394 patent was filed, and a POSITA would have found combining Miwa with Bange to constitute combining prior art elements where the ~~total concentration~~combined fraction of BaO and SrO ($\text{SrO} + \text{BaO}$ $X_{\text{SrO}} + X_{\text{BaO}}$) can be optimized to obtain low-density alkali-free substrate glasses according to known fabrication methods. Such modifications would have been well within the skill of a POSITA as confirmed by the teachings of the references.

X. Ground 1: Claims 1-16 would have been obvious over Miwa in view of Bange

A. Independent Claim 1

60. Limitation 1[p]: An alkali-free glass comprising in mole percent on an

oxide basis

61. Miwa discloses an alkali-free glass comprising in weight percent on an oxide basis. EX1004, at [Claim 3], Tables 1-5. For example, Miwa teaches that “The characteristic feature of the invention is that it comprises SiO₂ 55-70%, Al₂O₃ 12-20%, B₂O₃ 5-15%, MgO 0-5%, CaO 0-12%, SrO 0 – 10%, BaO 0-10%, ZnO 0-5%, ZrO₂ 0-5%, Cl 0-0.5% **alkali free glass** substrate as described in Claim 1 EX1004, at [Claim 3]. Table 4 of Miwa illustrates various embodiments, including ~~e~~Embodiment 15 of alkali-free glass defined by weight percentages of each listed oxide.

62. It is well-known that glass compositions may be presented on a weight percent or a mole percent basis, where weight% can be converted to mole% and vice-versa. EX1007 The methodology to convert a composition from weight% to mole% has been presented below using a hypothetical glass composition 30 wt% Na₂O – 10 wt% Al₂O₃ – 10 wt% B₂O₃ – 50 wt% SiO₂ as an example.

Step 1. Divide the concentration of each oxide (in weight percent) with their respective molecular weight (grams/mole), i.e., $\frac{wt\%_i}{MW_i}$ is the concentration of i_{th} oxide in weight percent, e.g., 30 wt% for Na₂O; MW_{*i*} is the molecular weight of i_{th} oxide, e.g., 61.98 g/mole for Na₂O; x_i is the number of moles of i_{th} oxide, e.g., 0.48 for Na₂O.

Step 2. Calculate the total number of moles (x) by adding the number of moles of each oxide, e.g., $x = \sum x_i = 1.56$.

Step 3. Divide the number of moles of i_{th} oxide (x_i) by total number of moles (x)

and multiply it by 100 to calculate the concentration of i_{th} oxide in mole percent, i.e.,

$(mole\%)_i = \frac{x_i}{x} \times 100$, where $(mole\%)_i$ is the concentration of i_{th} oxide in mole%, e.g., 31.07

mole% of Na₂O.

	wt%	Molecular weight (MW) (g/mole)	$x_i = (wt_i\%/MW_i)$	$(mole\%)_i$
Na ₂ O	30	61.98	0.48	31.07
Al ₂ O ₃	10	101.96	0.10	6.30
B ₂ O ₃	10	69.62	0.14	9.22
SiO ₂	50	60.08	0.83	53.42
			$x = \sum x_i = 1.56$	

63. Limitation 1[a]: SiO₂: 64.0-71.0, Al₂O₃: 9.0-12.0, B₂O₃: 7.0-12.0, MgO:

1.0-3.0, CaO: 6.0-11.5, SrO: 0-2.0, BaO: 0-0.1

64. The composition of Miwa's ~~e~~Embodiment 15 was converted from

weight percent (mass fractions) to mole percent, ~~as shown in (fractions) according to~~

~~the table below.~~ Formula $x C_I = \frac{W_i/m_i}{\sum_{i=1}^N W_i/m_i}$ and is shown in the table below.

EX1004, Table 4.

Oxide	Miwa Embodiment 15 <u>(mol%0</u>	Limitation 1[a] <u>(mol%)</u>
SiO ₂ :	~~67.19 mole%~~ <u>67.2</u>	~~64.0-71.0~~ ~~mole%~~ <u>64.0-71.0</u>
Al ₂ O ₃ :	~~10.22 mole%~~ <u>10.2</u>	~~9.0-12.0~~ ~~mole%~~ <u>9.0-12.0</u>

B ₂ O ₃ :	~~10.29 mole%~~ <u>10.3</u>	~~7.0-12.0 mole%~~ <u>7.0-12.0</u>
MgO:	~~2.10 mole%~~ <u>2.1</u>	~~1.0-3.0 mole%~~ <u>1.0-3.0</u>
CaO:	~~9.29 mole%~~ <u>9.3</u>	~~6.0-11.5 mole%~~ <u>6.0-11.5</u>
SrO:	~~0.63 mole%~~ <u>0.63</u>	~~0-2.0 mole%~~ <u>0-2.0</u>
BaO	~~0.21 mole %~~ <u>0.21</u>	~~0-0.1 mole%~~ <u>0-0.1</u>

65. All mole percentages of limitation 1[a] are disclosed by Miwa in ~~e~~Embodiment 15, except the mole percentage of BaO.

66. Miwa discloses that the glass composition can comprise a mass fraction of “BaO 0-10%,” Ex1004, ¶[0022] and further, again referring to mass fractions, discloses “BaO, like SrO, is an ingredient that improves the chemical resistance and impermeability of glass. The foregoing effects can be obtained when the content is 10% or less. The preferred range is 0-5%. As the BaO-~~content~~ increases, the density of the glass and the coefficient of thermal expansion tend to increase, and its fusibility tends to deteriorate significantly.” EX1004, [0030].

67. Both SrO and BaO play a network-modifying role in these glasses and their ~~total concentrations, i.e., SrO+BaO, combined mass fraction ($W_{\text{SrO}} + W_{\text{BaO}}$) or, equivalently, combined mole fraction ($X_{\text{SrO}} + X_{\text{BaO}}$)~~ can be optimized to obtain glasses with desired density, coefficient of thermal expansion and refractive index. In other words, to obtain low-density glasses, BaO may be set to 0 and the corresponding ~~amount~~fraction of BaO may be replaced by SrO. For example, the concentration of SrO in Miwa’s ~~e~~Embodiment 15 may be increased to $X_{\text{SrO}} = 0.84$ mole-percentmol%

with ~~BaO being~~ $X_{\text{BaO}} = 0.00 \text{ mol}\%$, while the other components remain unchanged.

~~Replacing~~ Completely replacing BaO with SrO is one of a finite number of identified ways to obtain non-alkali low-density glasses and would have had a reasonable expectation of success of their combination.

68. With SrO and BaO playing equivalent roles in the glass compositions,
as discussed, it would have been obvious to adjust the ~~amount~~ mole fraction of BaO from $X_{\text{BaO}} = 0.21 \text{ mole percent}$ ~~mol%~~ to $0.00 \text{ mol}\%$ and adjust the mole ~~percentage~~ fraction of SrO from $X_{\text{SrO}} = 0.63$ to $0.84 \text{ mol}\%$ to keep ~~the~~ their combined mole ~~percentage as 100% with SrO and BaO playing the same role in the glass~~ fraction ($X_{\text{SrO}} + X_{\text{BaO}}$) constant compositions, as discussed.

69. A zero mole percentage of BaO also overlaps the 0-0.1 mole percentage in limitation 1[a].

70. Additionally, all mole percentages of limitation 1[a] of the '394 patent are disclosed in Bange: "The method of claim 2, wherein the resultant glass comprises an aluminoborosilicate glass, expressed in terms of mole percent on the oxide basis, having SiO₂: 60-73, Al₂O₃: 8-14, B₂O₃: 5-17, MgO: 0-5, CaO: 1-13, SrO: 0-8, BaO: 0-14, TiO₂: 0-5 and Ta₂O₅: 0-5. *Id*, EX 1005, Claim 13.

71. Limitation 1[b]: wherein: (a) $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al₂O₃ and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO

72. Embodiment 15 of Miwa (EX1004, Table 4) discloses a ratio of 1.21

for $\sum[\text{RO}]/[\text{Al}_2\text{O}_3]$, which is in the range of 1.00 to 1.25 as in limitation 1[b].

Therefore, limitation 1[b] “ $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO , CaO , SrO , and BaO ” is disclosed by Miwa. EX1004, Table 4.

73. Limitation 1[c]: (b) the glass has the compositional characteristic that on an oxide basis, the glass comprised at least 0.01 mole percent SnO_2

74. Embodiment 15 of Miwa (EX1004, Table 4) describes a 0.04 mole percentage of SnO_2 , which overlaps with “at least 0.01 mole percent SnO_2 ,” as in limitation 1[c]. Therefore, limitation 1[c] “the glass has the compositional characteristic that on an oxide basis, the glass comprised at least 0.01 mole percent SnO_2 ” of ‘394 is disclosed by Miwa. EX1004, Table 4. Miwa also describes that the glass can comprise 0.01 to 0.3% SnO_2 (by weight). EX1004, ¶17.

75. Limitation 1[d]: (c) the glass has a density that is less than or equal to 2.41 grams/cm³

76. Embodiment 15 of Miwa (EX1004, Table 4) discloses a glass with density of 2.39 grams/cm³, which overlaps with “a density that is less than or equal to 2.41 grams/cm³” as in limitation 1[d]. Therefore, limitation 1[d] “a density that is less than or equal to 2.41 grams/cm³” of ‘394 is obvious, as exemplified by Miwa. EX1004, Table 4.

77. As Miwa discloses the same or substantially the same composition and

properties, a skilled person would have found Claim 1 obvious when Miwa is properly understood.

B. Dependent Claim 2

78. The glass of claim 1 wherein the glass has the additional compositional characteristic that on an oxide basis, the glass comprises at most 0.05 mole percent Sb_2O_3 .

79. Miwa discloses a glass with Sb_2O_3 in ~~e~~Embodiment 15 where the glass comprises 0.02 mole percent Sb_2O_3 , which overlaps with “at most 0.05 mole percent Sb_2O_3 .” EX1004, Table 4. Miwa also describes that the glass can comprise 0 to 1% Sb_2O_3 (by weight). EX1004, ¶14.

80. Thus, Claim 2 is disclosed by Miwa.

C. Dependent Claim 3

81. The glass of claim 1 wherein the glass has the further compositional characteristic that on an oxide basis, the glass comprises at most 0.05 mole percent As_2O_3 .

82. Miwa, in Embodiment 15, discloses a glass comprising ~~zero~~an As_2O_3 ~~in embodiment 15~~mass/weight/mole fraction of zero, which overlaps with “at most 0.05 mole percent As_2O_3 .” EX1004, Table 4.

83. Thus, Claim 3 is disclosed by Miwa.

D. Dependent Claim 4

84. The glass of claim 2 wherein the glass has the further compositional characteristic that on an oxide basis, the glass comprises at most 0.05 mole percent As_2O_3 .

85. Miwa, in Embodiment 15, discloses a glass with an As_2O_3 ~~in~~

~~embodiment 15 in which the glass comprises~~ mass/weight/mole fraction of zero

~~As₂O₃~~, which overlaps with “at most 0.05 mole percent As₂O₃.” EX1004, Table 4.

86. Thus, Claim 4 is disclosed by Miwa.

E. Independent Claim 5

87. Limitation 5[p]: An alkali-free glass comprising in mole percent on an oxide basis.

88. Since limitation 5[p] is identical to limitation 1[p] in Independent Claim 1, Miwa overlaps limitation 5[p] for the same reasons, as discussed for limitation 1[p]. Miwa discloses ~~an~~ a range of alkali-free glass ~~comprising in compositions by specifying mass (weight percent) fractions of components~~ on an oxide basis. EX1004, at [Claim 3], Tables 1-5. As discussed above, ~~it is well known to convert a glass composition from weight percent to compositions can be specified as mass fractions or mole percent fractions, and these can be converted into each other with the help of the known atomic and molecular masses.~~

89. Limitation 5[a]: SiO₂: 64.0-71.0, Al₂O₃: 9.0-12.0, B₂O₃: 7.0-12.0, MgO: 1.0-3.0, CaO: 6.0-11.5, BaO: 0-0.1.

90. Limitation 5[a] is substantially identical to limitation 1[a] except that SrO is not listed in limitation 5[a].

91. The mass (weight percentages) fractions of Miwa’s ~~e~~ Embodiment 15, when converted to mole ~~percentage clearly~~ fractions, show that Miwa describes an alkali-free glass where the ~~concentration~~ mole fractions of SiO₂, Al₂O₃, B₂O₃, MgO and

CaO are in the respective ~~concentration~~ ranges claimed in limitation 5[a]. EX1004, Table 4. A comparison of the ~~concentration~~mole-fraction ranges of each oxide (~~in mole%~~) in limitation 5[a] and the ~~molar composition~~mole fractions of eEmbodiment 15 of Miwa is presented ~~below~~in the following:

Oxide	Miwa Embodiment 15 (<u>mole%</u>)	Limitation 5[a] (<u>mole%</u>)
SiO ₂ :	67. ~~19~~ <u>mole%2</u>	64.0-71.0 ~~mole%~~
Al ₂ O ₃ :	10. ~~22~~ <u>mole%2</u>	9.0-12.0 ~~mole%~~
B ₂ O ₃ :	10. ~~29~~ <u>mole%3</u>	7.0-12.0 ~~mole%~~
MgO:	2. ~~10~~ <u>mole%1</u>	1.0-3.0 ~~mole%~~
CaO:	9. ~~39~~ <u>mole%3</u>	6.0-11.5 ~~mole%~~
BaO	0.21 ~~mole%~~	0-0.1 ~~mole%~~

92. All mole percentages of limitation 5[a] are also disclosed in Bange: “The method of claim 2, wherein the resultant glass comprises an aluminoborosilicate glass, expressed in terms of mole percent on the oxide basis, having SiO₂: 60-73, Al₂O₃: 8-14, B₂O₃: 5-17, MgO: 0-5, CaO: 1-13, SrO: 0-8, BaO: 0-14, TiO₂: 0-5 and Ta₂O₅: 0-5. *Id*, EX 1005, Claim 13.

93. Limitation 5[b]: wherein the glass has the compositional characteristics: (a) on an oxide basis, SrO is at most 1.0 mole percent.

94. Miwa discloses in eEmbodiment 15 that the glass comprises 0.63 mole percent SrO, which overlaps with “SrO is at most 1.0 mole percent”. EX1004, Table 4.

95. Limitation 5[c]: (b) on an oxide basis, the glass comprises at least 0.01 mole percent SnO₂.

96. Embodiment 15 of Miwa teaches that the glass comprises 0.04 mole

percent SnO₂, which overlaps with “at least 0.01 mole percent SnO₂” claimed in limitation 5[c]. EX1004, Table 4.

97. Limitation 5[d]: (c) $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al₂O₃ and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO

98. Miwa teaches glass compositions with $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al₂O₃ and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO. For example, the $\sum[\text{RO}]/[\text{Al}_2\text{O}_3]$ ratio for the glass composition presented in ~~e~~Embodiment 15 of Miwa is 1.21, which is in the range of 1.00 to 1.25, as in limitation 5[d]. EX1004, Table 4.

99. As all of limitations of Claim 5 are described by Miwa, Claim 5 would have been obvious in view of Miwa.

F. Dependent Claim 6

100. The glass of claim 5 wherein the glass has a density that is less than or equal to 2.41 grams/cm³.

101. Embodiment 15 of Miwa teaches a glass density of 2.39 grams/cm³, which overlaps with “a density that is less than or equal to 2.41 grams/cm³” as in dependent claim 6. EX1004, Table 4.

102. Thus, Claim 6 is disclosed by Miwa.

G. Dependent Claim 7

103. Limitation 7[a]: The glass of claim 1 wherein the glass has one or more

of the following properties: (a) a liquidus viscosity that is greater than or equal to 100,000 poise;

104. It is ~~well~~-known in the field that for an alkali-free glass substrate to be fabricated using downdraw technique, the liquidus viscosity should be greater than or equal to 100,000 P (poise), equivalent to $10^{5.0}$ dPa·s (decipascal-seconds) in SI units.

Bange teaches:

Preferred glasses formed in accordance with the present invention exhibit linear coefficients of thermal expansion over the temperature range of 0°-300 °C between $32-46 \times 10^{-7} / ^\circ\text{C}$, more preferably between $32-40 \times 10^{-7} / ^\circ\text{C}$, strain points higher than 630 °C, more preferably higher than 640 °C, and most preferably greater than 650 °C, liquidus temperatures less than 1125 °C, liquidus viscosities which are sufficient to enable the formation by downdraw manufacturing process, preferably greater than 400,000, and more preferably greater than 600,000 poises (60,000 Pa.s)....” EX1005, at 5:22-32.

105. Limitation 7[b]: (b) a strain point that is greater than or equal to 650°C

106. Miwa discloses “a strain point that is greater than or equal to 650°C.” EX1004, Table 4. For example, ~~e~~Embodiment 15 of Miwa describes a strain point at 673°C, which is within the range of “a strain point that is greater than or equal to 650°C” as in limitation 7[b]. EX1004, Table 4.

107. Thus, Miwa discloses limitation 7[b].

108. Limitation 7[c]: (c) a linear coefficient of thermal expansion (CTE) over the temperature range 0-300°C, which satisfies the relationship: $28 \times 10^{-7} / ^\circ\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}$

$7/^{\circ}\text{C}$.

109. Miwa discloses “a linear coefficient of thermal expansion (CTE) over the temperature range $0\text{-}300^{\circ}\text{C}$ which satisfies the relationship: $28\times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34\times 10^{-7}/^{\circ}\text{C}$.” EX1004, at [0047].

As can be seen from the table, the transmittance of all of the test samples (No. 1 to 20) was high, at 55% or more at a wavelength of 300 nm, and 90% or more at wavelengths of 400 to 800 nm. The density was low at 2.43 g/cm^3 or less, making it possible to reduce the weight of the substrate. The coefficient of thermal expansion was **$30\text{-}34\times 10^{-7}/^{\circ}\text{C}$** . Because the strain point was high at 665°C or higher, a glass substrate with low heat shrinkage was obtained. In addition, the temperature corresponding to 102.5 poise² is 1610°C or less, and the liquid phase temperature³ is 1120°C or less, so it also has excellent fusibility and formability. In addition, it showed excellent in acid resistance and BHF resistance.

110. Miwa’s ~~e~~Embodiment 15 reports a coefficient of thermal expansion (CTE) of $34\times 10^{-7}/^{\circ}\text{C}$ measured over a temperature range of $30\text{-}380^{\circ}\text{C}$, which is in the range of $28\times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34\times 10^{-7}/^{\circ}\text{C}$ as in limitation 7[c]. EX1004, Table 4.

111. The differences between the CTE measured over a temperature range of $0\text{-}300^{\circ}\text{C}$ and $30\text{-}380^{\circ}\text{C}$ are of no consequence because the CTE is calculated from the slope of a linear portion of the graph between, $\frac{\Delta l}{l}$ vs. T, where Δl is the change in

² This is understood to be 102.5 poise.

³ This is understood to be liquidus temperature.

length of the glass upon heating, l is the original length of the glass and T is the temperature, which is lower than the glass transition temperature. Since the slope of a linear graph is independent of the beginning or end value of x-axis (in this case, temperature), the temperature range over which CTE is measured in this case, i.e., 0-300°C ('394 patent) vs. 30-380°C (Miwa), is inconsequential. Said another way, the temperature interval $[T_1, T_2] = [0^\circ\text{C}, 300^\circ\text{C}]$ referenced in the '394 Patent, the CTE of Miwa's glass will overlap with the interval of $[28 \cdot 10^{-7} \text{ K}^{-1}, 34 \cdot 10^{-7} \text{ K}^{-1}]$ reported in the in the '394 Patent.

112. Thus, Miwa discloses limitation 7[c].

113. As all of limitations of Claim 7 are described by Miwa when Barge is also considered, Claim 7 would have been obvious.

H. Independent Claim 8

114. Limitation 8[p]: An alkali-free glass comprising in mole percent on an oxide basis

115. Because limitation 8[p] is identical to limitation 1[p], Miwa teaches limitation 8[p] for the same reasons regarding limitation 1[p].

116. Limitation 8[a]: SiO₂: 64.0-71.0, Al₂O₃: 9.0-12.0, B₂O₃: 7.0-12.0, MgO: 1.0-3.0, CaO: 6.0-11.5, SrO: 0-1.0, BaO: 0-0.1

117. The only difference between limitation 8[a] and limitation 1[a] is that 1[a] includes 0-2.0 mole% of SrO whereas 8[a] includes 0-1.0 mole%. Embodiment 15 of

Miwa, when converting from mass percent to mole percent includes 0.63 mole% of SrO that falls within the range defined in limitation 8[a]. An alignment of 8[a] and ~~e~~Embodiment 15 of Miwa is shown in the table below:

Oxide	Miwa Embodiment 15 (mol%)	Limitation 8[a] (mol%)
SiO ₂ :	67.19 ~~mole%~~ <u>2</u>	64.0-71.0 ~~mole%~~
Al ₂ O ₃ :	10.21 ~~mole%~~ <u>2</u>	9.0-12.0 ~~mole%~~
B ₂ O ₃ :	10.29 ~~mole%~~ <u>3</u>	7.0-12.0 ~~mole%~~
MgO:	2.10 ~~mole%~~ <u>1</u>	1.0-3.0 ~~mole%~~
CaO:	9.29 ~~mole%~~ <u>3</u>	6.0-11.5 ~~mole%~~
SrO:	0.63 ~~mole%~~	0-1.0 ~~mole%~~
BaO	0.21 ~~mole%~~	0-0.1 ~~mole%~~

118. Although the molar concentration of BaO exceeds its concentration range disclosed in limitation 8[a], it would have been obvious to adjust the ~~amount~~mole fraction of BaO from $X_{\text{BaO}} = 0.21$ ~~mole percent~~mol% to 0.00 mol% and adjust the mole percentage of SrO from $X_{\text{SrO}} = 0.63$ mol% to 0.84 mol% to keep ~~the total~~their combined mole ~~percentage as 100% with~~fraction, SrO and BaO ~~playing the same role~~play equivalent roles in the glass compositions, as explained in response to limitation 1[a].

119. Limitation 8[b]: wherein: $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \geq 1.00$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO

120. Miwa teaches glass compositions with $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \geq 1.00$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO , CaO , SrO , and BaO . For example, the $\sum[\text{RO}]/[\text{Al}_2\text{O}_3]$ ratio for the glass composition presented in ~~e~~Embodiment 15 of Miwa is 1.21, which is greater than or equal to 1.00, as in limitation 8[b]. EX1004, Table 4.

121. Thus, Miwa discloses limitation 8[b].

122. As all of the limitations of Claim 8 are described by Miwa, Claim 8 would have been obvious in view of Miwa.

I. Dependent Claim 9

123. The glass of claim 8 wherein: $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$.

124. The limitation of claim 9 is described by Miwa. For example, ~~e~~Embodiment 15 of Miwa describes a ~~ratio~~value of ~~1.21~~20 for $\sum[\text{RO}]/[\text{Al}_2\text{O}_3]$, which overlaps with $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, as in dependent claim 9. EX1004, Table 4.

125. Thus, Claim 9 is disclosed by Miwa.

J. Dependent Claim 10

126. The glass of claim 8 wherein the glass has a density that is less than or equal to 2.41 grams/cm^3

127. Embodiment 15 of Miwa describes a glass density of 2.39 grams/cm^3 , which overlaps with “a density that is less than or equal to 2.41 grams/cm^3 ” as in dependent claim 10. EX1004, Table 4.

128. Thus, Claim 10 is disclosed by Miwa.

K. Dependent Claim 11

129. Limitation 11[p]: The glass of claim 8 wherein the glass has one or more of the following properties: Limitation 11[a]: (a) a liquidus viscosity that is greater than or equal to 100,000 poise.

130. Limitation 11[a] is identical to limitation 7[a]. It is well-known in the field that for an alkali-free glass substrate to be fabricated using downdraw technique, the liquidus viscosity should be greater than or equal to 100,000 poise. Bange teaches: Preferred glasses formed in accordance with the present invention exhibit linear coefficients of thermal expansion over the temperature range of 0°-300 ° C between $32-46 \times 10^{-7} / ^\circ\text{C}$, more preferably between $32-40 \times 10^{-7} / ^\circ\text{C}$, strain points higher than 630 °C, more preferably higher than 640 °C, and most preferably greater than 650 °C, liquidus temperatures less than 1125 °C, liquidus viscosities which are sufficient to enable the formation by downdraw manufacturing process , preferably greater than 400,000, and more preferably greater than 600,000 poises (60,000 Pa.s)... EX1005, at 5:22-32.

131. Thus, Miwa's ~~e~~Embodiment 15 considered with Bange's teachings ~~clearly~~ point to the fact that it would have been obvious that Miwa's glass would have and/or would be modified to have a liquidus viscosity greater than or equal to 100,000 poise.

132. Limitation 11[b]: (b) a strain point that is greater than or equal to 650°C

133. Because limitation 11[b] is identical to limitation 7[b], Miwa describes limitation 11[b] for the same reasons regarding limitation 7[b]. Miwa discloses “a strain point that is greater than or equal to 650°C.” EX1004, Table 4. For example, ~~e~~Embodiment 15 of Miwa describes a strain point at 673°C, which is within the range of “a strain point that is greater than or equal to 650°C.” as in limitation 7[b]. EX1004, Table 4.

134. Limitation 11[c]: (c) a linear coefficient of thermal expansion (CTE) over the temperature range 0-300°C which satisfies the relationship: $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$

135. Because limitation 11[c] is identical to limitation 7[c], Miwa teaches limitation 11[c] for the same reasons regarding limitation 7[c].

136. Miwa discloses “a linear coefficient of thermal expansion (CTE) over the temperature range 0-300°C which satisfies the relationship: $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$.” EX1004, at [0047].

As can be seen from the table, the transmittance of all of the test samples (No. 1 to 20) was high, at 55% or more at a wavelength of 300 nm, and 90% or more at wavelengths of 400 to 800 nm. The density was low at 2.43 g/cm³ or less, making it possible to reduce the weight of the substrate. The coefficient of thermal expansion was **30-34** $\times 10^{-7}/^{\circ}\text{C}$. Because the strain point was high at 665°C or higher, a glass substrate with low heat shrinkage was obtained. In addition, the temperature corresponding to 102.5 poise (should be 10^{2.5} poise)

is 1610°C or less, and the liquid phase temperature (should be liquidus temperature) is 1120°C or less, so it also has excellent fusibility and formability. In addition, it showed excellent in acid resistance and BHF resistance.

137. Miwa's ~~e~~Embodiment 15 reports a coefficient of thermal expansion (CTE) of $34 \times 10^{-7}/^{\circ}\text{C}$ measured over a temperature range of 30-380°C, which is in the range of $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$, as in limitation 11[c]. EX1004, Table 4.

138. The differences between a CTE over a temperature range of 0-300°C and 30-380°C are of no consequence because the CTE is calculated from the slope of a linear portion of the graph between $\frac{\Delta l}{l}$ vs T where Δl is the change in length of the glass upon heating, l is the original length of the glass and T is the temperature, which is lower than the glass transition temperature. Since the slope of a linear graph is independent of the temperature range in which the data has been collected, the temperature range over which CTE is measured in this case, i.e., 0-300°C ('394 patent) vs. 30-380°C (Miwa) is inconsequential. Said another way, the temperature interval $[T_1, T_2] = [0^{\circ}\text{C}, 300^{\circ}\text{C}]$ referenced in the '394 Patent, the CTE of Miwa's glass will overlap with the interval of $[28 \cdot 10^{-7} \text{ K}^{-1}, 34 \cdot 10^{-7} \text{ K}^{-1}]$ reported in the in the '394 Patent.

139. As all of the limitations of Claim 11 are described by Miwa, Claim 11 would have been obvious in view of Miwa

L. Dependent Claim 12

140. Limitation 12[p]: The glass of claim 8 wherein the glass has at least one of the following compositional characteristics: Limitation 12[a]: (a) on an oxide basis, the glass comprises at most 0.05 mole percent As_2O_3

141. Limitation 12[a] of claim 12 is described in Miwa. For example, eEmbodiment 15 of Miwa describes that the glass comprises ~~zero~~an As_2O_3 mole/mass/weight fraction of zero, which overlaps with “at most 0.05 mole percent As_2O_3 ” as in limitation 12[a]. EX1004, Table 4.

142. Thus, Miwa discloses limitation 12[a].

143. Limitation 12[b]: (b) on an oxide basis, the glass comprises at most 0.05 mole percent Sb_2O_3

144. The additional limitation 12[b] of claim 12 is described by Miwa. For example, eEmbodiment 15 of Miwa describes that the glass comprises 0.02 mole percent Sb_2O_3 , which overlaps with “at most 0.05 mole percent Sb_2O_3 ” as in limitation 12[b]. EX1004, Table 4.

145. Thus, Miwa discloses limitation 12[b].

146. Limitation 12[c]: (c) on an oxide basis, the glass comprises at least 0.01 mole percent SnO_2

147. The additional limitation 12[c] of claim 12 is described by Miwa. For example, eEmbodiment 15 of Miwa describes a glass composition comprising 0.04 mole percentage of SnO_2 , which overlaps with “at least 0.01 mole percent SnO_2 ” as in limitation 12[c]. EX1004, Table 4.

148. Thus, Miwa discloses limitation 12[c].

149. As all of the limitations of Claim 12 are described by Miwa, Claim 12 would have been obvious in view of Miwa.

M. Dependent Claim 13

150. The glass of claim 12 wherein the glass has compositional characteristics (a) and (b).

151. Dependent Claim 13 is described in Miwa. For example, embodiment 15 of Miwa describes a glass composition comprising zero mole percent As_2O_3 and 0.02 mole percent Sb_2O_3 , which overlap with “the glass of claim 12 wherein the glass has compositional characteristics a and b.”

152. As all of the limitations of Claim 13 are described by Miwa, Claim 13 would have been obvious in view of Miwa.

N. Dependent Claim 14

153. The glass of claim 12 wherein the glass has compositional characteristics (a) and (c).

154. Dependent Claim 14 is described in Miwa. For example, ~~e~~Embodiment 15 of Miwa describes a glass composition comprising ~~zero mole percent an~~ As_2O_3 mole fraction $X_{\text{As}_2\text{O}_3}$ of zero and ~~an Sb_2O_3 0.04 mole-percent Sb_2O_3~~ fraction of $X_{\text{Sb}_2\text{O}_3} = 0.02\text{mol}\%$, which overlap with “the glass of claim 12 wherein the glass has compositional characteristics (a) and (c).”

155. As all of the limitations of Claim 14 are described by Miwa, Claim 14

would have been obvious in view of Miwa.

O. Dependent Claim 15

156. The glass of claim 12 wherein the glass has compositional characteristics (b) and (c).

157. Dependent Claim 15 is described in Miwa. For example, ~~e~~Embodiment 15 of Miwa describes a glass composition comprising 0.02 mole percent Sb_2O_3 and 0.04 mole percent SnO_2 , which overlap with “the glass of claim 12 wherein the glass has compositional characteristics (b) and (c).”

158. As all of the limitations of Claim 15 are described by Miwa, Claim 15 would have been obvious in view of Miwa.

P. Dependent Claim 16

159. The glass of claim 12 wherein the glass has compositional characteristics (a), (b), and (c).

160. Dependent Claim 16 is described in Miwa. For example, ~~e~~Embodiment 15 of Miwa describes a glass composition comprising ~~zero an~~ As_2O_3 mole ~~percent~~ As_2O_3 , ~~0.02 mole percent~~ fraction $X_{\text{As}_2\text{O}_3}$ of zero, an Sb_2O_3 mole fraction of $X_{\text{Sb}_2\text{O}_3} =$ 0.02mol%, and an SnO_2 mole fraction of $X_{\text{SnO}_2} = 0.04$ mole percent SnO_2 , ~~which~~ mol%. These values overlap with “the glass of claim 12 wherein the glass has compositional characteristics (a), (b) and (c).”

161. As all of the limitations of Claim 16 are described by Miwa, Claim 16

would have been obvious in view of Miwa.

VII. Ground 2: Claims 1 and 3 are anticipated by Miwa

A. Independent Claim 1

162. Limitation 1[p]: An alkali-free glass comprising in mole percent on an oxide basis

163. Miwa teaches limitation 1[p] for the same reasons as discussed in ground 1.

That is, Miwa discloses ~~ana~~ a continuous range of alkali-free glass comprising incompositions by specifying ranges for the mass (or weight-percent) fractions of components on an oxide basis. EX1004, at [Claim 3], Tables 1-5. For example, Miwa teaches that “The characteristic feature of the invention is that it comprises SiO₂ 55-70%, Al₂O₃ 12-20%, B₂O₃ 5-15%, MgO 0-5%, CaO 0-12%, SrO 0 – 10%, BaO 0-10%, ZnO 0-5%, ZrO₂ 0-5%, Cl 0-0.5% **alkali free glass** substrate as described in either of the above Claims 1 or 2” EX1004, at [Claim 3]. Tables 4 and 5 of Miwa illustrates various embodiments, including ~~e~~Embodiments 15 and 20 of alkali-free glasses defined by weight percentages of each listed oxide.

164. It is ~~well~~-known that glass compositions ~~maycan~~ be ~~presented on~~ aspecified as mass (or weight-percent) fractions W_i or a mole percent basis, where weight%fractions X_i , which can be converted ~~to mole% and vice versa~~ into each other with the help of the known atomic or molecular masses m_i . EX1007.

165. Limitation 1[a]: SiO₂: 64.0-71.0, Al₂O₃: 9.0-12.0, B₂O₃: 7.0-12.0, MgO: 1.0-3.0, CaO: 6.0-11.5, SrO: 0-2.0, BaO: 0-0.1

166. Miwa discloses limitation 1[a] in ~~e~~Embodiment 20. The table below shows the composition of ~~e~~Embodiment 20 in weight percent. EX1004, Table 5.

	Embodiment				
	16	17	18	19	20
Composition (mass percent)					
SiO ₂	63.0	59.5	62.0	61.1	64.0
Al ₂ O ₃	16.0	18.0	17.0	17.5	15.5
B ₂ O ₃	9.5	10.5	10.0	9.5	9.0
MgO	—	—	0.3	—	0.7
CaO	9.0	8.0	8.5	5.5	6.5
SrO	1.0	—	0.5	3.5	2.0
BaO	0.5	3.0	1.5	0.5	—
ZnO	0.5	0.5	—	1.0	1.0
ZrO ₂	—	0.2	—	0.3	0.5
SnO ₂	0.15	0.15	0.15	0.1	0.1
As ₂ O ₃	—	—	—	—	—
Sb ₂ O ₃	0.25	0.15	—	0.9	0.4
Cl	0.1	—	0.05	0.1	0.3
All Fe ₂ O ₃	0.010	0.010	0.01	0.015	0.015
Transmittance (%)					
300 nm	72	71	71	66	65
400 nm	91	91	91	91	91
600 nm	92	92	92	91	91
800 nm	92	92	92	92	92
Density (g/cm ³)	2.42	2.43	2.40	2.43	2.41
Coefficient of thermal expansion [30-380°C] (×10 ⁻⁶ /°C)	34	34	33	31	30
Strain point (°C)	677	680	682	686	685
Logn at 10 ⁻⁵ (°C)	1585	1520	1585	1560	1605
Liquid phase temperature (°C)	1095	1115	1100	1115	1045
Acid resistance	○	○	○	○	○
Buffered hydrofluoric acid resistance	○	○	○	○	○

EX1004, Table 5.

167. The composition of Miwa's ~~e~~Embodiment 20 was converted from weight percent to mole percent. A table presenting the comparison of the molar concentration of various oxides in ~~e~~Embodiment 20 (Miwa) and limitation 1[a] of '394 is given below.

Oxide	Miwa Embodiment 20 (mol%)	Limitation 1[a] (<u>mol%</u>)
-------	---------------------------------	------------------------------------

SiO ₂ :	~~69.80~~ ~~mole%~~ <u>8</u>	64.0-71.0 ~~mole%~~
Al ₂ O ₃ :	~~9.96~~ ~~mole%~~ <u>10.0</u>	9.0-12.0 ~~mole%~~
B ₂ O ₃ :	~~8.47~~ ~~mole%~~ <u>5</u>	7.0-12.0 ~~mole%~~
MgO:	~~1.14~~ ~~mole%~~ <u>1</u>	1.0-3.0 ~~mole%~~
CaO:	~~7.60~~ ~~mole%~~ <u>6</u>	6.0-11.5 ~~mole%~~
SrO:	~~1.26~~ ~~mole%~~ <u>3</u>	0-2.0 ~~mole%~~
BaO	0.0 ~~mole%~~	0-0.1 ~~mole%~~

168. As shown above, all composition mole percentages of limitation 1[a] are disclosed by Miwa in ~~e~~Embodiment 20.

169. Limitation 1[b]: wherein: (a) $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO;

170. Embodiment 20 of Miwa (EX1004, Table 5) discloses a ~~ratio~~value of 1.00 for ~~$\sum XR / X\text{Al}_2\text{O}_3$~~ $\sum[\text{RO}]/[\text{Al}_2\text{O}_3]$, ~~which, where $R = \text{MgO, CaO, SrO, and BaO}$.~~ This value is in the range of 1.00 to 1.25, as claimed ~~in~~the limitation 1[b]. Therefore, limitation 1[b] “ $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO” is disclosed by Miwa. EX1004, Table 5.

171. Thus, Miwa discloses limitation 1[b].

172. Limitation 1[c]: (b) the glass has the compositional characteristic that on an oxide basis, the glass comprised at least 0.01 mole percent SnO₂; and

173. Embodiment 20 of Miwa (EX1004, Table 5) describes a 0.04 mole percentage of SnO₂, which overlaps with “at least 0.01 mole percent SnO₂,” as claimed in the limitation 1[c]. Therefore, limitation 1[c] “the glass has the compositional characteristic that on an oxide basis, the glass comprised at least 0.01 mole percent SnO₂” of ‘394 is disclosed by Miwa. EX1004, Table 5. Miwa also describes that the glass can comprise 0.01 to 0.3% SnO₂ (by weight). EX1004, ¶17.

174. Thus, Miwa discloses limitation 1[c].

175. Limitation 1[d]: (c) the glass has a density that is less than or equal to 2.41 grams/cm³.

176. Embodiment 20 of Miwa (EX1004, Table 5) discloses a glass with density of 2.41 grams/cm³, which overlaps with “a density that is less than or equal to 2.41 grams/cm³” as claimed in the limitation 1[d]. Therefore, Miwa discloses limitation 1[d] “a density that is less than or equal to 2.41 grams/cm³.” EX1004, Table 5.

177. Miwa discloses limitation 1[d].

178. Accordingly, Miwa, in Embodiment 20, discloses each and every limitation of claim 1.

B. Dependent Claim 3

179. The glass of claim 1 wherein the glass has the further compositional

characteristic that on an oxide basis, the glass comprises at most 0.05 mole percent As_2O_3 .

180. The limitations of claim 3 are described in Miwa. For example, embodiment 20 of Miwa describes that the glass comprises zero As_2O_3 , which is within the range of “at most 0.05 mole percent As_2O_3 ”. EX1004, Table 5.

181. Accordingly, Miwa discloses each and every limitation of claim 3.

VIII. Ground 3: Claims 2 and 4-16 would have been obvious over Miwa in view of Bange

A. Dependent Claim 2

182. The glass of claim 1 wherein the glass has the additional compositional characteristic that on an oxide basis, the glass comprises at most 0.05 mole percent Sb_2O_3 .

183. Miwa discloses a glass with Sb_2O_3 in ~~e~~Embodiment 15 where the glass comprises 0.02 mole percent Sb_2O_3 , which overlaps with “at most 0.05 mole percent Sb_2O_3 ”. EX1004, Table 4. Miwa also describes that the glass can comprise 0 to 1% Sb_2O_3 (by weight) and when converted to mole percent would overlap with the range of Sb_2O_3 as in Claim 2. EX1004, ¶14.

184. Thus, adjusting the mole ~~percent~~fractions of ~~e~~Embodiment 20 in Miwa to ~~have an amount of~~ Sb_2O_3 ~~in an amount~~mole fraction of $X_{\text{Sb}_2\text{O}_3} = 0.05$ mole percentmol% is ~~clearly~~ shown when Miwa’s description is considered in its entirety.

185. Thus, Claim 2 would have been obvious.

B. Dependent Claim 4

186. The glass of claim 2 wherein the glass has the further compositional characteristic that on an oxide basis, the glass comprises at most 0.05 mole percent As_2O_3 .

187. The limitations of claim 4 are described by Miwa. For example, ~~e~~Embodiment 20 of Miwa describes that the glass comprises ~~zero~~an As_2O_3 mole fraction $X_{\text{As}_2\text{O}_3}$ of zero, which is within the range of “at most 0.05 mole percent As_2O_3 ”. EX1004, Table 5.

188. Thus, Claim 4 would have been obvious.

C. Independent Claim 5

189. Limitation 5[p]: An alkali-free glass comprising in mole percent on an oxide basis

190. Miwa discloses an alkali-free glass comprising in weight percent on an oxide basis. EX1004, at [Claim 3], Tables 1-5. For example, Miwa teaches that “The characteristic feature of the invention is that it comprises SiO_2 55-70%, Al_2O_3 12-20%, B_2O_3 5-15%, MgO 0-5%, CaO 0-12%, SrO 0 – 10%, BaO 0-10%, ZnO 0-5%, ZrO_2 0-5%, Cl 0-0.5% **alkali free glass** substrate as described in either of the above Claims 1 or 2” EX1004, at [Claim 3]. Tables 4 and 5 of Miwa illustrates various embodiments, including ~~e~~Embodiments 15 and 20 of alkali-free glasses defined by weight percentages of each listed oxide.

191. It is ~~well~~-known that glass compositions ~~may~~can be ~~presented on~~ aspecified as mass (or weight-percent) fractions W_i or a mole percent basis, where weight%fractions X_i , which can be converted ~~to mole% and vice-versa. into each other~~ with the help of the known atomic or molecular masses m_i . EX1007.

192. Limitation 5[a]: SiO₂: 64.0-71.0, Al₂O₃: 9.0-12.0, B₂O₃: 7.0-12.0, MgO: 1.0-3.0, CaO: 6.0-11.5, BaO: 0-0.1

193. The concentration range of all the oxides of limitation 5[a] are disclosed in Claim 3 of Miwa: “The characteristic of the invention is that it comprises SiO₂ 55-70%, Al₂O₃ 12-20%, B₂O₃ 5-15%, MgO 0-5%, CaO 0-12%, SrO 0-10%, BaO 0-10%, ZnO 0-5%, ZrO₂ 0-5%, Cl 0-0.5% alkali-free glass substrate as described in either of the above Claims 1 or 2.” Although the ~~concentration~~composition ranges ~~of oxides~~ disclosed in Miwa are presented ~~in weight percent as~~ mass fractions on an oxide basis, when converted to mole ~~percent~~fractions, they overlap the ~~concentration~~composition ranges disclosed in limitation 5[a] of ‘394, as evident from the ~~e~~Embodiments 15 and 20 of Miwa. EX1004, Tables 4 and 5.

Oxide	Miwa Embodiment 15 (<u>mol%</u>)	Limitation 5[a] (<u>mol%</u>)
SiO ₂ :	67. ~~19~~ <u>mole%2</u>	64.0-71.0 ~~mole%~~
Al ₂ O ₃ :	10. ~~21~~ <u>mole%2</u>	9.0-12.0 ~~mole%~~
B ₂ O ₃ :	10. ~~29~~ <u>mole%3</u>	7.0-12.0 ~~mole%~~
MgO:	2. ~~10~~ <u>mole%1</u>	1.0-3.0 ~~mole%~~
CaO:	9. ~~29~~ <u>mole%3</u>	6.0-11.5 ~~mole%~~
SrO:	0.63 ~~mole%~~	-
BaO	0.21 ~~mole%~~	0-0.1 mole%

Element	Miwa Embodiment 20	Limitation 5[a]
SiO ₂ :	69. ~~80~~ <u>mole%8</u>	64.0-71.0 ~~mole%~~
Al ₂ O ₃ :	~~9.96~~ <u>mole%10.0</u>	9.0-12.0 ~~mole%~~
B ₂ O ₃ :	8. ~~47~~ <u>mole%5</u>	7.0-12.0 ~~mole%~~
MgO:	1. ~~14~~ <u>mole%1</u>	1.0-3.0 ~~mole%~~
CaO:	7. ~~60~~ <u>mole%6</u>	6.0-11.5 ~~mole%~~

SrO:	1.26 ~~mole%~~ <u>3</u>	-
BaO	0.0 ~~mole%~~	0-0.1 ~~mole%~~

193. All mole percentages of limitation 5[a] are also disclosed in Bange: “The method of claim 2, wherein the resultant glass comprises an aluminoborosilicate glass, expressed in terms of mole percent on the oxide basis, having SiO₂: 60-73, Al₂O₃: 8-14, B₂O₃: 5-17, MgO: 0-5, CaO: 1-13, SrO: 0-8, BaO: 0-14, TiO₂: 0-5 and Ta₂O₅: 0-5. *Id.*, EX 1005, Claim 13.

194. Thus, Bange discloses the composition ranges presented in limitation 5[a].

195. Both SrO and BaO play a network-modifying role in these glasses and their ~~total concentrations, i.e., SrO+BaO,~~ combined mass fraction ($W_{\text{SrO}} + W_{\text{BaO}}$) or, equivalently, combined mole fraction ($X_{\text{SrO}} + X_{\text{BaO}}$) can be optimized to obtain glasses with desired density, coefficient of thermal expansion and refractive index, as discussed earlier.

196. Limitation 5[b]: wherein the glass has the compositional characteristics:
(a) on an oxide basis, SrO is at most 1.0 mole percent

197. Miwa discloses “on an oxide basis, SrO is at most 1.0 mole percent.” EX1004, Table 4. For example, ~~e~~Embodiment 15 of Miwa describes a glass that includes 0.63 mole percent SrO, which is within the range of “SrO is at most 1.0 mole percent”. EX1004, Table 4.

198. Furthermore, adjusting the mole percent of SrO within the embodiments in Miwa and/or within the broader ranges described by Miwa, EX1004, [0029] is clearly

shown when Miwa's description is considered in its entirety.

199. Thus, limitation 5[~~ab~~] would have been obvious when considering Miwa and Bange.

200. Limitation 5[c]: (b) on an oxide basis, the glass comprises at least 0.01 mole percent SnO₂

201. Miwa discloses "on an oxide basis, the glass comprises at least 0.01 mole percent SnO₂." EX1004, tables 4 and 5. For example, both ~~e~~Embodiments 15 and 20 of Miwa teach that the glass comprises an SnO₂ mole fraction of $X_{\text{SnO}_2} = 0.04$ ~~mole percent SnO₂, mol%~~, which is within the range of "at least 0.01 mole percent SnO₂". EX1004, tables 4 and 5.

202. Thus, Miwa discloses limitation 5[c].

203. Limitation 5[d]: (c) $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al₂O₃ and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO

204. Miwa teaches glass compositions with $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where ~~$[\text{Al}_2\text{O}_3]$~~ $X_{\text{Al}_2\text{O}_3}$ is the mole ~~percent~~fraction of Al₂O₃ ~~and $\sum[\text{RO}]$ equals the sum of the mole percents of, $R =$ MgO, CaO, SrO, and BaO. For example, the $\sum[\text{RO}]/[\text{Al}_2\text{O}_3]$ ratio for the glass composition presented in embodiment, and X_R are the mole fractions X_{MgO} , X_{CaO} , X_{SrO} , X_{BaO} . In Embodiment 15 of Miwa is, for example, $\sum X_R/X_{\text{Al}_2\text{O}_3} = 1.21$~~ $= 1.2120$, which is in the range of 1.00 to 1.25 as in limitation 5[d].

205. As all the limitations in Claim 5 of Miwa are described and suggested by Miwa. Further considering the teachings in Bange, Claim 5 would have been obvious.

D. Dependent Claim 6

206. The glass of claim 5 wherein the glass has a density that is less than or equal to 2.41 grams/cm³.

207. Miwa discloses, for example in ~~e~~Embodiment 15, a glass with density of 2.39 grams/cm³, which is within the range of “a density that is less than or equal to 2.41 grams/cm³” as in dependent claim 6. EX1004, Table 4. Further, ~~e~~Embodiment 20 of Miwa discloses a glass density of 2.41 grams/cm³, which also is within the range of “a density that is less than or equal to 2.41 grams/cm³” EX1004, Table 5.

208. Thus, adjusting the glass density within the embodiments or even within the broader teachings by Miwa, EX1004, is ~~clearly~~ shown and conventional when Miwa’s description is considered in its entirety.

209. Accordingly, dependent claim 6 would have been obvious to in view of Miwa.

E. Dependent Claim 7

210. Limitation 7[p]: The glass of claim 1 wherein the glass has one or more of the following properties: Limitation 7[a]: (a) a liquidus viscosity that is greater than or equal to 100,000 poise

211. It is well-known in the field that for an alkali-free glass substrate to be

fabricated using downdraw technique, the liquidus viscosity should be greater than or equal to 100,000 poise. Bange teaches:

Preferred glasses formed in accordance with the present invention exhibit linear coefficients of thermal expansion over the temperature range of 0°-300°C between $32\text{--}46 \times 10^{-7} / ^\circ\text{C}$, more preferably between $32\text{--}40 \times 10^{-7} / ^\circ\text{C}$, strain points higher than 630 °C, more preferably higher than 640 °C, and most preferably greater than 650 °C, liquidus temperatures less than 1125 °C, liquidus viscosities which are sufficient to enable the formation by downdraw manufacturing process , preferably greater than 400,000, and more preferably greater than 600,000 poises (60,000 Pa.s)....” EX1005, at 5:22-32.

212. Thus, Bange discloses limitation 7[a].

213. Limitation 7[b]: (b) a strain point that is greater than or equal to 650°C

214. Miwa discloses “a strain point that is greater than or equal to 650°C.”

EX1004, Table 4. For example, ~~e~~E**Embodiment** 15 of Miwa has a strain point at 673°C, which is within the range of “a strain point that is greater than or equal to 650°C.³” as in limitation 7[b]. EX1004, Table 4. Further, ~~e~~E**Embodiment** 20 of Miwa has a strain point at 685°C, which also is within the range of “a strain point that is greater than or equal to 650°C.³” as in limitation 7[b]. EX1004, Table 5.

215. Thus, Miwa discloses limitation 7[b].

216. Limitation 7[c]: (c) a linear coefficient of thermal expansion (CTE)

over the temperature range 0-300°C which satisfies the relationship: $28 \times 10^{-7} / ^\circ\text{C} \leq \text{CTE} \leq$

$34 \times 10^{-7} / ^\circ\text{C}$

217. Miwa discloses “a linear coefficient of thermal expansion (CTE) over the temperature range 0-300°C which satisfies the relationship: $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$.” EX1004, at [0047].

As can be seen from the table, the transmittance of all of the test samples (No. 1 to 20) was high, at 55% or more at a wavelength of 300 nm, and 90% or more at wavelengths of 400 to 800 nm. The density was low at 2.43 g/cm³ or less, making it possible to reduce the weight of the substrate. The coefficient of thermal expansion was **30-34** $\times 10^{-7}/^{\circ}\text{C}$. Because the strain point was high at 665°C or higher, a glass substrate with low heat shrinkage was obtained. In addition, the temperature corresponding to 102.5 poise⁴ is 1610°C or less, and the liquid phase temperature⁵ is 1120°C or less, so it also has excellent fusibility and formability. In addition, it showed excellent in acid resistance and BHF resistance.

218. Miwa’s ~~e~~Embodiment 15 reports a coefficient of thermal expansion (CTE) of $34 \times 10^{-7}/^{\circ}\text{C}$ over a temperature range of 30-380°C, which is in the range of $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$ as in limitation 7[c]. EX1004, Table 4.

219. The differences between a CTE over a temperature range of 0-300°C and 30-380°C are of no consequence ~~because the CTE is calculated from the slope of a linear portion of the graph between $\frac{\Delta l}{l}$ v. T , where Δl is the change in length of as discussed above for Claim 7 in Ground 1, the glass upon heating, l is the original length of the glass and T is the temperature, which is lower than the glass transition~~

⁴ This is understood to be 102.5 poise.

⁵ This is understood to be liquidus temperature.

~~temperature. Since the slope of a linear graph is independent of the beginning or end value of x-axis (in this case, temperature), the temperature range over which CTE is measured in this case, i.e., 0-300°C ('394 patent) vs. 30-380°C (Miwa), is inconsequential.~~

220. Miwa discloses limitation 7[c] and all the limitations of Claim 7. Therefore, Claim 7 would have been obvious in view of Miwa.

F. Independent Claim 8

221. Limitation 8[p]: An alkali-free glass comprising in mole percent on an oxide basis

222. Miwa teaches limitation 8[p] for the same reasons as discussed in ground 1. That is, Miwa discloses ~~ana~~ a continuous range of alkali-free glass ~~comprising compositions~~ in ~~weight percent on an oxide basis~~ mass fractions. EX1004, at [Claim 3], Tables 1-5. For example, Miwa teaches that “The characteristic feature of the invention is that it comprises SiO₂ 55-70%, Al₂O₃ 12-20%, B₂O₃ 5-15%, MgO 0-5%, CaO 0-12%, SrO 0 – 10%, BaO 0-10%, ZnO 0-5%, ZrO₂ 0-5%, Cl 0-0.5% **alkali free glass** substrate as described in either of the above Claims 1 or 2” EX1004, at [Claim 3]. Tables 4 and 5 of Miwa illustrates various embodiments, including ~~e~~ Embodiments 15 and 20 of alkali-free glasses defined by weight percentages of each listed oxide.

223. It is ~~well~~-known that glass compositions ~~maycan~~ be ~~presented on~~ aspecified as mass (or weight-percent) fractions W_i or a mole percent basis, where

~~weight% fractions X_i , which~~ can be converted ~~to mole% and vice-versa.~~ into each other
with the help of the known atomic or molecular masses m_i . EX1007.

224. Limitation 8[a]: SiO₂: 64.0-71.0, Al₂O₃: 9.0-12.0, B₂O₃: 7.0-12.0, MgO: 1.0-3.0, CaO: 6.0-11.5, SrO: 0-1.0, BaO: 0-0.1

225. The only difference between limitation 8[a] and limitation 1[a] is that 1[a] includes 0-2.0 mole% of SrO whereas 8[a] includes 0-1.0 mole%. As discussed in Ground 2, Miwa's ~~e~~Embodiment 20 anticipates limitation 1[a]. However, this difference in mole% of SrO between ~~e~~Embodiment 20 and limitation 8[a] is not significant. For example, ~~e~~Embodiment 15 of Miwa, when converted from mass percent to mole percent includes 0.63 mole% of SrO that falls within the range defined in limitation 8[a]. A comparison of 8[a] and ~~e~~Embodiment 15 of Miwa is shown in the table below. EX1004, Table 4. Accordingly, the comparison of limitation 8[a] and Miwa regarding the listed compositions mole percentages is summarized as below:

	Embodiment				
	11	12	13	14	15
Composition (mass percent)					
SiO ₂	61.0	62.0	63.0	62.0	62.0
Al ₂ O ₃	16.0	15.0	16.0	16.0	16.0
B ₂ O ₃	12.0	9.4	12.0	11.0	11.0
MgO	—	0.5	—	—	1.3
CaO	7.0	7.0	7.0	8.0	8.0
SrO	1.9	4.0	1.0	0.5	1.0
BaO	1.0	0.05	0.3	1.5	0.5
ZnO	0.5	0.5	—	0.5	—
ZrO ₂	—	0.4	—	0.15	—
SnO ₂	0.1	0.25	0.15	0.15	0.1
As ₂ O ₃	—	0.1	—	—	—
Sb ₂ O ₃	0.5	0.7	0.5	—	0.1
Cl	—	0.1	0.05	0.2	—
All Fe ₂ O ₃	0.015	0.015	0.015	0.010	0.010
Transmittance (%)					
300 nm	65	72	70	74	70
400 nm	91	91	91	92	91
600 nm	92	92	92	92	92
800 nm	92	92	92	92	92
Density (g/cm ³)	2.40	2.44	2.35	2.40	2.39
Coefficient of thermal expansion [30-380°C] (×10 ⁻⁷ /°C)	34	33	31	33	34
Strain point (°C)	665	671	668	669	673
Logn at 10 ^{2.5} (°C)	1555	1560	1605	1565	1560
Liquid phase temperature (°C)	1105	1055	1090	1085	1120
Acid resistance	○	○	○	○	○
Buffered hydrofluoric acid resistance	○	○	○	○	○

EX1004, Table 4 of Miwa

Element	Miwa Embodiment 15_ (mol%)	Limitation 8[a]_ (mol%)
SiO ₂ :	67.19-mole% <u>2</u>	64.0-71.0-mole%
Al ₂ O ₃ :	10.22-mole% <u>2</u>	9.0-12.0 mole%
B ₂ O ₃ :	10.29-mole% <u>3</u>	7.0-12.0-mole%
MgO:	2.10-mole% <u>1</u>	1.0-3.0-mole%
CaO:	9.29-mole% <u>3</u>	6.0-11.5-mole%
SrO:	0.63-mole%	0-1.0-mole%
BaO	0.21-mole%	0-0.1-mole%

226. Although the molar concentration of BaO in ~~e~~Embodiment 15 exceeds the concentration range disclosed in limitation 8[a], the amount in ~~e~~Embodiment 20 is within the range of limitation 8[a]. Further, Miwa teaches that “The characteristic feature of the invention is that it comprises SiO₂ 55-70%, Al₂O₃ 12-20%, B₂O₃ 5-15%, MgO 0-5%, CaO 0-12%, SrO 0 – 10%, BaO 0-10%, ZnO 0-5%, ZrO₂ 0-5%, Cl 0-0.5% alkali free glass substrate as described in either of the above Claims 1 or 2” EX1004, at [Claim 3].

227. Additionally, all mole percentages of limitation 8[a] of the ‘394 patent are disclosed in Bange: “The method of claim 2, wherein the resultant glass comprises an aluminoborosilicate glass, expressed in terms of mole percent on the oxide basis, having SiO₂: 60-73, Al₂O₃: 8-14, B₂O₃: 5-17, MgO: 0-5, CaO: 1-13, SrO: 0-8, BaO: 0-14, TiO₂: 0-5 and Ta₂O₅: 0-5. Id, EX 1005, Claim 13.

228. ~~It~~ Considering SrO and BaO playing the same role in the glass compositions, as explained above in relation to limitation 1[a], it would thus have been obvious to modify ~~e~~Embodiment 20 to adjust the ~~amount~~ mole fraction of BaO from $X_{BaO} = 0.21$ ~~mole percent~~ mol% to 0 and adjust the mole percentage of SrO from $X_{SrO} = 0.63$ to 0.84 mol% to keep the ~~total combined~~ mole ~~percentage as~~ 100% with SrO and BaO fraction $X_{SrO} + X_{BaO}$ constant, playing the same role in the glass compositions, as explained above in relation to limitation 1[a].

229. Thus, limitation 8[a] would have been obvious in view of Miwa and Bange.

230. Limitation 8[b]: wherein: $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \geq 1.00$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO.

231. Miwa discloses “ $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \geq 1.00$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO.” EX1004, Table 5. For example, ~~e~~E**Embodiment** 20 of Miwa teaches a ratio of 1.00 for $\sum[\text{RO}]/[\text{Al}_2\text{O}_3]$, which is within the range of $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \geq 1.00$ as in limitation 8[b]. EX1004, Table 5.

232. Miwa discloses limitation 8[b].

233. Thus, Claim 8 would have been obvious in view of Miwa and Bange.

G. Dependent Claim 9

234. The glass of claim 8 wherein: $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$.

235. The limitations of claim 9 are described in Miwa. For example, ~~e~~E**Embodiment** 20 of Miwa describes a ratio of 1.00 for $\sum[\text{RO}]/[\text{Al}_2\text{O}_3]$, which is within the range of $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$ as in dependent claim 9. EX1004, Table 5.

236. Accordingly, Miwa discloses claim 9.

H. Dependent Claim 10

237. The glass of claim 8 wherein the glass has a density that is less than or equal to 2.41 grams/cm³.

238. The limitations of claim 10 are described by Miwa. For example,

~~e~~Embodiment 20 of Miwa describes a glass density of 2.41 grams/cm³, which is within the range of “a density that is less than or equal to 2.41 grams/cm³” as in dependent claim 10. EX1004, Table 5.

239. Accordingly, Miwa discloses claim 10.

I. Dependent Claim 11

240. Limitation 11[a]: (a) a liquidus viscosity that is greater than or equal to 100,000 poise

241. Limitation 11[a] is identical to limitation 7[a]. It is well-known in the field that for an alkali-free glass substrate to be fabricated using downdraw technique, the liquidus viscosity should be greater than or equal to 100,000 poise. Bange teaches:

Preferred glasses formed in accordance with the present invention exhibit linear coefficients of thermal expansion over the temperature range of 0°-300° C between $32-46 \times 10^{-7} / ^\circ\text{C}$, more preferably between $32-40 \times 10^{-7} / ^\circ\text{C}$, strain points higher than 630 °C, more preferably higher than 640 °C, and most preferably greater than 650 °C, liquidus temperatures less than 1125 °C, liquidus viscosities which are sufficient to enable the formation by downdraw manufacturing process , preferably greater than 400,000, and more preferably greater than 600,000 poises (60,000 Pa.s).... EX1005, at 5:22-32

242. Thus, Miwa’s ~~e~~Embodiments 15 and 20 considered with Bange’s teachings clearly point to the fact that it would have been obvious that Miwa’s glass would have and/or would be modified to have a liquidus viscosity greater than or equal to 100,000 poise.

243. Limitation 11[b]: (b) a strain point that is greater than or equal to 650°C

244. Because the limitation 11[b] is identical to limitation 7[b], Miwa describes limitation 11[b] for the same reasons regarding limitation 7[b]. Miwa discloses “a strain point that is greater than or equal to 650°C.” EX1004, Table 4. For example, eEmbodiment 15 of Miwa describes a strain point at 673°C, which is within the range of “a strain point that is greater than or equal to 650°C.” as in limitation 7[b].
EX1004, Table 4

245. Limitation 11[c]: (c) a linear coefficient of thermal expansion (CTE) over the temperature range 0-300°C which satisfies the relationship: $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$.

246. Because limitation 11[c] is identical to limitation 7[c], Miwa teaches limitation 11[c] for the same reasons regarding limitation 7[c].

247. Miwa discloses “a linear coefficient of thermal expansion (CTE) over the temperature range 0-300°C which satisfies the relationship: $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$.” EX1004, at [0047].

“As can be seen from the table, the transmittance of all of the test samples (No. 1 to 20) was high, at 55% or more at a wavelength of 300 nm, and 90% or more at wavelengths of 400 to 800 nm. The density was low at 2.43 g/cm³ or less, making it possible to reduce the weight of the substrate. The coefficient of thermal expansion was **30-34**×10⁻⁷/°C. Because the strain point was high at 665°C or higher, a glass substrate with low heat shrinkage was obtained. In addition, the temperature corresponding to 102.5 poise (should be 10^{2.5} poise)

is 1610°C or less, and the liquid phase temperature (should be liquidus temperature) is 1120°C or less, so it also has excellent fusibility and formability. In addition, it showed excellent in acid resistance and BHF resistance.”

248. Miwa’s ~~e~~Embodiment 15 reports a coefficient of thermal expansion (CTE) of $34 \times 10^{-7}/^{\circ}\text{C}$ measured over a temperature range of 30-380°C, which is in the range of $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$ as in limitation 11[c]. EX1004, Table 4.

249. As all the limitations of Claim 11 are described by Miwa, Claim 11 would have been obvious in view of Miwa.

J. Dependent Claim 12

250. Limitation 12[p]: The glass of claim 8 wherein the glass has at least one of the following compositional characteristics: Limitation 12[a]: (a) on an oxide basis, the glass comprises at most 0.05 mole percent As_2O_3

251. Limitation 12[a] is described in Miwa. For example, ~~e~~Embodiment 20 of Miwa describes that the glass comprises zero As_2O_3 , which is within the range of “at most 0.05 mole percent As_2O_3 ,” as in limitation 12[a]. EX1004, Table 5.

252. Thus, Miwa discloses limitation 12[a].

253. Limitation 12[b]: (b) on an oxide basis, the glass comprises at most 0.05 mole percent Sb_2O_3

254. The additional limitation 12[b] of claim 12 is described by Miwa. For

example, ~~e~~Embodiment 15 of Miwa describes that the glass comprises 0.02 mole percent Sb_2O_3 , which overlaps with “at most 0.05 mole percent Sb_2O_3 ” as in limitation 12[b]. EX1004, Table 4.

255. Thus, Miwa discloses limitation 12[b].

256. Limitation 12[c]: (c) on an oxide basis, the glass comprises at least 0.01 mole percent SnO_2 .

257. Limitation 12[c] is described in Miwa. For example, ~~e~~Embodiment 20 (as well as ~~e~~Embodiment 15) of Miwa describes that the glass comprises a 0.04 mole percentage of SnO_2 , which is within the range of “at least 0.01 mole percent SnO_2 ” as in limitation 12[c]. EX1004, tables 4 and 5.

258. Thus, Miwa discloses limitation 12[c].

259. As all the limitations of Claim 12 are described by Miwa, Claim 12 would have been obvious in view of Miwa.

K. Dependent Claim 13

260. The glass of claim 12 wherein the glass has compositional characteristics (a) and (b).

261. Dependent Claim 13 is described in Miwa. For example, ~~e~~Embodiment 15 of Miwa describes a glass composition comprising zero mole percent As_2O_3 and 0.02 mole percent Sb_2O_3 , which overlap with “the glass of claim 12 wherein the glass has compositional characteristics (a) and (b).”

262. Thus, Claim 13 is disclosed in Miwa and thus would have been obvious in view of Miwa.

L. Dependent Claim 14

263. The glass of claim 12 wherein the glass has compositional characteristics (a) and (c).

264. The limitations of claim 14 requiring (a) and (c) are described in Miwa. Embodiment 20 of Miwa describes that the glass comprises zero As_2O_3 and a 0.04 mole percentage of SnO_2 and, thus describes compositional characteristics (a) and (c) as in claim 12.

265. As all of the limitations of Claim 14 are described by Miwa, Claim 14 would have been obvious in view of Miwa.

M. Dependent Claim 15

266. The glass of claim 12 wherein the glass has compositional characteristics (b) and (c).

267. Dependent Claim 15 is described in Miwa. For example, ~~e~~Embodiment 15 of Miwa describes a glass composition comprising 0.02 mole percent Sb_2O_3 and 0.04 mole percent SnO_2 , which overlap with “the glass of claim 12 wherein the glass has compositional characteristics (b) and (c).”

268. As all of the limitations of Claim 15 are described by Miwa, Claim 15 would have been obvious in view of Miwa.

N. Dependent Claim 16

269. ~~The glass of claim 12 wherein the glass has compositional characteristics (a), (b), and (c). Claim 16 depends from claim 12. The limitations of claim 16 would have been obvious to a POSITA for the reasons discussed above for claim 12.~~

270. Dependent Claim 16 is described in Miwa. For example, ~~e~~Embodiment 15 of Miwa describes a glass composition comprising zero mol percent As_2O_3 , 0.02 mole percent Sb_2O_3 and 0.04 mole percent SnO_2 , which overlap with “the glass of claim 12 wherein the glass has compositional characteristics (a), (b) and (c).”

271. As all of the limitations of Claim 16 are described by Miwa, Claim 16 would have been obvious in view of Miwa.

IX. CONCLUSION

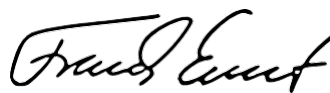
272. For the reasons set forth above, Claims 1-16 of the 394 Patent are unpatentable in view of the prior art.

273. In signing this declaration, I recognize that it will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place in the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

274. I reserve the right to supplement my opinions in the future to respond to any arguments that the Patent Owner raises and to consider new information as it becomes available to me.

275. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Respectfully Submitted,



 Digitally signed by Ashutosh