

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

PETITION FOR INTER PARTES REVIEW

OF U.S. PATENT NO. 7,851,394

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PETITIONER’S EXHIBIT LIST

EX1001	U.S. Patent No. 7,851,394 (the “’394 Patent”)
EX1002	Prosecution History of the ’394 Patent
EX1003	Declaration of Dr. Ashutosh Goel
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)
EX1008	Dr. Ashutosh Goel <i>Curriculum Vitae</i>
EX1009	Case Report: <i>Corning Incorporated v. Caihong Display Devices Co., Ltd. et al</i> , Case No. 1-24-cv-02328
EX1010	Eastern District of Virginia District TimeLine

I. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8

A. Real Party-in-Interest

Caihong Display Devices Co., Ltd. (“Caihong”) is the Petitioner and a real party-in-interest.

B. Related Matters

U.S. Patent No. 7,851,394 (“the ’394 Patent”) is presently the subject of a patent infringement lawsuit filed against Petitioner in the United States District Court for the Eastern District of Virginia *Corning Incorporated v. Caihong Display Devices Co., Ltd. et al*, Case No. 1-24-cv-02328. The ’394 Patent is also asserted in the ITC investigation *Corning Inc v. HKC Overseas Ltd et al.*, Case No. 337-TA-3795. This is the first case in which the ’394 Patent was litigated. The ’394 Patent has not been subjected to post-grant review by the Patent Trial & Appeal Board.

C. Lead and Back-up Counsel and Service Information

Please address correspondence to lead and back-up counsel as set forth below. Petitioner consents to electronic service.

Lead Counsel:

Daniel J. Pereira (Reg. No. 45,518)
Merchant and Gould PC
1900 Duke Street, Suite 600
Alexandria, VA 22314
Telephone: (703) 518-4509
E-Mail: dpereira@merchantgould.com

Backup Counsel:

Donald McPhail (Reg. No. 35,811)
Merchant and Gould PC
1900 Duke Street, Suite 600
Alexandria, VA 22314
Telephone: (703) 518-4509
E-Mail: dmcphail@merchantgould.com

Service Information: Petitioner consents to electronic service by email to the following addresses:

- dpereira@merchantgould.com
- dmcphail@merchantgould.com

II. FEE AUTHORIZATION

The PTO is authorized to charge any fees due during this proceeding to Deposit Account No. 132725.

III. GROUNDS FOR STANDING

Petitioner certifies that the '394 Patent is available for *inter partes* review and that Petitioner is not barred or estopped from requesting *inter partes* review challenging the patent claims on the grounds identified in this Petition.

IV. REQUESTED RELIEF

Petitioner requests review and cancellation of Claims 1-16 as unpatentable based on the following grounds, supported by a declaration from Dr. Ashutosh Goel. Ex-1003.

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

IV. REASONS FOR THE REQUESTED RELIEF

“The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007). If a person of ordinary skill can implement a predictable variation, § 103 likely bars its patentability. 550 U.S. at 417.

Miwa with or without Bange renders obvious all elements of the Challenged Claims under Grounds 1-3 as set forth below. Ground 1 primarily relies on embodiment 15 of Miwa with other relevant teachings in Miwa and Bange. Ground 2 relies on embodiment 20 of Miwa. Ground 3 primarily relies on embodiment 20 with other relevant teachings in Miwa, including embodiment 15.

The ’394 Patent is directed to alkali-free glasses suited for use as substrates in flat panel display devices, such as active matrix liquid crystal displays (AMLCDs). It addresses the fining (refining) process of such glasses to achieve the desired physical and chemical properties. The ‘394 Patent alleges that the claimed glasses are dimensionally stable, have specific thermal and expansion characteristics, and can undergo semiconductor type processes without degradation.

The Challenged Claims, however, are neither novel nor unobvious. For example, the combination of Miwa in view of Bange, also related to alkali-free glasses suited for use as substrates in flat panel display devices, renders all the elements of the Challenged Claims obvious as discussed in more detail below.

This Petition's showing that the cited art renders the Challenged Claims unpatentable is fully supported by the Declaration of Dr. Ashutosh Goel (EX1003). Dr. Goel is an expert in the field of alkali-free glasses for use as substrates in flat panel display devices and fully agrees with and supports the showing herein that the claims at issue merely recite long-known aspects of such glasses.

Accordingly, the Board should institute the trial and cancel the Challenged Claims.

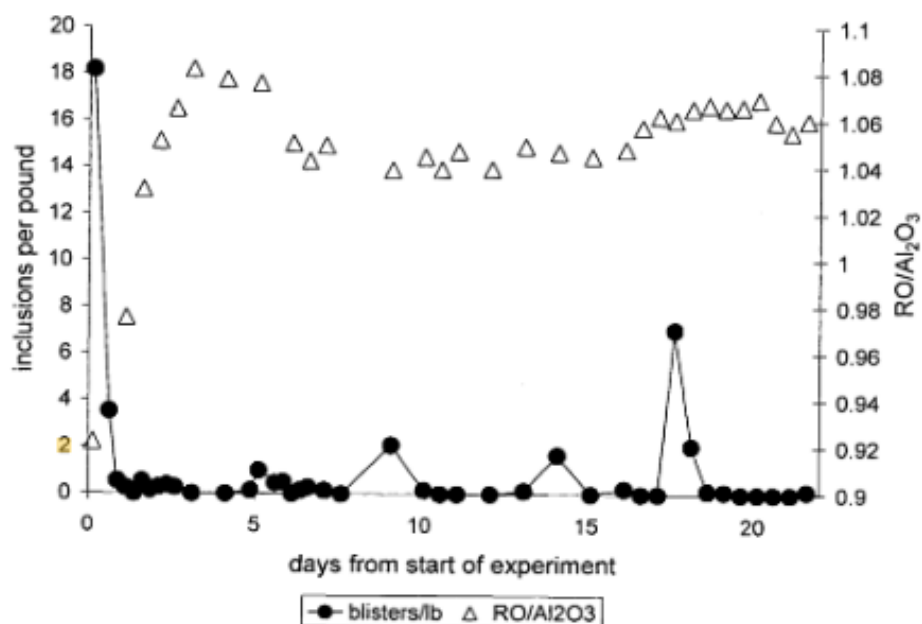
A. Summary of the '394 Patent

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. EX1003, ¶43.

Traditionally, As_2O_3 and Sb_2O_3 are used as fining agents during glass finning process. *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. EX1003, ¶ 44.

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. EX1003, ¶ 45.

To make the finning process easier and more effective, 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 described in the '394 Patent, the mole percentage of MgO should be within 1% to 3% range to reduce the liquidus temperature, thus increasing the liquidus viscosity. *Id.*, at 10:19-44. In addition, the $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$ ratio should be higher than 1 to avoid inclusions (blisters) in the glasses and maintain high viscosity during the fining process. *Id.*, Abstract, FIG. 3 as reproduced below EX1003, ¶ 46.



B. The Prosecution History of the '394 Patent

Miwa (JP2004189535) was merely cited by the Applicant in a Supplemental Information Disclosure Statement (“SIDS”) of August 4, 2008. EX1002, 000177. Miwa was not discussed, addressed, or otherwise relied upon by the Examiner during prosecution.

Similarly, Bange (U.S. Patent No. 5,824,127) was merely cited in an IDS on March 20, 2008 and cited in the originally filed specification at page 4, line 31. EX1002, 000275; 000323. Bange was not discussed, addressed, or otherwise relied upon by the Examiner during prosecution.

Notably, all the specific parameters that form the bases for either obviousness or anticipation of the Challenged Claims in this Petition are only disclosed by Miwa

in the Tables, not in the text. However, the Applicant omitted all Tables in the English translation of Miwa when submitting the SIDS. EX1002, 000194-000226. Hence, no English version of the Tables of Miwa was ever presented to the Examiner during the prosecution history.

C. Priority Date

The '394 Patent was filed on June 28, 2006, and claims priority to Provisional Application No. 60/694,478 filed on June 28, 2005. EX1001, cover page. That date is the assumed priority date for the purposes of this Petition. Thus, the earliest possible effective U.S. filing date for the '349 Patent is June 28, 2005.

While Petitioner does not accede to an invention date of June 28, 2005, for the '394 Patent, for purposes of this Petition only it is assumed that the '349 Patent is entitled to that date. Accordingly, any art published before June 28, 2005, is prior art under § 102(a), any art published before June 28, 2004, is prior art under § 102(b), and patents granted on applications filed before June 28, 2005, are prior art under § 102(e). See 35 U.S.C. § 102 (pre-AIA). All of the references cited in the instant Petition qualify as prior art based on a priority date of June 28, 2005.

D. Discretionary Denial under § 325(d) or § 314(a) Is Not Warranted.

Caihong has not been involved in any previous review of the '394 Patent. Additionally, the Office has not considered the combinations of references forming the grounds for this Petition, and the combinations are not redundant to any

combination of references considered during prosecution. Additionally, the instant Petition provides the analysis of Dr. Goel, which has likewise not been presented to the Office before. As the same or similar arguments have not been previously considered by the Office, discretionary denial under § 325(d) is not warranted here. See also, *Amgen Inc. v Alexion Pharmaceuticals, Inc.*, IPR2019-00740, slip op. at 65 (PTAB Aug. 30, 2019) (Paper 15):

Both of these citations, however, are to an Information Disclosure Statement signed by the Examiner. See *id.* (citing Ex. 1014, 565, 566). Patent Owner does not direct us to, nor do we discern, where either Bell or some version of Bowdish was substantively considered during prosecution. The Board has consistently declined exercising its discretion under Section 325(d) when the only fact a Patent Owner can point to is that a reference was disclosed to the Examiner during the prosecution. See, e.g., *Amneal Pharms. LLC v. Alkermes Pharma Ireland Ltd.*, IPR2018- 00943, slip op. at 40 (PTAB Nov. 7, 2018) (Paper 8) (declining to deny institution based on Section 325(d) where the reference was listed on the face of the patent, but Patent Owner provided no evidence “about the extent to which the Examiner evaluated” the reference during prosecution); *Digital Check Corp. d/b/a ST Imaging v. E-Imagedata Corp.*, IPR2017-00178, slip op. at 12–13 (PTAB Apr. 25, 2017) (Paper 6) (acknowledging that a prior art reference was cited in an IDS, but granting institution because there was no indication that the claims were rejected based on those references or that the Examiner substantively discussed those references during prosecution); *Fox Factory, Inc. v. SRAM, LLC*, IPR2016-01876, slip op. at 7–9 (PTAB Apr. 3, 2017) (Paper 8) (refusing to deny institution based on Section 325(d) for grounds based on a prior art reference that was simply cited in an IDS and not considered at any length); *Praxair Distribution, Inc. v. INO Therapeutics LLC*, IPR2015-00893, slip op. at 8 (PTAB Sept. 22, 2015) (Paper 14) (granting institution even though the references were previously cited in an IDS because patent owner failed to identify with specificity where the references were considered); *HyperBranch Medical Technology, Inc. v. Confluent Surgical, Inc.*, IPR2018-01099, slip op. at 17 (PTAB Nov. 27, 2018) (Paper 14) (instituting IPR because, inter alia, “[t]he Examiner does not appear to have

considered the combined teachings of Spero and Haber during examination of the '021 patent.”).

Likewise, denial under § 314(a) is not warranted because application of the factors in *General Plastic Industrial Co. v. Canon Kabushiki Kaisha* IPR2016-01357 (P.T.A.B. Sept. 6, 2017) (Paper 19) (precedential) demonstrates that the filing of the instant Petition is not abusive, that neither the Patent Owner, the Office, nor the Board has addressed the merits of the grounds in this Petition, and instituting the present proceeding is an efficient use of the Board’s resources. Thus, the Board should institute trial on the instant petition.

Moreover, the Petition should not be denied under the discretionary factors set out in *Apple v. Finitiv, Inc.*, IPR2020-00019 (PTAB Mar. 20, 2020) (“*Finitiv I*”) (Paper 11 at 6). Petitioner addresses each of those factors below.

1. Whether the court granted a stay or evidence exists that one may be granted if a proceeding is instituted

No stay of the co-pending district court litigation has been requested. Patent Owner waited years after the '394 Patent issued on December 14, 2010, before filing its litigation Complaint and ITC Investigation in December 2024. As such, the litigation is in its early stages, and a stay pending IPR would be appropriate.

However, given that a motion to stay has not yet been filed, the Board should not infer the outcome of that motion. *Intel Corp. v. VLSI Tech. LLC*, IPR2020-00158,

Paper 16, at 7 (PTAB May 20, 2020); *Apple v. Finitiv, Inc.*, IPR2020-00019, Paper 15, at 12 (PTAB May 13, 2020). Thus, this factor is neutral on discretionary denial.

2. Proximity of the court’s trial date to the Board’s projected statutory deadline for a final written decision

The trial in the litigation is not yet scheduled and the court has not yet entered a Scheduling Order. EX10008. This case remains at the pleading stage.

In the Eastern District of Virginia, the average time to trial is estimated to be 26 months. EX1010. The fact that it remains in the pleading stage means that it is unlikely the litigation will be ready for trial before the Board enters a final written decision based on this Petition. Thus, this factor weighs against discretionary denial.

3. Investment in parallel proceedings by the court and parties

The litigation is in its early stages, and the investment in it has been minimal. Patent Owner has just filed its Complaint. No scheduling order has been entered, and the case remains in its pleading stage. EX10008. The early stage of the litigation weighs against discretionary denial.

4. Overlap between issues raised in the Petition and in the parallel proceeding

No deadline requiring Petitioner to articulate its invalidity positions in the litigation has passed or is pending. Instituting a proceeding will allow the Board to address the art, and the issues will be narrowed in the litigation due to the estoppel provisions of 35 U.S.C. § 315(e)(2). To reduce potential overlap, if the Board

institutes trial, Petitioner will decline to assert in the related litigation the prior art combinations on which trial is instituted for the claims on which trial is instituted, while trial is instituted. The most efficient course is for the Board to address the issues before it and the district court to address only the issues that would remain. This factor weighs against discretionary denial.

5. Whether the Petitioner and the defendant in the parallel proceeding are the same party

Petitioner is a defendant in the litigation. EX1008. That is true of many Petitioners in IPR proceedings and is consistent with one purpose of IPRs as a process available to defendants faced with allegations of infringement. This factor should not be a basis for denying institution.

6. Other circumstances that impact the Board's exercise of discretion, including the merits

As discussed in more detail below in Sections VIIIA, VIIIB and VIIC, the prior art relied upon herein demonstrates that Claims 1-16 are unpatentable as obvious. The merits of Petitioner's argument are strong, and this factor weighs against discretionary denial.

As such, this Petition should not be denied on discretionary factors.

E. Secondary Considerations

At this stage of these proceedings, Petitioner has no burden to identify and rebut secondary considerations. Rather, Patent Owner must first present a *prima*

facie case for such consideration, which Petitioner should then have the chance to rebut. *Sega of Am., Inc. v. Uniloc USA, Inc.*, IPR2014-01453, Paper 11, at 20 (PTAB Mar. 10, 2015). For that reason, the Board typically rejects arguments against institution based on objective indicia so that Petitioner can have a fair opportunity to address any secondary indicia evidence on reply. *Petroleum Geo-Services, Inc. v. WesternGeco LLC*, IPR2014-01478 (Mar. 17, 2015) (Paper 18 at 36).

V. CLAIM CONSTRUCTION

In *inter partes* review, claims are “construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b).” 37 C.F.R. § 42.100(b). Claim must be given their ordinary and customary meaning as understood by a POSITA at the time of the invention in light of the specification and the prosecution history pertaining to the patent. *Id.*; *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312-13 (Fed. Cir. 2015) (en banc); *see also* 83 Fed. Reg. 51340, Vol. 83, No. 197 (Oct. 11, 2018). As such, this Petition and Dr. Goel’s declaration construe claim terms consistent with the understanding a POSITA would have in view of the ’394 Patent’s intrinsic evidence and, where appropriate, extrinsic evidence. *Phillips*, 415 F.3d at 1312. EX1003, ¶¶38-41.

Terms not specifically construed below have their plain and ordinary meaning, as discussed in more detail for particular terms. Petitioner believes the remaining claim terms do not require construction for the purpose of evaluating the

prior art in this Petition. Petitioner, however, may pursue constructions of additional claim terms, including that certain terms are indefinite in the related litigation concerning the '257 Patent to help the jury understand the relevant technical terms.

VI. STATUTORY GROUNDS FOR CHALLENGES AND

REFERENCES USED

Claims 1-16 are obvious over Miwa (EX1004) in view of Bange (EX1005), which constitutes Ground 1. Claims 1 and 3 are anticipated by Miwa, which constitutes Ground 2. Claims 2 and 4-16 are obvious over Miwa, which constitutes Ground 3.

Miwa was made public in the United States no later than July 8, 2004, EX1004, cover page; and Bange was made public in the United States no later than October 20, 1998, EX1005, cover page. Accordingly, Miwa and Bange qualify as prior art to the '394 Patent under at least 35 U.S.C. 102(a) (pre-AIA) and 35 U.S.C. 102(b) (pre-AIA). A certified translation of Miwa accompanies this petition, and this translation will be cited in this petition. EX1005.

VII. LEVEL OF ORDINARY SKILL IN THE ART

The person of ordinary skill in the art ("POSITA") with respect to this patent would have an educational background, would have had knowledge of and experience with the concepts of glass science relevant to '394 patent, for example

(but not limited to), liquidus temperature, viscosity, coefficient of thermal expansion (CTE), strain point, density, and have 5-10 years of experience with design, synthesis and characterization of silicate, borosilicate, aluminosilicate and boroaluminosilicate glasses, demonstrable in the form of peer-reviewed publications and /or patents. EX1003, ¶36.

VIII. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS

A. Miwa (EX1004)

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-free boroaluminosilicate 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.* EX1003, ¶51.

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.* EX1003, ¶52.

Like the '394 Patent, Miwa also describes the specified glass compositions, including SiO₂, B₂O₃, Al₂O₃, MgO, CaO, SrO, and BaO, in certain weight percentages to achieve properties such as high thermal shock resistance, chemical

resistance, transparency across visible and ultraviolet regions, low density, and a thermal expansion coefficient matched to silicon substrates. *Id.* at [0022]. For example, the glass disclosed by Miwa demonstrates excellent mechanical stability and resistance to hydrochloric acid, making it ideal for Thin Film Transistor (“TFT”) 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 are also suitable for flat panel display applications. EX1003, ¶ 53

For example, Miwa’s 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 ²⁻³ (°C)	1555	1560	1605	1565	1560
Liquid phase temperature (°C)	1105	1055	1090	1085	1120
Acid resistance	○	○	○	○	○
Buffered hydrofluoric acid resistance	○	○	○	○	○

EX1004, Table 4; EX1003, ¶54.

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%

Al₂O₃: 10.22 mole%

B₂O₃: 10.29 mole%

MgO: 2.10 mole%

CaO: 9.29 mole%

SrO: 0.63 mole%

BaO: 0.21 mole%

SnO₂: 0.04 mole%

As₂O₃: 0.0 mole%

Sb₂O₃: 0.02 mole%

Fe₂O₃: 0.00 mole%

$\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3] = 1.21$

EX1003, ¶54.

B. Bange (EX1005)

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. EX1003, ¶56.

Like the '394 Patent, Bange also describes the glass compositions ranges, including SiO₂, B₂O₃, Al₂O₃, MgO, CaO, SrO, and BaO, in certain mole percentages to 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. EX1003, ¶57.

Similar to the '394 Patent, Bange also describes using SnO_2 and Sb_2O_3 as the fining agents among others. *Id.*, 6:37-41; 4:35-41. EX1003, ¶5

C. Motivation to combine Miwa in view of Bange

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 ($IFS = \frac{Z}{(r_c + r_o)^2}$, 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 of BaO and SrO ($\text{SrO} + \text{BaO}$) 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. EX1003, ¶59.

VIII. CLAIMS 1-16 ARE UNPATENTABLE.

A. Ground 1: Claims 1-16 are invalid under 35 U.S.C. § 103(a) (pre-AIA) as obvious over Miwa in view of Bange

1. Independent Claim 1

There are several limitations in Claim 1 and each is addressed in turn.

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

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. . .” EX1004, at [Claim 3]. Table 4 of Miwa illustrates various embodiments, including embodiment 15 of alkali-free glass defined by weight percentages of each listed oxide. EX1003, ¶ 61.

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., $x_i = \frac{wt\%_i}{MW_i}$, where wt%_{*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>i</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
			$x = \sum x_i = 1.56$	

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

The composition of Miwa's embodiment 15 was converted from weight percent to mole percent, as shown in the table below. EX1004, Table 4.

Oxide	Miwa Embodiment 15	Limitation 1[a]
SiO ₂ :	67.19 mole%	64.0-71.0 mole%
Al ₂ O ₃ :	10.22 mole%	9.0-12.0 mole%
B ₂ O ₃ :	10.29 mole%	7.0-12.0 mole%
MgO:	2.10 mole%	1.0-3.0 mole%
CaO:	9.29 mole%	6.0-11.5 mole%
SrO:	0.63 mole%	0-2.0 mole%
BaO	0.21 mole %	0-0.1 mole%

EX1003, ¶64.

All mole percentages of limitation 1[a] are disclosed by Miwa in embodiment 15, except the mole percentage of BaO. EX1003, ¶65.

Miwa discloses that the glass composition can comprise “BaO 0-10%,” Ex1004, [0022] and further 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]. EX1003, ¶66.

Both SrO and BaO play a network modifying role in these glasses and their total concentrations, *i.e.*, SrO+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 of BaO may be replaced by SrO. For example, the concentration of SrO in Miwa's embodiment 15 may be increased to 0.84 mole percent with BaO being 0, while the other components remain unchanged. 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. EX1003, ¶67.

It would have been obvious to adjust the amount of BaO from 0.21 mole percent to 0 and adjust the mole percentage of SrO from 0.63 to 0.84 to keep the total mole percentage as 100% with SrO and BaO playing the same role in the glass compositions, as discussed. EX1003, ¶68.

A zero mole percentage of BaO also overlaps the 0-0.1 mole percentage in limitation 1[a]. EX1003, ¶69.

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; EX1003, ¶ 70.

Limitation 1[b]: wherein: (a) $1.00 \leq \sum[RO]/[Al_2O_3] \leq 1.25$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO , CaO , SrO , and BaO

Embodiment 15 of Miwa (EX1004, Table 4) discloses a ratio of 1.21 for $\sum[RO]/[Al_2O_3]$, which is in the range of 1.00 to 1.25 as in limitation 1[b]. Therefore, limitation 1[b] “ $1.00 \leq \sum[RO]/[Al_2O_3] \leq 1.25$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO , CaO , SrO , and BaO ” is disclosed by Miwa. EX1004, Table 4; EX1003, ¶ 72.

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

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; EX1003, ¶74.

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

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; EX1003, ¶76.

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. EX1003, ¶77.

2. Dependent Claim 2

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 .

Miwa discloses a glass with Sb_2O_3 in 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; EX1003, ¶ 79. Thus, Claim 2 is disclosed by Miwa. EX1003, ¶ 80.

3. Dependent Claim 3

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 .

Miwa discloses a glass comprising zero As_2O_3 in embodiment 15, which overlaps with “at most 0.05 mole percent As_2O_3 .” EX1004, Table 4; EX1003, ¶81. Thus, Claim 3 is disclosed by Miwa. EX1003, ¶ 83.

4. Dependent Claim 4

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 .

Miwa discloses a glass with As_2O_3 in embodiment 15 in which the glass comprises zero As_2O_3 , which overlaps with “at most 0.05 mole percent As_2O_3 .” EX1004, Table 4. EX1003, ¶ 85.

Thus, Claim 4 is disclosed by Miwa.

5. Independent Claim 5

There are several limitations in Claim 5 and each is addressed in turn.

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

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 alkali-free glass comprising in weight percent 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 mole percent. EX1003, ¶ 88.

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

Limitation 5[a] is substantially identical to limitation 1[a] except that SrO is not listed in limitation in 5[a]. EX1003, ¶ 90.

The weight percentages of Miwa's embodiment 15 when converted to mole percentage clearly show that Miwa describes an alkali-free glass where the concentration 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 ranges of each oxide (in mole%) in limitation 5[a] and the molar composition of embodiment 15 of Miwa is presented below:

Oxide	Miwa Embodiment 15	Limitation 5[a]
SiO ₂ :	67.19 mole%	64.0-71.0 mole%
Al ₂ O ₃ :	10.22 mole%	9.0-12.0 mole%
B ₂ O ₃ :	10.29 mole%	7.0-12.0 mole%
MgO:	2.10 mole%	1.0-3.0 mole%
CaO:	9.39 mole%	6.0-11.5 mole%
BaO	0.21 mole %	0-0.1 mole %

EX1003, ¶ 91.

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. EX1003, ¶ 92.

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

Miwa discloses in embodiment 15 that the glass comprises 0.63 mole percent SrO, which overlaps with “SrO is at most 1.0 mole percent”. EX1004, Table 4; EX1003, ¶94.

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

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; EX1003, ¶ 96.

Limitation 5[d]: (c) $1.00 \leq \sum[RO]/[Al_2O_3] \leq 1.25$, where $[Al_2O_3]$ is the mole percent of Al₂O₃ and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO

Miwa teaches glass compositions with $1.00 \leq \sum[RO]/[Al_2O_3] \leq 1.25$, where $[Al_2O_3]$ is the mole percent of Al₂O₃ and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO. For example, the $\sum[RO]/[Al_2O_3]$ ratio for the glass composition presented in 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. EX1003, ¶ 98.

As all of limitations of Claim 5 are described by Miwa, Claim 5 would have been obvious in view of Miwa. EX1003, ¶ 99.

6. Dependent Claim 6

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

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.; EX1003, ¶ 101. Thus, Claim 6 is disclosed by Miwa. EX1003, ¶ 102.

7. Dependent Claim 7

There are several limitations in Claim 7 and each is addressed in turn.

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;

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; EX1003, ¶ 104.

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

Miwa discloses “a strain point that is greater than or equal to 650°C.” EX1004, Table 4. For example, 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; EX1003, ¶ 106. Thus, Miwa discloses limitation 7[b]. EX1003, ¶ 107.

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

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 poise¹ is 1610°C or less, and the liquid phase temperature² is 1120°C or less, so it also has excellent fusibility and formability. In addition, it showed excellent in acid resistance and BHF resistance.

¹ This is understood to be 10^{2.5} poise.

² This is understood to be liquidus temperature.

EX1003, ¶ 109.

Miwa's 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 7[c]. EX1004, Table 4. EX1003, ¶ 110.

The differences between the CTE measured 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 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. EX1003, ¶ 111.

Thus, Miwa discloses limitation 7[c]. EX1003, ¶ 112.

As all of limitations of Claim 7 are described by Miwa when Barge is also considered, Claim 7 would have been obvious. EX1003, ¶ 113.

8. Independent Claim 8

There are several limitations in Claim 8 and each is addressed in turn.

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

Because limitation 8[p] is identical to limitation 1[p], Miwa teaches limitation 8[p] for the same reasons regarding limitation 1[p]. EX1003, ¶ 115.

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

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 embodiment 15 of Miwa is shown in the table below:

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

EX1003, ¶ 117.

Although the molar concentration of BaO exceeds its concentration range disclosed in limitation 8[a], it would have been obvious to adjust the amount of BaO from 0.21 mole percent to 0 and adjust the mole percentage of SrO from 0.63 to 0.84

to keep the total mole percentage as 100% with SrO and BaO playing the same role in the glass compositions, as explained in response to limitation 1[a]. EX1003, ¶ 118.

Limitation 8[b]: wherein: $\sum[RO]/[Al_2O_3] \geq 1.00$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO

Miwa teaches glass compositions with $\sum[RO]/[Al_2O_3] \geq 1.00$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO. For example, the $\sum[RO]/[Al_2O_3]$ ratio for the glass composition presented in embodiment 15 of Miwa is 1.21, which is greater than or equal to 1.00, as in limitation 8[b]. EX1004, Table 4; EX1003, ¶ 120. Thus, Miwa discloses limitation 8[b]. EX1003, ¶ 121.

As all of the limitations of Claim 8 are described by Miwa, Claim 8 would have been obvious in view of Miwa. EX1003, ¶ 122.

9. Dependent Claim 9

The glass of claim 8 wherein: $\sum[RO]/[Al_2O_3] \leq 1.25$.

The limitation of claim 9 is described by Miwa. For example, embodiment 15 of Miwa describes a ratio of 1.21 for $\sum[RO]/[Al_2O_3]$, which overlaps with $\sum[RO]/[Al_2O_3] \leq 1.25$, as in dependent claim 9. EX1004, Table 4; EX1003, ¶ 124.. Thus, Claim 9 is disclosed by Miwa. EX1003, ¶ 125.

10. Dependent Claim 10

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

Embodiment 15 of Miwa describes 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 10. EX1004, Table 4; EX1003, ¶ 1217. Thus, Claim 10 is disclosed by Miwa. EX1003, ¶ 128.

11. Dependent Claim 11

There are several limitations in Claim 11 and each is addressed in turn.

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

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; EX1003, ¶ 130.

Thus, Miwa's 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. EX1003, ¶ 131.

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

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, 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; EX1003, ¶ 133.

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

Because limitation 11[c] is identical to limitation 7[c], Miwa teaches limitation 11[c] for the same reasons regarding limitation 7[c]. EX1003, ¶ 135.

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.

EX1003, ¶ 136.

Miwa's embodiment 15 reports a coefficient of thermal expansion (CTE) of 34×10⁻⁷/°C measured over a temperature range of 30-380°C, which is in the range of 28×10⁻⁷/°C ≤ CTE ≤ 34×10⁻⁷/°C, as in limitation 11[c]. EX1004, Table 4; EX1003, ¶ 137.

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. EX1003, ¶ 138.

As all of the limitations of Claim 11 are described by Miwa, Claim 11 would have been obvious in view of Miwa. EX1003, ¶ 139.

12. Dependent Claim 12

There are several limitations in Claim 12 and each is addressed in turn.

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

Limitation 12[a] of claim 12 is described in Miwa. For example, embodiment 15 of Miwa describes that the glass comprises zero As_2O_3 , which overlaps with “at most 0.05 mole percent As_2O_3 ” as in limitation 12[a]. EX1004, Table 4; EX1003, ¶ 141. Thus, Miwa discloses limitation 12[a]. EX1003, ¶ 142.

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

The additional limitation 12[b] of claim 12 is described by Miwa. For example, 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; EX1003, ¶ 144. Thus, Miwa discloses limitation 12[b]. EX1003, ¶ 145.

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

The additional limitation 12[c] of claim 12 is described by Miwa. For example, embodiment 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; EX1003, ¶ 147. Thus, Miwa discloses limitation 12[c]. EX1003, ¶ 148.

As all of the limitations of Claim 12 are described by Miwa, Claim 12 would have been obvious in view of Miwa. EX1003, ¶ 149.

13. Dependent Claim 13

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

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.” EX1003, ¶ 151.

As all of the limitations of Claim 13 are described by Miwa, Claim 13 would have been obvious in view of Miwa. EX1003, ¶ 152.

14. Dependent Claim 14

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

Dependent Claim 14 is described in Miwa. For example, embodiment 15 of Miwa describes a glass composition comprising zero mole percent As_2O_3 and 0.04 mole percent Sb_2O_3 , which overlap with “the glass of claim 12 wherein the glass has compositional characteristics (a) and (c).” EX1003, ¶ 154.

As all of the limitations of Claim 14 are described by Miwa, Claim 14 would have been obvious in view of Miwa. EX1003, ¶ 155.

15. Dependent Claim 15

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

Dependent Claim 15 is described in Miwa. For example, 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).” EX1003, ¶ 157.

As all of the limitations of Claim 15 are described by Miwa, Claim 15 would have been obvious in view of Miwa. EX1003, ¶ 158.

16. Dependent Claim 16

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

Dependent Claim 16 is described in Miwa. For example, embodiment 15 of Miwa describes a glass composition comprising zero mole 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).” EX1003, ¶ 160.

As all of the limitations of Claim 16 are described by Miwa, Claim 16 would have been obvious in view of Miwa. EX1003, ¶ 161.

B. Ground 2: Claims 1 and 3 are invalid under 35 U.S.C. §102(a) (pre-AIA) as being anticipated by Miwa

1. Independent Claim 1

There are several limitations in Claim 12 and each is addressed in turn.

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

Miwa teaches limitation 1[p] for the same reasons as discussed in ground 1. That is, 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 embodiments 15 and 20 of alkali-free glasses defined by weight percentages of each listed oxide. EX1003, ¶ 163.

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; EX1003, ¶ 164.

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

Miwa discloses limitation 1[a] in embodiment 20. The table below shows the composition of embodiment 20 in weight percent. EX1004, Table 5; EX1003, ¶ 166.

	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] ($\times 10^{-7}/^{\circ}\text{C}$)	34	34	33	31	30
Strain point (°C)	677	680	682	686	685
Logn at 10 ^{2.5} (°C)	1585	1520	1585	1560	1605
Liquid phase temperature (°C)	1095	1115	1100	1115	1045
Acid resistance	○	○	○	○	○
Buffered hydrofluoric acid resistance	○	○	○	○	○

EX1004, Table 5

The composition of Miwa's embodiment 20 was converted from weight percent to mole percent. A table presenting the comparison of the molar concentration of various oxides in embodiment 20 (Miwa) and limitation 1[a] of '394 is given below. EX1003, ¶ 167.

Oxide	Miwa Embodiment 20	Limitation 1[a]
SiO ₂ :	69.80 mole%	64.0-71.0 mole%
Al ₂ O ₃ :	9.96 mole%	9.0-12.0 mole%
B ₂ O ₃ :	8.47 mole%	7.0-12.0 mole%
MgO:	1.14 mole%	1.0-3.0 mole%
CaO:	7.60 mole%	6.0-11.5 mole%
SrO:	1.26 mole%	0-2.0 mole%
BaO	0.0 mole%	0-0.1 mole%

As shown above, all composition mole percentages of limitation 1[a] are disclosed by Miwa in embodiment 20. EX1003, ¶ 168.

Limitation 1[b]: wherein: (a) $1.00 \leq \sum[RO]/[Al_2O_3] \leq 1.25$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO

Embodiment 20 of Miwa (EX1004, Table 5) discloses a ratio of 1.00 for $\sum[RO]/[Al_2O_3]$, which is in the range of 1.00 to 1.25 as claimed in the limitation 1[b]. Therefore, limitation 1[b] " $1.00 \leq \sum[RO]/[Al_2O_3] \leq 1.25$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO,

SrO, and BaO” is disclosed by Miwa. EX1004, Table 5; EX1003, ¶ 170. Thus, Miwa discloses limitation 1[b]. EX1003, ¶ 171.

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

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; EX1003, ¶ 173. Thus, Miwa discloses limitation 1[c]. EX1003, ¶ 174.

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

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; EX1003, ¶ 176. Miwa discloses limitation 1[d]. EX1003, ¶ 177.

Accordingly, Miwa, in Embodiment 20, discloses each and every limitation of claim 1. EX1003, ¶ 178.

2. Dependent Claim 3

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 .

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; EX1003, ¶ 180.

Accordingly, Miwa discloses each and every limitation of claim 3. EX1003, ¶ 181.

C. Ground 3: Claims 2 and 4-16 are invalid under 35 U.S.C. § 103(a) (pre-AIA) as obvious over Miwa

1. Dependent Claim 2

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 .

Miwa discloses a glass with Sb_2O_3 in 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; EX1003, ¶ 183.

Thus, adjusting the mole percent of embodiment 20 in Miwa to have an amount of Sb_2O_3 in an amount of 0.05 mole percent is clearly shown when Miwa's description is considered in its entirety. EX1003, ¶ 184. Thus, Claim 2 would have been obvious. EX1003, ¶ 185.

2. Dependent Claim 4

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 .

The limitations of claim 4 are described by 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; EX1003, ¶ 1004. Thus, Claim 4 would have been obvious. EX1003, ¶ 188.

3. Independent Claim 5

There are several limitations in Claim 5 and each is addressed in turn.

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

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%,

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 embodiments 15 and 20 of alkali-free glasses defined by weight percentages of each listed oxide. EX1003, ¶ 190.

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; EX1003, ¶ 191.

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

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 ranges of oxides disclosed in Miwa are presented in weight percent, when converted to mole percent, they overlap the concentration ranges disclosed in limitation 5[a] of ‘394, as evident from the embodiments 15 and 20 of Miwa. EX1004, Tables 4 and 5.

Oxide	Miwa Embodiment 15	Limitation 5[a]
SiO ₂ :	67.19 mole%	64.0-71.0 mole%
Al ₂ O ₃ :	10.21 mole%	9.0-12.0 mole%
B ₂ O ₃ :	10.29 mole%	7.0-12.0 mole%

MgO:	2.10 mole%	1.0-3.0 mole%
CaO:	9.29 mole%	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 mole%	64.0-71.0 mole%
Al ₂ O ₃ :	9.96 mole%	9.0-12.0 mole%
B ₂ O ₃ :	8.47 mole%	7.0-12.0 mole%
MgO:	1.14 mole%	1.0-3.0 mole%
CaO:	7.60 mole%	6.0-11.5 mole%
SrO:	1.26 mole%	-
BaO	0.0 mole%	0-0.1 mole%

EX1003, ¶ 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; EX1003, ¶ 194.

Thus, Bange discloses the composition ranges presented in limitation 5[a]. EX1003, ¶ 195.

Both SrO and BaO play a network modifying role in these glasses and their total concentrations, i.e., SrO+BaO, can be optimized to obtain glasses with desired density, coefficient of thermal expansion and refractive index, as discussed earlier. EX1003, ¶ 196.

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

Miwa discloses “on an oxide basis, SrO is at most 1.0 mole percent.” EX1004, Table 4. For example, 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; EX1003, ¶ 196.

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. EX1003, ¶ 197.

Thus, limitation 5[a] would have been obvious when considering Miwa and Bange. EX1003, ¶199.

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

Miwa discloses “on an oxide basis, the glass comprises at least 0.01 mole percent SnO₂.” EX1004, tables 4 and 5. For example, both embodiments 15 and 20 of Miwa teach that the glass comprises 0.04 mole percent SnO₂, which is within the range of “at least 0.01 mole percent SnO₂”. EX1004, Tables 4 and 5; EX1003, ¶ 201. Thus, Miwa discloses limitation 5[c]. EX1003, ¶ 202.

Limitation 5[d]: (c) $1.00 \leq \sum[RO]/[Al_2O_3] \leq 1.25$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO

Miwa teaches glass compositions with $1.00 \leq \sum[RO]/[Al_2O_3] \leq 1.25$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO. For example, the $\sum[RO]/[Al_2O_3]$ ratio for the glass composition presented in embodiment 15 of Miwa is 1.21, which is in the range of 1.00 to 1.25 as in limitation 5[d]. EX1003, ¶ 204.

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. EX1003, ¶ 205.

4. Dependent Claim 6

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

Miwa discloses, for example in 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, 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; EX1003, ¶ 207.

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. EX1003, ¶ 208. Accordingly, dependent claim 6 would have been obvious to in view of Miwa. EX1003, ¶ 209.

5. Dependent Claim 7

There are several limitations in Claim 7 and each is addressed in turn.

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

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; EX1003, ¶ 211.

Thus, Bange discloses limitation 7[a]. EX1003, ¶ 212.

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

Miwa discloses “a strain point that is greater than or equal to 650°C.” EX1004, Table 4. For example, 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, 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; EX1003, ¶ 214. Thus, Miwa discloses limitation 7[b]. EX1003, ¶ 215.

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

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 poise³ is 1610°C or less, and the liquid phase temperature⁴ is 1120°C or less, so it also has

³ This is understood to be 10^{2.5} poise.

⁴ This is understood to be liquidus temperature.

excellent fusibility and formability. In addition, it showed excellent in acid resistance and BHF resistance.

EX1003, ¶ 217.

Miwa's 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; EX1003, ¶ 218.

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 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. EX1003, ¶ 219.

Miwa discloses limitation 7[c] and all the limitations of Claim 7. Therefore, Claim 7 would have been obvious in view of Miwa. EX1003, ¶ 220.

6 Independent Claim 8

There are several limitations in Claim 8 and each is addressed in turn.

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

Miwa teaches limitation 8[p] for the same reasons as discussed in ground 1. That is, 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 either of the above Claims 1 or 2” EX1004, at [Claim 3]. Tables 4 and 5 of Miwa illustrates various embodiments, including embodiments 15 and 20 of alkali-free glasses defined by weight percentages of each listed oxide. EX1003, ¶ 222.

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; EX1003, ¶ 223.

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

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 embodiment 20 anticipates limitation 1[a]. However, this difference in mole% of SrO between embodiment 20 and limitation 8[a] is not significant. For example, 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 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] ($\times 10^{-7}/^{\circ}\text{C}$)	34	33	31	33	34
Strain point (°C)	665	671	668	669	673
Logn at 10 ⁻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	Limitation 8[a]
SiO ₂ :	67.19 mole%	64.0-71.0 mole%
Al ₂ O ₃ :	10.22 mole%	9.0-12.0 mole%
B ₂ O ₃ :	10.29 mole%	7.0-12.0 mole%
MgO:	2.10 mole%	1.0-3.0 mole%
CaO:	9.29 mole%	6.0-11.5 mole%
SrO:	0.63 mole%	0-1.0 mole%
BaO	0.21 mole%	0-0.1 mole%

EX1003, ¶ 22.

Although the molar concentration of BaO in embodiment 15 exceeds the concentration range disclosed in limitation 8[a], the amount in 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]; EX1003, ¶ 226.

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; EX1003, ¶227.

It would thus have been obvious to modify embodiment 20 to adjust the amount of BaO from 0.21 mole percent to 0 and adjust the mole percentage of SrO

from 0.63 to 0.84 to keep the total mole percentage as 100% with SrO and BaO playing the same role in the glass compositions, as explained above in relation to limitation 1[a]. EX1003, ¶ 228.

Thus, limitation 8[a] would have been obvious in view of Miwa and Bange. EX1003, ¶ 229.

Limitation 8[b]: wherein: $\sum[RO]/[Al_2O_3] \geq 1.00$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO.

Miwa discloses “ $\sum[RO]/[Al_2O_3] \geq 1.00$, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\sum[RO]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO.” EX1004, Table 5. For example, embodiment 20 of Miwa teaches a ratio of 1.00 for $\sum[RO]/[Al_2O_3]$, which is within the range of $\sum[RO]/[Al_2O_3] \geq 1.00$ as in limitation 8[b]. EX1004, Table 5; EX1003, ¶ 231.

Miwa discloses limitation 8[b]. EX1003, ¶ 232. Thus, Claim 8 would have been obvious in view of Miwa and Bange. EX1003, ¶ 233.

7. Dependent Claim 9

The glass of claim 8 wherein: $\sum[RO]/[Al_2O_3] \leq 1.25$.

The limitations of claim 9 are described in Miwa. For example, embodiment 20 of Miwa describes a ratio of 1.00 for $\sum[RO]/[Al_2O_3]$, which is within the range

of $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$ as in dependent claim 9. EX1004, Table 5; EX1003, ¶ 235.

Accordingly, Miwa discloses claim 9. EX1003, ¶ 236.

8. Dependent Claim 10

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

The limitations of claim 10 are described by Miwa. For example, 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; EX1003, ¶ 238. Accordingly, Miwa discloses claim 10. EX1003, ¶ 239.

9. Dependent Claim 11

There are several limitations in Claim 11 and each is addressed in turn.

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

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; EX1003, ¶ 241.

Thus, Miwa's 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. EX1003, ¶ 242.

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

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, 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; EX1003, ¶ 244.

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

Because limitation 11[c] is identical to limitation 7[c], Miwa teaches limitation 11[c] for the same reasons regarding limitation 7[c]. EX1003, ¶ 246.

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 **$30\text{-}34 \times 10^{-7}/^{\circ}\text{C}$** . 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 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.

EX1003, ¶ 247.

Miwa’s 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; EX1003, ¶ 248.

As all the limitations of Claim 11 are described by Miwa, Claim 11 would have been obvious in view of Miwa. EX1003, ¶ 249.

10. Dependent Claim 12

There are several limitations in Claim 12 and each is addressed in turn.

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

Limitation 12[a] is 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 ,” as in limitation 12[a]. EX1004, Table 5; EX1003, ¶ 251.

Thus, Miwa discloses limitation 12[a]. EX1003, ¶ 252.

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

The additional limitation 12[b] of claim 12 is described by Miwa. For example, 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; EX1003, ¶ 254.

Thus, Miwa discloses limitation 12[b]. EX1003, ¶ 255.

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

Limitation 12[c] is described in Miwa. For example, embodiment 20 (as well as 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; EX1003, ¶ 257.

Thus, Miwa discloses limitation 12[c]. EX1003, ¶ 258.

As all the limitations of Claim 12 are described by Miwa, Claim 12 would have been obvious in view of Miwa. EX1003, ¶ 259.

11. Dependent Claim 13

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

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).” EX1003, ¶ 261.

Thus, Claim 13 is disclosed in Miwa and thus would have been obvious in view of Miwa. EX1003, ¶ 262.

12. Dependent Claim 14

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

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. EX1003, ¶ 264.

As all of the limitations of Claim 14 are described by Miwa, Claim 14 would have been obvious in view of Miwa. EX1003, ¶ 265.

13. Dependent Claim 15

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

Dependent Claim 15 is described in Miwa. For example, 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).” EX1003, ¶ 267.

As all of the limitations of Claim 15 are described by Miwa, Claim 15 would have been obvious in view of Miwa. EX1003, ¶ EX1003, ¶ 268.

14. Dependent Claim 16

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

Dependent Claim 16 is described in Miwa. For example, 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).” EX1003, ¶269.

As all of the limitations of Claim 16 are described by Miwa, Claim 16 would have been obvious in view of Miwa. EX1003, ¶ 272.

IX. CONCLUSION

Petitioner respectfully requests that a trial be instituted. Claims 1-16 should be cancelled.

Respectfully Submitted,

/Daniel J. Pereira//
Daniel J. Pereira (Reg. No. 45,518)

CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. §42.24(d), Petitioner certifies that this Petition includes 12,678 words, as measured by Microsoft Word®, exclusive of the table of contents, mandatory notices under §42.8, certificates of service, word count, and exhibits.

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The undersigned hereby certifies that the above document was served on January 13, 2025, by filing this document through the Patent Trial and Appeal Board P-TACTS System, as well as delivering a copy via express mail upon the following attorneys of record for the Patent Owner and Petitioner:

Corning Incorporated
SP-TI-3-1
Corning, NY 14831

A courtesy copy was sent to the below counsel via electronic mail:

Charles B. Molster, III THE LAW OFFICES OF CHARLES B. MOLSTER, III PLLC 2141 Wisconsin Ave., NW Suite M Washington, DC 20007 Telephone: (202) 787-1312 Email: cmolster@molsterlaw.com	KELLOGG, HANSEN, TODD, FIGEL & FREDERICK, P.L.L.C. 1615 M Street NW Suite 400 Washington, DC 20036 Tel.: (202) 326-7900 Email: jthorne@kellogghansen.com eleo@kellogghansen.com grapawy@kellogghansen.com jhall@kellogghansen.com ttraxler@kellogghansen.com jhartman@kellogghansen.com hdepalo@kellogghansen.com dzhang@kellogghansen.com jmason@kellogghansen.com
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Dated: January 13, 2025

Respectfully submitted,

/Daniel J. Pereira/

Daniel J. Pereira (Reg. No. 45,518)
Merchant and Gould PC
1900 Duke Street, Suite 600
Alexandria, VA 22314
Telephone: (703) 518-4509

E-Mail: dpereira@merchantgould.com
Attorney for Petitioner

APPENDIX A – CLAIM LISTING

U.S. Patent No. 7,851,394

Claim or Element #	Claim Language
1[p]	An alkali-free glass comprising in mole percent on an oxide basis:
1[a]	SiO ₂ : 64.0-71.0 Al ₂ O ₃ : 9.0-12.0 B ₂ O ₃ : 7.0-12.0 MgO: 1.0-3.0 CaO: 6.0-11.5 SrO: 0-2.0 BaO: 0-0.1
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 ₂ O ₃ and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO;
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 ; and
1[d]	(c) the glass has a density that is less than or equal to 2.41 grams/cm ³ .

2	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 .
3	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 .
4	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 .
5[p]	An alkali-free glass comprising in mole percent on an oxide basis:
5[a]	SiO_2 : 64.0-71.0 Al_2O_3 : 9.0-12.0 B_2O_3 : 7.0-12.0 MgO : 1.0-3.0 CaO : 6.0-11.5 SrO : 0-2.0 BaO : 0-0.1
5[b]	wherein the glass has the compositional characteristics: on an oxide basis, SrO is at most 1.0 mole percent;

5[c]	(b) on an oxide basis, the glass comprises at least 0.01 mole percent SnO ₂ ; and
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 Al ₂ O ₃ and $\sum[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO.
6	The glass of claim 5 wherein the glass has a density that is less than or equal to 2.41 grams/cm ³ .
7[p]	The glass of claim 1 wherein the glass has one or more of the following properties:
7[a]	(a) a liquidus viscosity that is greater than or equal to 100,000 poise;
7[b]	(b) a strain point that is greater than or equal to 650°C.;
7[c]	(c) a linear coefficient of thermal expansion (CTE) over the temperature range 0-300°C. which satisfies the relationship: $28 \times 10^{-7}/^\circ\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^\circ\text{C}$.
8[p]	An alkali-free glass comprising in mole percent on an oxide basis:
8[a]	SiO ₂ : 64.0-71.0 Al ₂ O ₃ : 9.0-12.0 B ₂ O ₃ : 7.0-12.0 MgO: 1.0-3.0

	CaO: 6.0-11.5 SrO: 0-2.0 BaO: 0-0.1
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.
9	The glass of claim 8 wherein: $\sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$.
10	The glass of claim 8 wherein the glass has a density that is less than or equal to 2.41 grams/cm ³ .
11[p]	The glass of claim 8 wherein the glass has one or more of the following properties:
11[a]	(a) a liquidus viscosity that is greater than or equal to 100,000 poise;
11[b]	(b) a strain point that is greater than or equal to 650°C.;
11[c]	(c) a linear coefficient of thermal expansion (CTE) over the temperature range 0-300°C. which satisfies the relationship: $28 \times 10^{-7}/^\circ\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^\circ\text{C}$.
12[p]	The glass of claim 8 wherein the glass has at least one of the following compositional characteristics:

12[a]	(a) on an oxide basis, the glass comprises at most 0.05 mole percent As_2O_3 ;
12[b]	(b) on an oxide basis, the glass comprises at most 0.05 mole percent Sb_2O_3 ;
12[c]	(c) on an oxide basis, the glass comprises at least 0.01 mole percent SnO_2 .
13	The glass of claim 12 wherein the glass has compositional characteristics (a) and (b).
14	The glass of claim 12 wherein the glass has compositional characteristics (a) and (c).
15	The glass of claim 12 wherein the glass has compositional characteristics (b) and (c).
16	The glass of claim 12 wherein the glass has compositional characteristics (a), (b), and (c).