

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.: IPR2025-01017

U.S. Patent No. 8,642,491

PETITION FOR INTER PARTES REVIEW

OF U.S. PATENT NO. 8,642,491

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PETITIONER'S EXHIBIT LIST

EX1001	U.S. Patent No. 8,642,491 (the "'491 Patent")
EX1002	Prosecution History of the '491 Patent
EX1003	Declaration of Dr. Frank Ernst
EX1004	JP2004-189535A ("Miwa '535") Certified Translation
EX1005	JP1998059741 ("JP-741") Certified Translation
EX1006	U.S. 2005/0101469 ("Peuchert '469")
EX1007	JP2002308643 ("JP '643") Certified Translation
EX1008	JP2003192377 ("Miwa '377") Certified Translation
EX1009	Introduction to Glass Science and Technology, 2 nd Ed. (2005)
EX1010	Foshan Ceramics Research Institute Testing Co., Ltd, Test Report: Sample #5
EX1011	Foshan Ceramics Research Institute Testing Co., Ltd, Test Report: Sample #6
EX1012	<i>Curriculum Vitae</i> of Dr. Frank Ernst
EX1013	U.S. Patent No. 4,018,965
EX1014	U.S. PG PUB 2004/0224834
EX1015	W. Vogel, Glass Chemistry, 2 nd Ed., Chapter 4: Classical Theories of Structure, Springer-Verlag (1994)

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. 8,640,491 (“the ’491 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 and captioned *Corning Incorporated v. Caihong Display Devices Co., Ltd. et al*, Case No. 1-24-cv-02328. The ’491 Patent is also asserted in the investigation captioned *Certain Glass Substrates for Liquid Crystal Displays, Products Containing the Same, and Methods for Manufacturing the Same II*, Investigation No. 337-TA-1441, at the U.S. International Trade Commission. This is the first case in which the ’491 Patent was litigated. The ’491 Patent has not been subjected to post-grant review by the Patent Trial & Appeal Board.

C. Lead and Back-up Counsel and Service Information

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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 '491 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 1-24 as unpatentable based on the following grounds, supported by a declaration from Dr. Frank Ernst. EX1003.

Ground	Challenged Claims	Asserted Prior Art
1	1-24	Miwa '535, Peuchert '469 and JP '741
2	1-24	JP '643, JP '741 and Peuchert '469
3	13-14, 16, and 19-23	Miwa '377 and/or Miwa '377 and Peuchert '469

V. REASONS FOR THE REQUESTED RELIEF

As set forth in detail below in Grounds 1-3, the asserted prior art anticipates and/or renders obvious each of the claims of the '491 Patent.

The '491 Patent is directed to alkali-free glasses suitable 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 '491 Patent alleges that the claimed glasses are dimensionally stable, have specific thermal and expansion characteristics, and can undergo semiconductor type processes without degradation. EX1003, ¶¶ 31-37.

The Challenged Claims, however, are neither novel nor unobvious. For example, the combination of Miwa '535 in view of Peuchert '469 and JP '741, the combination of JP '643 in view of JP '741 and Peuchert '469, Miwa '377 alone, and the combination of Miwa '377 in view of Peuchert '469 – all of which also relate to alkali-free glasses suitable for use as substrates in flat panel display devices – render all of the Challenged Claims anticipated and/or 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. Frank Ernst (EX1003). Dr. Ernst is an expert in material sciences, including the composition and manufacture 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 and processes for making the same.

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

A. Summary of the '491 Patent

The '491 Patent focuses on the development of alkali-free boroaluminosilicate glasses intended for use as substrates in flat panel displays, such as AMLCDs. EX1001, 1:16-22. 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 5:57-60. Specifically, the Applicant claims that the specified glass composition is tailored for a thermal expansion coefficient suitable for stress-balancing with deposited films, high liquidus viscosity, high strain point, low (mass) density, and low density of defects (“blisters” or “bubbles”), accomplished by fining with components of reduced toxicity. *Id.*, 3:55-67. EX1003, ¶ 31.

Traditionally, As_2O_3 and Sb_2O_3 have been used as fining agents during glass manufacturing. EX1001, 11:66-12:24. However, since both of these fining agents are toxic, special handling is needed. *Id.* To solve this issue, the ’491 Patent proposes to use SnO_2 as the fining agent. *Id.*, 12:25-44. EX1003, ¶ 32.

Further, the ’491 Patent requires the liquidus temperature of the glass to be lower than 1170°C and the liquidus viscosity to be no less than 100,000P (poise). EX1001, 14:42-52. EX1003, ¶ 33.

The ’491 Patent indicates that it is critical to the glass performance, meltability, and fining to control the MgO fraction and the ratio $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$, where $\Sigma[\text{RO}]$ denotes the sum of the mole fractions X_i of $\text{RO} = \text{MgO}, \text{CaO}, \text{SrO}, \text{BaO}$ (*i.e.*, all earth-alkaline metal oxides). $[\text{Al}_2\text{O}_3]$ denotes the mole fraction X_i of Al_2O_3 . EX1001, 7:23-28. In the notation used in the patent, brackets “[...]” are used to indicate “concentration.” “Concentration” can be a confusing concept, as it is sometimes used with reference to a volume, *e.g.*, as the number of molecules (or

moles thereof) per liter. EX1001, ¶ 36. Also, the bracket notation does not make it explicit that the concentration that is meant here refers to the *number* of molecules or atoms, not their masses. *Id.* More clearly, the ratio $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$ can be written as $\Sigma_R X_i/X_{\text{Al}_2\text{O}_3}$, where $R = \{\text{MgO}, \text{CaO}, \text{SrO}, \text{BaO}\}$ is the set of the earth-alkaline oxides without BeO (toxic) and RaO (radioactive). So, $\Sigma_R X_i/X_{\text{Al}_2\text{O}_3}$ is a shorthand for

$$\frac{X_{\text{MgO}} + X_{\text{CaO}} + X_{\text{SrO}} + X_{\text{BaO}}}{X_{\text{Al}_2\text{O}_3}}$$

Id.

Further, the '491 Patent indicates that the MgO mole fraction X_{MgO} should be within the range $X_{\text{MgO}} = 1$ to 3 mol%, in order to reduce the liquidus temperature, and thereby increase the liquidus viscosity. EX1001, 10:26-34, 10:54-64. In addition, $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$ (or, preferably, $\Sigma_R X_i/X_{\text{Al}_2\text{O}_3}$) should be greater than 1.00 to avoid inclusions (blisters) in the glasses and maintain high viscosity during the fining process. *Id.*, Abstract, FIG. 3. EX1003, ¶ 37.

B. The Prosecution History of the '491 Patent

Miwa '535 (EX1005), original Japanese language publication, machine translation of the same, and a professional translation were cited and considered by the Examiner. EX1002 at ¶¶ 000033, 000034, 000044, 000049. Miwa was used in a

rejection and specifically addressed by the Applicant during prosecution. EX1002 at 000060, 000065, 000072.

The USPTO has not, however, previously considered JP '741, Peuchert '469, JP '643, or Miwa '377. And, more importantly, the Office has not previously considered any of the combinations of these references that form the grounds for this Petition. Thus, this Petition presents substantially new arguments that were not previously considered during prosecution in the UPSTO.

C. Priority Date

The '491 Patent was filed on December 10, 2010, and claims priority to Provisional Application No. 60/694,478 filed on June 28, 2005. EX1001, cover page. Thus, the earliest possible effective U.S. filing date for the '491 Patent is June 28, 2005.

While Petitioner does not accede to an invention date of June 28, 2005, for the '491 Patent, it will be assumed, solely for purposes of this Petition, that the '491 Patent is entitled to that date. Accordingly, any patent or printed publication published before June 28, 2005, is prior art under § 102(a), any patent or printed publication published before June 28, 2004, is prior art under § 102(b), and any patent granted on an application filed before June 28, 2005, is 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.

D. Secondary Considerations

At this stage of these proceedings, Petitioner has no burden to identify and rebut any possible 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, Paper 18, at 36 (Mar. 17, 2015).

VII. 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). Claims must therefore 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. Ernst’s declaration construe claim terms consistent with the understanding a POSITA would

have in view of the '491 Patent's intrinsic evidence and, where appropriate, extrinsic evidence. *Phillips*, 415 F.3d at 1312.

Terms for which a specific construction is not provided below have been given their plain and ordinary meaning, as discussed in more detail for particular terms. Petitioner, however, may pursue constructions of additional claim terms in the related litigation(s) concerning the '491 Patent to help the Administrative Law Judge and/or jury understand the relevant technical terms and expressly reserves the right to assert that certain claim terms are indefinite.

VIII. STATUTORY GROUNDS FOR CHALLENGES AND REFERENCES USED

Claims 1-10 and 12 are obvious over Miwa '535 (EX1004) in view of Peuchert '469 (EX1006); Claim 11 is obvious over Miwa '535 (EX1004) in view of JP '741 (EX1005) and Peuchert '469 (EX1006); Claims 13, 15 and Claims 17-24 are obvious over Miwa '535 (EX1004); Claim 14 is obvious over Miwa '535 (EX1004) in view of JP '741 (EX1005); and Claim 16 is obvious over Miwa '535 (EX1004) in view of Peuchert '469 (EX1006), which constitutes Ground 1.

Claims 1-12 and 16 are obvious over JP '643 (EX1007) in view of JP '741 (EX1005) and Peuchert '469 (EX1006); and Claims 13-15 and 17-24 are obvious over JP '643 (EX1007) in view of JP '741 (EX1005), which constitutes Ground 2.

Claims 13-14 and 19-21 are anticipated by Miwa '377 (EX1008); Claim 16 is obvious over Miwa '377 (EX1008) in view of Peuchert '469 (EX1006); and Claims 22-23 are obvious over Miwa '377 (EX1008), which constitutes Ground 3.

Miwa '535 was made public in the United States no later than July 8, 2004; JP '741 was made public in the United States no later than March 3, 1998; Peuchert '469 was made public in the United States no later than May 12, 2005; JP '643 was made public in the United States no later than October 23, 2002; Miwa '377 was made public in the United States no later than July 9, 2003. EX1003, ¶¶ 48, 54, 57, 62, 68.

Accordingly, each piece of prior art relied upon in this petition qualifies as prior art to the '491 Patent under at least 35 U.S.C. 102(a) (pre-AIA).

IX. LEVEL OF ORDINARY SKILL IN THE ART

The person of ordinary skill in the art ("POSITA") with respect to the '491 Patent would have had knowledge of and experience with the concepts of glass science relevant to '491 Patent. For example, a POSITA would have comprehensive knowledge and deep understanding of the materials science aspects and the underlying physical, chemical, and mathematical concepts of the science of glasses as relevant to the '491 Patent. This would include (but is not limited to) the concepts of liquidus temperature, viscosity, density, coefficient of thermal expansion, strain point, and fining. Further, a POSITA would have considerable

understanding of and experience with design, synthesis, and characterization of silicate, borosilicate, aluminosilicate, and boroaluminosilicate glasses. EX1003, ¶ 24.

X. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS

A. Miwa '535 (EX1004)

Miwa '535 was filed on December 11, 2002, and published on July 8, 2004. Therefore, it is prior art at least under 35 U.S.C. § 102(a) (pre-AIA). EX1004, cover page. Similar to the '491 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.*, 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 '535 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, ¶ 48.

Additionally, Miwa '535 emphasizes the necessity for high transmittance in the ultraviolet to visible spectrum, which is crucial for device performance in displays and sensors. EX1004, ¶¶ [0001]-[0017]. Miwa '535 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 '491 Patent, Miwa '535 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, ¶ 50.

Similar to the '491 Patent, Miwa '535 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. EX1004, ¶ [0022].

For example, the glass disclosed by Miwa '535 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.*, ¶ 0055. In summary, Miwa '535 teaches similar alkali-free glass substrates with similar compositions and similar physical and chemical properties as the '491 Patent, which are also suitable for flat panel display applications. EX1003, ¶ 51.

For example, Miwa '535'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] ($\times 10^{-7}/^{\circ}\text{C}$)	34	33	31	33	34
Strain point (°C)	665	671	668	669	673
Logn at 10 ⁻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, ¶ 52.

Converting the weight percentages in Miwa '535's Embodiment 15 to mole percentage, Miwa '535 teaches that the glass has the following alkali-free compositions in mole percentages as shown below:

Component	X (mol%)
SiO ₂	67.2
Al ₂ O ₃	10.2
B ₂ O ₃	10.3
MgO	2.1
CaO	9.3
SrO	0.63
BaO	0.21
SnO ₂	0.04
As ₂ O ₃	0.0
Sb ₂ O ₃	0.02
Fe ₂ O ₃	0.00
$\sum_{i \in R} X_i / X_{\text{Al}_2\text{O}_3} = 1.20$	

EX1003, ¶ 53.

B. JP '741 (EX1005)

JP '741 was filed on August 21, 1996, and published on March 3, 1998. EX1005, cover page; EX1003, ¶ 54.

Similar to the '491 Patent, JP '741 relates to alkali-free boroaluminosilicate glass compositions primarily suitable for application as a substrate for displays. EX1005, ¶¶ [0001]-[0005]; EX1003, ¶54. JP '741 describes that a key finding is the use of SnO₂ instead of As₂O₃ as a clarifying agent “because As₂O₃ is highly toxic and may contaminate the environment during glass production and waste glass treatment, its use is being restricted”. EX1005, ¶¶ [0005], [0007]; EX1003; ¶ 55.

JP '741 further describes processes “[f]or display applications, the fusion method, down-draw method, float method, or roll-out method, etc. is used to mold the glass into thin sheets. EX1005, ¶ [0021]; EX1003, ¶ 56.

C. Peuchert '469 (EX1006)

Peuchert '469 was filed on March 6, 2002, and published on May 12, 2005, and has a priority claim to a German application, DE 10114581.0, filed on March 24, 2001. EX1006, cover page; EX1003, ¶ 57.

Similar to the '491 Patent, Peuchert '469 also relates to alkali-free aluminoborosilicate glass. EX1006, ¶ [0001]. Peuchert '469 discusses the benefits of low fractions of BaO – preferably the complete absence of BaO – as well as the

similar roles that SrO and BaO play in the properties of the glass. EX1006, ¶¶ [0024], [0025], [0026]; EX1003, ¶ 57-61.

D. JP '643 (EX1007)

JP '643 was filed on May 17, 2001, and published on October 23, 2002, and has a priority claim to a Japanese application, JPA-2001-26116, filed on February 1, 2001. EX1007, cover page; EX1003, ¶ 62.

Similar to the '491 Patent, JP '643 also relates to “alkali-free glass comprising SiO₂ 67.2 mol%, Al₂O₃ 10.9 mol%, B₂O₃ 11.2 mol%, MgO 1.6 mol%, CaO 9.3 mol%, SrO 0.3 mol%.” EX1007, Table 3 (Embodiment 5); EX1003, ¶ 66.

	Sample No. 4		Sample No. 5		Sample No. 6	
	Mass %	mol%	Mass %	mol%	Mass %	mol%
SiO ₂	61.2	67.4	61.2	67.2	61.7	68.2
Al ₂ O ₃	16.8	10.9	16.8	10.9	17.0	11.1
B ₂ O ₃	11.8	11.3	11.8	11.2	10.5	10.0
MgO	0.5	0.8	1.0	1.6	-	-
CaO	7.4	8.7	6.9	9.3	8.0	9.5
SrO	0.5	0.3	0.5	0.3	1.0	0.6
BaO	0.5	0.2	0.5	0.2	0.5	0.2
ZnO	-	-	-	-	-	-
P ₂ O ₅	-	-	-	-	-	-
As ₂ O ₃	-	-	-	-	-	-
SnO ₂	-	-	-	-	-	-
Sb ₂ O ₃	1.0	0.2	1.0	0.2	1.0	0.2
ZrO ₂	0.3	0.2	0.3	0.2	0.3	0.2
Cl	-	-	-	-	-	-
(BaO + SrO)/BaO	2		2		3	
Density (g/cm ³)	2.382		2.379		2.400	
Thermal expansion coefficient [30-380°C] (x10 ⁻⁷ /°C)	33		32		34	
Viscosity	Strain point (°C)	669	670	674		
	Annealing point (°C)	724	724	731		
	Softening point (°C)	973	973	984		
	10 ^{4.0} (°C)	1301	1301	1322		
	10 ^{3.0} (°C)	1467	1467	1488		
	10 ^{2.5} (°C)	1573	1573	1597		
Young's modulus		70	70	71		
Specific Young's modulus		29.3	29.5	29.4		
BHF resistance	Corrosion (μm)	0.6	0.6	0.6		
	Visual appearance evaluation	○	○	○		
HC resistance	Corrosion (μm)	7.3	7.3	4.6		
	Visual appearance evaluation	○	○	○		
Liquidus temperature (°C)		1128	1146	1094		
Liquidus viscosity		10 ^{5.6}	10 ^{5.4}	10 ^{6.1}		

EX1007, Table 3.

JP '643 discloses alkali-free glass that has a liquidus temperature of 1,150°C or lower (preferably 1,130°C or lower, more preferably 1,100°C or lower) and a viscosity at the liquidus temperature of $10^{5.4}$ dPa·s or higher (preferably 106.0 dPa·s or higher), enabling formation into sheets by the downdraw method without devitrification and allowing the omission of polishing processes to reduce production costs. EX1007, ¶ [0030]; EX1003, ¶ 309.

JP '643 further describes BaO and SrO as components that improve the chemical resistance and devitrification resistance of the glass, but if contained in large amounts, they increase the glass's density and thermal expansion coefficient. Therefore, their respective contents must be restricted to 0.1–5% for BaO and 0–4% for SrO. Particularly when reducing BaO and SrO to achieve lower density, if the contents of these two components become extremely imbalanced, the effect of improving BHF resistance diminishes. EX1007, ¶ [0039]; EX1003, ¶ 309.

Embodiment No. 5 of JP '643 further discloses a $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]=1.05$. EX1007, Table 3 (Sample 5); EX1003, ¶ 67.

Embodiment No. 5 of JP '643 includes As₂O₃ 0 mol%, and SnO₂ 0 mol%. EX1007, Table 3 (Sample 5); EX1003, ¶ 67.

E. Miwa '377 (EX1008)

Miwa '377 was filed on December 21, 2001, and published on July 9, 2003. Similar to the '491 Patent, Miwa '377 also relates to glass articles particularly useful

for an LCD glass substrate that does not substantially contain arsenic oxide or alkali metal oxides and can be formed using the downdraw method. EX1008, ¶ [0073]; EX1003, ¶ 68.

Miwa '377 includes a number of embodiments specifying glass compositions on an oxide basis including the fractions of SiO₂, Al₂O₃, B₂O₃, MgO, and CaO, such as in Embodiment 8. EX1008, Table 3; EX1003, ¶ 69.

Miwa '377 also describes that “the liquid phase temperature of the glass is preferably less than 1200°C, and more preferably less than 1150°C, and the liquid phase viscosity is preferably no less than 10⁵ dPa·s, and more preferably no less than 10^{5.5} dPa·s.” EX1008, ¶ [0012]; EX1003, ¶ 69.

F. Motivation to combine

As set forth below in more detail with respect to certain specific limitations, a POSITA would have found it obvious to combine the prior art described above as applied in this Petition. In particular, all of the references are in the same technical field as the '491 Patent and each other: alkali-free glasses developed primarily for use as substrates in flat panel display technologies. Sr and Ba play a *similar* role of network modifiers in the silicate glass structure. This information was well known at the time the '491 patent was filed. Combining the references outlined in each of Grounds 1, 2, and 3 to constitute combining prior art elements, a POSITA would have found that when making alkali-free substrate glasses according to known

fabrication methods, glass properties can be optimized for specific applications by balancing the fractions of SrO versus BaO (e.g. the SrO mole fraction X_{SrO} versus the BaO mole fraction X_{BaO}) within a *constant combined* fraction of SrO and BaO (e.g. $X_{\text{SrO}} + X_{\text{BaO}} = \text{const}$). Thus, the prior art references are analogous references, and a POSITA would have found combining those references as described herein to be a small set of a finite number of identified means for obtaining the desired non-alkali low-density glass useful as substrates in display technologies and would have had a reasonable expectation of success in making such combinations. EX1003, ¶¶ 72-75.

XI. CLAIMS 1-24 ARE UNPATENTABLE

A. Ground 1: Claims 1-10 and 12 would have been obvious over Miwa '535 in view of Peuchert '469; Claim 11 would have been obvious over Miwa '535 in view of JP '741 and Peuchert '469; Claims 13, 15 and Claims 17-24 would have been obvious over Miwa '535; Claim 14 would have been obvious over Miwa '535 in view of JP '741; Claim 16 would have been obvious over Miwa '535 in view of Peuchert '469

1. Independent Claim 1

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

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

Miwa '535 discloses a continuous range of alkali-free glass compositions, specified as *mass* fractions 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] (emphasis added). Table 4 of Miwa illustrates various embodiments, including Embodiment 15 of alkali-free glass defined by mass fractions (in percent) of each listed oxide. EX1003, ¶ 77.

Limitations 1[a]-1[g]: 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 Embodiment 15 of Miwa '535 was converted from mass fractions W_i to mole fractions X_i , and the resulting mole fractions X_i are shown in the following table – as percentages (mol%). EX1003, ¶ 79-80.

Oxide	Miwa '535 Embodiment 15 (mol%)	'491 Patent (mol%)
SiO ₂	67.2	64.0 - 71.0
Al ₂ O ₃	10.2	9.0 - 12.0
B ₂ O ₃	10.3	7.0 - 12.0
MgO	2.1	1.0 - 3.0
CaO	9.3	6.0 - 11.5
SrO	0.63	0 - 2.0
BaO	0.21	0 - 0.1
SnO ₂	0.04	0.01 – 0.15
As ₂ O ₃	0.0	0
Sb ₂ O ₃	0.02	0
Fe ₂ O ₃	0.00	0

EX1003, ¶ 80.

For Miwa '535's Embodiment 15, where $W_{\text{BaO}} = 0.5 \text{ ms\%}$, this means setting $W_{\text{BaO}} = 0$, while increasing the mass fraction $W_{\text{SrO}} = 1 \text{ ms\%}$ of SrO to $X_{\text{SrO}} = 1.5 \text{ ms\%}$. This will change the *mole* fractions of all components as shown in the third (rightmost) column of following Table 4, compared to the original mass fractions of Miwa '535's Embodiment 15 in the second column. EX1003,

¶ 87

Table 1: Glass Composition

Oxide	Miwa '535 Embodiment 15 (mol%)	Replacing W_{BaO} by ΔW_{SrO} (mol%)
SiO ₂	67.22	67.1
Al ₂ O ₃	10.22	10.22
B ₂ O ₃	10.33	10.33
MgO	2.11	2.10
CaO	9.33	9.33
SrO	0.63	0.94
BaO	0.21	0.00

EX1003, ¶ 87

All mole fractions of limitations 1[a]-1[f] are disclosed by Miwa in Embodiment 15, except the mole fraction of BaO. However, it is clear from Miwa '535 and Peuchert '469 that the mole fraction of BaO was known to be used in amounts as defined in Limitation 1[g]. EX1003, ¶ 81.

Miwa '535 discloses that the glass composition can comprise a mass fraction of "BaO 0-10%," Ex1004, ¶ [0022]. Further, again referring to mass fractions, Miwa '535 discloses that "BaO, like SrO, is an ingredient that improves the chemical resistance and impermeability of glass." However, Miwa '535 also teaches the adverse effects that *too much* BaO can have on glass properties: "The foregoing

effects can be obtained when the content is 10% or less. The preferred range is 0-5%. As the BaO 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, ¶ 83.

Sr and Ba play a *similar* role of network modifiers in the silicate glass structure. Therefore, BaO can be replaced by SrO without compromising essential properties of the glass. This means that their *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 mass density, coefficient of thermal expansion, and refractive index. For example, completely replacing BaO with SrO could be used to obtain non-alkali glasses with somewhat lower mass density. (The reduction may be somewhat less than suggested by the atom mass ratio $m_{\text{Sr}}/m_{\text{Ba}} = 0.64$: Sr^{2+} are smaller ions than Ba^{2+} . The reduced Sr–O bond length, compared to Ba–O, will increase the volume number density of ions. This will work to diminish the actual effect of replacing BaO with SrO on reducing mass density compared to just replacing every Ba^{2+} ion 1:1 with an Sr^{2+} ion without changing the atomistic structure.) EX1003, ¶ 84.

With SrO and BaO playing equivalent roles in the glass compositions, as discussed, it would have been obvious to adjust the mole fractions of BaO and SrO to keep their combined mole fraction constant. EX1003, ¶¶ 85-87.

A zero mole fraction of BaO also overlaps the BaO mole fraction of $X_{\text{BaO}} = 0$ -0.1 mol% in limitation 1[g]. EX1003, ¶¶ 88-89.

Additionally, Peuchert '469 describes the utilities of BaO and SrO and that **“The sum of the two heavy alkaline earth metal oxides SrO and BaO is preferably limited to a maximum of 4% by weight.”** EX1006, ¶¶ [0024], [0025], [0026]; EX1003, ¶ 90.

Thus, when Miwa '535 and Peuchert '469 are understood, it would be reasonable for a POSITA to optimize the fraction of BaO, including having a mole- or mass fraction of BaO equal to zero. This overlaps the BaO mole fraction of $X_{\text{BaO}} = (0..0.1)$ mol% in limitation 1[g]. EX1003, ¶ 91.

Limitation 1[h], wherein: (a) $1.00 \leq \Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$, 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;

Embodiment 15 of Miwa '535 discloses $\Sigma X_R / X_{\text{Al}_2\text{O}_3} = 1.20$, which is in the range of 1.00 to 1.25, as in limitation 1[h]. Therefore, limitation 1[h] “ $1.00 \leq \Sigma[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\Sigma[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO” is disclosed by Miwa '535. EX1004, Table 4; EX1003, ¶ 93.

Limitation 1[i]-[l]: (b) the glass has the following compositional characteristics:

- (i) on an oxide basis, the glass comprises at most 0.05 mole percent As₂O₃;*
- (ii) on an oxide basis, the glass comprises at most 0.05 mole percent Sb₂O₃;*
- and*
- (iii) on an oxide basis, the glass comprises at least 0.01 mole percent SnO₂;*
- and*

Embodiment 15 of Miwa '535 includes an As₂O₃ mole fraction of $X_{\text{As}_2\text{O}_3} = 0$ mol%; an Sb₂O₃ mole fraction of $X_{\text{Sb}_2\text{O}_3}$ of an SnO₂ mole fraction of $X_{\text{SnO}_2} = 0.04$ mol%, which overlaps with each of limitations [j]-[l]. Therefore, each of limitations 1[j]-[l] are disclosed by Miwa '535. EX1004, Table 4. EX1003, ¶ 95.

Limitation 1[m]: (c) the glass has a liquidus viscosity that is greater than or equal to 100,000 poise.

The need for a minimum viscosity of 10^{5.00} dPa·s (100,000 P) is common knowledge. For example, two Corning disclosures US4018965A and US20040224834A1 teach that the downdraw method requires a liquidus viscosity of at least 10^{5.00} dPa·s (100,000 P). EX1003, ¶ 98.

A testing of a sample (Sample #5) was conducted that is very similar to the glass described in Miwa '535's Embodiment 15. Differences in the mole fractions, if any, are in the sub-percent range and will, therefore, not significantly impact the viscosity. Regarding viscosity, the glass composition of Sample #5 is *identical* to that of Miwa '535's Embodiment 15 except a) BaO in Embodiment 15 is replaced by SrO and b) Sb₂O₃, as a controlled substance, is not included in sample 5# but it has little impact on the liquidus viscosity. EX1003, ¶¶ 99-106.

Glasses with the composition specified in Miwa '535 Embodiment 15 meet the requirement of Limitation 1[m]. EX1003, ¶ 107.

Each and every limitation of Claim 1 is described identically with the exception of BaO but as established, it would be reasonable for a POSITA to optimize the fraction of BaO, including having a mole- or mass fraction of BaO equal to zero. EX1003, ¶ 108.

2. Dependent Claim 2

Claim 2 depends from Claim 1 and further limits the $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$, *i.e.*, $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$. Embodiment 15 of Miwa '535 (EX1004, Table 4) discloses $[\text{RO}]/[\text{Al}_2\text{O}_3] = 1.20$, which is in the range of ≤ 1.25 as in Claim 2. EX1003, ¶ 110.

Thus, Claim 2 is disclosed by and would have been obvious in view of Miwa '535. EX1003, ¶ 111.

3. Dependent Claim 3

Claim 3 also depends from claim 1 and further limits the mole percent for SrO, *i.e.*, SrO is at most 1.0 mole percent. Embodiment 15 of Miwa (EX1004, Table 4) discloses an SrO mole fraction of $X_{\text{SrO}} = 0.94 \text{ mol\%}$, which within the range in Claim 3. EX1003, ¶¶ 87, 113.

Thus, Claim 3 is disclosed by and would have been obvious in view of Miwa '535. EX1003, ¶ 114.

4. Dependent Claim 4

The glass of claim 1 wherein the glass has at least one of the following properties:

(a) a density that is less than or equal to 2.41 g/cm³;

Embodiment 15 of Miwa '535 describes a glass density of 2.39 g/cm³, which overlaps with “a density that is less than or equal to 2.41 g/cm³” as in Claim 4. EX1004, Table 4; EX1003 ¶¶ 117-118.

(b) 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 '535 discloses “a linear coefficient of thermal expansion (CTE) over the temperature range 30-380°C which satisfies the relationship: $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$.” EX1004, ¶ 0047; EX1003, ¶ 120. Embodiment 15 of Miwa '535 reports a coefficient of thermal expansion (CTE) of $34 \times 10^{-7}/^{\circ}\text{C}$ measured over a temperature range of 30 to 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 4(b). EX1004, Table 4; EX1003 ¶ 121.

These differences between temperature ranges are of no consequence as for the temperature interval $[T_1, T_2] = [0, 300]^{\circ}\text{C}$ recited in the '491 Patent, the CTE of the glass in Miwa '535 satisfies the requirement that the CTE fall within the range $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$. EX1003, ¶¶ 122-143.

(c) a liquidus temperature less than or equal to 1170° C;

Embodiment 15 of Miwa '535 describes a liquidus temperature at 1120°C, which is within the range of Claim 4(c). EX1004, Table 4; EX1003, ¶¶ 145-146.

(d) a strain point that is greater than or equal to 650° C.

Embodiment 15 of Miwa '535 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 4[d]. EX1004, Table 4; EX1003, ¶¶ 148-149.

All the limitations in Claim 4 are disclosed by Miwa '535 and as such Claim 4 would have been obvious. EX1003, ¶ 150.

5. Dependent Claim 5

Claim 5 depends from Claim 4 and further requires *at least properties (a) through (c)*. As is evident from Claim 4, Embodiment 15 of Miwa '535 describes (a) through (c) as in Claim 5 and thus would have been obvious. EX1004, Table 4; EX1003, ¶ 152.

6. Dependent Claim 6

As is evident from Claim 4, Embodiment 15 of Miwa '535 describes (a) through (d) as in Claim 6 and thus would have been obvious. EX1004, Table 4; EX1003, ¶ 154.

7. Dependent Claim 7

Claim 7 depends from claim 1 and further limits the liquidus viscosity, i.e., liquidus viscosity greater than or equal to 200,000 poise.

200,000 poise corresponds to $10^{5.30}$ dPa·s. EX1003, ¶ 156.

Glass with the composition specified in Miwa '535's Embodiment 15 meet the requirement of Claim 7 and as such Claim 7 would have been obvious. EX1003, ¶¶ 157-158.

8. Dependent Claim 8

Claim 8 depends from claim 1 and further limits the mole percent of SnO₂, i.e., the glass comprises at most 0.15 mole percent SnO₂.

Embodiment 15 of Miwa '535 has 0.04 mol% SnO₂, which is less than 0.15 mole percent and thus renders Claim 8 obvious. EX1004, Table 4; EX1003, ¶ 160.

9. Dependent Claim 9

Dependent Claim 9 depends from claim 1 and further limits the mole percent of MgO, i.e., the glass has a MgO content between 1.2 and 2.8 mole percent.

Embodiment 15 of Miwa '535 has 2.10 mol% MgO, which is within the range of Claim 9 and thus would have been obvious. EX1004, Table 4; EX1003, ¶ 162.

10. Dependent Claim 10

Dependent Claim 10 also depends from claim 1 and recites that the glass is substantially free of BaO.

As is evident from Claim 1, Miwa '535 in view of Peuchert '469 discloses the

glass is substantially free of BaO. EX1004, Table 4; EX1003, ¶¶ 164-168.

That is, it would be reasonable for a POSITA to optimize the amount of BaO, including having a zero mole fraction of BaO when Miwa '535 and Peuchert '469 are properly understood. EX1003, ¶ 169.

11. Dependent Claim 11

Dependent Claim 11 also depends from Claim 1 and recites that the glass comprises at most 0.005 mole percent As_2O_3 and at most 0.005 mole percent Sb_2O_3 .

Miwa '535 describes (emphasis added): “The alkali-free glass substrate of this invention does not contain alkali metal oxides, and is characterized by the following: **SnO_2 0.01-0.3%, As_2O_3 0-0.1%, Sb_2O_3 0-1.0%**, and the Fe content in the glass is 0.005-0.03% by mass, when converted to Fe_2O_3 .” EX1004, cover page; EX1003, ¶ 171.

JP'741 provides salient teachings that would have been understood by a POSITA to minimize As_2O_3 . EX1005, ¶¶ [0005], [0006], [0022], [0019]; EX1003, ¶ 172.

JP '741 considered with Miwa '535 provides the motivation for avoiding the use of toxic fining agents and instead using only SnO_2 as a fining agent. Additionally, the composition of Example 5 in Miwa '535 falls within the compositional range described in JP '741, making it applicable to use the same type and content of fining

agent. EX1003, ¶¶ 173-174.

Thus, Claim 11 would have been obvious when considering the combination of Miwa '535 and JP '741. EX1003, ¶ 175.

12. Dependent Claim 12

Dependent Claim 12 also depends from Claim 1 and recites that the downdraw process is a fusion process.

Miwa '535 describes a downdraw process that is a fusion process and thus would have been obvious. EX1004, ¶ [0036]; EX1003, ¶¶ 177-180.

13. Independent Claim 13

There are several limitations in Claim 13 and each is addressed in turn.

Limitation 13[p]: An alkali-free glass sheet produced by a downdraw process comprising a glass that comprises SiO₂, Al₂O₃, B₂O₃, MgO, and CaO, and, on an oxide basis, has:

Miwa '535 discloses a continuous range of alkali-free glass compositions, specified as *mass* fractions on an oxide basis. EX1004, at [Claim 3], Tables 1-5. For example, Miwa '535 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] (emphasis added). Table 4 of Miwa illustrates various embodiments, including Embodiment 15 of alkali-free

glass defined by mass fractions (in percent) of each listed oxide. EX1003, ¶ 182.

The composition of Embodiment 15 of Miwa '535 was converted from mass fractions W_i to mole fractions X_i , and the resulting mole fractions X_i are shown in the following table – as percentages (mol%).

Oxide	Miwa Embodiment 15 (mol%)
SiO ₂	67.2
Al ₂ O ₃	10.2
B ₂ O ₃	10.3
MgO	2.1
CaO	9.3
SrO	0.63
BaO	0.21

EX1003, ¶¶ 183-184.

Additionally, Miwa '535 describes a downdraw process. EX1003, ¶¶ 185-186.

Limitation 13[a]: (i) a $\Sigma[RO]/[Al_2O_3]$ ratio greater than or equal to 1.0, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\Sigma[RO]$ is the sum of the mole percents of MgO, CaO, SrO, and BaO; and

Embodiment 15 of Miwa '535 discloses a value 1.2, which is in the range of 1.00 to 1.25, as in limitation 13[a]. Therefore, " $1.00 \leq \sum[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$ ", 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 '535. EX1004, Table 4; EX1003, ¶ 188.

Limitation 13[b]-[f]: (ii) a MgO content greater than or equal to 1.0 mole percent; wherein: 13[d] (a) on an oxide basis, the glass comprises at most 0.005 mole percent As_2O_3 ; 13[e] (b) on an oxide basis, the glass comprises at most 0.005 mole percent Sb_2O_3 ; 13[f] (c) on an oxide basis, the glass comprises at least 0.01 mole percent SnO_2 ; and

The glass compositions shown in JP '741 are free of both As_2O_3 and Sb_2O_3 . EX1003, ¶¶ 190-191. Combining Miwa '535's Embodiment 15 (EX1004, Table 4) with the teachings of JP '741 discloses Limitations 1[b-f]. EX1003, ¶¶ 192-195.

Limitation 13[g]: (d) the glass has a liquidus viscosity that is greater than or equal to 100,000 poise.

The glass composition described in Miwa '535's Embodiment 15 is identical to that of Sample #5 except a) BaO in Embodiment 15 is replaced by SrO and b) Sb_2O_3 , as a controlled substance, is not included in sample 5# but it has little impact on the liquidus viscosity, this means that the glass of Miwa '535's Embodiment 15 has a viscosity greater than $10^{5.0} \text{ dPa}\cdot\text{s}$ (100,000 P), as required by Limitation 13[g].

EX1003, ¶¶ 197-201.

As all of the limitations of Claim 13 are described by Miwa '535, Claim 13 would have been obvious. EX1003, ¶ 202.

14. Dependent Claim 14

Dependent Claim 14 depends from Claim 13 and further requires that on an oxide basis, the glass comprises at most 0.15 mole percent SnO₂.

JP '741 teaches:

Next, SnO₂ is added to the glass raw material mixture. The amount of SnO₂ added is 0.05 to 2.0 wt% of the glass raw material mixture. The reason for this range is that an amount less than 0.05% has no clarifying effect, and an amount more than 2.0% increases the amount of volatiles, making the glass more susceptible to deterioration.

EX1005, ¶ [0019]; EX1003, ¶ 204.

Embodiment 15 of Miwa '535 describes a SnO₂ mole fraction of $X_{\text{SnO}_2} = 0.04$ mol%. Miwa '535 also describes that the glass can comprise a mass (or weight) fraction of $W_{\text{SnO}_2} = 0.01$ to 0.3 ms%. EX1004, ¶ [0017]; EX1003, ¶ 205.

Therefore, as the glass described in Miwa '535's Embodiment 15 when considered with JP '741 would reasonably result in no more than 0.15 mol% of SnO₂, as required by Claim 14 as this value is optimizing known variables conventionally used in these types of glass compositions. As a result, Claim 14 would have been obvious. EX1003, ¶ 206.

15. Dependent Claim 15

Dependent Claim 15 depends from Claim 13 and further requires that the glass has a MgO content between 1.2 and 2.8 mole percent.

Embodiment 15 of Miwa '535 includes an MgO mole fraction of $X_{\text{MgO}}=2.1$, and as such Claim 15 would have been obvious. EX1003, ¶ 208.

16. Dependent Claim 16

Dependent Claim 16 depends from Claim 13 and further requires that the glass is substantially free of BaO.

As is evident from Claim 1, Miwa '535 in view of Peuchert '469 discloses the glass is substantially free of BaO and as such Claim 16 would have been obvious. EX1003, ¶¶ 210-214.

17. Dependent Claim 17

Dependent Claim 17 depends from Claim 13 and further requires that the glass has a density that is less than or equal to 2.41 grams/cm³.

Embodiment 15 of Miwa '535 describes a glass density of 2.39 g/cm³ and as such Claim 17 would have been obvious. EX1004, Table 4; EX1003, ¶¶ 216-217.

18. Dependent Claim 18

Dependent Claim 18 depends from Claim 13 and further requires that the glass has a linear coefficient of thermal expansion (CTE) over the temperature range 0-300° C. which satisfies the relationship: $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$.

As is evident from Limitation 4[b], Miwa '535 discloses $28 \times 10^{-7}/^{\circ}\text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ}\text{C}$. EX1003, ¶¶ 120-143, 219-222.

Thus, Claim 18 would have been obvious by Miwa '535. EX1003, ¶ 223.

19. Dependent Claim 19

Dependent Claim 19 depends from Claim 13 and further the glass has a liquidus temperature less than or equal to 1170° C.

Miwa '535's Embodiment 15 teaches a glass that overlaps with Claim 19 and has a liquidus temperature less than or equal to 1170° C. EX1004, Table 4; EX1003, ¶¶ 225-227.

Thus, Claim 19 would have been obvious by Miwa '535. EX1003, ¶ 227.

20. Dependent Claim 20

Dependent Claim 20 depends from Claim 13 and further requires that the glass has a strain point that is greater than or equal to 650° C.

Embodiment 15 of Miwa '535 describes a strain point at 673°C and thus would have been obvious. EX1004, Table 4; EX1003, ¶¶ 229-230.

21. Dependent Claim 21

Dependent Claim 21 depends from Claim 13 and further requires that the downdraw process is a fusion process.

Miwa '535 describes “overflow downdraw method” EX1004, ¶ [0036] (emphasis added), which is the same as a downdraw fusion process and as such Claim 21 would have been obvious EX1003, ¶¶ 232-235.

22. Dependent Claim 22

Dependent Claim 22 depends from Claim 13 and further requires that (i) the glass sheet has a volume of at least 500 cubic centimeters; and (ii) a population of 50 of the glass sheets sequentially produced by the downdraw process has an average gaseous inclusion level of less than 0.05 gaseous inclusions/cubic centimeter.

While Miwa '535 does not provide experimental data on glass quality under the – insufficient and arbitrary – conditions of Claim 22, Miwa '535 meets all relevant specifications given in the '491 Patent. This includes the fusion downdraw process, the specified conditions for the glass composition – including a sufficient level of a fining agent and resulting meltability, as well as the condition for the liquidus temperature and liquidus viscosity. Moreover, Miwa '535 describes the same manner of making the glass sheets. Since the '491 Patent does not specify any further process parameters required to obtain the specified limit for defects in Claim

22, what Miwa '535 describes includes the ability to produce glass sheets of equivalent or better quality in terms of blister/bubble defects. This includes producing populations of 50 sequential glass sheets produced by the fusion downdraw process from the melted and fined batch materials with “an average gaseous inclusion level of less than 0.05 gaseous inclusions per cm³, where each glass sheet in the population has a volume of at least 500 cm³.” EX1003, ¶¶ 237-241.

Thus, Claim 22 is included in what is disclosed by Miwa '535. EX1003, ¶ 242.

23. Dependent Claim 23

Dependent Claim 23 depends from Claim 13 and further requires that the glass has a liquidus viscosity greater than or equal to 200,000 poise.

Regarding viscosity, the glass composition described in Miwa '535's Embodiment 15 is identical to that of Sample #5 except a) BaO in Embodiment 15 is replaced by SrO and b) Sb₂O₃, as a controlled substance, is not included in sample 5# but it has little impact on the liquidus viscosity. The glass of Miwa '535's Embodiment 15 has a viscosity of 10^{6.2} dPa and thus greater than 10^{5.0} dPa·s (100,000 P) and as such would have been obvious. EX1003, ¶¶ 196-201; 245-246.

24. Dependent Claim 24

Dependent Claim 23 depends from Claim 1 and further the glass has a density

that is less than or equal to 2.41 grams/cm³.

Embodiment 15 of Miwa '535 describes a glass density of 2.39 g/cm³, which “less than or equal to 2.41 g/cm³” and as such Claim 24 would have been obvious. EX1004, Table 4; EX1003, ¶¶ 248-249.

B. Ground 2: Claims 1-12 and 16 would have been obvious over JP '643 in view of JP '741 and Peuchert '469; and Claims 13-15 and 17-24 would have been obvious over JP '643 in view of JP '741

1. Independent Claim 1

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

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

JP '643 describes:

Additionally, the alkali-free glass of the present invention has a liquidus temperature of 1,150°C or lower (preferably 1,130°C or lower, more preferably 1,100°C or lower) and a viscosity at the liquidus temperature of 10^{5.4} dPa·s or higher (preferably 106.0 dPa·s or higher), enabling formation into sheets by the downdraw method without devitrification and allowing the omission of polishing processes to reduce production costs.

EX1007, ¶ [0030]; EX1003 ¶ 251.

JP '741 describes:

The molten glass is then molded into the desired shape. For display applications, the fusion method, down-draw method, float method, or roll-out method, etc. is used to mold the glass into thin sheets.

EX1005, ¶ [0021]; EX1003 ¶ 252.

Peuchert '469 describes:

The invention relates to an alkali-free aluminoborosilicate glass. The invention also relates to uses of this glass.

High requirements are placed on glasses for applications as Substrates in flat-panel liquid-crystal display technology . . .

EX1006, ¶¶ [0001], [0002]; EX1003 ¶ 253.

Thus, JP '643, JP '741 and Peuchert '469 describe limitation 1[p]. EX1003, ¶

254.

Limitations 1[a]-1[ff]: 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

JP '643 describes several examples, including Embodiment No. 5:

	Sample No. 4		Sample No. 5		Sample No. 6	
	Mass %	mol%	Mass %	mol%	Mass %	mol%
SiO ₂	61.2	67.4	61.2	67.2	61.7	68.2
Al ₂ O ₃	16.8	10.9	16.8	10.9	17.0	11.1
B ₂ O ₃	11.8	11.3	11.8	11.2	10.5	10.0
MgO	0.5	0.8	1.0	1.6	-	-
CaO	7.4	8.7	6.9	9.3	8.0	9.5
SrO	0.5	0.3	0.5	0.3	1.0	0.6
BaO	0.5	0.2	0.5	0.2	0.5	0.2
ZnO	-	-	-	-	-	-
P ₂ O ₅	-	-	-	-	-	-
As ₂ O ₃	-	-	-	-	-	-
SnO ₂	-	-	-	-	-	-
Sb ₂ O ₃	1.0	0.2	1.0	0.2	1.0	0.2
ZrO ₂	0.3	0.2	0.3	0.2	0.3	0.2
Cl	-	-	-	-	-	-
(BaO + SrO)/BaO	2		2		3	
Density (g/cm ³)	2.382		2.379		2.400	
Thermal expansion coefficient [30-380°C] (x10 ⁻⁷ /°C)	33		32		34	
Viscosity	Strain point (°C)	669	670		674	
	Annealing point (°C)	724	724		731	
	Softening point (°C)	973	973		984	
	10 ^{4.0} (°C)	1301	1301		1322	
	10 ^{3.0} (°C)	1467	1467		1488	
	10 ^{2.5} (°C)	1573	1573		1597	
Young's modulus		70	70		71	
Specific Young's modulus		29.3	29.5		29.4	
BHF resistance	Corrosion (μm)	0.6	0.6		0.6	
	Visual appearance evaluation	○	○		○	
HC resistance	Corrosion (μm)	7.3	7.3		4.6	
	Visual appearance evaluation	○	○		○	
Liquidus temperature (°C)		1128	1146		1094	
Liquidus viscosity		10 ^{5.6}	10 ^{5.4}		10 ^{6.1}	

EX1007, Table 3; EX1003, ¶ 256.

Each of limitations 1[a]-1[f] are the same as Embodiment No. 5 in JP '643 as shown below:

	Claim 1 of the '491 Patent	Sample No. 5
1[a]	SiO ₂ : 64.0-71.0	SiO ₂ 67.2 mol%
1[b]	Al ₂ O ₃ : 9.0-12.0	Al ₂ O ₃ 10.9 mol%
1[c]	B ₂ O ₃ : 7.0-12.0	B ₂ O ₃ 11.2 mol%
1[d]	MgO: 1.0-3.0	MgO 1.6 mol%
1[e]	CaO: 6.0-11.5	CaO 9.3 mol%
1[f]	SrO: 0-2.0	SrO 0.3 mol%

EX1003, ¶ 257.

Limitation 1[g]; BaO: 0-0.1

JP '643 describes:

BaO and SrO are components that improve the chemical resistance and devitrification resistance of the glass, but if contained in large amounts, they increase the glass's density and thermal expansion coefficient. Therefore, their respective contents must be restricted to 0.1–5% for BaO and 0–4% for SrO. Particularly when reducing BaO and SrO to achieve lower density, if the contents of these two components become extremely imbalanced, the effect of improving BHF resistance diminishes.

EX1007, ¶ [0039]; EX1003, ¶ 259.

Peuchert '469 describes:

The glass may furthermore contain BaO, which has a positive effect on its devitrification stability. The maximum content is restricted to <2% by weight to keep the density of the glass low. The BaO content of the glass is particularly

preferably between 0 and 0.5% by weight. When a very lightweight glass is required, the glass is most preferably free of BaO.

The glass may furthermore contain SrO. Its presence likewise has a positive effect on the devitrification stability. The maximum SrO content is restricted to <3% by weight to keep the density of the glass low. The glass contains particularly preferably between 0 and 1% by weight and most preferably between 0 and 0.5% by weight.

The sum of the two heavy alkaline earth metal oxides SrO and BaO is preferably limited to a maximum of 4% by weight.

EX1006, ¶¶ [0024], [0025], [0026]; EX1003, ¶ 260.

JP '643 considered with Peuchert '469 provides motivation for not using BaO, and that the roles of BaO are similar to that of SrO. Thus, the corresponding mass percentage of BaO can be substituted by SrO and optimized resulting in amounts of BaO as well as SrO within the ranges of Claim 1. EX1003, ¶ 261-263.

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

Embodiment No. 5 of JP '643 includes a $\Sigma[RO]/[Al_2O_3]=1.05$, which is within the range of Limitation 1[h]. EX1003, ¶ 265.

Limitations 1[i]-[l]: (b) the glass has the following compositional characteristics:

- (i) on an oxide basis, the glass comprises at most 0.05 mole percent As_2O_3 ;***
- (ii) on an oxide basis, the glass comprises at most 0.05 mole percent Sb_2O_3 ;***
- and***

(iii) on an oxide basis, the glass comprises at least 0.01 mole percent SnO₂; and

JP '741 considered with JP '643 provides a motivation to avoid the use of toxic fining agents and instead using only SnO₂ as a fining agent. Additionally, the composition of Embodiment No. 5 in JP '643 falls within the compositional range described in JP '741, making it applicable to use the same types and contents of fining agents. EX1003, ¶¶ 267-268.

JP '741 discloses that the mass fraction W_{SnO_2} of the SnO₂ fining agent is 0.05–2 ms%. When adding 0.05 ms% SnO₂ as the sole fining agent to Example 5, then converting the mass fractions of Example 5 to mole fractions yields a mole fraction $X_{\text{SnO}_2} = 0.02 \text{ mol\%}$. This mole fraction is larger than 0.01 mol%, as in Claim 1. EX1003, ¶¶ 269-272.

Each of Limitations 1[i]–[l] would have been obvious in view of JP '643 and JP '741. EX1003, ¶¶ 272-273.

Limitation 1[m]: (c) the glass has a liquidus viscosity that is greater than or equal to 100,000 poise

Embodiment No. 5 of JP '643 reports a liquidus viscosity of $10^{5.4} \text{ dPa}\cdot\text{s}$, which equals to 251190 poise and is thus within the range of Limitation 1[m]. EX1003, ¶ 275.

As JP '643 considered with JP '741 and Peuchert '439 discloses substantially

the same composition and properties, a skilled person would have found Claim 1 obvious, particularly when considering that liquidus temperature and viscosity parameters are well known properties to consider and optimize in a down draw manufacturing process. EX1003, ¶ 276.

2. Dependent Claim 2

Claim 2 depends from Claim 1 and further defines $\Sigma[RO]/[Al_2O_3] \leq 1.25$. Embodiment No. 5 in JP '643 meets this ratio as shown in Table 3 of JP '643 above as the calculation $\Sigma[RO]/[Al_2O_3]=1.05$ and as such Claim 2 would have been obvious. EX1003, ¶¶ 278-279.

3. Dependent Claim 3

Claim 3 also depends from claim 1 and further limits the mole percent for SrO, *i.e.*, SrO is at most 1.0 mole percent. Embodiment No. 5 in JP '643 includes 0.3 mol% of SrO and as such Claim 3 would have been obvious. EX1003, ¶¶ 281-282.

4. Dependent Claim 4

The glass of claim 1 wherein the glass has at least one of the following properties: (a) a density that is less than or equal to 2.41 grams/cm³; (b) a linear coefficient of thermal expansion (CTE) over the temperature range 0-300° C. which satisfies the relationship: $28 \times 10^{-7}/^{\circ}C. \leq CTE \leq 34 \times 10^{-7}/^{\circ}C.$; (c) a liquidus temperature less than or equal to 1170° C.; (d) a strain point that is greater than or equal to 650° C.

(a) Sample 5 of JP '643 has a density of 2.379 g/cm^3 and is thus within the range of Claim 4. EX1003, ¶ 284.

(b) Within the temperature interval $[T_3, T_4] = [30, 380] \text{ }^\circ\text{C}$, Sample 5 of JP '643 has an effective thermal expansion coefficient of $\bar{\alpha} = 32 \cdot 10^{-7} \text{ K}^{-1}$. This is within the range specified in Claim 4. Within $[T_1, T_2] = [0, 300] \text{ }^\circ\text{C}$, the temperature interval to which Claim 4 refers, glasses with this composition have a somewhat *lower* effective thermal expansion coefficient $\bar{\alpha}$. $\bar{\alpha}$ will be lower by $(1..2) \cdot 10^{-7} \text{ K}^{-1}$ over that temperature interval, i.e., $\bar{\alpha} = (30..31) \cdot 10^{-7} \text{ K}^{-1}$. This value is within the range specified in Claim 4. EX1003, ¶ 285.

(c) Embodiment No. 5 of JP '643 has a liquidus temperature of 1146°C and is thus within the range of Claim 4. EX1003, ¶ 286.

(d) Embodiment No. 5 of JP '643 has a strain point of 670°C and is thus within the range of Claim 4. EX1003, ¶ 287.

Thus, Claim 4 is disclosed by and would have been obvious in view of Sample 5 of JP '643. EX1003, ¶ 288.

5. Dependent Claim 5

Claim 5 depends from Claim 4 and further requires *at least properties (a) through (c)*. As is evident from Claim 4, JP '643 includes properties (a), (b) and (c) and as such Claim 4 would have been obvious. EX1003, ¶ 290.

6. Dependent Claim 6

Claim 6 depends from Claim 4 and further requires *properties (a) through (d)*. As is clear from the analysis of Claim 4 above, JP '643 includes properties (a)-(d) and as such Claim 6 would have been obvious. EX1003, ¶ 292.

7. Dependent Claim 7

Claim 7 depends from Claim 1 and further defines that the glass has a liquidus viscosity greater than or equal to 200,000 poise. Embodiment No. 5 of reports a liquidus viscosity of $10^{5.4}$ dPa·s ($250,000 \pm 60,000$) P. This value is greater than 200,000 P, as in Claim 7 and would thus have been obvious in view of JP '643. EX1003, ¶ 294.

8. Dependent Claim 8

Claim 8 also depends from claim 1 and further limits the mole percent of SnO₂, i.e., the glass comprises at most 0.15 mole percent SnO₂.

Embodiment No. 5 of JP '643 has 0 mol% SnO₂. Additionally, JP '741 teaches an amount of SnO₂ added is 0.05 to 2.0 wt% of the glass raw material mixture. EX1005, ¶ [0019]; EX1003, ¶ 296.

Therefore, it would have been obvious to adjust the mole fraction of SnO₂ through JP '741 to achieve optimal glass performance such as for example to facilitate clarification and attenuate deterioration. EX1003, ¶ 296.

9. Dependent Claim 9

Dependent Claim 9 also depends from claim 1 and further limits the mole percent of MgO, i.e., the glass has a MgO content between 1.2 and 2.8 mole percent. Embodiment No. 5 of JP '643 has 1.6 mol% MgO and as this falls within the range of 1.2 and 2.8 mole percent in Claim 9, Claim 9 would have been obvious. EX1003, ¶ 298.

10. Dependent Claim 10

The glass of claim 1 wherein the glass is substantially free of BaO.

Dependent Claim 10 also depends from claim 1 and recites that the glass is substantially free of BaO. As is evident from limitation 1[g], JP '643 considered with Peuchert '469 provides motivation for not using BaO. EX1003, ¶¶ 258-263; 300.

11. Dependent Claim 11

Dependent Claim 11 also depends from Claim 1 and recites that the glass comprises at most 0.005 mole percent As_2O_3 and at most 0.005 mole percent Sb_2O_3 .

The glass compositions shown in JP '741 are free of both As_2O_3 and Sb_2O_3 . EX1003, ¶ 302.

As is discussed in the context of Claim 1, limitations [i]-[l], JP '741 considered with JP '643 provides a motivation to avoid the use of toxic fining agents and instead using only SnO_2 as a fining agent. Additionally, the composition of Sample 5 in JP

'643 falls within the compositional range described in JP '741, making it applicable to use the same types and contents of fining agents. EX1003, ¶¶ 267-273, 304-305.

Thus, Claim 11 would be obvious when the combination of JP '643 and JP '741 is considered. EX1003, ¶ 306.

12. Dependent Claim 12

Dependent Claim 12 also depends from Claim 1 and recites that the downdraw process is a fusion process. JP '643 (EX1007, ¶ [0030]) and JP '741 (EX1005, ¶0021) describe that it was well-known to make glass articles by a downdraw fusion process. EX1003, ¶¶ 308-311.

Thus, Claim 12 is described by JP '643. EX1003, ¶ 311.

13. Independent Claim 13

There are several limitations in Claim 13 and each is addressed in turn.

Limitation 13[p]: An alkali-free glass sheet produced by a downdraw process comprising a glass that comprises SiO₂, Al₂O₃, B₂O₃, MgO, and CaO, and, on an oxide basis, has:

JP '643 describes:

Additionally, the alkali-free glass of the present invention has a liquidus temperature of 1,150°C or lower (preferably 1,130°C or lower, more preferably 1,100°C or lower) and a viscosity at the liquidus temperature of 10^{5.4} dPa·s or higher (preferably 10^{6.0} dPa·s or higher), enabling formation into sheets by the downdraw method without devitrification and allowing the omission of polishing processes to reduce production costs.

EX1007, ¶ [0030]; EX1003, ¶ 313.

JP '741 describes:

The molten glass is then molded into the desired shape. For display applications, the fusion method, down-draw method, float method, or roll-out method, etc. is used to mold the glass into thin sheets.

EX1005, ¶ [0021]; EX1003, ¶ 314.

Peuchert '469 describes:

“The invention relates to an alkali-free aluminoborosilicate glass. The invention also relates to uses of this glass. High requirements are placed on glasses for applications as substrates in flat-panel liquid-crystal display technology . . .”

EX1006, ¶¶ 0001, 0002; EX1003, ¶ 315.

Thus, all of JP '643 JP '741, and Peuchert describe limitation 1[p] in Claim

13. EX1003, ¶ 316.

Limitation 13[a]: (i) a $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$ ratio greater than or equal to 1.0, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al_2O_3 and $\Sigma[\text{RO}]$ is the sum of the mole percents of MgO , CaO , SrO , and BaO ; and

Embodiment No. 5 of JP '643 includes a $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]=1.05$, which is within the range of Limitation 13[a]. EX1003, ¶ 318.

Limitation 13[b]: a MgO content greater than or equal to 1.0 mole percent

Embodiment No. 5 of JP '643 includes 1.6 mol% of MgO , which is within the range of Limitation 13[b]. EX1003, ¶ 320.

Limitations 13[c]-[f] wherein:

(a) on an oxide basis, the glass comprises at most 0.005 mole percent As₂O₃;

(b) on an oxide basis, the glass comprises at most 0.005 mole percent Sb₂O₃;

(c) on an oxide basis, the glass comprises at least 0.01 mole percent SnO₂;
and

JP '741 considered jointly with JP '643 provides a motivation to avoid the use of toxic fining agents and instead using only SnO₂ as a fining agent. Additionally, the composition of Sample 5 in JP '643 falls within the compositional range described in JP '741, making it applicable to use the same types and contents of fining agents. EX1003, ¶¶ 322-323.

Combining the example of JP '643's Sample 5 with the teachings of JP '741 discloses Limitations 13[c-f] in that the glass compositions shown in JP '741 are free of both As₂O₃ and Sb₂O₃. This is confirmed by the observation that the glass compositions shown in the examples in Table 2 in JP '741 do neither list As₂O₃, nor Sb₂O₃, and add up to exactly 1 (100 ms%). JP '643's Sample 5 is free of As₂O₃. With that, a mass fraction of $W_{\text{Sb}_2\text{O}_3} = 0$ implying a mole fraction of $X_{\text{Sb}_2\text{O}_3} = 0$ mol% and the mole fraction of $X_{\text{SnO}_2} = 0.02$ mol% (at least). EX1003, ¶¶ 324-327.

Thus, each of Limitations 13 [c-f] is disclosed and would have been obvious based on the JP '741 and JP '643. EX1003, ¶ 328.

Limitation 13[g]: (d) the glass has a liquidus viscosity that is greater than or

equal to 100,000 poise.

Embodiment 5 of JP '643 reports a liquidus viscosity of $10^{5.4}$ dPa·s ($250,000 \pm 60,000$) P, which is greater than 200,000 P. EX1003, ¶ 330.

As JP '643 considered with JP '741 discloses substantially the same composition and properties, a skilled person would have found Claim 13 obvious when these citations are properly understood. EX1003, ¶ 331.

14. Dependent Claim 14

Dependent Claim 14 depends from Claim 13 and further requires that on an oxide basis, the glass comprises at most 0.15 mole percent SnO₂.

As discussed in regards to Limitation 13[f], JP '741 considered with JP '643 provides a motivation to avoid the use of toxic fining agents and instead using only SnO₂ as a fining agent. The calculated molar percentage range of SnO₂ is 0.02–0.88 mol%, which is within the range of Claim 14 and as such Claim 14 would have been obvious. EX1003, ¶ 324-327, 333-335.

15. Dependent Claim 15

Dependent Claim 15 depends from Claim 13 and further requires that the glass has a MgO content between 1.2 and 2.8 mole percent.

Embodiment No. 5 of JP '643 has 1.6 mol% MgO, which falls within the range of 1.2 and 2.8 mole percent in Claim 15 and as such Claim 15 would have been

obvious. EX1003, ¶¶ 337-338.

16. Dependent Claim 16

Dependent Claim 16 depends from Claim 13 and further requires that the glass is substantially free of BaO.

JP '643 considered with Peuchert '469 provides motivation for not using BaO. EX1003, ¶¶ 259-263, 340-342.

Thus, Claim 16 would have been obvious when JP '643 considered with JP '741 and Peuchert '469. EX1003, ¶ 342.

17. Dependent Claim 17

Dependent Claim 17 depends from Claim 13 and further requires that the glass has a density that is less than or equal to 2.41 grams/cm³.

Embodiment No. 5 of JP '643 has a density of 2.379 and as this within the range of Claim 17, Claim 17 would have been obvious. EX1003, ¶ 344.

18. Dependent Claim 18

Dependent Claim 18 depends from Claim 13 and further requires that the glass has a linear coefficient of thermal expansion (CTE) over the temperature range 0-300° C. which satisfies the relationship: $28 \times 10^{-7}/^{\circ} \text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ} \text{C}$.

A skilled person would have found Claim 13 obvious since Sample 5 of JP '643 has a CTE within the specified range, JP '643 overlaps with Claim 18. EX1003, ¶¶

346-347.

19. Dependent Claim 19

Dependent Claim 19 depends from Claim 13 and further the glass has a liquidus temperature less than or equal to 1170° C.

Embodiment No. 5 of JP '643 has a liquidus temperature of 1146°C and is thus within the range of Claim 19 and thus would have been obvious in view of JP '643. EX1003, ¶ 349.

20. Dependent Claim 20

Dependent Claim 20 depends from Claim 13 and further requires that the glass has a strain point that is greater than or equal to 650° C.

Embodiment No. 5 of JP '643 has a strain point of 670°C and as this is within the range of Claim 20, Claim 20 would have been obvious in view of JP '643. EX1003, ¶ 351.

21. Dependent Claim 21

Dependent Claim 21 depends from Claim 13 and further requires that the downdraw process is a fusion process.

JP '643 (EX1007, ¶ [0030]) and JP '741 (EX1005, ¶ 0021) describe that it was well-known to make glass articles by a downdraw fusion process and as such Claim

21 would have been obvious. EX1003, ¶¶ 353-355.

22. Dependent Claim 22

Dependent Claim 22 depends from Claim 13 and further requires that (i) the glass sheet has a volume of at least 500 cubic centimeters; and (ii) a population of 50 of the glass sheets sequentially produced by the downdraw process has an average gaseous inclusion level of less than 0.05 gaseous inclusions/cubic centimeter.

While JP '643, JP '741 and Peuchert '469 do not provide experimental data on glass quality under the – insufficient and arbitrary – conditions of Claim 22, JP '643, JP '741 and Peuchert '469 meet all relevant specifications given in the '491 Patent. This includes the fusion downdraw process, the specified conditions for the glass composition – including a sufficient level of a fining agent and resulting meltability, as well as the condition for the liquidus temperature and liquidus viscosity. Moreover, JP '643, JP '741 and Peuchert '469 describe the same manner of making the glass sheets. Since the '491 Patent does not specify any further process parameters required to obtain the specified limit for defects in Claim 22, I expect that what JP '643, JP '741 and Peuchert '469 describe includes the ability to produce glass sheets of equivalent or better quality in terms of blister/bubble defects. This includes producing populations of 50 sequential glass sheets produced by the fusion downdraw process from the melted and fined batch materials with “an average

gaseous inclusion level of less than 0.05 gaseous inclusions per cm^3 , where each glass sheet in the population has a volume of at least 500 cm^3 . EX1003, ¶¶ 357-361.

Thus, Claim 22 would have been obvious in view of JP '643, and JP '741. EX1003, ¶ 362.

23. Dependent Claim 23

Dependent Claim 23 depends from Claim 13 and further requires that the glass has a liquidus viscosity greater than or equal to 200,000 poise.

Embodiment No. 5 of JP '643 reports a liquidus viscosity of $10^{5.4} \text{ dPa}\cdot\text{s}$, which is within this range such that Claim 23 would have been obvious in view of JP '643. EX1003, ¶ 364.

24. Dependent Claim 24

Dependent Claim 23 depends from Claim 1 and further the glass has a density that is less than or equal to 2.41 grams/cm^3 .

Embodiment No. 5 of JP '643 has a density of 2.379 and as this within the range of Claim 24, Claim 24 would have been obvious in view of JP '643. EX1003, ¶ 366.

C. Ground 3: Claims 13-14 and 19-21 are anticipated by Miwa '377, Claim 16 would have been obvious over Miwa '377 in view of Peuchert '469, and Claims 22-23 would have been obvious over Miwa '377

1. Independent Claim 13

There are several limitations in Claim 13 and each is addressed in turn.

Limitation 13[p]: An alkali-free glass sheet produced by a downdraw process comprising a glass that comprises SiO₂, Al₂O₃, B₂O₃, MgO, and CaO, and, on an oxide basis, has:

Miwa '377 describes alkali-free glass sheet produced by a downdraw process comprising a glass that comprises SiO₂, Al₂O₃, B₂O₃, MgO, and CaO, and, on an oxide basis. EX1008, ¶¶ [0028], [0073]; EX1003, ¶ 368.

Miwa '377 includes a number of examples, including Sample No. 8 in Table 3:

Sample Composition	No. 7		No. 8		No. 9	
	mass %	mol %	mass %	mol %	mass %	mol %
SiO ₂	62.0	68.62	61.2	66.61	60.0	67.72
Al ₂ O ₃	16.0	10.44	17.0	10.90	14.0	9.31
B ₂ O ₃	10.5	10.03	8.0	7.52	11.0	10.72
MgO	-	-	2.0	3.24	-	-
CaO	8.0	9.49	6.0	7.00	6.5	7.86
SrO	0.8	0.51	4.0	2.52	2.3	1.51
BaO	0.5	0.22	0.5	0.21	1.5	0.66
ZnO	-	-	-	-	0.7	0.58
ZrO ₂	0.4	0.22	0.15	0.08	0.45	0.25
TiO ₂	-	-	-	-	0.	0.42
SnO ₂	0.3	0.13	0.15	0.07	0.05	0.02
P ₂ O ₅	-	-	-	-	1.0	0.48
Sb ₂ O ₃	1.5	0.34	-	-	2.0	0.47
Cl	-	-	1.0	1.84	-	-
MCSB	9.3	10.22	12.5	12.97	10.3	10.03
0.13 x X-1		0.33		0.69		0.30
Density (g/cm ³)	2.39		2.44		2.45	
Thermal Expansion Coefficient (x 10 ⁻¹ /°C)	33		35		34	
Stress Point	669°C		693°C		650°C	

$10^{2.5}$ dPa · s	1603°C	1619°C	1539°C
Liquid Phase Temperature	1042°C	1089°C	1065°C
SnO ₂ Opacity	No	No	No
HCl Resistance			
Amount of Corrosion	1.8 μm	0.1 μm	0.8 μm
Appearance	○	○	○
BHF Resistance			
Amount of Corrosion	0.7 μm	0.6 μm	0.7 μm
Appearance	○	Δ	○
Bubble Retention	○	○	○

EX1008, page 10; EX1003, ¶ 369.

Thus, Miwa '377 describes Limitation 13[p]. EX1003, ¶ 370.

Limitation 13[a]: (i) a $\Sigma[RO]/[Al_2O_3]$ ratio greater than or equal to 1.0, where $[Al_2O_3]$ is the mole percent of Al_2O_3 and $\Sigma[RO]$ is the sum of the mole percents of MgO , CaO , SrO , and BaO ; and

The composition of Sample 8 in Miwa '377, $\sum_{i \in R} X_i / X_{Al_2O_3} = 1.20$. This value is within the range of Limitation 13[a]. EX1003, ¶ 372.

Limitation 13[b]-[f]: (ii) a MgO content greater than or equal to 1.0 mole percent; 13[d] (a) on an oxide basis, the glass comprises at most 0.005 mole percent As_2O_3 ; 13[e] (b) on an oxide basis, the glass comprises at most 0.005 mole percent Sb_2O_3 ; 13[f] (c) on an oxide basis, the glass comprises at least 0.01 mole percent SnO_2 ; and

Sample No. 8 of Miwa '377 includes 3.24 mol% of MgO ; 0 mol% of As_2O_3 ; 0 mol% of Sb_2O_3 ; and 0.07 mol% of SnO_2 . EX1003, ¶ 374.

Thus, Embodiment No. 8 of Miwa '377 is within the range of each of Limitations [b]-[f]. EX1003, ¶ 375.

Limitation 13[g]: (d) the glass has a liquidus viscosity that is greater than or equal to 100,000 poise.

100,000 P corresponds to $10^{5.00}$ dPa·s. Thus, “preferably no less than 10^5 dPa·s, and more preferably no less than $10^{5.5}$ dPa·s” overlaps with Limitation 13[g] and as such Limitation 13[g] is described Miwa '377. EX1008, ¶ [0012]; EX1003, ¶¶ 377-378.

As all of the limitations are disclosed in the same manner in Sample No. 8 in Miwa '377, Claim 13 is anticipated. EX1003, ¶ 379.

2. Dependent Claim 14

Dependent Claim 14 depends from Claim 13 and further requires that on an oxide basis, the glass comprises at most 0.15 mole percent SnO₂.

Sample 8 of Miwa '377 includes 0.07 mol% of SnO₂. Thus, Sample 8 of Miwa '377 is within the range of Claim 14 and is anticipated by this Sample. EX1003, ¶¶ 381-382.

3. Dependent Claim 16

Dependent Claim 16 depends from Claim 13 and further requires that the glass is substantially free of BaO.

Sample 8 of Miwa '377 includes 0.2 mol% of BaO. EX1003, ¶ 384.

Peuchert '469 describes:

The glass may furthermore contain BaO, which has a positive effect on its devitrification stability. The maximum content is restricted to <2% by weight to keep the density of the glass low. The BaO content of the glass is particularly preferably between 0 and 0.5% by weight. When a very lightweight glass is required, the glass is most preferably free of BaO.

The glass may furthermore contain SrO. Its presence likewise has a positive effect on the devitrification stability. The maximum SrO content is restricted to <3% by weight to keep the density of the glass low. The glass contains particularly preferably between 0 and 1% by weight and most preferably between 0 and 0.5% by weight.

The sum of the two heavy alkaline earth metal oxides SrO and BaO is preferably limited to a maximum of 4% by weight.

EX1006, ¶¶ [0024], [0025], [0026]; EX1003, ¶ 385.

Miwa '377 considered with Peuchert '469 provides motivation for not using BaO, and shows that the roles of BaO and SrO are similar regarding devitrification stability. A small fraction of BaO can be substituted by a corresponding fraction SrO, yielding a glass with a SrO fraction within the range specified in Claim 1 and substantially free of BaO, as in Claim 16. Thus, Claim 16 would have been obvious. EX1003, ¶ 386.

4. Dependent Claim 19

Dependent Claim 19 depends from Claim 13 and further the glass has a liquidus temperature less than or equal to 1170° C.

Sample 8 of Miwa '377 has a liquidus temperature of 1089 °C. This liquidus temperature overlaps with the range in Claim 19. Thus, Claim 19 is anticipated by Miwa '377. EX1003, ¶ 388-389.

5. Dependent Claim 20

Dependent Claim 20 depends from Claim 13 and further requires that the glass has a strain point that is greater than or equal to 650° C.

Table 1 in Miwa '377 indicates that Sample 8 has a strain point, of 693 °C, which is greater than or equal to 650°C as in Claim 20. Thus, Claim 20 is anticipated by Miwa '377. EX1003, ¶¶ 391-392.

6. Dependent Claim 21

Dependent Claim 21 depends from Claim 13 and further requires that the downdraw process is a fusion process.

Miwa '377 describes an *overflow* downdraw method, which is the same as a *fusion* downdraw process – as in Claim 21. Thus, Claim 21 is anticipated. EX1003, ¶¶ 394-395.

7. Dependent Claim 22

Dependent Claim 22 depends from Claim 13 and further requires that (i) the glass sheet has a volume of at least 500 cubic centimeters; and (ii) a population of 50 of the glass sheets sequentially produced by the downdraw process has an average

gaseous inclusion level of less than 0.05 gaseous inclusions/cubic centimeter.

Miwa '377 teaches the desire and manner of reducing defects in the glass. Even if the defect density in Sample 1 appears to be slightly higher than the maximum of Claim 22, this does not necessarily mean that the quality of the glass is lower. For example, if Glass A has spherical bubbles with a number density of twice as high as Glass B, but the diameter of the bubbles in Glass A is only half of what it is in Glass B, then the total bubble volume per cm³ in Glass A is only 1/4 of what it is in Glass B. This is because the volume of a spherical bubble increases with a third power of its diameter. While the specifics of bubble size distribution and statistics are not disclosed in either one patent, reducing the number density and total volume of defects to a minimum is well-within the knowledge and abilities of a POSITA. This would have motivated obtaining a glass with an average gaseous inclusion level of less than 0.05 gaseous inclusions/cubic centimeter, as recited in Claim 22. Thus, Claim 22 is obvious. EX1003, ¶¶ 397-403.

8. Dependent Claim 23

Dependent Claim 23 depends from Claim 13 and further requires that the glass has a liquidus viscosity greater than or equal to 200,000 poise.

Miwa '377 describes **liquid phase viscosity is preferably no less than 10⁵ dPa·s, and more preferably no less than 10^{5.5} dPa·s.** EX1008, ¶ 0012; EX1003, ¶

405.

100,000 P equals $10^{5.00}$ dPa·s. $10^{5.5}$ dPa·s equals $(316,000 \pm 73,000)$ P. These figures overlap with those in Claim 23. EX1003, ¶ 405. Thus, Claim 23 would have been obvious in view of Miwa '377. EX1003, ¶ 406.

XII. CONCLUSION

Petitioner respectfully requests that a trial be instituted. Claims 1-24 should be cancelled.

Respectfully Submitted,

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. §42.24(d), Petitioner certifies that this Petition includes 12,481 words, as measured by Microsoft Word®, exclusive of the table of contents, mandatory notices under §42.8, certificates of service, word count, and exhibits.

CERTIFICATE OF SERVICE (37 C.F.R. § 42.6(e)(1))

The undersigned hereby certifies that the above document was served on May 21, 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:

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APPENDIX A – CLAIM LISTING

U.S. Patent No. 8,640,491

Claim or Element #	Claim Language
1[p]	1. An alkali-free glass for a downdraw process comprising in mole percent on an oxide basis:
1[a]	SiO ₂ : 64.0-71.0
1[b]	Al ₂ O ₃ : 9.0-12.0
1[c]	B ₂ O ₃ : 7.0-12.0
1[d]	MgO: 1.0-3.0
1[e]	CaO: 6.0-11.5
1[f]	SrO: 0-2.0
1[g]	BaO: 0-0.1
1[h]	wherein: (a) $1.00 \cong \Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al ₂ O ₃ and $\Sigma[\text{RO}]$ equals the sum of the mole percents of MgO, CaO, SrO, and BaO;
1[i]	(b) the glass has the following compositional characteristics:
1[j]	(i) on an oxide basis, the glass comprises at most 0.05 mole percent As ₂ O ₃ ;

1[k]	(ii) on an oxide basis, the glass comprises at most 0.05 mole percent Sb ₂ O ₃ ; and
1[l]	(iii) on an oxide basis, the glass comprises at least 0.01 mole percent SnO ₂ ; and
1[m]	(c) the glass has a liquidus viscosity that is greater than or equal to 100,000 poise.
2	The glass of claim 1 wherein: $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3] \leq 1.25$.
3	The glass of claim 1 wherein, on an oxide basis, SrO is at most 1.0 mole percent.
4[p]	The glass of claim 1 wherein the glass has at least one of the following properties:
4[a]	(a) a density that is less than or equal to 2.41 grams/cm ³ ;
4[b]	(b) a linear coefficient of thermal expansion (CTE) over the temperature range 0-300° C. which satisfies the relationship: $28 \times 10^{-7}/^\circ \text{C.} \leq \text{CTE} \leq 34 \times 10^{-7}/^\circ \text{C.}$;
4[c]	(c) a liquidus temperature less than or equal to 1170° C.;
4[d]	(d) a strain point that is greater than or equal to 650° C.
5	The glass of claim 4 wherein the glass has at least properties (a) through (c).

6	The glass of claim 4 wherein the glass has properties (a) through (d).
7	The glass of claim 1 wherein the glass has a liquidus viscosity greater than or equal to 200,000 poise.
8	The glass of claim 1 wherein, on an oxide basis, the glass comprises at most 0.15 mole percent SnO ₂ .
9	The glass of claim 1 wherein the glass has a MgO content between 1.2 and 2.8 mole percent.
10	The glass of claim 1 wherein the glass is substantially free of BaO.
11	The glass of claim 1 wherein the glass comprises at most 0.005 mole percent As ₂ O ₃ and at most 0.005 mole percent Sb ₂ O ₃ .
12	The glass of claim 1 wherein the downdraw process is a fusion process.
13[p]	An alkali-free glass sheet produced by a downdraw process comprising a glass that comprises SiO ₂ , Al ₂ O ₃ , B ₂ O ₃ , MgO, and CaO, and, on an oxide basis, has:
13[a]	(i) a $\Sigma[\text{RO}]/[\text{Al}_2\text{O}_3]$ ratio greater than or equal to 1.0, where $[\text{Al}_2\text{O}_3]$ is the mole percent of Al ₂ O ₃ and $\Sigma[\text{RO}]$ is the sum of the mole percents of MgO, CaO, SrO, and BaO; and
13[b]	(ii) a MgO content greater than or equal to 1.0 mole percent;

13[c]	wherein:
13[d]	(a) on an oxide basis, the glass comprises at most 0.005 mole percent As_2O_3 ;
13[e]	(b) on an oxide basis, the glass comprises at most 0.005 mole percent Sb_2O_3 ;
13[f]	(c) on an oxide basis, the glass comprises at least 0.01 mole percent SnO_2 ; and
13[g]	(d) the glass has a liquidus viscosity that is greater than or equal to 100,000 poise.
14	The glass sheet of claim 13 wherein on an oxide basis, the glass comprises at most 0.15 mole percent SnO_2 .
15	The glass sheet of claim 13 wherein the glass has a MgO content between 1.2 and 2.8 mole percent.
16	The glass sheet of claim 13 wherein the glass is substantially free of BaO.
17	The glass sheet of claim 13 wherein the glass has a density that is less than or equal to 2.41 grams/cm ³ .

18	The glass sheet of claim 13 wherein the glass has a linear coefficient of thermal expansion (CTE) over the temperature range 0-300° C which satisfies the relationship:
	$28 \times 10^{-7}/^{\circ} \text{C} \leq \text{CTE} \leq 34 \times 10^{-7}/^{\circ} \text{C}.$
19	The glass sheet of claim 13 wherein the glass has a liquidus temperature less than or equal to 1170° C.
20	The glass sheet of claim 13 wherein the glass has a strain point that is greater than or equal to 650° C.
21	The glass sheet of claim 13 wherein the downdraw process is a fusion process.
22	The glass sheet of claim 13 wherein:
	(i) the glass sheet has a volume of at least 500 cubic centimeters; and
	(ii) a population of 50 of the glass sheets sequentially produced by the downdraw process has an average gaseous inclusion level of less than 0.05 gaseous inclusions/cubic centimeter.
23	The glass sheet of claim 13 wherein the glass has a liquidus viscosity greater than or equal to 200,000 poise.
24	The glass of claim 1 wherein the glass has a density that is less than or equal to 2.41 grams/cm ³ .