

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

COREPHOTONICS, LTD.,
Patent Owner.

IPR2020-00896
Patent 10,317,647

Before BRYAN F. MOORE, MONICA S. ULLAGADDI, and
BRENT M. DOUGAL, *Administrative Patent Judges*.

ULLAGADDI, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
All Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

Apple Inc. (“Petitioner”) filed a Petition to institute an *inter partes* review of claims 1–12 (“the challenged claims”) of U.S. Patent No. 10,317,647 (Ex. 1001, “the ’647 patent”). Paper 2 (“Pet.”). Patent Owner did not file a preliminary response.

We instituted trial on the challenged claims on all grounds set forth in the Petition on December 8, 2020. Paper 7 (“Inst. Dec.”). After institution, Patent Owner filed a Patent Owner Response (Paper 14, “PO Resp.”), Petitioner filed a Reply to Patent Owner’s Response (Paper 21, “Pet. Reply”), and Patent Owner filed a Sur-Reply (Paper 22, “PO Sur-Reply”). An oral hearing was held on September 8, 2021, and a copy of the transcript was entered in the record. Paper 32 (“Tr.”).

We have jurisdiction pursuant to 35 U.S.C. § 6. This Decision is a Final Written Decision under 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73 as to the patentability of the claims on which we instituted trial. Having reviewed the arguments and the supporting evidence, we determine that Petitioner has shown, by a preponderance of the evidence, that claims 1–11 of the ’647 patent are unpatentable. We determine that Petitioner has not shown by a preponderance of the evidence that claim 12 of the ’647 patent is unpatentable.

II. BACKGROUND

A. *Related Proceedings*

Petitioner and Patent Owner identify the following corresponding district court proceeding: *Corephotonics, Ltd. v. Apple Inc.*, No. 5:19-cv-04809 (N.D. Cal.) (“’4809 case”). Pet. 1; Paper 5, 1.¹

From the IPR2020-00897 proceeding, we are aware of a pending civil action, *Corephotonics, Ltd. v. Apple Inc.*, No. 5-18-cv-02555 (N.D. Cal.) (’2555 case) that concerns a parent of the ’647 patent. The ’2555 and ’4809 cases were found related to a previously filed case in the Northern District of California between the same parties, No. 17-cv-06457 (N.D. Cal.). *See* ’2555 case, Dkt. 14; ’4809 case, Dkt. 16. The parties are reminded that they *must* keep the Board apprised of the status of related litigations and identify all related administrative matters.

We identify the following related administrative matters, including every application and patent claiming the benefit of the priority of the filing date of patents in the priority chain of the ’647 patent. *See* Patent Trial and Appeal Board Consolidated Trial Practice Guide² (Nov. 2019) at 18; *see also* 84 Fed. Reg. 64,280 (Nov. 21, 2019).

The ’647 patent, along with Application No. 15/976,391 (now U.S. Patent No. 10,330,897, “the ’897 patent”) claims priority to:

¹ Patent Owner cites *Corephotonics, Ltd. v. Apple Inc.*, No. 3:19-cv-04809-LHK (N.D. Cal.) (Paper 5, 1), but this case number appears to reflect a typographical error. A PACER search of Case No. 5:19-cv-04809 reveals that Patent Owner’s complaint in that case was erroneously identified as “Civil Action No. 3:19-cv-4809” on its cover page.

² Available at <https://www.uspto.gov/TrialPracticeGuideConsolidated>.

Application No. 15/817,235 (now U.S. Patent No. 10,324,277, “the ’277 patent”), which claims priority to

Application No. 15/418,925 (now U.S. Patent No. 9,857,568, “the ’568 patent”), which claims priority to

Application No. 15/170,472 (now U.S. Patent No. 9,568,712, “the ’712 patent”), which claims priority to

Application No. 14/932,319 (now U.S. Patent No. 9,402,032, “the ’032 patent”), which claims priority to

Application No. 14/367,924 (abandoned), which claims priority to PCT/IB2014/062465, which claims priority to Prov. No. 61/842,987.

Application No. 16/296,272 (now U.S. Patent No. 10,488,630), which, along with Application No. 16/296,275 (now U.S. Patent No. 10,437,020) claim priority to the ’647 patent.

The following AIA trial proceedings challenge patents in the chain of priority for the ’647 patent:

IPR2020-00878 (challenges the ’878 patent);

IPR2020-00897 (challenges the ’277 patent);

IPR2019-00030 (challenges the ’568 patent);

IPR2018-01146 (challenged the ’712 patent); and

IPR2018-01140 (challenged the ’032 patent).

B. The ’647 Patent

The ’647 patent issued on June 11, 2019, and is based on an application filed on May 10, 2018, which claimed priority back to a provisional application filed July 4, 2013. Ex. 1001, codes (22), (45), (60). The ’647 patent discloses an optical lens assembly with five lens elements. *Id.* at code (57). Figure 1A of the ’647 patent is reproduced below.

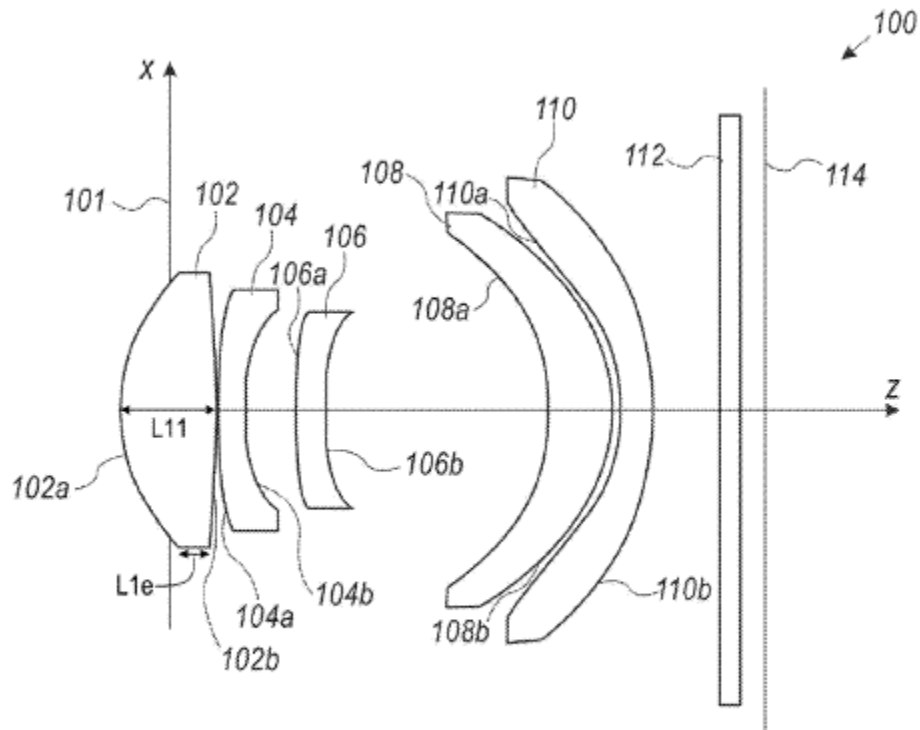


FIG. 1A

Figure 1A of the '647 patent illustrates a first embodiment of an optical lens system.

The embodiments disclosed refer to an optical lens assembly comprising, in order from an object side to an image side: optional stop 101; first plastic lens element 102 with positive refractive power having a convex, object-side surface 102a; second plastic lens element 104 with negative refractive power having a meniscus, convex, object-side surface 104a; third plastic lens element 106 with negative refractive power having a concave, object-side surface 106a; fourth plastic lens element 108 with positive refractive power having a positive meniscus with a concave, object-side surface marked 108a; fifth plastic lens element 110 with negative refractive power having a negative meniscus with a concave, object-side surface 110a. *Id.* at 3:25–42.

In Table 1, reproduced below, the '647 patent discloses radii of curvature, R , for the lens elements, lens element thicknesses and distances between each of the lens elements, as well as a refractive index, Nd , for each lens element.

TABLE 1

#	Comment	Radius R [mm]	Distances [mm]	Nd/Vd	Diameter [mm]
1	Stop	Infinite	-0.466		2.4
2	L11	1.5800	0.894	1.5345/57.095	2.5
3	L12	-11.2003	0.020		2.4
4	L21	33.8670	0.246	1.63549/23.91	2.2
5	L22	3.2281	0.449		1.9
6	L31	-12.2843	0.290	1.5345/57.095	1.9
7	L32	7.7138	2.020		1.8
8	L41	-2.3755	0.597	1.63549/23.91	3.3
9	L42	-1.8801	0.068		3.6
10	L51	-1.8100	0.293	1.5345/57.095	3.9
11	L52	-5.2768	0.617		4.3
12	Window	Infinite	0.210	1.5168/64.17	3.0
13		Infinite	0.200		3.0

Table 1 of the '647 patent set forth optical parameters for the optical lens assembly.

The '647 patent discloses that

[T]he distances between various elements (and/or surfaces) are marked “L_{mn}” (where m refers to the lens element number, n=1 refers to the element thickness and n=2 refers to the air gap to the next element) and are measured on the optical axis z, wherein the stop is at z=0. Each number is measured from the previous surface. Thus, the first distance -0.466 mm is measured from the stop to surface 102a, the distance L11 from surface 102a to surface 102b (i.e. the thickness of first lens element 102) is 0.894 mm, the gap L12 between surfaces 102b and 104a is 0.020 mm, the distance L21 between surfaces 104a and 104b (i.e. thickness d2 of second lens element 104) is 0.246 mm, etc. Also, L21=d₂, and L51=d₅.

Id. at 4:16–29.

C. Challenged Claims

Petitioner challenges claims 1–12 of the '647 patent. Claims 1 and 8 are independent. Claim 1 is reproduced below.

1. An optical lens assembly comprising, in order from an object side to an image side:
 - a) a first lens element L_1 with positive refractive power, a focal length f_1 ;
 - b) a second lens element L_2 with negative refractive power and a focal length f_2 and having a meniscus shape with convex object-side surface;
 - c) a third lens element L_3 with negative refractive power and a focal length f_3 ;
 - d) a fourth lens element L_4 ; and
 - e) a fifth lens element L_5 , wherein $1.2 \times |f_3| > |f_2| > 1.5 \times f_1$, wherein the lens assembly has an effective focal length (EFL), wherein a lens system that includes the lens assembly plus a window positioned between the fifth lens element and an image plane has a total track length (TTL) of 6.5 millimeters or less and wherein the lens assembly has a ratio $TTL/EFL < 1.0$.

Ex. 1001, 8:22–39.

D. Asserted Grounds of Unpatentability

Petitioner challenges claims 1–12 as follows. *See* Pet. 9–10. In support, Petitioner relies on the First and Second Declarations of Dr. José Sasián (Exs. 1003, 1037). Patent Owner supports its briefing with the Declaration of Dr. Tom D. Milster (Ex. 2001).

Claim(s) Challenged	35 U.S.C. § ³	Reference(s)/Basis
1–3, 5	103	Iwasaki ⁴
1, 4	103	Ogino ⁵ and Chen II ⁶
2, 3, 5, 8–11	103	Ogino, Chen II, and Bareau ⁷
6	103	Ogino, Chen II, Bareau, and Kingslake ⁸
7	103	Hsieh ⁹ and Beich ¹⁰
12	103	Chen ¹¹ , Iwasaki, and Beich

III. ANALYSIS

A. Principles of Law

A claim is unpatentable under 35 U.S.C. § 103 if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said

³ Because the application leading to the '647 patent was filed after March 16, 2013, the effective date of the Leahy Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284 (2011) (“AIA”), patentability is governed by the post-AIA version of 35 U.S.C. § 103.

⁴ U.S. Patent No. 9,678,310 B2 to Iwasaki et al. (Ex. 1009, “Iwasaki”).

⁵ U.S. Patent No. 9,128,267 B2 to Ogino et al. (Ex. 1005, “Ogino”).

⁶ U.S. Patent No. 8,233,224 B2 to Chen (Ex. 1008, “Chen II”).

⁷ Jane Bareau et al., “The Optics of Miniature Digital Camera Modules,” SPIE Proceedings Volume 6342, *International Optical Design Conference 2006*, (2006), available at <https://doi.org/10.1117/12.692291> (Ex. 1012, “Bareau”).

⁸ Rudolf Kingslake, *Optics in Photography* (1992) (Ex. 1013, “Kingslake”).

⁹ U.S. Patent No. 9,864,171 B2 to Hsieh et al. (Ex. 1025, “Hsieh”).

¹⁰ William S. Beich et al., “Polymer Optics: A manufacturer’s perspective on the factors that contribute to successful programs,” SPIE Proceedings Volume 7788, *Polymer Optics Design, Fabrication, and Materials* (August 12, 2010), available at <https://doi.org/10.1117/12.861364> (Ex. 1007, “Beich”).

¹¹ U.S. Patent No. 10,324,273 B2 to Chen et al. (“Chen”).

subject matter pertains. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) when in evidence, objective evidence of nonobviousness, i.e., secondary considerations. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

“In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.” *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (2012) (requiring *inter partes* review petitions to identify “with particularity . . . the evidence that supports the grounds for the challenge to each claim”)). The burden of persuasion never shifts to Patent Owner. *See Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (citing *Tech. Licensing Corp. Videotek, Inc.*, 545 F.3d 1316, 1326–27 (Fed. Cir. 2008)) (discussing the burden of proof in an *inter partes* review). Furthermore, Petitioner cannot satisfy its burden of proving obviousness by employing “mere conclusory statements.” *In re Magnum Oil Tools Int’l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016).

B. Level of Ordinary Skill in the Art

Petitioner contends:

[A] Person of Ordinary Skill in the Art (“POSITA”) would include someone who had, at the priority date of the ’647 Patent (i) a Bachelor’s degree in Physics, Optical Sciences, or equivalent training, as well as (ii) approximately three years of experience in designing multi-lens optical systems. Such a person would have had experience in analyzing, tolerancing,

adjusting, and optimizing multi-lens systems for manufacturing, and would have been familiar with the specifications of lens systems. In addition, a POSITA would have known how to use lens design software such as Code V, Oslo, or Zemax, and would have taken a lens design course. Lack of work experience can be remedied by additional education, and vice versa.

Pet. 7 (citing Ex. 1003 ¶¶ 19, 20). Patent Owner indicates that it “does not disagree with Dr. Durand’s definition of a POSITA.” PO Resp. 11 (citing Ex. 2001 ¶ 20).

We determine that the level of ordinary skill in the art proposed by Petitioner is consistent with the ’647 patent and the asserted prior art. The findings and conclusions set forth in this Decision are based on this definition proposed by Petitioner.

C. Claim Construction

For *inter partes* reviews filed on or after November 13, 2018, we apply the same claim construction standard used by Article III federal courts and the ITC, both of which follow *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc), and its progeny. 37 C.F.R. § 42.100(b) (2019). Accordingly, we construe each challenged claim of the ’647 patent to generally have “the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.” *Id.*

Petitioner notes that we construed “effective focal length” (EFL) as the focal length of a lens assembly in the IPR2018-01140 proceeding. Pet. 8–9 (citing *Apple Inc. v. Corephotonics Ltd.*, IPR2018-01140, Paper 37, 10–18 (PTAB Dec. 3, 2019)). Petitioner notes that we construed “total track length” (TTL) as the length of the optical axis spacing between the object-side surface of the first lens element and one of: an electronic sensor, a film

sensor, and an image plane corresponding to either the electronic sensor or film sensor. *Id.*

We not discern a dispute between the parties regarding these claim terms (EFL and TTL) or any other term or limitation and as such, we need not expressly construe this limitation to resolve the controversy before us. *See, e.g., Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (“[W]e need only construe terms ‘that are in controversy, and only to the extent necessary to resolve the controversy.’” (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999))).

D. Obviousness over Iwasaki

Petitioner contends that claims 1–3 and 5 are unpatentable as obvious under 35 U.S.C. § 103 over Iwasaki. Pet. 12–23. For the reasons that follow, we determine that Petitioner establishes unpatentability of independent claim 1 and dependent claims 2, 3, and 5 over Iwasaki by a preponderance of the evidence. Patent Owner does not dispute this challenge.

1. Overview of Iwasaki

Iwasaki discloses “a fixed focus imaging lens for forming optical images of subjects” designed for use in portable devices including smart phones and mobile devices to meet a “demand for miniaturization of the entirety of the photography devices” and “high resolution and high performance.” Ex. 1009, 1:18–26, 1:36–41. Iwasaki concerns an imaging lens including, in order from an object side, the following lenses: first lens L1 that has a positive refractive power; second lens L2 that has a negative refractive power; third lens L3 that has a negative refractive power; fourth

lens L4 having a positive refractive power; fifth lens L5 that has a positive refractive power; and sixth lens L6 having a negative refractive power. *See id.* at 5:60–67. Figure 4 of Iwasaki is reproduced below.

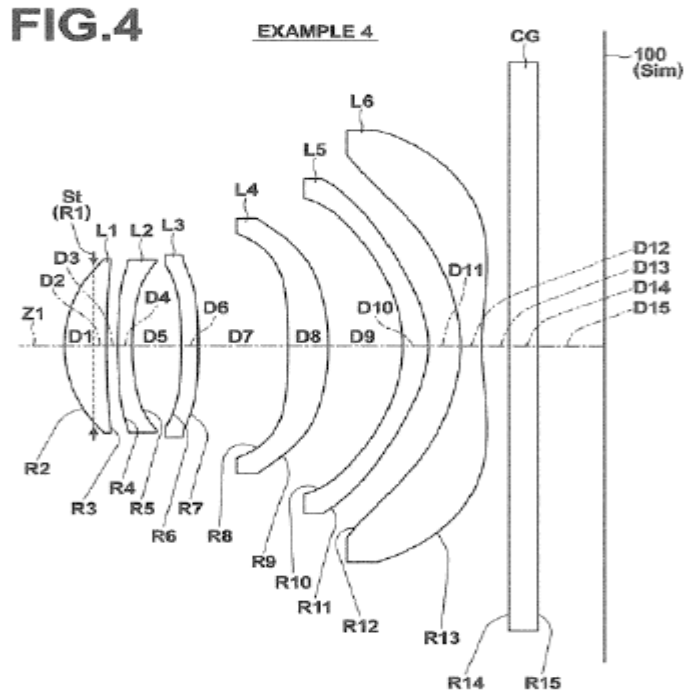


Figure 4 of Iwasaki illustrates lenses in an arrangement according to an embodiment of the invention.

Figure 4 is a sectional diagram that illustrates a fourth example of the configuration of an imaging lens according to an embodiment of the invention. *Id.*; *see id.* at 4:9–12.

2. Independent Claim 1

[1.0] “An optical lens assembly comprising, in order from an object side to an image side:”

Petitioner contends Iwasaki discloses imaging lens L including optical lens elements arranged “in order from the object side to the image side. . . .”

Pet. 14 (quoting Ex. 1009, 5:60–6:3). Petitioner points primarily to Example 4, as depicted in Figure 4, reproduced above. *Id.* (citing Ex. 1009, Fig. 4).¹²

[1.1] “a) a first lens element L_1 with positive refractive power, a focal length f_1 ,”

[1.2] “b) a second lens element L_2 with negative refractive power and a focal length f_2 and having a meniscus shape with convex object-side surface,”

[1.3] “c) a third lens element L_3 with negative refractive power and a focal length f_3 ,”

Petitioner contends Iwasaki discloses these limitations because, “[e]xample 4 includes ‘a first lens L1 having a positive refractive power, a second lens L2 having a negative refractive power, [and] a third lens L3 having a negative refractive power’” Pet. 15 (quoting Ex. 1009, 5:62–65) (alterations in the original) (emphasis omitted). Iwasaki specifies optical parameters, in Table 9, for the lenses depicted in Example 4. Lens L1 is shown as having a focal length (f_1) of 2.50 mm. *Id.* (citing Ex. 1009, 17:54–62; Ex. 1004, 30). Table 9 of Iwasaki is reproduced below.

TABLE 9

Values Related to Conditional Formulae					
Formula	Condition	Example 1	Example 2	Example 3	Example 4
(1)	TL/f	0.99	0.99	0.96	0.97
(2)	f/fl	1.79	1.74	1.87	1.60
(3)	f	4.01	4.02	3.28	4.00
(4)	fl	2.25	2.31	1.75	2.50
(5)	Da/f	0.006	0.008	0.015	0.019

¹² We need not determine whether the preamble is limiting because Petitioner shows sufficiently that it is satisfied by the prior art.

Table 9 of Iwasaki discloses optical parameters for the lenses in each of its examples.

The focal lengths of lenses L2 and L3 are not expressly disclosed in Iwasaki, but Petitioner contends the focal lengths of these lenses can be calculated by using the optical data for each lens and the “lens maker’s equation.” Pet. 15. According to Petitioner,

[T]he focal lengths of L2 and L3 can be calculated by using the optical data for each lens and the commonly known “lens maker’s equation,” provided in Born (Ex.1010):

$$f = - \frac{nr_1r_2}{(n-1)[n(r_1-r_2)-(n-1)t]}$$

where, “ f is the focal length, n is the index of refraction, r_1 and r_2 are the curvature of the two surfaces of lens, and t is the axial thickness of the lens.”

Id. at 15–16 (citing Ex. 1010, 162).¹³

Petitioner’s annotated version of the Table 7 of Iwasaki is reproduced below and shows from where the optical data for each surface of lenses L2 and L3 is obtained.

¹³ Max Born et al., *Principles of Optics*, 6th Ed. (1980) (Ex. 1010, “Born”).

TABLE 7

$f = 4.00$, $Fno. = 2.8$, $2\omega = 71.2$, $TL = 3.89$

Si	Ri	Di	Ndj	vdj
1 (aperture stop)	∞	-0.210000		
*2	1.152778	0.303593	1.51	56.8
*3	10.159658	0.037275		
*4	6.219245	0.104330	1.65	21.4
*5	2.353031	0.354965		
*6	-8.266512	0.123829	1.63	23.8
*7	-9.893200	0.053703		
*8	-7.130996	0.292307	1.54	55.9
*9	-2.086276	0.534767		
*10	-1.378463	0.183911	1.54	55.9
*11	-0.920547	0.233322		
*12	-1.368934	0.148256	1.54	55.9
*13	2.390504	0.197715		
14	∞	0.210000	1.52	64.2
15	∞	0.483000		
16 (imaging surface)	∞			

*aspherical surface

Petitioner contends that using the values from Iwasaki's Table 7 in the lens maker's equation yields " $f_2 = -5.886$ mm and $f_3 = -82.221$ mm." Pet. 17.

Petitioner also contends that, "[a] POSITA would have understood, as observed in Fig. 4, that L2 has a meniscus shape that is convex toward the object-side because the radii of curvature for L2's surfaces (surfaces 4 and 5) are both positive, meaning that the object-side is convex and the image-side is concave." *Id.* (citing Ex. 1003, 31–32; Ex. 1010, Fig. 4.15).

[1.4] "d) a fourth lens element L4; and"

[1.5] "e) a fifth lens element L5,

[1.6] “wherein $1.2 \times |f_3| > |f_2| > 1.5 \times f_1$,”

[1.7] “wherein the lens assembly has an effective focal length (EFL),”

[1.8] “wherein a lens system that includes the lens assembly plus a window positioned between the fifth lens element and an image plane

[1.9] “has a total track length (TTL) of 6.5 millimeters or less and”

[1.10] “wherein the lens assembly has a ratio $TTL/EFL < 1.0$.”

Petitioner contends that Iwasaki discloses that Example 4 includes a fourth lens L4 having a positive refractive power and a fifth lens L5 having a positive refractive power. Pet. 17 (quoting Ex. 1009, 5:63–66; Ex. 1003, 35–36). As discussed above, Petitioner also contends “ f_1 is about 2.50 mm, f_2 is -5.886 mm, and f_3 is -82.221 mm, thus meeting the claimed expression $1.2 \times |f_3| > |f_2| > 1.5 \times f_1$.” *Id.* at 18.

Petitioner contends that Example 4 includes, “a cover glass (‘CG’) element (i.e., window) positioned between the lens assembly, including the L5 lens element, and the image plane.” *Id.* Petitioner further contends a POSITA would have understood the language “*positioned between the fifth lens element and an image plane*,” to be broad enough to encompass Iwasaki’s lens system because Iwasaki’s lens elements are positioned between the fifth lens element and the image plane. *Id.* at 20 (citing Ex. 1003, 39). Petitioner cites Table 7 of Iwasaki as disclosing a TTL of 3.89 mm. *Id.* (citing Ex. 1009, Table 7). Petitioner also cites Example 4 of Iwasaki as disclosing an EFL of 4.00 mm and a TTL of 3.89 thus, meeting the claimed ratio of $TTL/EFL < 1.0$. *Id.* at 21 (citing Ex. 1003, 40–41).

Having reviewed the cited evidence and Petitioner's contentions, we determine that Petitioner's contentions and Dr. Sasián's supporting testimony are sufficiently supported by the cited portions of Iwasaki and that Iwasaki teaches each of the limitations of claim 1 and its preamble. Patent Owner does not dispute Petitioner's showing. For the foregoing reasons, we are persuaded that Petitioner establishes the unpatentability of claim 1 over Iwasaki by a preponderance of the evidence.

3. *Dependent Claims 2, 3, and 5*

Claim 2 recites "[t]he optical lens assembly of claim 1, wherein the lens assembly has a f-number $F\# < 2.9$."

According to Petitioner, Iwasaki's Example 4, specified in Table 7, discloses $Fno=2.8$. Pet. 21 (citing Ex. 1009, Table 7).

Claim 3 recites "[t]he lens assembly of claim 2, wherein the TTL is equal or smaller than 6.0 mm."

Petitioner contends that Iwasaki's Example 4, specified in Table 7, has a TTL of 3.89 mm, which is less than 6.0 mm. Pet. 21 (citing Ex. 1003, 42); see Ex. 1009, Table 7.

Claim 5 recites "[t]he lens assembly of claim 1, wherein lens element L_1 has a concave image-side surface."

Petitioner contends Example 4 shows L1 lens has a meniscus shape. Pet. 22. Also, Petitioner contends, "[a] POSITA would have understood [] that L1 is meniscus, convex toward the object-side because the radii of curvature for L1's surfaces (R_i columns for surfaces 2 and 3 in Table 7) are both positive, meaning that the object-side is convex and the image-side is concave." Pet. 22–23 (citing Ex. 1003, 42–43; Ex. 1009, Fig. 4; Ex. 1010, Fig. 4.15).

Having reviewed the cited evidence and Petitioner's contentions, we determine that Petitioner's contentions and Dr. Sasián's supporting testimony are sufficiently supported by the cited portions of Iwasaki and that Iwasaki teaches the limitations recited in claims 2, 3, and 5. As set forth above, Patent Owner does not dispute Petitioner's showing. For the foregoing reasons, we are persuaded that Petitioner establishes the unpatentability of claims 2, 3, and 5 over Iwasaki by a preponderance of the evidence.

E. Obviousness over Ogino and Chen II

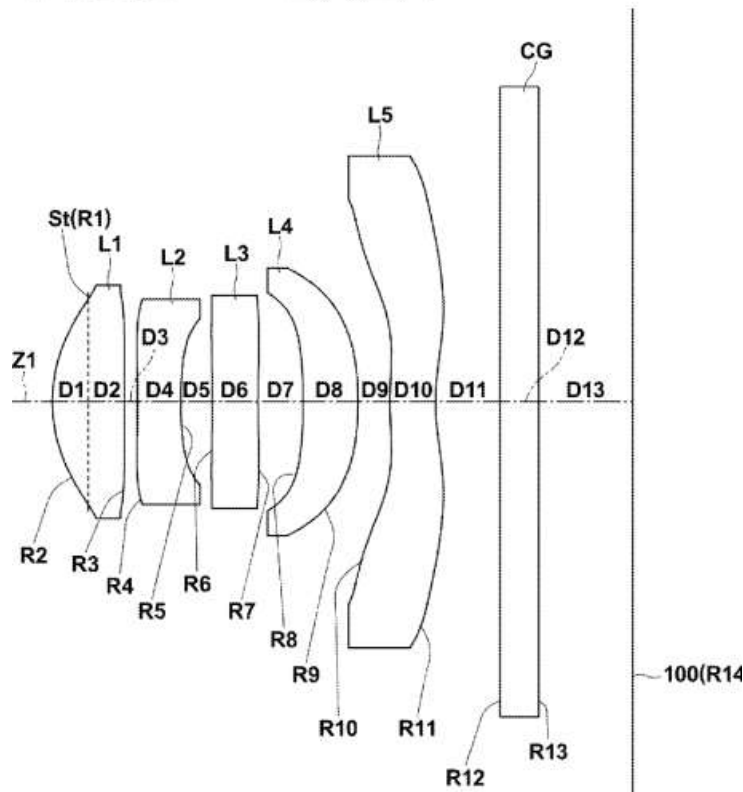
Petitioner contends that claims 1 and 4 are unpatentable as obvious under 35 U.S.C. § 103 over Ogino and Chen II. Pet. 23–46. For the reasons that follow, we determine that Petitioner establishes unpatentability of independent claim 1 and dependent claim 4 over Ogino and Chen II by a preponderance of the evidence.

1. Overview of Ogino

Ogino relates to an imaging lens substantially consisting of, in order from an object side, five lenses: a first lens (L1) that has a positive refractive power and has a meniscus shape which is convex toward the object side; a second lens (L2) that has a biconcave shape; a third lens (L3) that has a meniscus shape which is convex toward the object side; a fourth lens (L4) that has a meniscus shape which is convex toward an object side; and a fifth lens (L5) that has a negative refractive power and has at least one inflection point on an image side surface. *See* Ex. 1005, 2:4–13. Figure 6 of Ogino is reproduced below.

FIG.6

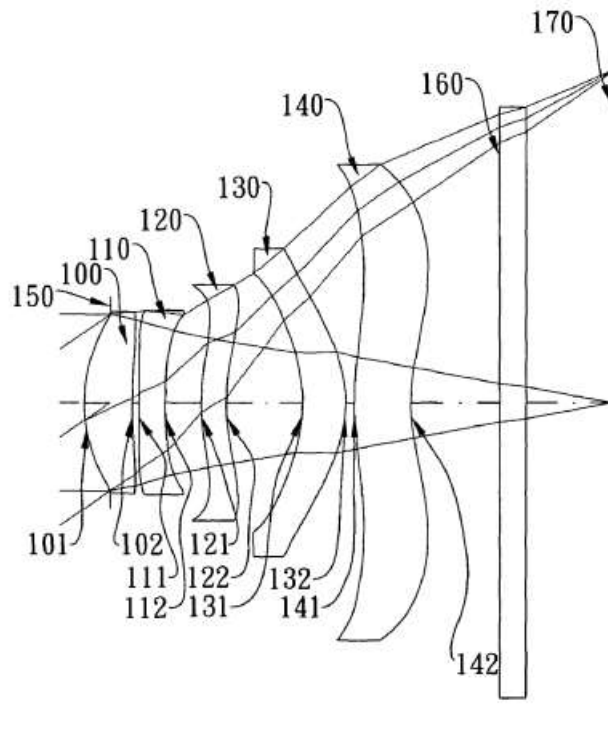
EXAMPLE 6



See id. at 4:9–11.

2. Overview of Chen II

Chen II concerns an imaging lens system including, in order from the object side to the image side: a first lens element (100) with positive refractive power having a convex object-side surface; a second lens element (110) with negative refractive power; a third lens element (120) having a concave image-side surface; a fourth lens element (130) with positive refractive power; a fifth lens element (140) with negative refractive power having a concave image-side surface, at least one surface thereof being provided with at least one inflection point. Ex. 1008, 1:36–43. Figure 1 of Chen II is reproduced below:



3. Independent Claim 1

[1.0] “An optical lens assembly comprising, in order from an object side to an image side:”

Petitioner contends “Ogino’s Example 5 with meniscus L2 renders [the preamble] obvious because as taught in Ogino, it is still ‘[a]n imaging lens substantially consists of, in order from an object side, five lenses’” Pet. 36 (citing Ex. 1005, code (57)).¹⁴ We are persuaded that Ogino expressly depicts and discloses an optical lens assembly with an object side

¹⁴ We need not determine whether the preamble is limiting because Petitioner shows sufficiently that it is satisfied by the prior art.

and image side and thus discloses the subject matter of the preamble [1.0] independent claim 1. Ex. 1005, code (57), Fig. 5.

[1.1] “a) a first lens element L_1 with positive refractive power, a focal length f_1 ,”

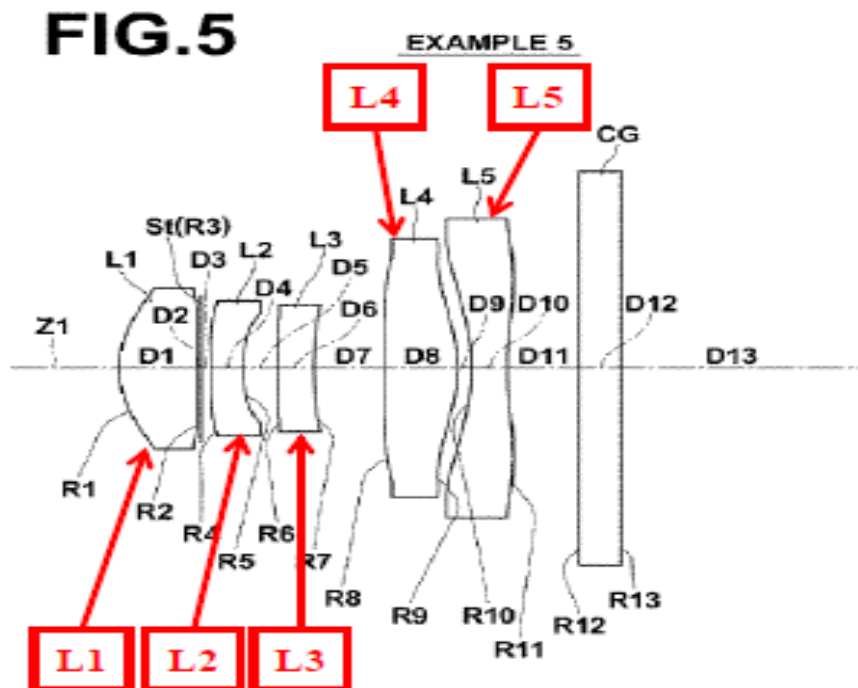
[1.2] “b) a second lens element L_2 with negative refractive power and a focal length f_2 and having a meniscus shape with convex object-side surface;”

[1.3] “c) a third lens element L_3 with negative refractive power and a focal length f_3 ,”

[1.4] “d) a fourth lens element L_4 ; and”

[1.5] “e) a fifth lens element L_5 ,”

Petitioner contends “Example 5 includes “five lenses [including] a first lens that has a positive refractive power..., a second lens ..., [and] a third lens ..., a fourth lens...; and a fifth lens” which are shown in Petitioner’s annotated version of Ogino’s Figure 5 below and are labeled below.” Pet. 39 (citing Ex. 1005, code (57)) (emphasis omitted) (second alteration in original).



Petitioner's Annotated Version of Ogino's
Example 5. *Id.*

Petitioner further contends that “a POSITA would have found it obvious to modify [Ogino’s] L2 lens from biconcave to meniscus” “by applying Chen II’s teaching of a meniscus shape for [its] L2 lens, as Chen II shows no vignetting and, as observed above, the vignetting in Ogino starts at the second lens.” *Id.* at 35, 39 (Ex. 1003 ¶ 67; Ex. 1012, 3). Petitioner presents a Zemax ray trace diagram and accompanying prescription data depicting its modification to Ogino’s Example 5 (i.e., modifying Ogino’s biconcave L2 lens to have, instead, a meniscus shape). *Id.* at 39 (citing Ex. 1003, 61). Petitioner contends that Ogino’s unmodified Example 5 has $f_1=2.068$ mm, $f_2=-3.168$ mm, and $f_3=-6.926$ and that the negative sign of f_2 and f_3 indicate that that lens L1 has a positive refractive power and lenses L2 and L3 have negative refractive powers. *Id.* at 41. Petitioner contends that its prescription data for Ogino’s Example 5 as modified with Chen II’s

meniscus shape for lens L2 results in $f_1=2.384$ mm, $f_2=-5.525$ mm, and $f_3=-6.952$ mm, which also indicate that lens L1 has a positive refractive power and lenses L2 and L3 have negative refractive powers. *Id.*

We are persuaded that Ogino discloses five lens elements, L1 through L5, in which lens L1 has a positive refractive power. Ex. 1005, 7:28–31, Table 9. Ogino further discloses that each of the lenses has a corresponding focal length f_1 – f_5 . *Id.* at 3:17–21. Chen II discloses a second lens having a meniscus shape with convex object-side surface. Ex. 1008, Fig. 1.

According to Petitioner's Zemax diagrams, modifying the shape of Ogino's second lens L2 in Example 5, which is biconcave, with that of Chen II's second lens results in focal lengths of $f_1=2.384$ mm, $f_2=-5.525$ mm, and $f_3=-6.952$ mm, which is supported by the corresponding prescription data and ray trace diagram explained by Dr. Sasián. Pet. 40 (citing Ex. 1003, 63, Appendix, Figs. 2A, 2D); *see* Ex. 1003, 63. Petitioner also points to values from Ogino's Table 13—from which $f_1=2.068$ mm, $f_2=-3.168$ mm, and $f_3=-6.926$ mm are derived by Dr. Sasián—and contends that unmodified Ogino's Example 5, prior to modification, indicates that lens L1 has a positive refractive power and that lens L2 and L3 have negative refractive powers. Pet. 41; Ex. 1003, 62–63. As Petitioner's derived values and calculated values for f_2 and f_3 are negative, we are persuaded that, in modified and unmodified Example 5, lens L2 and lens L3 have negative refractive powers in and that, as the derived and calculated value for f_1 is positive, lens L1 has a positive refractive power. *Id.*

Accordingly, we are persuaded that the combination of Ogino and Chen II teaches limitations [1.1] through [1.5].

We address Petitioner's motivation to combine below in Section III.E.3.a.

[1.6] “wherein $1.2 \times |f_3| > |f_2| > 1.5 \times f_1$,”

Petitioner contends that “Example 5 with meniscus L2 renders [sic] claimed expression.” *Id.* at 41 (citing Ex. 1003, 65–66). In particular, Petitioner contends that unmodified, “original Example 5 has $f_1=2.068$ mm, $f_2=-3.168$ mm, and $f_3=-6.926$ mm and satisfies the claimed expression: $1.2 \times |-6.926\text{mm}| > |-3.168\text{mm}| > 1.5 \times 2.068\text{mm}$ ” with the following values: “ $8.3112\text{mm} > 3.168\text{mm} > 3.102\text{mm}$.” *Id.* (emphasis omitted). Petitioner further contends that “Example 5 *modified* . . . also satisfies the claimed expression:” with $f_1=2.384$ mm, $f_2=-5.525$, and $f_3=-6.952$ mm, which are input to the claimed expression “ $1.2 \times |-6.952\text{mm}| > |-5.525\text{mm}| > 1.5 \times 2.384\text{mm}$ ” evaluating to “ $8.342\text{ mm} > 5.525\text{ mm} > 3.576\text{ mm}$.” *Id.* (emphasis added).

We are persuaded that Petitioner explicitly provides detailed calculations to show how its f_1 , f_2 , and f_3 values are derived for unmodified Example 5 and how its f_1 , f_2 , and f_3 values are calculated (by Zemax) for Ogino's Example 5 modified with the meniscus shape of Chen II's second lens L2, and how both sets of focal lengths satisfy the claimed condition “ $1.2 \times |f_3| > |f_2| > 1.5 \times f_1$.” Pet. 41; Ex. 1003, 62–63, Appendix, Fig. 2D. As such, we are persuaded that the combination of Ogino and Chen II teaches limitation [1.6].

[1.7] “wherein the lens assembly has an effective focal length (EFL),”

[1.8] “wherein a lens system that includes the lens assembly plus a window positioned between the fifth lens element and an image plane”

[1.9] “has a total track length (TTL) of 6.5 millimeters or less and”

[1.10] “wherein the lens assembly has a ratio $TTL/EFL < 1.0$.”

Petitioner contends that “[t]he effective focal length (EFL) of [unmodified] Example 5 is represented in Table 9 as $EFL=5.956$ ” and modified Example 5 “with meniscus L2 has an $EFL=5.460$ mm.” *Id.* at 41–42 (citing Ex. 1005, Table 9; Ex. 1003, Appendix, 67, Fig. 2A); *see* Ex. 1003, 66 (Dr. Sasián’s analysis as to the claimed EFL).

Petitioner further contends that “Ogino defines the CG element as ‘a flat-plate-shaped optical member, such as a cover-glass for protecting an imaging surface and an infrared ray cut filter.’” *Id.* at 43 (citing Ex. 1003, 67, Appendix, Fig. 2A; Ex. 1005, 5:58–60) (emphasis omitted); *compare* Ex. 1005, Table 9 (surface 12), *with* Ex. 1001, Tables 1, 3, 5 (surface 12).

Petitioner contends that in unmodified Ogino’s Example 5, “[t]he sum of D1-D13 is 5.273 mm as confirmed by Zemax” and that “Example 5 modified with meniscus L2 maintains this TTL.” *Id.* at 44 (emphasis omitted) (citing Ex. 1003, Appendix, Fig. 1A, Fig. 2A). Petitioner particularly contends that its modified Example 5 with meniscus-shaped second lens L2 meets the limitation that “ $TTL/EFL < 1.0$ ” because “the $EFL=5.460$ mm (see [1.7]), the $TTL=5.273$ mm (see [1.7]), and the claimed ratio of TTL/EFL ($5.273/5.460$) yields 0.966, which is less than 1.0.” *Id.* at 44–45 (citing Ex. 1003, Appendix, Fig. 1A, Fig. 2A).

We have reviewed the cited portions of Ogino and Chen II, Dr. Sasián’s testimony, along with Zemax ray trace diagrams and associated prescription data, and we are persuaded that they support Petitioner’s contentions and calculations. *See e.g.*, Ex. 1003, 65–71. As such, we are

persuaded that the combination of Ogino and Chen II teaches limitations [1.7] through [1.10].

a) Petitioner's Motivation to Combine

Petitioner contends that “a POSITA would have found it obvious to modify [Ogino’s] L2 lens from biconcave to meniscus” and presents a Zemax ray trace diagram and accompanying prescription data depicting and describing the modification to Ogino’s Example 5. Pet. 28–36 (citing Ex. 1003, 61–68); *id.* at 39.

More particularly, Petitioner contends that “[a] POSITA would have been aware of lens specifications related to mobile phones, as evidenced by Bareau[,] including acceptable values for relative illumination, ray aberration, and the chief ray angle (CRA) at the sensor in modern mobile phone applications.” *Id.* at 26 (citing Ex. 1003 ¶ 55; Ex. 1012, 3). Petitioner explains that “[a] POSITA also would have been aware, as Ogino recognizes, of the importance of reducing ‘deterioration in the light receiving efficiency and occurrence of color mixture due to increase of incident angle’ to ‘achieve optimum optical performance.’” *Id.* (citing Ex. 1003 ¶ 55; Ex. 1005, 7:21–25). Petitioner contends that a “POSITA would have been motivated to modify Example 5 to achieve benefits like reduced vignetting, improve[d] . . . relative illumination, [and] reduce[d] aberration to produce brighter, higher quality images,” and further, that “a POSITA would have found it obvious to combine Chen II’s meniscus second lens that does not cause vignetting with Ogino’s Example 5 lens system to provide the same benefit seen in Chen II—of decreased vignetting and ray aberration—in Ogino’s similar five-lens system.” *Id.* (citing Ex. 1003 ¶ 57).

Petitioner further explains that

[w]hile vignetting may help to reduce undesirable aberrations, it also reduces the relative illumination of the lens system. Such reduction may be beneficial for some cases but for lens systems designed for cellular telephones, like in Ogino and Chen II, it is desirable for relative illumination to be greater than 50%. Ogino's Example 5 fails this because, as shown in the Zemax chart below, the relative illumination is below 50% at the edge of the field of view. Consequently, a POSITA would have looked at also improving the relative illumination of Ogino's Example 5"

Pet. 30–31 (citing Ex. 1010, 188; Ex. 1012, 3; Ex. 1003 ¶ 62, Appendix, Figs. 1A and 1B).

b) Analysis of Petitioner's Motivation to Combine

We are persuaded that Petitioner's motivation to combine Ogino and Chen II is supported by sufficient rational underpinnings with a reasonable expectation of success. In the Final Written Decision in the IPR2018-01140 proceeding, we found that a POSITA would have been motivated to modify Ogino's Example 6 by changing second lens L2 that has a biconcave shape to the meniscus shape of Chen II's second lens. IPR2018-01140, Paper 37 ("1140FWD") at 36–38. In the 1140FWD, we found that "in view of Ogino's low relative illumination at the edge of the field, the skilled artisan 'would have been motivated to adjust the Ogino Example 6 lens system' in view of Chen II 'to reduce vignetting, improve the relative illumination, reduce aberration, and reduce the CRA.'" *Id.* We further found that "[e]ven if Ogino suggests there are benefits to having the second lens biconcave, a person of ordinary skill can weigh those benefits against the benefits of having a meniscus shape." *Id.* at 36 (citing *Winner Int'l Royalty Corp. v. Wang*, 202 F.3d 1340, 1349, n.8 (Fed. Cir. 2000) (competing benefits do not weigh against obviousness, rather, the benefits, both lost and gained, in

combining the teachings of the prior art should be weighed against one another). The Federal Circuit affirmed the 1140FWD on October 6, 2021. *Corephotonics, Ltd. v. Apple Inc.*, No. 2020-1424, 2021 WL 4944467, October 25, 2021.

Like in the IPR2018-01140 proceeding, Petitioner proposes to modify Ogino's biconcave-shaped second lens L2 with the meniscus shape of Chen II's second lens, although in the present proceeding, Petitioner modifies Example 5. Further, in the present proceeding, Dr. Sasián's testimony explains that relative illumination falls to about 40% in Ogino's unmodified Example 5—this figure is similar that of unmodified Ogino's Example 6 as discussed in the 1140FWD.¹⁵ 1140FWD at 30. With respect to modifying the shape of the second lens L2 in Ogino's *Example 5* with Chen II's meniscus shape, the present facts are not shown to deviate in a dispositive fashion from the facts we cited in our 1140FWD in reaching our conclusion as to the combination of Ogino and Chen II. As such, with respect to Ogino and Chen II, we are not persuaded to deviate substantially from our earlier findings and conclusions in IPR2018-01140.

Here, we are persuaded Petitioner shows, with its Zemax ray trace diagrams, that Ogino's Example 5 "suffers from TIR [total internal refraction] vignetting on the second surface of the second lens [and] . . . has aberrated rays that would need to be removed by further vignetting, thereby causing the relative illumination at the edge of the field to fall to 40%," and has a CRA for the full field that is 38 degrees. Pet. 26–27 (citing 1003 ¶ 56,

¹⁵ Dr. Sasián's testimony explains that "vignetting has been allowed by the aperture on surface seven" and accompanying Zemax diagrams show that this relative illumination falls to about 40%." Ex. 1003, Appendix, Fig. 1B.

Appendix, 1A). As such, we are persuaded that Ogino's Example 5 has a relatively low illumination at the edge of the field but advantageously has a relatively "short total track length (5.273 mm) [and] low telephoto ratio (0.885)" as Petitioner contends, and would have motivated a POSITA to generally consider "deterioration of light receiving efficiency" in modifying the lens assembly. Pet. 26–27 (quoting Ex. 1005, 7:21–25). We further agree that a "POSITA would have been motivated to modify Example 5 to achieve benefits like reduced vignetting, improve[d] [] relative illumination, reduce[d] aberration to produce brighter, higher quality images" in view of the similarities between Ogino's Example 5 lens assembly and Chen II's Figure 1 lens assembly and because Chen II's meniscus second lens does not cause vignetting. *Id.* at 27–28 (citing Ex. 1003 ¶ 57; Ex. 1005, code (57), Table 13, 13:3–5, 7:28–31, 7:58–8:25, 23:30–40; Ex. 1008, 6:51–7:4 (Chen II disclosing refractive powers and surface shapes of its lens assembly)). Dr. Sasián's testimony and Zemax ray trace diagrams and prescription data support Petitioner's contentions about the benefits conferred by Petitioner's proposed modification to Ogino's Example 5 with the meniscus shape of Chen II's L2 lens. *See e.g.*, Ex. 1003 ¶¶ 52, 53, 61, 62, 65, 66, Appendix, Figs. 1A, 1B, 1D, 2A, 2B, and 2D.

For the foregoing reasons, we are persuaded that Petitioner's motivation to combine Ogino and Chen II is supported by sufficient rational underpinning with a reasonable expectation of success. As we set forth above, we have reviewed the cited portions of Ogino, Chen II, Dr. Sasián's testimony, along with Zemax ray trace diagrams and associated prescription data, and we are persuaded that the combination of Ogino and Chen II teaches limitations [1.1] through [1.10] and preamble [1.0].

Accordingly, we are persuaded that Petitioner establishes unpatentability of claim 1 over the combination of Ogino and Chen II by a preponderance of the evidence.

4. *Dependent Claim 4*

Claim 4 recites, “[t]he lens assembly of claim 1, wherein lens element L_1 has a convex image-side surface.”

Petitioner points to its “[r]easons to combine Ogino and Chen [III],” (see Pet. 26–36) and contends that “a POSITA would have found it obvious to modify Example 5 based on Chen II to make L2 meniscus.” *Id.* at 45 (citing Ex. 1003, 72, Appendix Fig. 2A). Petitioner contends that “[i]n modified Example 5, L1 has an object-side-radius of 1.648 and an image-side-radius of -5.409, and are therefore convex on both sides” and that “[t]hese were adjusted due to software optimization for better perform[ance] with the meniscus L2 lens, thereby yielding the predictable result of the image-side surface changing from concave to convex.” *Id.* at 45–46 (citing Ex. 1003, 72, Appendix Fig. 3D).

We have reviewed the cited portions of Ogino, Chen II, Dr. Sasián’s testimony, and the accompanying Zemax diagrams and we are persuaded that Petitioner establishes that the combination of Ogino and Chen II teaches the limitation recited in claim 4. Petitioner apparently relies on the same motivation to combine Ogino and Chen II as it does for independent claim 1, which we determined above is supported by sufficient rational underpinning with a reasonable expectation of success. See Pet. 26–36; *supra* § III.E.3.b. Accordingly, we are persuaded that Petitioner establishes unpatentability of claim 4 over the combination of Ogino and Chen II by a preponderance of the evidence.

5. *Patent Owner's Arguments with Respect to Claims 1 and 4*

First, Patent Owner contends that “Chen II does not discuss vignetting, nor does it discuss the advantages of L2 being meniscus with respect to vignetting” because “[t]he fact that the front surface of L2 of Example 1 in Chen II is convex with respect to the object has nothing to do with vignetting.” PO Resp. 28 (citing Ex. 2001 ¶ 87). Instead, Patent Owner contends that “[t]he vignetting in this lens is determined far away from the center of the lens, near the edge of the L2, as shown by the arrow from the ‘No Vignetting’ box. . . .” *Id.* (citing Ex. 1003 ¶ 52). Patent Owner further contends that, “[i]n Chen II, the fact that the front surface is convex toward the object side (+ sign) has nothing to do with vignetting, because either a plus (+) sign or a minus (-) sign can produce effectively the same result” because “[t]he aspheric coefficients can be adjusted in either case to provide no vignetting.” *Id.* at 29 (citing Ex. 2001 ¶ 88). According to Patent Owner, vignetting “occur[s] due to shapes of the second lenses near their edges, which are indicated by the arrows labeled ‘Aspherics’.” *Id.* at 31. *Second*, Patent Owner also contends that “a POSITA would have recognized how to improve performance in Example 5 of Ogino without using Chen II.” *Id.* at 37.

Petitioner responds by pointing to our Final Written Decision in IPR2018-01140 (Paper 37) in which we found that a POSITA would have been motivated to modify the shape of the second lens L2 of Ogino’s Example 6 with Chen II’s meniscus shape to obtain certain benefits. 1140FWD at 30. Petitioner argues that “a POSITA would have understood that changing the radius of curvature of the object-side surface of Ogino’s L2 lens from negative to positive (*even without changing the aspherics*)

would reduce vignetting, as shown . . . in the comparison of the original Example 5 lens with an object-side radius of -18.78836 mm and a modified Example 5 lens with an object-side radius of +18.78836 mm, *with no changes to aspheric coefficients*” and presents two new Zemax drawings in support of its argument. Pet. Reply 3 (citing Ex. 1037 ¶ 5, Appendix, Figs. 1A, 1B) (emphasis added); *see id.* at 2 (citing Pet. 31–32; Ex. 1009, Fig. 1).

In its Sur-Reply, Patent Owner responds to Petitioner’s argument by distinguishing the facts of the present proceeding with those addressed in the 1140FWD:

But that decision [in IPR2018-01140] involved combining Ogino Example 6 with the teachings of Chen II because “Ogino’s Example 6 lens assembly ‘has relative illumination less than 50%’ and that a person having ordinary skill in the art ‘would have looked to improve the relative illumination of Ogino’s Example 6.’” *See* IPR2018-01140, Paper 37, p. 30. The Board’s decision regarding a different embodiment of Ogino modified by Chen II for different reasoning is not binding on the Board or the parties.

* * *

Apple provides a modified Example 5 lens which changes the radius of curvature of the object-side lens from negative to positive to allegedly show that vignetting would be the same. First, this design must be rejected, as it is a new design and new evidence not previously offered by Apple in its Petition. Second, this new design has not been applied against the claims of the ‘647 patent. But even if this new modification is accepted, it does not address Patent Owner’s arguments regarding vignetting.

PO Sur-Reply 4, 5. Patent Owner further contends that “[e]ven with the changes to Ogino[’s] Example 5, the decrease in vignetting is not due Chen II, as Example 1 in Chen II displays the same near-vertical-line shape

characteristic near the center of the first surface of the second lens.” PO Sur-Reply 5 (citing PO Resp., 30–31; Ex. 2001 ¶ 90).

Patent Owner’s arguments distinguishing the facts of the instant proceeding from that of the IPR2018-01140 proceeding are unavailing. In the IPR2018-01140 proceeding, we determined that a POSITA would have been motivated to modify the shape of the biconcave second lens L2 in Ogino’s Example 6 with the meniscus shape of Chen II’s second lens. 1140FWD, 36–38. As we discussed above, although Petitioner relies on Ogino’s Example 5 in this proceeding, we note that it too has a biconcave lens that Petitioner proposes to modify with a meniscus shape from Chen II. Further, Dr. Sasián’s testimony explains that relative illumination falls to about 40% in Ogino’s unmodified Example 5—this figure is similar that of Ogino’s Figure 6 as discussed in the 1140FWD.¹⁶ 1140FWD at 30.

Petitioner persuasively shows that modifying Ogino’s second lens L2 in its Example 5 with the meniscus shape of Chen II’s second lens would reduce vignetting and that the modification of the shape of Ogino’s second lens L2 is what causes the benefit—not the aspheric coefficients, as Patent Owner contends. *See* Pet. Reply 3 (citing Ex. 1037 ¶ 5, Appendix, Fig. 1A, 1B); PO Resp. 28–29, 31. Figures 1A and 1B, submitted with Dr. Sasián’s Reply Declaration (Ex. 1037, Appendix, Figs. 1A and 1B), support Petitioner’s argument and are properly responsive to Patent Owner’s argument that reduced vignetting is due to aspheric coefficients instead of the change in radius of curvature in Ogino’s lens L2. Petitioner need not

¹⁶ Dr. Sasián’s testimony explains that “vignetting has been allowed by the aperture on surface seven” and accompanying Zemax diagrams show that this relative illumination falls to about 40%.” Ex. 1003, Appendix, Fig. 1B.

have submitted Figures 1A and 1B in its Petition or Dr. Sasián's opening Declaration because Petitioner cannot be expected to anticipate each of Patent Owner's potential arguments. *See Dynamic Drinkware*, 800 F.3d at 1379 (finding an *inter partes* review petitioner has both the "burden of persuasion to prove unpatentability" and also "the initial burden of production," which "is a shifting burden, 'the allocation of which depends on where in the process of trial the issue arises.' The burden of production may entail 'producing additional evidence and presenting persuasive argument based on new evidence or evidence already of record'").

We consider Patent Owner's argument that, in Petitioner's proposed combination, "the decrease in vignetting is not due Chen II, as Example 1 in Chen II displays the same near-vertical-line shape characteristic near the center of the first surface of the second lens" unavailing as we consider the ray trace diagrams presented in its Petitioner's Reply to support Petitioner's argument and to be more credible and more precise than Patent Owner's visual inspection of the surfaces of Chen II's lenses. *See* PO Sur-Reply 5 (citing PO Resp., 30–31; Ex. 2001 ¶ 90).

Third, Patent Owner contends that "[w]hen designing and improving an optical lens assembly, a POSITA would allow almost all of the dimensions and inputs to vary" instead of "[m]aking a particular set of dimensions static (i.e., set and unchanging in an optical design software)" because doing so "would limit the results and prevent a POSITA from obtaining a locally best result." PO Resp. 44 (citing Ex. 2001 ¶ 103). Patent Owner explains that "a POSITA would have allowed the inputs of radii of the lenses, spacings between lens surfaces and the conic coefficients to vary" instead of varying "only the radius for surfaces 1, 2 and 5" because doing so

“would permit better performance to be obtained during the design process.” *Id.* at 46 (citing Ex. 2001 ¶ 109; Ex. 2003, 135:8–22). According to Patent Owner, “[n]one of the other surface radius were allowed to vary, nor were the distances between surface or conic constants allowed to vary, as none have a ‘V’ next to the entries.” *Id.*; compare Ex. 1003, 150 (Fig. 2D), with Ex. 1005, Table 9, 21:10–35); Ex. 2001 ¶ 110; PO Sur-Reply 5–6 (arguing that Dr. Milster followed a step-wise process to improve Ogino’s Example 5 without Chen II by allowing small changes to many parameters at the same time). Accordingly, Patent Owner contends, that “Petitioner’s process would have been contrary to a POSITA’s goal of improving performance.” PO Resp. 46 (emphasis omitted).

Petitioner responds that “keeping certain variables constant, such as lens spacing, while varying other parameters, is precisely the approach a POSITA would have taken.” Pet. Reply 5 (citing Ex. 1037 ¶ 9; Ex. 1017 (Fischer), 168 (disclosing that to improve a lens design, “each variable is changed a small amount, called an *increment*, and the effect to performance is then computed”)).¹⁷ Petitioner contends that “Dr. Milster took a similar gradual ‘step-wise process’ in modifying lenses.” *Id.* (citing Ex. 1028, 21:6–18).

Petitioner has the better position. Petitioner has persuasively explained why a POSITA guided by Ogino would look to Chen II in order to address vignetting and begin with Example 5, with a minimum of other changes to the design by following the incremental process evidenced by Fischer. *See* Ex. 1017, 168–69 (disclosing an example in which each

¹⁷ Robert E. Fischer, Optical System Design (2008) (Ex. 2017, “Fischer”).

variable is varied—individually and sequentially—by small amount, 0.05 mm. As discussed above, it is not necessary for Petitioner’s combination to be the best or most optimal design. *See PAR Pharm., Inc. v. TWI Pharm., Inc.*, 773 F.3d 1186, 1197–98 (Fed. Cir. 2014) (“Our precedent . . . does not require that the motivation be the best option, only that it be a suitable option from which the prior art did not teach away.” (emphasis omitted)); *In re Fulton*, 391 F.3d 1195, 1200 (Fed. Cir. 2004) (holding that “a particular combination” need not “be the preferred, or the most desirable, combination described in the prior art in order to provide motivation”). Dr. Milster’s deposition testimony that “there’s a fairly logical sequence to go through with designing lenses this complicated . . . you usually step through a sequence where you gradually increase *the field of view* in steps . . . [y]ou don't just do it all at once” does not support its argument that a step-wise process involves “small changes to *many parameters* at the same time,” as Petitioner contends. Ex. 1028, 20:19–31:5; PO Sur-Reply 5–6 (emphases added).

Fourth, Patent Owner argues that “Dr. Sasián also input unmodified Example 5 of Ogino into the Zemax software into his declaration for IPR2020-00897, stating that he input the ‘[p]rescription data as provided in Ogino’” yet “the relative illumination graph for differs from Fig. 1B” in the present proceeding. PO Resp. 49 (alteration in original) (citing Ex. 1005, Table 9; IPR2020-00897, Ex. 2005, 119); *see* PO Sur-Reply 9–10.

Petitioner responds that “a POSITA would have sought to improve the relative illumination of Ogino’s Example 5 lens given either graph, and the modified Example 5 lenses shows improvements to relative illumination.” Pet. Reply 14 (citing Ex. 1003, 35). Petitioner further contends that “Patent

Owner presents no evidence that the minimal difference of 10% for only a portion of the relative illumination graph would have impacted a POSITA's design process or decisions.” *Id.* (citing 1037 ¶ 30).

The fact that Petitioner's relative illumination graphs for the same Example 5 of Ogino differ between proceedings does not undermine Petitioner's challenge because Dr. Sasián explains “that the slight difference between the graphs is due to adjustments for vignetting.” *Id.* at 14–15 (citing Ex. 2003, 149:16–23). We are persuaded by Petitioner's explanation that “[o]ptical data describing a precise amount of vignetting is not included in the lens prescription for [Ogino's] Example 5 lens” and Dr. Sasián testifies that “all the information about vignetting is contained in [Ogino's] drawing” and as such, “slight differences in interpreting the amount of vignetting in the drawing may result in slightly different relative illumination graphs.” *Id.* (citing Ex. 2003, 150:18–22, 151:12–13). Thus, we find unavailing Patent Owner's argument that “Dr. Sasián could not explain why he made different vignetting choices for Ogino Example 5 or what those different vignetting choices were” “despite Dr. Sasián's testimony that ‘all the information about vignetting is contained in the drawing. With the drawing, a person of skill would have known the amount of vignetting there, because the rays are showing and it can be reproduced.’” PO Sur-Reply 9 (citing Ex. 2003, 150:18–22; 71:12–20; 149:16–23). Dr. Sasián's testimony expresses the imprecise nature of determining vignetting in Ogino, in particular by visual inspection, and provides a credible reason why the amount of vignetting, and thus, the relative illumination, might vary between different models developed during different proceedings.

Fifth, Patent Owner argues that neither Petitioner nor its Expert discuss “how a POSITA would address tolerances, manufacturing, or ensuring system desensitization of the optical design” “that would necessarily be considered by a POSITA” in Petitioner’s first modification to Example 5 of Ogino with Chen II.¹⁸ PO Resp. 44–45 (citing Ex. 2001 ¶ 119). Patent Owner also takes issue with the fact that Petitioner’s proposed combination and Dr. Sasián’s modeling does not oversize lenses of the lens assembly. Patent Owner argues that “a POSITA, when looking to combine two references directed to cell phone cameras, would have considered manufacturability.” PO Sur-Reply 7; *see id.* at 8. More particularly, Patent Owner argues that a “POSITA, when modifying Ogino Example 5 in view of Chen II, would not have stopped with a design that was not manufacturable” and that “[i]nstead, the POSITA would have continued modifying the design until it could be manufactured.” *Id.* at 9.

Petitioner points out that independent claim 1 and dependent claim 4 do not include any manufacturing requirements or considerations. Pet. Reply 6. Petitioner also points out that “manufacturing criteria” such as “center-to-edge thickness ratio only appears in claims 7 and 12 and is thus not required of the other claims.” *Id.* at 7 (citing *SRI Int’l v. Matsushita Elec. Corp.*, 775 F. 2d 1107 (“It is settled law that when a patent claim does

¹⁸ Petitioner refers to a “first modification” to Ogino’s Example 5 to describe modifying second lens L2 to have a meniscus shape as does Chen II’s second lens. Petitioner also refers to a “second modification” to Ogino’s Example 5 to describe lowering the F# of Ogino’s lens assembly. Lastly, Petitioner refers to a “third modification” to describe increasing the distance between, D7, between the third lens L3 and the fourth lens L4 in Ogino’s Example 5. We adopt similar conventions.

not contain a certain limitation and another claim does, that limitation cannot be read into the former claim in determining either validity or infringement.”)). Petitioner further argues that

the center-to-edge thickness ratio at issue was not originally described in the specification of previous patents in the family of the '647 patent but was later added in the continuation-in-part application that issued as U.S. Patent No. 9,857,568 (“the '568 patent”) which was found unpatentable based on Ogino’s Example 6. Patent Owner does not dispute that claims with this limitation (claims 7 and 12) are not entitled to the original priority date of the other claims. Thus, based on Dr. Milster’s opinion, the other claims of the '647 patent do not include any manufacturing requirements. Accordingly, Patent Owner’s arguments to import manufacturing considerations where they are conspicuously absent should be rejected.

Id. at 7–8 (citing Ex. 1021, 1:6–17; IPR2019-00030, paper 32; Ex. 2002 ¶ 35 (Dr. Milster giving an effective filing date of July 4, 2013 for claims 1–6 and 8–11 and January 30, 2017 for claims 7 and 12)).

It is not clear, despite Patent Owner’s attempts at clarification in its Sur-Reply (*see* PO Sur-Reply 7–9), whether Patent Owner’s argument regarding manufacturability is based on either: the design proposed by Petitioner being inoperable for its intended purpose, or that there is no reasonable likelihood of success in creating a manufacturable version of the lens design offered by Petitioner, or simply that a person of ordinary skill in the art would not be motivated to pursue the combined design.

Irrespective of which of these arguments Patent Owner intends to make, the record does not identify any authority holding that or explaining how manufacturability is relevant to the ultimate conclusion of obviousness. The record also does not identify any theory of patentability based on an alleged inability to manufacture the claimed invention. At their core, Patent

Owner's arguments relate to physical combinability of the references based on manufacturing issues. Problems in physically combining references are irrelevant to whether a person of ordinary skill would have had reason to combine the references. *See In re Keller*, 642 F.2d 413, 426 (CCPA 1981) (test for obviousness is not "whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference; nor is it that the claimed invention must be expressly suggested in any one or all of the references.").

We agree that claims 1 and 4 do not include any manufacturing requirements or tolerances, including for center-to-edge thickness ratio, therefore we decline to read a limitation to a manufacturability requirement/tolerance/consideration and/or edge thickness into these claims. Because manufacturability requirements/tolerances/considerations regarding, for example, edge thickness are not claimed, a POSITA can have a reasonable expectation of success in making the lens design of claim 1 without regard to manufacturability. Thus, Patent Owner's argument does not undermine Petitioner's showing.

Even if we were to agree that a POSITA would have considered manufacturability in making the combination of Ogino and Chen II, we find persuasive Petitioner's argument that "even the strictest manufacturing requirements would have been balanced with other considerations" and agree that the record does not contain evidence, "that any lens design, including the designs in the Petition, would have been impossible to produce." Pet. Reply 11 (citing Ex. 1037 ¶ 22). Even if we agreed that manufacturability is relevant to the question of patentability, Patent Owner's manufacturability arguments would not undermine Petitioner's showing

because a “POSITA would have been motivated to design lenses for *other purposes* like prototyping, limited manufacturing, or experimentation” which “would not have been limited by mass-produced injection molding as Patent Owner argues.” *Id.* at 10 (citing Ex. 1037 ¶ 19) (emphasis added). Still further, the record does not support the finding that a POSITA, having weighed certain benefits of the proposed lens assembly against its alleged failure to meet certain manufacturing considerations, would have found the failure to outweigh all of the benefits.

Even if we agreed with Patent Owner that manufacturability is relevant to the question of patentability, we credit the testimony of Dr. Sasián that states, “[e]ven in the case where certain manufacturing considerations are important for a particular design or purpose and are not met, it does not automatically mean that the design is impossible to make.” Ex. 1037 ¶ 24 (citing Ex. 1007, 9). Dr. Sasián’s testimony that Petitioner’s “designs would have been manufacturable even with the tolerances suggested by Dr. Milster with manufacturing methods such as ultraprecision diamond turning” is supported by underlying evidence—articles by Leung (Ex. 1038) and Scheiding (Ex. 1039), and a book by Suet To (Ex. 1040).

Ex. 1037 ¶ 22 (citing Ex. 1038, 7–8; Ex. 1039, 11; Ex. 1040, 3).^{19, 20, 21} As such, we credit Dr. Sasián’s testimony about diamond turning:

“‘[c]ommonly already used for several decades, this technology can shape sharp corners’ and ‘edge slopes up to 60°’ as well as manufacturing tolerances ‘smaller than one part in 10⁴ or perhaps one part in 10⁵’ and that thus, ‘a POSITA would have understood that [] [Petitioner’s] modified designs set forth in [the] Declaration would be physically manufacturable.’” *Id.* Patent Owner does not dispute Dr. Sasián’s testimony about diamond turning in its Sur-Reply. *See generally* PO Sur-Reply.

For the foregoing reasons, Patent Owner’s arguments do not undermine Petitioner’s challenge to claims 1 and 4 based on Ogino and Chen II.

F. Obviousness over Ogino, Chen II, and Bareau

Petitioner contends that claims 2, 3, 5, and 8–11 are unpatentable as obvious under 35 U.S.C. § 103 over Ogino, Chen II, and Bareau. Pet. 46–63. For the reasons that follow, we determine that Petitioner establishes

¹⁹ Ex. 1038 is an article entitled “Diamond turning and soft lithography processes for liquid tunable lenses” 20 J. Micromechanics Microengineering 1 (Jan. 18, 2010) by H. M. Leung et al.

²⁰ Ex. 1039 is an article entitled “Diamond milling or turning for the fabrication of micro lens arrays: comparing different diamond machining technologies” to Sebastian Scheiding et al., Proc. SPIE 7927, Advanced Fabrication Technologies for Micro/Nano Optics and Photonics IV, 79270N (14 February 2011), *available at* <https://doi.org/10.1117/12.874751>.

²¹ Exhibit 1040 is an article entitled “Materials Characterisation and Mechanism of Micro-Cutting in Ultra-Precision Diamond Turning” to Sandy Suet To et. al (2018).

unpatentability of independent claim 8 and dependent claims 2, 3, 5, and 9–11 over Ogino, Chen II, and Bareau by a preponderance of the evidence.

1. *Overview of Bareau*

Bareau concerns “the design and manufacturing of consumer and commercial imaging systems using lens elements” that have millimeter-scale diameters. Ex. 1012, 1. Bareau lists an f-number of 2.8 in its “typical lens specifications for a ¼” sensor format.” *Id.* at 3, 4.

2. *Independent Claim 8*

[8.0] “An optical lens assembly comprising five lens elements, in order from an object side to an image side:”

[8.1] “a) a first lens element L_1 with positive refractive power and a focal length f_1 ;

[8.2] “b) a second lens element L_2 with negative refractive power and having a meniscus shape with convex object-side surface;”

[8.3] “c) a third lens element L_3 ;

[8.4] “d) a fourth lens element L_4 ; and”

[8.5] “e) a fifth lens element L_5 ,”

According to Petitioner, Ogino renders at least the above-quoted limitations of claim 8 obvious for the same reasons discussed above with respect to claim limitations [1.1]–[1.5] and preamble [1.0], in which “Example 5 is shown to be a lens assembly with five lens elements arranged along an optical axis.” Pet. 54 (citing Ex. 1003, 83). We are persuaded that the combination of Ogino and Chen II (i.e., the first modification to the base combination) teaches limitations [8.1] through [8.5] and preamble [8.0], for the reasons discussed in Section III.E.3, except for the claimed negative refractive power of the second lens L_2 of Ogino’s Example 5 as modified by

the first (i.e., changing to meniscus shape) and second (i.e., lowering the F# to 2.8) modifications to Ogino's Example 5.²² Stated differently, in this Section, III.F.2, Petitioner explains the calculations for focal length, and thus the sign of the refractive power, for the second lens L2 based on applying both the first and second modifications to Ogino's Example 5—the focal length calculated in Section III.E.3 is based on applying only the first modification to Ogino's Example 5.

a) Petitioner's Motivation to Combine

We discuss Petitioner's motivation to combine here as it is necessary to explain how the combination of Ogino, Chen II, and Bareau obtains a focal length that indicates the claimed refractive power of the second lens L2 with respect to Ogino's Example 5 as modified by Petitioner's first and second modifications.

Petitioner combines Ogino, Chen II, and Bareau to teach limitation [8.10] of claim 8 which recites, "wherein a f-number F# of the optical lens assembly is smaller than 2.9." As to Petitioner's motivation to combine Ogino and Bareau for teaching claim 8, Petitioner discusses two further modifications—a second modification to lower its F# to 2.8, and a third modification in which the gap, D7, between Ogino's third (L3) and fourth (L4) lens elements, is increased, which are applied to Ogino's Example 5 in addition to the first modification in which the shape of Ogino's second lens is modified to have a meniscus shape. With respect to dependent claims 9–11, which depend from claim 8, the first, second, and third modifications are applied. With respect to claims 2, 3, and 5, which depend from claim 1,

²² We need not determine whether the preamble is limiting because Petitioner shows sufficiently that it is satisfied by the prior art.

only the first and second modifications are applied. Petitioner apparently relies on the motivation to combine Ogino and Chen II that was discussed in Section III.E.3 with respect to independent claim 1.

Petitioner contends that “[a] POSITA would have found it obvious to modify Ogino’s Example 5 lens assembly based on Bareau’s specifications for cell phone camera lenses desiring an $F\#=2.8$ or less for $\frac{1}{4}$ ” and smaller pixel image sensors” because, in order “[t]o have a competitive lens design, a POSITA therefore would have sought to modify existing lens designs to achieve faster f-numbers like 2.8 while still maintaining a short total track length appropriate for thin cell phone designs.” Pet. 47–48 (citing Ex. 1003 ¶¶ 74, 75). Petitioner further contends that “[a] POSITA thus would have been aware of Bareau’s specifications for lens assemblies designed for modern cellular telephones and particularly the importance of supporting a faster f-number for smaller pixel sensor formats.” *Id.* at 48 (citing Ex. 1003 ¶ 76). According to Petitioner, “modifying Ogino’s Example 5 to have an f-number of 2.8 would have been nothing more than applying Bareau’s teaching according to known lens design methods (as taught in Fischer (APPL-1017)) to allow Example 5 to likewise ha[ve] a lower f-number.” *Id.* (citing Ex. 1017; Ex. 1003 ¶ 76).

Petitioner contends that “[a] POSITA would have found it obvious to lower the f-number of Example 5 whether original or modified with a meniscus L2 lens,” the latter of which is “shown in the modified design in Appendix Fig. 3A, working at $F\#=2.8$ and using the L2 lens with a meniscus shape.” *Id.* (citing Ex. 1003 ¶ 74, Appendix, Fig. 3A).

With respect to Bareau, Petitioner contends that “[w]hile Bareau specifies a field of view (FOV) of 60 degrees, this would have been

understood to be a design consideration since most cell phones at the time used a single wide lens.” *Id.* at 48 (citing Ex. 1003 ¶ 77; Ex. 1005, Figs. 14, 15). According to Petitioner, “[a] POSITA designing a cell phone with both wide and telephoto lenses using the same sensor format, (*see, e.g.,* APPL-1014, Fig.16), though, would have recognized that Bareau’s specifications for low f-number and short TTL would still be highly relevant to incorporating a telephoto lens like Example 5 since TTL dictates the thickness of the cell phone and the f-number indicates how much light reaches the image sensor pixels *regardless of a lens’s focal length or FOV.*” *Id.* at 48–49 (citing Ex. 1003 ¶ 77; Ex. 1012, 3–4; Ex. 1005, Figs. 14, 15) (emphasis added).

Petitioner further contends that

A POSITA would have understood that one way of modifying Ogino’s Example 5 is to increase the diameter of one or more lens element surfaces, particularly the image-side surface of L1 since it is closest the entrance aperture. This is due to the relationship between f-number, focal length (EFL), and the diameter of the entrance aperture (i.e. the entrance pupil diameter EPD) which controls the amount of light that enters the assembly: $fnumber = \frac{EFL}{diameter} = \frac{EFL}{EPD}$. Given the arrangement of Example 5 where the aperture is located behind the first lens L1, a POSITA would have recognized that increasing the diameter of L1’s surfaces would thereby also increase the aperture and allow more light to enter the system.

Pet. 49–50 (citing Ex. 1003 ¶¶ 77, 78; Ex. 1016, 59); *see also id.* (citing Ex. 1003 ¶¶ 60, 67–69 (Petitioner arguing that “a change in the entrance pupil or aperture stop leads to a change in the diameter of the lens”))).

In Petitioner’s design, modified by the first, second, and third modifications discussed below, the “EFL=5.569 mm, TTL=5.274 mm, and thickness and spacing of L2-L5 remain unchanged” from Ogino’s original

Example 5 and “[t]he focal lengths f1 and f2 as calculated by Zemax change slightly due to software optimization [with] the L2 lens having a meniscus shape and increasing the diameter of the aperture.” *Id.* at 50 (citing Ex. 1003 ¶ 79, Appendix, Figs. 3A–3D). Petitioner contends that its modified design with “Example 5 at F#=2.8 (and L2 meniscus) maintains the same structural design (i.e., similar focal lengths and spacing) and similar performance characteristics when compared to the original Example 5 design.” *Id.* at 51 (citing Ex. 1003, Appendix, Figs. 1B, 1C, 3B, 3C).

Petitioner further contends that “Example 5 with meniscus L2 and F#=2.8 further modified with a larger D7 gap between the third (L3) and fourth (L4) lens elements renders [8.0-11.0] obvious.” Pet. 55 (citing Ex. 1003, 83). Petitioner contends that “[e]nlarging D7 would have been obvious for a POSITA to try because Ogino expressly teaches it.” *Id.* (citing Ex. 1005, 12:51–63). According to Petitioner, Ogino teaches that

it is desirable that the spacing D7 on the optical axis between the third lens L3 and the fourth lens L4 and the focal length f of the whole system satisfy the following conditional expression (10).
$$0.05 < DD7/f < 0.2.$$

Id. (quoting Ex. 12:51–63).

Petitioner further contends that

Ogino continues to explain that “conditional expression (10) defines a desirable numerical range of a ratio of the spacing D7 on the optical axis between the third lens L3 and the fourth lens L4 to the focal length f of the whole system.” This gap makes it possible “to appropriately suppress distortion which tends to occur when the total length is reduced” and “to satisfactorily correct astigmatism.” This conditional expression instructs a POSITA that D7 can be modified, based on the original Example 5 design, to a range between 0.298 mm and 1.191 mm. Example 5, though, shows D7 at 0.506 mm, the lower end of the range. A

POSITA thus would have found it obvious to try to modify Example 5 to see if any benefit exists with D7 at the other end of the range.

Id. at 55–56 (citing Ex. 1005, 12:51–63, Table 9; Ex. 1003, 85). Based on this understanding, Petitioner contends that “[w]hen conditional expression (10) is applied to Example 5 modified for a meniscus L2 lens and $F\#=2.8$, a POSITA would have realized better performance by increasing D7.” *Id.* at 56 (citing Ex. 1003, Figs. 4A–4D). Petitioner explains that “[t]his [is] apparent by comparing Example 5 modified for $F\#=2.8$ and meniscus L2 (see Figs. 3A–3D) against this modification with D7 increased” *Id.* (citing Ex. 1003, Appendix, Figs. 3A–3D, 4A–4D).

Based on the above-quoted modifications—a first modification to Ogino’s Example 5 to change its second lens to a meniscus shape, a second modification to Example 5 to lower its $F\#$ to 2.8, and a third modification to Example 5 to increase the length D7 of the gap between third lens L3 and fourth lens L4—Petitioner contends that “[i]n Example 5 as modified in [8.0],” “L1 has $f_1=+2.578$ mm, maintaining positive refractive power, L2 has $f_2=-5.510$ mm and positive radii of curvature on both surfaces, maintaining negative refractive power and meniscus shape, and L3 has $f_3=-6.952$ mm, maintaining negative refractive power.” *Id.* at 59 (citing Ex. 1003, Appendix, Figs. 4A–4D).

b) Analysis of Petitioner’s Motivation to Combine

We are persuaded that a POSITA would have sought to lower Ogino’s Example 5 $F\#$, 3.94, to 2.8, because a faster f-number, like 2.8 would have been desirable in a cell phone with a short TTL. The TTL would have been understood to dictate that thickness of a cell phone, and the cell phone would, in turn, have been understood to be improved by a lower $F\#$. Ex.

1003 ¶¶ 75, 77; Ex. 1012, 3–4. This is because a POSITA would have understood that a lower F# would mean brighter images and faster lenses, which would have been understood to be needed and trending in cell phones. Ex. 1013, 104. Dr. Sasián also testifies that Bareau teaches that “smaller pixel sensors suffer at higher f-numbers due to limited light capturing ability.” Ex. 1003 ¶ 71 (citing Ex. 1012, 3–4).

Bareau teaches “typical lens specifications for a ¼” sensor form” including an F# of 2.8. Ex. 1012, 3. Dr. Sasián explains that cell phone cameras with ¼” sensors with f-numbers of 2.8 or lower were common by the earliest possible priority date of the ’647 patent and “it was at least expected that cell phone camera lenses would satisfy similar specifications.” Ex. 1003 ¶ 75 (citing Ex. 1024 (Wang), 1:39–41). Dr. Sasián’s testimony is supported by Wang, which discloses “a high brightness requirement, which means that the lens system should have a small F number (FNo.) Generally, the FNo. should be 2.8 or less.” Ex. 1024, 1:39–41.

Although Bareau’s typical lens specifications are for lenses with a field of view of around 60 degrees (i.e., wide angle lenses), we are persuaded that its teachings would similarly apply to telephoto lenses because “the f-number indicates how much light reaches the image sensor pixels regardless of a lens’s focal length or FOV.” Pet. 48–49 (citing Ex. 1003 ¶ 77; Ex. 1012, 3–4; Ex. 1005, Figs. 14, 15).

We are also persuaded that a POSITA would have understood that Ogino’s Example 5 F# could be lowered by increasing the diameter of L1’s surfaces which “would thereby also increase the aperture and allow more light to enter the system.” Ex. 1003 ¶ 78. Dr. Sasián explains that this is because of “the relationship between f- number, focal length (EFL), and the

diameter of the entrance aperture (i.e. the entrance pupil diameter EPD) which controls the amount of light that enters the assembly” as indicated by the equation given by Walker.²³ *Id.* (citing Ex. 1016, 59–60, 67–69).

We are further persuaded that a POSITA would have been motivated to increase D7, the gap between Ogino’s third lens L3 and fourth lens L4. To prove obviousness under an obvious to try theory, one must show (1) a design or market need to solve a particular problem, *and* (2) that “there are a finite number of identified, predictable solutions” that would lead to an expectation of success. *KSR*, 550 U.S. at 421 (emphasis added). Here, Ogino discloses that it would be desirable for D7 to satisfy conditional expression 10, which specifies a range of desirable values for D7. Pet. 55 (citing Ex. 1005, 12:51–63). Petitioner also takes the position that a POSITA would experiment with values for D7, i.e., that it would be obvious to try different values for D7 within Ogino’s finite range, because the gap makes it possible “to appropriately suppress distortion which tends to occur when the total length is reduced” and “to satisfactorily correct astigmatism.” Ex. 1005, 12:51–63. Petitioner presents Zemax plots and persuasively shows that increasing the distance D7 between third lens L3 and fourth lens L4 in Ogino’s Example 5, along with modifying its second lens L2 to have a meniscus shape and lowering the F# to 2.8, would have resulted in improved relative illumination in certain areas, as well as other benefits. *See e.g.*, Ex. 1003, 84–89, Appendix, Figs. 3A, 3B, 4B.

²³ Walker is Ex. 1016, a book entitled “Optical Engineering Fundamentals” by Bruce H. Walker, copyright 1995.

For the foregoing reasons, we determine that Petitioner's motivation to combine is supported by sufficient rational underpinning with a reasonable expectation of success. *See e.g.*, Ex. 1003 ¶¶ 74–80.

[8.6] “wherein the lens assembly has an effective focal length (EFL),”

[8.7] “wherein a lens system that includes the lens assembly plus a window positioned between the fifth lens element and an image plane”

[8.8] “a total track length (TTL) of 6.0 millimeters or less and”

Petitioner contends “Example 5 as modified in [8.0] renders [8.6] obvious because it has an EFL= 5.569 mm.” Pet. 59 (citing Ex. 1003, Appendix, Fig. 4A). “Example 5 as modified in [8.0] renders [8.7] obvious because it maintains a cover glass element between the fifth element and the image plane, as discussed in [1.8].” *Id.* at 60 (citing Ex. 1003, Appendix, Fig. 4A). Petitioner further contends that “Example 5 as modified in [8.0] renders [8.8] obvious because it has a TTL=5.274 mm, which is less than 6.0 mm,” which is “similar to TTL=5.273 as in Example 5 unmodified (see [1.9]).” *Id.* (citing Ex. 1003, Appendix, Fig. 4A) (emphasis added).

[8.9] “wherein the lens assembly has a ratio $TTL/EFL < 1.0$,”

Petitioner contends that “Example 5 as modified in [8.0] renders [8.9] obvious because it has a TTL=5.274 mm (*see* [8.8]) and has an EFL=5.569 (*see* [8.6]), yielding $TTL/EFL=0.947$, which is less than 1.0.” Pet. 60.

[8.10] “wherein a *f*-number $F\#$ of the optical lens assembly is smaller than 2.9,”

Petitioner explains how this claim limitation is met and why it would have been obvious to a POSITA to modify Ogino's Example 5 with Bureau

with its motivation to combine Ogino, Chen II, and Bareau as set forth above. *See* Pet. 60 (citing Ex. 1003, 90, Appendix, Figs. 4A, 4D).

[8.11] “wherein f_1 is smaller than $TTL/2$,”

[8.12] “wherein lens elements L_3 and L_4 are separated by a gap greater than $TTL/5$,”

Petitioner contends that “Example 5 as modified in [8.0] renders [8.11] obvious because it has $f_1=+2.578$ mm (*see* [8.1]) and $TTL=5.274$ mm (*see* 8.8)” thus meeting the claimed ratio:

$$2.578 \text{ mm} < \frac{5.274}{2} \rightarrow 2.578 \text{ mm} < 2.637 .$$

Pet. 60–61 (citing Ex. 1003, 90, Appendix, Figs. 4A, 4D). Petitioner also contends that “Example 5 as modified in [8.0] renders [8.12] obvious because it has $TTL=5.274$ (*see* [8.8]), yielding $TTL/5=1.055$ mm, which is less than D7.” *Id.* at 61. According to Petitioner, “[a]s shown in APPL-1003, Appendix, Fig. 4D, D7 (L_3 - L_4 gap) is increased to 1.085 mm, which as discussed above in [8.0], would have been obvious to try based on conditional expression (10) ($0.05 < D7/f < 0.2$).” *Id.* (citing Ex. 1003, 91, Appendix, Fig. 4D (thickness for surface 7); Ex. 1005, 12:45–63). Petitioner argues that “D7 (1.085 mm) is greater than 1.055mm.” *Id.*

[8.13] “wherein lens elements L_4 and L_5 are separated by a gap smaller than $TTL/20$, and”

Petitioner contends that “Example 5 as modified in [8.0] renders [8.13] obvious” and that, “[a]s discussed above in [8.8], this modification maintains $TTL=5.274$ mm, yielding a $TTL/20$ of 0.264 mm.” Pet. 61 (citing Ex. 1003, 91, Appendix, Fig. 4D (thickness for surface 7); Ex. 1005, 12:45–63). Petitioner further contends that, “[i]n original Example 5, the L_4 - L_5 gap is 0.100 mm and is maintained in the [8.0] modification, which is smaller than 0.264 mm.” *Id.*

[8.14] “wherein the five lens elements are made of plastic.”

Petitioner contends that “Example 5 as modified in [8.0] renders [8.14] obvious” because “Table 9 provides indices of refraction (ndj) and Abbe numbers (vdj) for each lens indicating only two materials.” Pet. 62 (citing Ex. 1005, Table 9). According to Petitioner, “[m]aterial 1 has ndj=1.54488 and vdj=54.87” and “[m]aterial 2 has njd=1.63351 and vjd=23.63.” *Id.* Petitioner contends that “[t]hese values are consistent with plastic materials” *Id.* (citing Ex. 1018, 27).²⁴

For the foregoing reasons, we have reviewed the cited portions of Ogino, Chen II, Bareau, Dr. Sasián’s testimony, along with Zemax ray trace diagrams and associated prescription data and we are persuaded that the combination of Ogino, Chen II, and Bareau teaches limitations [8.1] through [8.14] and preamble [8.0]. As we set forth above, we are persuaded that Petitioner’s motivation to combine Ogino and Chen II is supported by sufficient rational underpinning with a reasonable expectation of success for the reasons discussed above in this section and in Section III.E.3.b.

Accordingly, we are persuaded that Petitioner establishes unpatentability of claim 8 over the combination of Ogino, Chen II, and Bareau by a preponderance of the evidence.

3. Dependent Claims 9, 10, and 11

Claim 9 recites “[t]he optical lens assembly of claim 8, wherein $F \# = 2.8$.”

²⁴ “Field Guide to Molded Optics” to Symmons et al. (Ex. 1018, “Field Guide”).

Petitioner contends that “it has been shown that a POSITA would have found it obvious to modify Example 5 to support $F\#=2.8$ ” and that “Example 5 modified in [8.0] maintains $F\#=2.8$.” *Id.* at 62 (citing Ex. 1003, Appendix, Figs. 4A, 4D). We note that Petitioner explains how this claim limitation is met with its motivation to combine Ogino and Bareau as set forth above in Sections III.F.2.a and III.F.2.b with respect to independent claim 8.

Claim 10 recites “[t]he optical lens assembly of claim 8, wherein the ratio TTL / EFL is between 0.85 and 0.95.”

According to Petitioner, “Example 5 as modified in [8.0] renders [10.0] obvious because, as shown in [8.9], the TTL/EFL ratio of this modification” to Ogino’s Example 5 is 0.947 which is between 0.85 and 0.95.” Pet. 63 (citing Ex. 1003, Appendix, Figs. 4A, 4D).

Claim 11 recites “[t]he optical lens assembly of claim 8, wherein a combined power of lens elements L_2 and L_3 is negative.”

Petitioner contends that “Example 5 as modified in [8.0] renders [11.0] obvious.” Pet. 63 (citing Ex. 1003, 94). More particularly, Petitioner argues that “[t]he optical power of a lens is equal to the inverse of its focal length.” *Id.* (citing Ex. 1010, 159). Petitioner points to its analysis for limitations in claim 8, arguing that “ $f_2=-5.510$ mm and $f_3=-6.952$ mm” and that the “[c]ombined optical power of two lenses separated by a gap can be calculated by” an equation based on the individual lens power of each lens and the separation between the lenses. *Id.* (citing Ex. 1016, 65). Substituting focal lengths into the equation yields -0.332 mm^{-1} , showing that

a combined optical power of L_2 and L_3 is, indeed, negative. *Id.* (citing Ex. 1003, 94).

We have reviewed the cited portions of Ogino, Chen II, Bareau, Dr. Sasián’s testimony, along with the accompanying Zemax diagrams and associated prescription data, as set forth above, and we are persuaded that Petitioner establishes that the limitations recited in claims 9, 10, and 11 are taught by the combination of Ogino, Chen II, and Bareau. Petitioner apparently relies on the same motivation to combine Ogino, Chen II, and Bareau as it does for independent claim 8, which we determined above is supported by sufficient rational underpinning with a reasonable expectation of success. *See* Pet. 47–53; *supra* §§ III.F.2.a, III.F.2.b. Accordingly, we are persuaded that Petitioner establishes unpatentability of claims 9, 10, and 11 over the combination of Ogino, Chen II, and Bareau by a preponderance of the evidence.

4. *Dependent Claims 2, 3, and 5*

Claim 2 recites “[t]he optical lens assembly of claim 1, wherein the lens assembly has a f-number $F\# < 2.9$.”

Petitioner contends that “a POSITA would have found it obvious to modify [Ogino’s] Example 5 based on Bareau’s teachings to achieve a telephoto lens with an $F\#=2.8$ or less.” Pet. 52 (citing Ex. 1003, 80). Petitioner further contends that “a POSITA would have found this modification to be both predictable and desirable due to Ogino’s other disclosed embodiments supporting a lower f-number (*see* APPL-1005, Figs. 8-13), Bareau’s teaching of cell phones supporting $F\#=2.8$ or less, and a general desire among POSITAs to design faster lenses.” *Id.* (citing Ex. 1013, 104; Ex. 1003 ¶ 80). In Petitioner’s modification to Ogino’s Example

5, “the entrance pupil diameter is EPD=1.989 mm so the $F\# = EFL/EPD = 2.8$.” *Id.* at 53. We note that Petitioner further explains how this claim limitation is met and why it would have been obvious to a POSITA to modify Ogino’s Example 5 with Bareau with its motivation to combine Ogino, Chen II, and Bareau as set forth above in Section III.F.2.a.

Claim 3 recites “[t]he lens assembly of claim 2, wherein the TTL is equal or smaller than 6.0 mm.”

Petitioner contends that “Example 5 has TTL=5.273 mm with the cover glass element (*see* [1.9]), which is less than 6.0 mm” and that “Example 5 with meniscus L2 and $F\# = 2.8$ maintain[s] this TTL.” Pet. 53 (citing Ex. 1003, 81, Appendix, Fig. 3A).

Claim 5 recites “[t]he lens assembly of claim 1, wherein lens element L₁ has a concave image-side surface.”

Petitioner contends that “the L1 lens in [Ogino’s] original Example 5 is ‘meniscus shape which is convex toward the object side.’” Pet. 54 (citing Ex. 1005, code (57)). According to Petitioner, “a POSITA would have recognized that the description of the L1 being ‘meniscus’ means that the lens has a convex object-side surface and a concave image-side surface.” *Id.* (citing Ex. 1003, 82; Ex. 1010, 163 (Fig. 4.15)). “Accordingly, a POSITA would have understood that the description of Ogino’s first lens L1 in Example 5 as having ‘a meniscus shape which is convex toward the object side,’ means that the other side—the image side—is concave.” *Id.* (citing Ex. 1003, 83). Petitioner argues that “Example 5 modified for $F\# = 2.8$ maintains this meniscus shape with positive radii of curvature for both the object-side (1.442) and image-side (252.975) surfaces of L1.” *Id.*

We have reviewed the cited portions of Ogino, Chen II, Bareau, Dr. Sasián’s testimony, along with the accompanying Zemax diagrams and associated prescription data, and we are persuaded that Petitioner establishes that the limitations recited in claims 2, 3, and 5 are taught by the combination of Ogino, Chen II, and Bareau. Petitioner apparently relies on the same motivation to combine Ogino, Chen II, and Bareau for claims 2, 3, and 5 as it does for independent claim 8, which we determined above is supported by sufficient rational underpinning with a reasonable expectation of success. *See* Pet. 47–53; *supra* §§ III.F.2.a, III.F.2.b.

Accordingly, we are persuaded that Petitioner establishes unpatentability of claims 2, 3, and 5 over the combination of Ogino, Chen II, and Bareau by a preponderance of the evidence.

5. *Patent Owner’s Arguments*

Patent Owner separates its arguments for claims 2, 3, and 5 from its arguments for claims 8–11 because, as discussed above, Petitioner’s challenge to claims 2, 3, and 5 involves only a first (i.e., changing second lens L2 to meniscus shape) modification and a second modification with Bareau (i.e., lowering to an F# of 2.8), whereas Petitioner’s challenge to claims 8–11 involves the first and second modifications, as well the third modification (i.e., increasing distance, D7, between Ogino’s third and fourth lenses, L3 and L4). We address Patent Owner’s arguments in similar fashion.

With respect to dependent claims 2, 3, and 5, Patent Owner presents the following arguments: “Ppetitioner ignores the manufacturability of the lenses,” “Ppetitioner’s proposed assembly has overlapping lenses in the region of the optical rays,” and “Ppetitioner’s process would have been

contrary to a POSITA's goal of improving performance." PO Resp. 52, 53, and 56 (emphasis omitted). Patent Owner's manufacturability and performance improvement arguments do not undermine Petitioner's challenge based on Ogino, Chen II, and Bareau to dependent claims 2, 3, and 5 for substantially the same reasons set forth in Section III.E.5 in the analysis of Petitioner's challenge based on Ogino and Chen II, except that Patent Owner references varying "only the radii for surfaces 1, 4, and 5" instead of varying "only the radi[i] for surfaces 1, 2, and 5." *Compare* PO Resp. 56, *with id.* at 46.

With respect to Patent Owner's overlapping lenses argument for dependent claims 2, 3, and 5, Patent Owner contends that Petitioner's first modified design with Bareau "results in two lens elements overlapping each other in the region of the optical rays," specifically, lenses L4 and L5, as shown in the red boxes in its annotated Fig. 3A. PO Resp. 53–54 (citing Ex. 2001 ¶ 122). Patent Owner further contends that "[a] POSITA would understand that such a lens assembly configuration would never be acceptable for an optical design, let alone for manufacturing." *Id.* at 54–55. Citing McGuire (Ex. 2006), Patent Owner contends that "tolerances for thickness (+/- 0.003 mm) and decenter (+/- 0.002 mm) in mobile phone cameras plastic injection molding indicate that lenses should be spaced greater than the maximum tolerance, which would be 0.006 mm added to 0.004 mm, or an absolute minimum of 0.010 mm, notwithstanding other possible tolerances associated with wedge, changes in lens size due to temperature variations and other factors." *Id.* at 55 (citing Ex. 2006).²⁵

²⁵ Exhibit 2006 is McGuire Jr., J. P., et al., "Approaching direct optimization of as-built lens performance." In *Novel Optical Systems Design and*

Patent Owner also cites “the Beich paper cited by Dr. Sasián” which, according to Patent Owner, “provides ‘rules of thumb’ for part tolerances of ‘< 0.020 mm’ for center thickness and diameter, ‘< 0.020 mm’ for the S1 to S2 Displacement,’ i.e., the displacement between the halves of the mold forming the front and back surfaces of the lens, and ‘< 0.010 mm’ for ‘wedge,’ i.e., the difference in edge thickness from one side of the lens to the other.” *Id.* at 55–56 (citing Ex. 1007, 7). Patent Owner also contends that “[t]olerances for glass molding are similar.” *Id.* at 56 (citing Ex. 2008, 95).²⁶

In its Sur-Reply, Patent Owner changes its position and contends that “a visual inspection of the magnified figures show that both are touching” and that Dr. Sasián confirms that “lenses L4 and L5 in both modifications are touching each other” which, according to Patent Owner “would not have been within the manufacturing tolerances of the lenses.” PO Sur-Reply 11 (citing Pet. Reply 18–19; Ex. 2010, 91:14–92:14; 92:18–23; PO Resp. 48–49).

Petitioner responds that “[t]he zoomed in ray trace of lens elements L4 and L5 above clearly shows that the lenses do not overlap.” Pet. Reply 19 (citing Ex. 1037 ¶ 40). In his Second Declaration, Dr. Sasián testifies that lenses L4 and L5 do not touch or overlap because “[t]he zoomed-in ray trace of lens elements L4 and L5 above clearly shows space between these lens elements.” Ex. 1037 ¶¶ 49, 50; *see also id.* ¶ 50. During his deposition,

Optimization XV (Vol. 8487, p. 84870D), International Society for Optics and Photonics (October, 2012).

²⁶ Exhibit 2008 is Symmons and Schaub, “Field Guide to Molded Optics” (2016).

Dr. Sasián testified that lenses L4 and L5 “may be touching at the very, very edge; but they don't appear to be touching in the region of the rays.” Ex. 2012, 91:17–19. He further testifies that “whether they are touching -- whether they touch or do not touch, physically, once the flange is designed, it could be left as in contact for alignment as I explained before, or for other purpose.” *Id.* at 92:9–14.

Petitioner further responds that “Patent Owner’s arguments that a lens assembly with lenses that are ‘touching in the area that optical rays pass through would never be acceptable for an optical design’ are contradicted by Dr. Milster’s testimony that a POSITA would not reject touching lenses that ‘are designed to be that way.’” Pet. Reply 20 (citing Ex. 1028, 143:16–144:6). According to Petitioner, “Dr. Sasián’s modified lens designs are designed in that way, and have good optical performance.” *Id.* (citing 1037 ¶ 40). Petitioner also argues

Dr. Milster also testified that contact between the mounting flanges of lenses presents no problems. As shown in the zoomed-in figures above, the modified lens designs would be suitable for implementation with mounting flanges that are in contact. As discussed above, this is acceptable for manufacturing by Dr. Milster’s own admission, and can actually help to align and precisely position the lens elements within the assembly. Thus, even in the case that Patent Owner’s manufacturing criteria were considered by a POSITA (which as discussed above, is not required for the modified lens design reading on the claims of the ’647 patent), a POSITA would find the modified lens design to be acceptable.

Pet. Reply 20 (citing Ex. 1037 ¶ 40; Ex. 1028, 139:9–18; Ex. 1003 ¶ 40).

We note that Dr. Sasián also testifies that, in comparison to Dr. Milster’s visual inspection of the modified ray trace diagram, “a more precise way to determine it would be to go to the ray trace, to the program,

have enough zooming and actually also looking at the exact table to determine if in this configuration the surfaces touch or is an artifact of the printer” because “the resolution may not be enough to show them are separate or maybe they are touching” and for that reason, Dr. Sasián “reserve[s] [his] answer to doing an analysis with the lens design program.” Ex. 2012, 94:8–19. Considering Petitioner’s zoomed-in ray trace diagram accompanied by Dr. Sasián’s Reply Declaration and deposition testimony tend to support a finding that lenses L4 and L5 are not overlapping and the record does not sufficiently support a finding that they touch. *See* Pet. Reply 19–20. In this regard, Petitioner’s evidence outweighs Patent Owner’s Expert’s visual inspection of the modified ray trace diagrams. *But see* Ex. 2012, 97:9–11 (Dr. Sasián testifying that he did not calculate the distance between lenses L4 and L5 *at their closest point* but that “a rough estimate would be within a few microns”).

We are further persuaded that, even if lenses L4 and lens L5 did touch each other, there are some applications for which a POSITA would want the lenses to touch, and that even if Patent Owner’s manufacturing tolerances were considered, a POSITA would consider Petitioner’s “modified lens design” for certain applications. We credit Dr. Sasián’s testimony that Petitioner’s “modified lens designs would be suitable for implementation with mounting flanges that are in contact” (Ex. 1037 ¶ 40) which is acknowledged by Dr. Milster’s testimony that “when [lenses] are fabricated with their mounting flanges, the mounting flanges can actually touch.” Ex. 1028, 139:15–17. Patent Owner’s argument that “Dr. Sasain only gives the example of a cemented doublet for such a lens design,” although he admits, during deposition, that “lens[es] L4 and L5 for the first and second modified

Ogino Example 5 are not designed to be cemented doublet lenses” is unavailing since Dr. Sasián also testifies as to lens designs with mounting flanges that are in contact as an example of a lens design that would support fourth L4 lens touching fifth lens L5. Ex. 1037 ¶ 40; Ex. 2012, 95:1–15.

With respect to dependent claims 8–11, Patent Owner also argues that “Petitioner ignores the manufacturability of the lenses,” “Petitioner’s proposed assembly has overlapping lenses in the region of the optical rays,” and “Petitioner’s process would have been contrary to a POSITA’s goal of improving performance.” PO Resp. 58, 59, and 61 (emphasis omitted).

Patent Owner’s manufacturability and performance improvement arguments do not undermine Petitioner’s challenge based on Ogino, Chen II, and Bareau to dependent claims 8–11 for substantially the same reasons set forth in Section III.E.5 in the analysis of Petitioner’s challenge based on Ogino and Chen II, except that Patent Owner’s argument references varying “only the radii for surfaces 1, 4, and 5” instead of varying “only the radi[i] for surfaces 1, 2, and 5.” *Compare* PO Resp. 61, *with id.* at 46. Patent Owner’s overlapping lenses argument does not undermine Petitioner’s challenge based on Ogino, Chen II, and Bareau to dependent claims 8–11 for substantially the same reasons discussed above with respect to dependent claims 2, 3, and 5 in this Section, III.F.5.

For the foregoing reasons, Patent Owner’s arguments do not undermine Petitioner’s challenge to claims 2, 3, 5, and 8–11 based on Ogino, Chen II, and Bareau.

G. Obviousness over Ogino, Chen II, Bareau, and Kingslake

Petitioner contends that claim 6 is unpatentable as obvious under 35 U.S.C. § 103 over Ogino, Chen II, Bareau, and Kingslake. Pet. 64–71. For

the reasons that follow, we determine that Petitioner establishes unpatentability of dependent claim 6 over Ogino, Chen II, Bareau, and Kingslake by a preponderance of the evidence.

1. Overview of Kingslake

Kingslake is titled “Optics in Photography.” Ex. 1013, Cover. In Chapter 11 titled “The Brightness of Images,” Kingslake indicates that “[t]he relation between the aperture of a lens and the brightness of the image produced by it . . . is often misunderstood, yet it is of the greatest importance to the photographer who wishes to make the best use of the equipment.” *Id.* at 104. Kingslake then states that “[t]he tremendous efforts of lens designers and manufacturers that have been devoted to the production of lenses of extremely high relative aperture are an indication of the need that exists for brighter images and ‘faster’ lenses.” *Id.*

2. Dependent Claim 6

Claim 6 recites “[t]he lens assembly of claim 1, wherein the TTL is equal or smaller than 6.0 mm and wherein lens element L₁ has an image-side surface diameter between 2.3 mm and 2.5 mm.”

Petitioner presents a fourth modification to Ogino’s Example 5 in which the f-number of the lens assembly is lowered to 2.45 by increasing the lens diameter of Ogino’s first lens L1. Pet. 69–70.

As motivation to combine Ogino with Chen II, Bareau, and Kingslake, Petitioner contends that Ogino’s “Example 5 has the highest F#=3.94,” in contrast to the f-numbers of Ogino’s other examples in “Examples 1-3 and 6 (which all utilize a similar structure to Example 5),” i.e., 2.47, 2.46, 2.45, and 2.64. *Id.* at 65 (citing Ex. 1005, Figs. 8–13 (showing f-numbers of Examples 1-6)). Petitioner contends that Bareau and

Kingslake would have motivated a POSITA to further modify an f-number “to achieve a lower f-number” as early as 1992. *Id.* (citing Ex. 1003 ¶ 86). Petitioner contends Kingslake teaches “the need that exists for brighter images and ‘faster’ lenses.” *Id.* at 66 (citing Ex. 1013, 104).

Petitioner contends that its “modified version of Example 5 uses [a] larger lens diameter for each lens, which, as taught in Walker, is one way to lower the f-number of a lens assembly since increasing a lens’s diameter allows more light to pass through the system while maintaining a similar focal length.” *Id.* at 67 (citing Ex. 1003 ¶ 88). Petitioner further contends that “[m]odified Example 5 above supports an $F\#=2.45$ while maintaining similar performance characteristics and achieving higher relative illumination when compared to the original Example 5 design.” *Id.* (citing Ex. 1003 ¶ 89). Petitioner contends the claim 6 limitation is met because “Example 5 has $TTL=5.273$ with the cover glass element (*see* [1.9]), which is less than 6.0 mm” and “Example 5 as modified above with $F\#=2.45$ maintains TTL at 5.274 mm.” Pet. 69 (citing Ex. 1003, 100–102, Appendix, Fig. 5A).

Petitioner further contends that “a POSITA would have found it obvious to modify Example 5 to achieve a telephoto lens with a lower f-number” because it would have found this modification to be “both predictable and desirable due to Ogino’s other disclosed embodiments supporting lower f-numbers, the teaching of Bareau and Wang indicating a desire for cell phone lenses with lower f-number for smaller sensors, and the teachings on Kingslake indicating a general desire among POSITAs to design faster lenses.” Pet. 69 (citing Ex. 1005, Figs. 8–13; Ex. 1012, 3–4; Ex. 1024, 1:39–42; Ex. 1013, 104; Ex. 1003, 102). Petitioner apparently

also relies on preceding sections for motivation to combine Ogino with Chen II (*supra* § III.E.3.a) and Ogino and Bareau (*supra* § III.F.2.a).

Petitioner contends that “[a]ccording to the data in the Appendix for this modification, the semi-diameter for the image-side surface of L1 (i.e., L_{1_1}) is 1.163 mm. This yields a diameter of 2.326 mm, which falls between the claimed ratio of 2.3 mm and 2.5 mm.” *Id.* at 70 (citing Ex. 1003, Appendix, Fig. 5D (semi-diameter for surface 2)).

We are persuaded that a POSITA would have sought to lower Ogino’s Example 5 F#, 3.94—while maintaining its relatively short TTL—because it is the highest F# in all of Ogino’s examples, and Ogino has an example with an F# as low as 2.45. Dr. Sasián testifies that Bareau teaches that “smaller pixel sensors suffer at higher f-numbers due to limited light capturing ability.” Ex. 1003 ¶ 71 (citing Ex. 1012, 3–4). The cited portions of Kingslake support the finding that a POSITA would have understood that a lower F# would mean brighter images and faster lenses, which we are persuaded would have been understood to be needed and trending in cell phones. Ex. 1013, 104. More particularly, we are further persuaded that Wang evidences Petitioner’s contention concerning lower f-numbers for smaller sensors. Ex. 1024, 1:39–42. As set forth above, Wang discloses “a high brightness requirement, which means that the lens system should have a small F number (FNo.) Generally, the FNo. should be 2.8 *or less*.” Ex. 1024, 1:39–41 (emphasis added); *see also* Ex. 1012, 3–4 (explaining that higher f-numbers have impacts on performance). We are further persuaded that a POSITA would have reasonable expectation of success in combining Ogino, Chen II, Bareau, and Kingslake to lower Ogino’s F# since Ogino’s Example 1 (having an F#=2.45) and Example 5 share similar characteristics

like lens groupings and lens shapes” and “given that Ogino’s other examples all show lower f-numbers, a POSITA would have reasonably expected that Example 5’s f-number could likewise be lower.” Pet. 66 (citing Ex. 1003 ¶¶ 88, Appendix, Fig. 5A). We are further persuaded that Petitioner’s Zemax diagrams support the argument that lowering Ogino’s Example 5 F# to 2.45 would improve the relative illumination of the combined lens assembly. *See e.g.*, Ex. 1003 ¶¶ 88–89, Appendix, Figs. 1A, 1B, 3A, 5B).

As we discussed above, we are persuaded that Bareau’s typical lens specifications can also apply to telephoto lenses because the f-number is independent of a lens’s focal length or field of view. *Supra* § II.F.2.b. We are also persuaded that, to lower the F# of Ogino’s Example 5, “a POSITA would use larger lens diameter for each lens . . . since increasing a lens’s diameter allows more light to pass through the system while maintaining a similar focal length.” *Id.*

We are further persuaded that Petitioner’s reasons to combine Ogino, Chen II, Bareau, and Kingslake are supported by sufficient rational underpinning with a reasonable expectation of success for the reasons discussed in this section and for the reasons discussed above in the sections analyzing Petitioner’s motivation to combine to combine Ogino with Chen II (*supra* § III.E.3.b) and Ogino and Bareau (*supra* § III.F.2.b).

We have also reviewed the cited portions of Ogino, Chen II, Bareau, Kingslake, Dr. Sasián’s testimony, and the accompanying Zemax diagrams and we are persuaded that Petitioner establishes that the limitation recited in claim 6 is taught by the combination of Ogino, Chen II, Bareau, and Kingslake. Accordingly, we are persuaded that Petitioner establishes

unpatentability of claim 6 over the combination of Ogino, Chen II, Bareau, and Kingslake by a preponderance of the evidence.

3. *Patent Owner's Arguments*

Patent Owner argues that “Petitioner ignores the manufacturability of the lenses,” “Petitioner’s proposed assembly has overlapping lenses in the region of the optical rays,” and “Petitioner’s process would have been contrary to a POSITA’s goal of improving performance.” PO Resp. 63, 64, 66 (emphasis omitted). Patent Owner’s manufacturability and performance improvement arguments do not undermine Petitioner’s challenge based on Ogino, Chen II, Bareau, and Kingslake to dependent claim 6 for substantially the same reasons set forth in Section III.E.5 in the analysis Petitioner’s challenge based on Ogino and Chen II, except that Patent Owner’s argument concerns not varying the radii of any particular surfaces, as contrasted with varying “only the radi[i] for surfaces 1, 2, and 5” in Section III.E.5 above. *Compare* PO Resp. 66–67, *with id.* at 46.

Furthermore, with respect to Patent Owner’s performance improvement arguments for claim 6, Patent Owner contends that “the values for all of these static entries in this modified Example 5 are identical to those found in the unmodified Example 5 of Ogino with the exception of the radius of lens surface 4,” which “is set and not allowed to vary.” *Id.* at 47, 67 (citing Ex. 1003, Appendix, Fig 2D at 150; Ex. 1005, Table 9). Patent Owner further contends that [p]rohibiting all of these inputs from varying while designing a lens would have greatly reduced the ability to improve the performance and would have almost certainly prevented a POSITA from finding the best performance result.” *Id.* at 67 (citing Ex. 2001 ¶ 141).

Petitioner reiterates its position that “a design process that keeps certain parameters while varying other parameters is not only well-known in the art, but is also the process carried out by Patent Owner’s experts.” Pet. Reply 22 (citing Ex. 1037 ¶ 46; Ex. 1017, 168; Ex. 1028, 21:6–18; Ex. 1013, 99:6–18). Particularly with respect to claim 6, Petitioner contends that “[i]n both modified Example 5 lens designs, a POSITA would have been motivated to lower the f-number of the original Example 5 lens assembly *with as few changes to the original lens as possible.*” *Id.* at 23 (citing Ex. Ex. 1037 ¶ 46) (emphasis added). Petitioner argues that “Patent Owner’s arguments that a POSITA would have varied *more* parameters to produce a lens design with more differences compared to the original Example 5 lens should be rejected.” *Id.* at 23 (citing Ex. 1037 ¶ 46).

We understand Petitioner did not allow certain parameters of Ogino’s Example 5 to vary because it did not need to in its third modification to the combined lens assembly of Ogino and Chen II. We agree that a POSITA would seek to improve an original lens assembly from the starting point of Ogino’s unmodified Example 5 and with minimal changes. *See* Pet. Reply 23. Patent Owner’s argument that prohibiting parameters from varying would have almost certainly prevented a POSITA from finding the best performance result” is unavailing because Petitioner’s proposed combination need not be the best or most optimal lens design. *See* PO Resp. 67; *PAR Pharm., Inc.*, 773 F.3d at 1197–98; *In re Fulton*, 391 F.3d at 1200.

Patent Owner’s overlapping lenses argument for claim 6 does not undermine Petitioner’s challenge to dependent claim 6 based on Ogino, Chen II, Bareau, and Kingslake for substantially the same reasons discussed above in Section III.F.5 with respect to Petitioner’s challenge to dependent

claims 2, 3, and 5 based on Ogino, Chen II, and Bareau. *See, e.g.* Ex. 1003 ¶¶ 85–89.

Patent Owner also argues that “the relative illumination for the modification of Example 5 of Ogino in view of Chen II, Bareau and Kingslake dips below 50% and at 29.5°, the farthest edge of the field, has a relative illumination of about 45%,” which Patent Owner contends contradicts Bareau’s teachings of “typical lens specifications for a 1/4” sensor format, relative illumination is ‘>50%.’” PO Resp. 69 (citing Ex. 1012, 7; Ex. 2001 ¶ 143).

Petitioner responds that “the claims of the ’647 patent do not include any requirements for relative illumination” and that “the relative illumination figure of >50% listed in the ‘typical lens specifications’ of Bareau is exactly that—a ‘typical’ lens characteristic and not a necessary requirement.” Pet. Reply 26 (citing Ex. 1012, 7; Ex. 1037 ¶ 32). Petitioner further responds that “[a] POSITA would have known that photographic lenses are also designed with a relative illumination less than 50%” and that “if a higher relative illumination was an indispensable design requirement, a POSITA could have considered making further modifications to Ogino’s Example 5 lens assembly to achieve this.” *Id.* (citing Ex. 1037 ¶ 53; Ex. 1003 ¶ 62; Ex. 1005, 19:28–22:60 (Ogino’s tables showing optical parameter data for each of its examples)).

Petitioner has the better position. We determine that even if the combined lens assembly of Ogino, Chen II, Bareau, and Kingslake does not meet Bareau’s greater than 50% specification for relative illumination, this would not be fatal to the combination. We agree with Petitioner that Bareau does not *require* a specific relative illumination figure, and instead

characterizes the figure as a “typical lens specification.” *See* Pet. Reply 26. A POSITA would have weighed the benefit of, for example, reducing an f-number of a lens assembly (i.e., brighter and faster images and compatibility with “small sensor formats”) against a 5% tradeoff in relative illumination at, for example, “29.5°, the farthest edge of the field.” *See* Pet. 65–66 (Ex. 1003 ¶ 86; Ex. 1013, 104); PO Resp. 69; *Winner Int’l Royalty*, 202 F.3d at 1349, n.8. There is insufficient evidence of record to support the finding that a 5% tradeoff in relative illumination at “the farthest edge of the field” would have been understood by a POSITA to outweigh the benefits offered by a lower f-number.

For the foregoing reasons, Patent Owner’s arguments do not undermine Petitioner’s challenge to claim 6 based on Ogino, Chen II, Bareau, and Kingslake.

H. Obviousness over Hsieh and Beich

Petitioner contends that claim 7 is unpatentable as obvious under 35 U.S.C. § 103 over Hsieh and Beich. Pet. 71–89. For the reasons that follow, we determine that Petitioner establishes unpatentability of dependent claim 7 over Hsieh and Beich by a preponderance of the evidence.

1. Overview of Hsieh

Hsieh concerns an “Optical Photographing Lens Assembly, Image Capturing Device and Electronic Device.” Ex. 1025, code (54). Hsieh discloses an

optical photographing lens assembly includes in order from an object side to an image side, an aperture stop 100, a first lens element 110, a second lens element 120, a third lens element 130, a fourth lens element 140, a fifth lens element 150, an IR-cut filter 160 and an image surface 170, wherein the image sensor

180 is disposed on the image surface 170 of the optical photographing lens assembly.

Id. at 9:16–25. Hsieh’s first embodiment lens assembly is depicted in Figure 1, which is reproduced below.

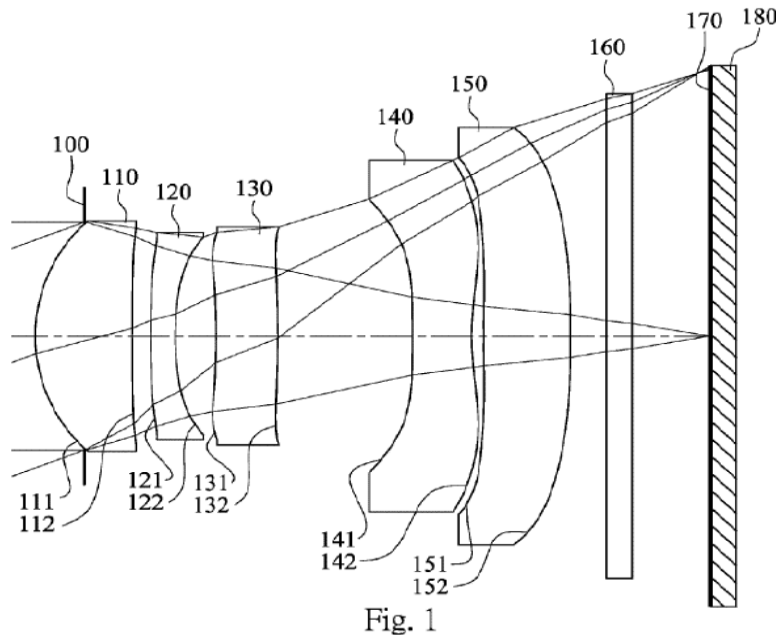


Figure 1 of Hsieh depicting lenses in Hsieh’s first embodiment lens assembly.

Hsieh discloses that first lens element 110 and fifth lens element 150 have a positive refractive power and second, third, and fourth lens elements 120, 130, and 140 have negative refractive power. *Id.* at 9: 31, 37, 44, 50, 59.

The optical parameters for Hsieh’s first embodiment lens assembly are presented in Table, reproduced below.

TABLE 1

1st Embodiment f = 5.88 mm, Fno = 2.83, HFOV = 21.8 deg.								
Surface #		Curvature Radius	Thickness	Material	Index	Abbe #	Focal Length	
0	Object	Plano	Infinity					
1	Ape. Stop	Plano	-0.406					
2	Lens 1	1.515 ASP	0.805	Plastic	1.544	55.9	2.86	
3		43.975 ASP	0.153					
4	Lens 2	7.236 ASP	0.200	Plastic	1.650	21.4	-5.62	
5		2.401 ASP	0.341					
6	Lens 3	-10.676 ASP	0.511	Plastic	1.614	25.6	-41.86	
7		-18.590 ASP	1.114					
8	Lens 4	-136.463 ASP	0.493	Plastic	1.544	55.9	-5.28	
9		2.941 ASP	0.099					
10	Lens 5	13.819 ASP	0.717	Plastic	1.650	21.4	17.15	
11		-56.425 ASP	0.300					
12	IR-cut filter	Plano	0.210	Glass	1.517	64.2	—	
13		Plano	0.655					
14	Image	Plano	—					

Reference wavelength is 587.6 nm (d-line).

Table 1 of Hsieh sets forth optical parameters for Hsieh's first embodiment lens assembly.

Hsieh further discloses that its first lens element 110 has an object-side surface 111 that is convex and an image-side surface 112 that is concave. *Id.* at 9:32–33. Its second lens element 120 also has a convex object-side surface 121 and concave image-side surface 122. *Id.* at 9:37–39. Hsieh's third lens element 130 has a concave object-side surface 131 and a convex image-side surface 132. *Id.* at 9:44–46. Fourth lens element 140 has a concave image-side surface 141 as well as a concave object-side surface 142. *Id.* at 9:50–53. Hsieh's fifth lens element 150 has a convex image-side surface 151, as well as a convex object-side surface 152. *Id.* at 9:59–61.

2. *Overview of Beich*

Beich concerns “the process of creating state-of-the-art polymer optics and a review of the cost tradeoffs between design tolerances, production volumes, and mold cavitation.” Ex. 1020, 2. Beich discloses design considerations, or “rules of thumb,” with respect to shape and tolerances of polymer-based optical devices that drive cost and manufacturability.” *Id.* at 7. These considerations include such knowledge as “thicker parts take longer to mold than thinner parts” and “[o]ptics with extremely thick centers and thin edges are very challenging to mold.” *Id.*

3. *Dependent Claim 7*

Claim 7 recites “[t]he lens assembly of claim 2, wherein the lens assembly further includes a ratio between a largest optical axis thickness $L1l$ and a circumferential edge thickness $L1e$ of lens element L_1 of $L1l/L1e < 3$.”

Petitioner shows how Hsieh and Beich teach the limitations of independent claim 1 and dependent claim 2 from which claim 7 depends. Petitioner contends that preamble [1.0] is met because Hsieh “teaches an ‘optical photographing lens assembly [that] has a total of five lens elements’ arranged ‘in order from an object side to an image side’” as shown in its annotated version of Hsieh’s Figure 1.²⁷ Pet. 82 (citing (Ex. 1025, 2:22–26) (emphasis omitted).

According to Petitioner, Hsieh discloses claim limitations [1.1] through [1.5] because

Example 1 includes a “first lens element 110 with positive refractive power,” “[a] second lens element 120 with negative

²⁷ We need not determine if preamble [1.0] is limiting because Petitioner has shown that the subject matter of the preamble [1.0] is taught by Hsieh.

refractive power [that] has an object-side surface 121 being convex . . . and an image-side surface 122 being concave,” and a “third lens element 130 with negative refractive power,” a “fourth lens element 140” and a “fifth lens element 150” A POSITA would have understood the L2 lens to be a meniscus shape because it is convex on the object-side and concave on the image-side.

In Example 1, L1 has a focal length (f_1) of 2.86 mm, L2 has a focal length (f_2) of -5.62 mm, and L3 has a focal length (f_3) of -41.86 mm as shown below in Table 1

Pet. 83–84 (citing 1025, 9:31–67, Table 1; Ex. 1003, 111; Ex. 1010, 163 (Fig. 4.15)) (emphasis omitted).

Petitioner further contends that Hsieh meets the expression set forth in limitation [1.6], $1.2 \times |f_3| > |f_2| > 1.5 \times f_1$, by substituting $f_1 = 2.86$ mm, $f_2 = -5.62$ mm, and $f_3 = -41.86$ mm into the expression to obtain:

$1.2 \times |-41.86\text{mm}| > |-5.62\text{mm}| > 1.5 \times 2.86\text{mm}$, which evaluates to $50.232\text{ mm} > 5.62 > 4.29$. *Id.* at 84.

Petitioner further contends that Hsieh meets limitation [1.7] because Hsieh’s Table 1, which has optical data for the optical lens set of Example 1, sets forth “a focal length ‘f’ (EFL) of 5.88 mm.” *Id.* at 85. According to Petitioner, Hsieh meets limitation [1.8] because “Example 1 includes an ‘IR-cut filter 160 [] made of glass material and located between the fifth lens element 150 and the image surface 170,” as shown in Figure 1. *Id.* (citing Ex. 1025, 10:1–4) (emphasis omitted) (alteration in original).

As to limitation [1.9], Petitioner contends that “a POSITA would have identified the TTL of Example 1 to be the distance between the object-side surface of the first lens L1 (100) and the image plane 170.” *Id.* at 86 (citing Ex. 1025, 116–117). Petitioner contends that “[t]he total track length (TTL) of Example 1 with the glass IR filter can thus be calculated by summing the

widths of D2 to D13 (Thicknesses) from Table 1” and that “[t]he sum of the distances D2 to D13 is 5.598 mm,” which Petitioner further contends is confirmed by Zemax and is “6.5 millimeters or less” as claimed. *Id.* at 87–88 (citing Ex. 1003, 117, Appendix; Ex. 1025, Table 1).

With respect to limitation [1.10], Petitioner substitutes its above-calculated value for TTL, 5.598 mm, and the EFL set forth in Hsieh’s Table 1, 5.88 mm, into the claimed expression $TTL/EFL < 1.0$ (i.e., $5.598/5.88$), which evaluates to 0.952 mm, and which is < 1.0 as claimed. *Id.* at 88 (citing Ex. 1003, 117).

With respect to the limitation recited in claim 2, Petitioner points to the value in Hsieh’s Table 1, “Fno=2.83,” which it contends is less than 2.9 as claimed. *Id.* at 89.

With respect to the limitation recited in claim 7, Petitioner contends that

Hsieh and Beich renders [7.0] obvious. As discussed above in the “Reasons to combine either Hsieh or Chen with Beich,” a POSITA would have found it obvious to limit the diameter of Hsieh’s Example 1 L1 lens so that the center-to-edge thickness is maintained at less than 3:1 according to Beich’s teaching. The Zemax model of Example 1, shows that the L1 lens has a center thickness of 0.805 mm and an edge thickness of 0.397 mm yielding a center-to-edge thickness ratio of 2.03. Because the center-to-edge-thickness is met as Hsieh’s Example 1 is designed and a POSITA would have found it obvious to set the diameter to maintain this ratio, the Hsieh combined with Beich renders [7.0] obvious.

Id. (citing Ex. 1003, 118–20, Appendix, Fig. 6E; Pet. § XI.G.6).

Petitioner contends that a POSITA would have combined Hsieh and Beich because Hsieh does not “specify diameters for its respective lens elements, thus leaving it as a design choice based on manufacturability.”

Pet. 80 (citing Ex. 1003 ¶¶ 99, 113). Petitioner further contends that “Hsieh’s L1 lens, as originally designed, ha[s] an edge thickness of 0.397 mm as calculated by Zemax, thus yielding a center-to-edge thickness ratio of about 2.03 mm.” *Id.* (citing Ex. 1003 ¶ 99, Appendix, Fig. 6E). In order for Hsieh’s lens element L1 to pass “through all intended light rays while being easier to manufacture,” “a POSITA would have looked to polymer injection molding references such as Beich, which ‘discuss[es] the polymer optics manufacturing process and examine[s] the best practices to use when working with a polymer optics manufacturer.’” *Id.* at 79 (citing Ex. 1003 ¶¶ 98, 112; Ex. 1007, 2); *see also id.* (Petitioner arguing that Hsieh discloses that it is preferably made of injection-molded plastic). According to Petitioner, a POSITA looking to manufacture Hsieh’s Example 1 lens design “would have understood the benefit of applying the teachings of Beich, thereby resulting in an either design having an L1 lens with a diameter set for manufacturing so that the center-to-edge thickness ratio is maintained at less than 3.” *Id.* (citing Ex. 1003 ¶¶ 91, 114).

Petitioner takes the position that, because “[o]ptics with extremely thick centers and thin edges are very challenging to mold,” and because Hsieh does not “provide diameters for their respective L1 lenses” but supports a “center-to-edge-thickness ratios be[ing] less than 3:1 within a diameter range suitable for manufacturing,” we should “consistently find here that a POSITA would have combined the teaching of Beich with either Hsieh or Chen for the same purpose as the Board found previously in IPR2019-00030.” *Id.* at 81. According to Petitioner, in the IPR2019-00030 proceeding, we determined that “it would have been obvious for a POSITA to combine the teaching of Beich with Ogino’s Example 6 design to

similarly set the diameter of the L1 lens to maintain a center-to-edge thickness ratio of less than 3:1.” *Id.* (citing IPR2019-00030, Paper 32 (Final Written Decision), 35–37).

Ogino does not provide the diameter of first lens L1. Given the need to set this diameter, Beich provides explicit disclosure as to why the ordinarily skilled artisan would select a diameter for Ogino’s first lens element based on Beich’s rules of thumb—because the ratio disclosed in Beich’s Table 2 constitutes the limits of fabrication in an ideal lens system. Ex. 1020, 7. We *emphasize* that a POSITA would have selected a diameter for lens L1 based on the limits of fabrication, i.e., manufacturability or manufacturing considerations, because claim 7 recites and *requires* a particular range of ratios of largest optical axis thickness to circumferential edge thickness for the claimed first lens.

For the foregoing reasons, we are persuaded that Petitioner’s reasons to combine Hsieh and Beich are supported by sufficient rational underpinning with a reasonable expectation of success. *See e.g.*, Ex. 1003 ¶¶ 96–99. We have reviewed the cited portions of Hsieh, Beich, Dr. Sasián’s testimony, and the accompanying Zemax diagrams and we are persuaded that Petitioner establishes that the combination of Hsieh and Beich teaches the limitation recited in claim 7. *See e.g., id.* at 101. Accordingly, we are persuaded that Petitioner establishes unpatentability of claim 7 over the combination of Hsieh and Beich by a preponderance of the evidence.

4. Patent Owner’s Arguments

Patent Owner argues that, “[n]owhere does Petitioner or Dr. Sasián discuss how a POSITA would address the manufacturing, tolerances, or

ensuring system desensitization of the optical design in the modification of Hsieh in view of Beich.” PO Resp. 70.

Patent Owner also argues that

when designing a lens assembly, a POSITA would have allowed the inputs of radius of the lenses, spacing between lens surfaces and the conic coefficients to vary. This would permit better performance to be obtained during the design process. However, as shown in the Prescription Data for in the modification of Hsieh in view of Beich in Fig. 6D, none of these values were allowed to vary, as can be seen by the there being no “V” next to the entries.

Id. at 71 (citing Ex. 2001 ¶ 149). In this regard, Patent Owner contends that “[p]rohibiting all of these inputs from varying while designing a lens would have greatly reduced the ability to improve the performance and would have almost certainly prevented a POSITA from finding the best performance result.” *Id.* at 72 (citing Ex. 2001 ¶ 150).

As to Patent Owner’s argument concerning the manufacturability of lenses, it is lacking in detail with regard to the specific combination of Hsieh and Beich, and is unavailing in part because Petitioner specifically addresses manufacturability in considering the limits of fabrication in Beich with respect to center-to-edge thickness ratio, as set forth above. Petitioner notes, and we agree, “claim 7 does not recite any manufacturing requirements besides the center-to-edge thickness ratio.” Pet. Reply 27 (citing Pet. 81–89; Ex. 1003 ¶¶ 96–100). So it is not clear what other manufacturability arguments Patent Owner thinks Petitioner lacks, or why they would be needed.

As to Patent Owner’s argument concerning vary parameters to improve performance, Petitioner explains that “no changes have been made

to Hsieh's lens assembly to meet the limitations of claim 7, and Beich's 'rule of thumb' is merely used to show how a POSITA would have chosen the diameter of lens L1 (which is not listed in Hsieh's lens prescription)." Pet. Reply 27 (citing Pet. 80). Petitioner characterizes Patent Owner's argument as taking the position that "it was unacceptable to *not* change any parameters of Hsieh's Fig. 1 lens." *Id.* (citing PO Resp. 72).

We are persuaded that Petitioner does not make any changes to Hsieh's lens assembly because it is not necessary in Petitioner's combination of Hsieh and Beich and Hsieh's lens assembly is Petitioner's starting point. *See* Pet. Reply 27. Patent Owner's argument lacks detail and explanation as to why allowing "the inputs of radius of the lenses, spacing between lens surfaces[,] and the conic coefficients" to vary provides a greater "ability to improve the performance" of Hsieh's lens design or the combined Hsieh and Beich lens design. *See* Pet. Reply 28; PO Resp. 72. Even if Patent Owner's argument was more detailed, it is not necessary for Petitioner's combination to be the best or most optimal design, contrary to Patent Owner's argument (*see* PO Resp. 72). *See PAR Pharm.*, 773 F.3d at 1197–98 ("Our precedent . . . does not require that the motivation be the best option, only that it be a suitable option from which the prior art did not teach away."); *Fulton*, 391 F.3d at 1200 (holding that "a particular combination" need not "be the preferred, or the most desirable, combination described in the prior art in order to provide motivation").

For the foregoing reasons, Patent Owner's arguments do not undermine Petitioner's challenge to claim 7 over Hsieh and Beich.

I. Obviousness over Chen, Iwasaki, and Beich

Petitioner contends that claim 12 is unpatentable as obvious under 35 U.S.C. § 103 over Chen, Iwasaki, and Beich. Pet. 71–81, 90–96. For the reasons that follow, we determine that Petitioner establishes unpatentability of dependent claim 12 over Chen, Iwasaki, and Beich by a preponderance of the evidence.

1. Overview of Chen

Chen concerns an “Optical Lens Set.” Ex. 1020, code (54). In its first exemplary optical lens set, Chen discloses five lens elements 10 to 50, filter 70, aperture stop 80, image plane 71. *Id.* at 8:55–58. First lens element 10, third lens element 30, and fifth lens element 50 have positive refractive powers, and second lens element 20 and fourth lens element 40 have negative refractive powers. *Id.* at 8:63, 9:6–7, 9:16, 9:25, 9:34. Figure 6, reproduced below, depicts these lens elements in Chen’s first exemplary optical lens set.

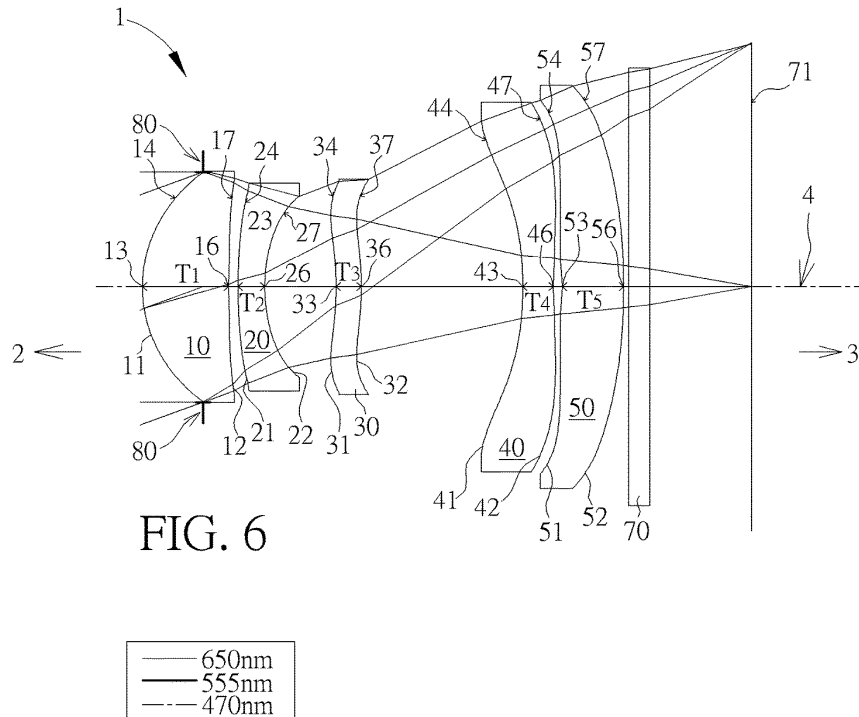


Figure 6 depicts Chen's first exemplary optical imaging lens set.

In the vicinity of the optical axis, Figure 6 also depicts first lens element 10 with first object-side surface 11 that is convex and first image-side surface 12 that is concave. *Id.* at 8:64–65, 9:1. In a similar vicinity, second lens element 20 is shown with second object-side surface 21 being convex and second image-side surface 22 being concave. *Id.* at 9:6–11. Third lens element 30 is shown with third object-side surface 31 being concave and third image-side surface 32 being convex. *Id.* at 9:16–22. Fourth lens element 40 is shown with fourth object-side surface 41 being concave and fourth image-side surface 42 being concave. *Id.* at 9:25–31. Fifth lens element 50 is shown with fifth object-side surface 51 being concave and fifth image-side surface 52 being convex, in the vicinity of the optical axis. *Id.* at 9:34–39.

Optical data for Chen's first exemplary optical lens set 1 is shown in Figure 24, reproduced below. *Id.* at 10:1–2.

First Example							
No.		Curvature Radius	Ape. Stop Distance Lens Thickness Air Gap		Refractive Index	Abbe No.	Focal Length
	Object	INFINITY	INFINITY				
		INFINITY	0.628				
80	Ape. Stop	INFINITY	-0.602				
11	First Lens	1.565	0.855	T ₁	1.545	55.987	2.975
		34,464	0.088	G ₁₂			
21	Second Lens	6.079	0.264	T ₂	1.642	22.409	-4.568
22		1.955	0.704	G ₂₃			
31	Third Lens	-3.412	0.249	T ₃	1.545	55.987	122.164
32		-3.330	1.598	G ₃₄			
41	Fourth Lens	-4.283	0.310	T ₄	1.545	55.987	-6.178
42		16.327	0.064	G ₄₅			
51	Fifth Lens	-61.049	0.619	T ₅	1.642	22.409	15.559
52		-8.680	0.050	G ₅₆			
70	IR Filter	INFINITY	0.210		1.517	64.167	
		INFINITY	1.007				
71	Image Plane	INFINITY					

Figure 24 of Chen sets forth optical data for the optical lens set in the first example.

2. *Dependent Claim 12*

Claim 12 recites “[t]he lens assembly of claim 8, wherein the lens assembly further includes a ratio between a largest optical axis thickness L11 and a circumferential edge thickness Lle of lens element of L11/Lle<3.”

Dependent claim 12 depends from independent claim 8 and thus, Petitioner must show how its proposed combination teaches or suggests all of the limitations of independent claim 8, in addition to showing how the combination satisfies the limitation recited in claim 12.

Petitioner contends that “Chen discloses [8.1-8.5] because Example 1 has a L1-L5 lens elements, each with respective focal lengths f_1 - f_5 , as provided in Fig. 24” Pet. 91. Petitioner explains that, from the optical data Figure 24, the following is extracted:

L1 has positive refractive power because $f_1=+2.975$ mm and L2 has negative refractive power because $f_2=-4.568$ mm. L2 has a meniscus shape that is convex toward the object-side because the radii of curvature for surfaces “21” and “22” are both positive, meaning that the object-side is convex and the image-side is concave. Thus, Chen teaches [8.1-8.5].

Pet. 92 (citing Ex. 1003, 129–31; *see* Ex. 1010, 159, footnote (stating that refractive power is the inverse of the focal length); Ex. 1010, Fig. 4.15 (showing lenses of meniscus shape)).

According to Petitioner, “Chen discloses [8.6] because Example 1 has a focal length EFL=6.582 mm.” *Id.* With respect to [8.7], “Chen teaches that the Example 1 lens system includes a glass IR [infrared] filter ‘placed between the image-side surface 52 of the fifth lens element 50 and the image plane 71.’” *Id.* at (citing Ex. 1020, 7:42–46, Fig. 24). The glass IR filter has a thickness of 0.210 mm, a refractive index of 1.517, and an Abbe No. of 64.167—values also obtained from Fig. 24. Petitioner contends that Iwasaki also “shows an IR filter of similar refractive index and Abbe No. but at 0.145 mm [of thickness].” *Id.* (citing Ex. 1009, Tables 1 and 3). Petitioner further contends that it “would have been obvious for a POSITA to replace

Chen's IR filter with Iwasaki's thinner filter to shorten the length but still protect the sensor and filter infrared light." *Id.* at 93 (citing Ex. 1003, 135).

With respect to limitation [8.8], Petitioner explains that

Iwasaki first two embodiments use IR filters 0.145 mm thick rather than 0.210 mm in embodiment four or 0.300 mm filter in embodiment three. Thus, POSITAs were aware IR filter thickness could vary which would have benefited Chen's desire to for "improved imaging quality with reduced lens set size," and Iwasaki demand for telephoto lenses with shortened lengths. A POSITA thus would have been motivated to use a 0.145 mm IR Filter in Chen's Example 1 to reduce the length.

Pet. 93–94 (citing Ex. 1003, 136; Ex. 1009, 1:54–65). Petitioner also contends that Chen's "Example 1 has TTL=6.019 mm," which "[a] POSITA would have considered [] to be 'equal' to 6.0 mm" and that "[u]sing a 0.145 mm IR filter as taught in Iwasaki shortens the TTL to 5.985 mm as calculated by Zemax." *Id.* at 94 (citing Ex. 1003, Appendix, Fig. 7A; Ex. 1009, Fig. 42). We are persuaded that Chen as modified with Iwasaki, having a TTL of 5.985 mm, sufficiently satisfies limitation [8.8].

With respect to limitation [8.9], Petitioner contends that Chen's "Example 1 has an EFL=6.582 mm (*see* [8.6]) and, when modified with a 0.145 mm IR filter, has a TTL=5.985 mm (*see* [8.8]), thereby satisfying the claimed ratio." *Id.* (citing Ex. 1003, Appendix, 7A). With respect to limitation [8.10], Petitioner contends that "Chen discloses this limitation because Example 1 has F#=2.661." *Id.* (citing Ex. 1020, 13:17–18, Fig. 42 (col. 1, row 'FNO') (emphasis omitted)). With respect to limitation [8.11], Petitioner contends that "Chen discloses this limitation because Example 1 has an $f_1=+2.975$ mm (*see* [8.1]) and, when modified with a 0.145 mm IR filter, has a TTL=+5.985 mm (*see* [8.8]), satisfying the claimed ratio." *Id.*

(citing Ex. 1003, 130, 138). With respect to limitation [8.12], Petitioner contends that “the combination of Chen and Iwasaki renders this limitation obvious” because “Chen’s Example 1 has a gap between L3 and L4 of 1.598 mm” and “Example 1 when modified with a 0.145 mm IR filter has a TTL=5.985 mm (*see* [8.8]), thereby satisfying the claimed ratio.” *Id.* at 95 (citing Ex. 1020, Fig. 24 (annotated)).

As motivation to combine, Petitioner contends that

A POSITA would have found it obvious and desirable to modify Chen’s Example 1 lens system with Iwasaki’s teaching of using a 0.145 mm cover glass element in a telephoto lens system. Such a combination would have both maintained the presence of a cover glass element in Example 1—for protecting the sensor and filtering infrared light, which Chen already teaches—while beneficially further reducing the total length of the lens system as indicated by Iwasaki. A POSITA would have been well aware that this modification simply required substituting the 0.210 mm cover glass element already present in Chen’s Example 1 with a 0.145 mm element as taught in Iwasaki and shifting the location of the image plane to correct for the thinner cover glass element (i.e., focus shift).

Pet. 75 (citing Ex. 1003 ¶¶ 107–108; Ex. 1009, 1:57–60 (“[D]emand for shortening of the total lengths of lenses is increasing for imaging lenses which are employed in devices such as smart phones and tablet terminals, which are becoming progressively thinner.”)).

We are persuaded that Petitioner’s motivation to combine Chen and Iwasaki is reasonable and well-supported and as such, we determine Petitioner’s motivation to combine Chen and Iwasaki has a rational underpinning and with a reasonable expectation of success. *See e.g.*, Ex. 1003 ¶¶ 107–113.

Petitioner explicitly addresses limitations [8.1] through [8.12] and preamble [8.0], but fails to explicitly set forth limitations [8.13] and [8.14] specifically with respect to the ground applying Chen, Iwasaki, and Beich. Patent Owner argues that “neither Petitioner nor its expert Dr. Sasián provide any analysis or evidence as to whether elements 8.13 or 8.14 are found in the combination of Chen, Iwasaki and Beich references.” PO Resp. 74 (citing Ex. 2001 ¶ 156).

With respect to limitation [8.13], citing its analysis of claim 8 over Ogino and Chen II on pages 61–62 of the Petition, Petitioner responds that “[l]imitation 8.13 recites ‘L4 and L5 are separated by a gap smaller than $TTL/20$ ’ and 8.14 recites ‘the five lens element are made of plastic’” and that Chen teaches both. Pet. Reply 28 (citing Pet. 61–62; Ex. 1001, 10:4–8).

Petitioner contends “[t]he TTL of Chen’s Example 1 with a thinner cover glass is 5.985 mm.” Pet. Reply 30 (citing Pet. 95–96; Ex. 1003, 136, Appendix, Fig. 7A). Petitioner further contends that “[t]he gap between L4 and L5 is 0.064 mm.” *Id.* (citing Pet. 91). Petitioner explains that “the gap disclosed by Chen meets the recited limitation of ‘L4 and L5 are separated by a gap smaller $TTL/20$.’” *Id.* (citing Pet. 30, n.2) (setting forth “ $0.064\text{ mm} < 5.985\text{ mm} / 20$ (or 0.29925 mm)”).

In its Sur-Reply, Patent Owner further contends that

[Petitioner] is applying, for the first time in this proceeding, some prior art combination to the limitations 8.13 and 8.14 of claim 8 in the context of claim 12 under Ground 6. This is all new argument. There was no previous application in the Petition of any combination, be it Chen, [Iwasaki], and Beich or Example 5 of Ogino, Chen II and Bareau, to limitations 8.13 and 8.14 of claim 8 in the context of claim 12.

PO Sur-Reply 18 (citing Pet. Reply 28–30).

Although Petitioner points out “the Gap between L3 and L4” with respect to limitation [8.12], Petitioner does not point out the Gap between L4 and L5. *Compare* Pet. 95, *with id.* at 91. Petitioner’s reference to pages 61 and 62 of the Petition in which Ogino and Chen II discuss limitations [8.13] and [8.14] is of questionable relevance because it involves an entirely different set of references.

In its discussion of limitation [8.9], Petitioner contends Chen’s “Example 1 has a TTL=6.019 mm” and that “[a] POSITA would have considered this to be ‘equal’ to 6.0 mm.” *Id.* at 94 (citing Ex. 1003, Fig. 42). Petitioner contends that “[u]sing a 0.145 mm IR filter as taught in Iwasaki shortens the TTL to 5.985 mm as calculated by Zemax. . . .” *Id.* (citing Ex. 1003, Appendix, Fig. 7A). Petitioner appears to rely on the smaller 5.985 mm TTL for satisfying limitation [8.12]. *Id.* at 95. Petitioner explains that “the gap disclosed by Chen meets the recited limitation of ‘L4 and L5 are separated by a gap smaller TTL/20.’” *Id.* (citing Pet. Reply 30, n.2) (setting forth “ $0.064\text{ mm} < 5.985\text{ mm} / 20$ (or 0.29925 mm)).

Our rules require that a petition specify with particularity where each element of a claim is found in the prior art, and include a detailed explanation of the relevance of the prior art to the claim. 37 C.F.R. § 42.104(b)(4) (“[t]he petition must specify where each element of the claim is found in the prior art patents or printed publications relied upon”); *id.* § 42.22(a)(2) (“[e]ach petition . . . must include . . . a detailed explanation of the significance of the evidence including material facts”); *id.* § 42.104(b)(5) (the petition must “identify . . . the relevance of the evidence to the challenge raised, including identifying specific portions of the evidence that support the challenge”). As the Federal Circuit has explained, “[i]n an IPR, the

petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.” *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016).

In that regard, a petition for inter partes review must identify how the challenged claims are unpatentable, and must specify where each element of the claim is found in the relied-upon prior art. 37 C.F.R. § 42.104(b); *see also* 35 U.S.C. § 312(a)(3) (a petition must identify “with particularity, each claim challenged, the grounds on which the challenge to each claim is based, and the evidence that supports the grounds for challenge to each claim”). A petition must also include “a detailed explanation of the significance of the evidence including material facts, and the governing laws, rules, and precedent.” 37 C.F.R. § 42.22(a)(2).

In the present proceeding, the Petition does not address limitation [8.13] in the challenge applying Chen, Iwasaki, and Beich, does not explicitly identify the gap value between L4 and L5, and does not explicitly give a value for TTL/20. Although Petitioner explains, in its Reply, that it intends to rely on the 5.985 mm TTL, the Petition sets forth two values for TTL, 5.985 mm and 6.019 mm, the latter of which Petitioner contends a POSITA would have understood to be equal to 6.0 mm. *See* Pet. 94. As set forth above, we are persuaded that the 5.985 TTL satisfies the limitations of independent claim 8. The Petition’s annotation of “the Gap between L3 and L4” with respect to limitation [8.12] make clear how the gap between L4 and L5 could be inferred from Chen’s Figure 24. Given that the TTL (from the modified design) was earlier identified, and the table shows the value for the gap between L4 and L5, it would be difficult for us to say we could not ascertain the nature of Petitioner’s challenge to limitation [8.13]—a value

for TTL/20 and a comparison between this value and the gap between L4 and L5—even if claim limitation [8.13] was not quoted in the section discussing the challenge based on Iwasaki, Chen, and Beich.

With regard to limitation [8.14], Petitioner contends that

Chen meets 8.14 as indicated by the refractive index and abbe number values provided in Fig. 24, as Dr. Sasián states that “a POSITA would have recognized that the refractive index and Abbe number of the lens elements in Example 1 are within the range of values of plastic materials used in injection molding manufacturing. Patent Owner does not dispute this.

Pet. Reply 30–31 (citing Pet. 79, 91 (citing Ex. 1003 ¶¶ 97, 111; Ex. 1018, 27)). On page 79 of the Petition, Petitioner contends that “the preferred polymer manufacturing technology for optical elements having a diameter smaller than 0.1 m and a thickness not greater than 3 cm.” Pet. 79 (citing Ex. 1019, 34.14). The Petition further states that “[i]n addition to size considerations, a POSITA would have recognized that the refractive index and Abbe number of the lens elements in Example 1 are within the range of values of plastic materials used in injection molding manufacturing.” *Id.* (citing Ex. 1003 ¶¶ 97, 111; Ex. 1018, 27). Petitioner’s citation to page 91 of the Petition merely references Chen’s Figure 24 that gives refractive indices and Abbe numbers to the lenses in its lens assembly.

While paragraph 97 of Dr. Sasián’s First Declaration relates to the challenge applying Hsieh and Beich, in paragraph 111, Dr. Sasián testifies that

While Chen does not discuss manufacturing or materials of its lens elements, a POSITA would have recognized that only a few methods and materials would have been used to craft such small aspheric components. One such method is to manufacture plastic lenses through injection molding, which is “the preferred

polymer manufacturing technology for optical elements having a diameter smaller than 0.1 m and a thickness not greater than 3 cm.” APPL-1019, p.34.14. In addition to size considerations, a POSITA would have recognized that the refractive index and Abbe number of the lens elements in Example 1 are within the range of values of plastic materials used in injection molding manufacturing.

Ex. 1003 ¶ 111 (citing Ex. 1018, 27; Ex. 1019, 34.14).

We are persuaded that refractive indices and Abbe numbers in Chen’s Figure 24 shown on page 91 of the Petition are in the range of values for plastic lenses based on the scatter plot shown in the Field Guide (Ex. 1018), that the Petition set forth this position on page 79, and that Dr. Sasián explained it further in paragraph 111 of his First Declaration. We are further persuaded that Chen in the combination of Iwasaki, Chen, and Beich teaches that “the five lens elements are all made of plastic,” as recited in limitation [8.14]—even if claim limitation [8.14] was not quoted in the section discussing the challenge based on Iwasaki, Chen, and Beich.

With respect to limitation [12.0], Petitioner contends,

Chen and Beich renders this limitation obvious. As discussed above in the “Reasons to combine either Hsieh or Chen with Beich,” a POSITA would have found it obvious to limit the diameter of Chen’s Example 1 L1 lens so that the center-to-edge thickness is maintained at less than 3:1 according to Beich’s teaching. The Zemax model of Example 1, shows that the L1 lens has a center thickness of 0.855 mm (*see* APPL-1020 Fig. 6) and an edge thickness of 0.293 mm yielding a center-to-edge thickness ratio of 2.92. Because the center-to-edge-thickness is met as Chen’s Example 1 is designed and a POSITA would have found it obvious to set the diameter to maintain this ratio, the combination of Chen and Beich renders this limitation obvious.

Pet. 96 (citing Ex. 1003, 139-42, Appendix, Fig. 7E; Pet. § XI.F.6).

As motivation to combine Chen and Beich, Petitioner contends, “[s]ince L1 in Example 1 of . . . Chen would preferably have been manufactured via injection molding, and to the extent that” Chen does not “provide manufacturing parameters,”

a POSITA would have looked to polymer injection molding references such as Beich, which “discuss[es] the polymer optics manufacturing process and examine[s] the best practices to use when working with a polymer optics manufacturer.” According to Beich, lens manufactures rely on “rules of thumb,” as discussed above, in manufacturing lens elements to maintain the ratio of center thickness to edge thickness to a value less than three (“< 3:1”). This is because “[o]ptics with extremely thick centers and thin edges are very challenging to mold.” The “center thickness” and “edge thickness” in Beich correspond to the “largest optical axis thickness L11” and the “circumferential edge thickness L1e” in the ’647 Patent.

A POSITA would have recognized that . . . Chen [does not] specify diameters for its respective lens elements, thus leaving it as a design choice based on manufacturability. Consequently, the L1 lens . . . with a thick center and edges that grow thinner as the lens diameter increases [] is of the type for which a POSITA would manufacture so that the ratio of center thickness to edge thickness is less than 3:1. In other words, to maintain the desirable 3:1 ratio, a POSITA would have known to make set the diameter of [] [Chen’s] L1 lens element[] so that, at a minimum, the lens would function for its intended purpose of passing through all intended light rays while being easier to manufacture.

Pet. 78–80 (citing Ex. 1003 ¶¶ 96, 98, 99, 110, 112, 113; Ex. 1007, 2, 7).

We are persuaded that Petitioner’s motivation to combine Chen and Beich is reasonable and well-supported and as such, we determine Petitioner’s motivation to combine Chen and Beich has a rational underpinning and with a reasonable expectation of success.

We have reviewed the cited portions of Iwasaki, Chen, and Beich, Dr. Sasián's testimony, Zemacs drawings, and accompanying prescription data, and we are persuaded that Petitioner establishes that each of the limitations of claim 8 and the limitation of claim 12 is taught by the combination of Iwasaki, Chen, and Beich for the reasons discussed above. As discussed above, we determine that Petitioner's motivation to combine Chen and Iwasaki and its motivation to combine Chen and Beich is supported by sufficient rational underpinning with a reasonable expectation of success. For the foregoing reasons, we conclude that Petitioner establishes unpatentability of claim 12 by a preponderance of the evidence.

IV. CONCLUSION

We conclude that Petitioner establishes unpatentability by a preponderance of the evidence with respect to its challenge to (1) claims 1, 2, 3, and 5 over Iwasaki, (2) its challenge to claims 1 and 4 over Ogino and Chen II, (3) its challenge to claims 2, 3, 5, and 8–11 over Ogino, Chen II, and Bareau, (4) its challenge to claim 6 over Ogino, Chen II, Bareau, and Kingslake, (5) its challenge to claim 7 over Hsieh and Beich, and (6) its challenge to claim 12 over Chen, Iwasaki, and Beich.²⁸

²⁸ Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. See 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. See 37 C.F.R. §§ 42.8(a)(3), (b)(2).

Our conclusions regarding the challenged claims are summarized below:

Claims Challenged	35 U.S.C. §	References/ Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1, 2, 3, 5	103(a)	Iwasaki	1, 2, 3, 5	
1, 4	103(a)	Ogino, Chen II	1, 4	
2, 3, 5, 8–11	103(a)	Ogino, Chen II, Bareau	2, 3, 5, 8–11	
6	103(a)	Ogino, Chen II, Bareau, Kingslake	6	
7	103(a)	Hsieh, Beich	7	
12	103(a)	Chen, Iwasaki, Beich	12	
Overall Outcome			1–12	

V. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that claims 1–12 of the '647 patent are determined to be unpatentable; and

FURTHER ORDERED that, because this a Final Written Decision, parties to this proceeding seeking judicial review of this Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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