

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CARL ZEISS SMT GMBH,
Petitioner,

v.

NIKON CORPORATION,
Patent Owner.

Case IPR2013-00362
Patent 7,348,575 B2

Before HOWARD B. BLANKENSHIP, SALLY C. MEDLEY, and
MATTHEW R. CLEMENTS, *Administrative Patent Judges*.

CLEMENTS, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

Carl Zeiss SMT GmbH (“Carl Zeiss”) filed a Petition requesting *inter partes* review of claims 1–3, 8–12, 16–20, 23–26, and 29–33 of U.S. Patent No. 7,348,575 B2 (Ex. 1001, “the ’575 patent”). Paper 3 (“Pet.”). The Patent Owner, Nikon Corporation (“Nikon”), did not file a Preliminary Response. On December 16, 2013, we granted an *inter partes* review for all challenged claims on certain grounds of unpatentability. Paper 10 (“Dec. to Inst.”).

After institution of trial, Nikon filed a Patent Owner Response (Paper 19, “PO Resp.”) to which Carl Zeiss filed a Reply (Paper 22, “Reply”).

Additionally, Nikon filed a Motion to Exclude Evidence (Paper 32), to which Carl Zeiss responded (Paper 36). Nikon then filed a Reply in Support of its Motion to Exclude. Paper 39.

Carl Zeiss also filed a Motion to Exclude Evidence (Paper 33), to which Nikon responded (Paper 37). Carl Zeiss then filed a Reply in Support of its Motion to Exclude. Paper 38.

Oral hearing was held on July 17, 2014.¹

The Board has jurisdiction under 35 U.S.C. § 6(c). This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73.

Carl Zeiss has shown by a preponderance of the evidence that claims 1–3, 8–12, 16–20, 23–26, and 29–33 of the ’575 patent are unpatentable.

¹ A transcript of the oral hearing is included in the record as Paper 40 (“Tr.”).

A. The '575 Patent

The subject matter of the '575 patent relates to a catadioptric projection optical system, exposure apparatus, and exposure method and, more particularly, to a high-resolution catadioptric projection optical system suitable for use in production of semiconductor devices and liquid-crystal display devices by photolithography. Ex. 1001, 1:18–23. In the production of semiconductor devices, photolithography uses a projection exposure apparatus to project an “image of a mask (or a reticle) through a projection optical system onto a wafer (or a glass plate or the like) coated with a photoresist or the like.” *Id.* at 1:27–32. As the dimensions of semiconductor devices shrink, the projection optical system of the projection exposure apparatus requires greater resolving power (resolution). *Id.* at 1:32–36. In order to satisfy the requirements for the resolving power of the projection optical system, it is necessary to shorten the wavelength of illumination light (exposure light) and to increase the image-side numerical aperture of the projection optical system. *Id.* at 1:37–41. It was known to increase the numerical aperture by putting a medium with a high refractive index, like a liquid, in the optical path between the projection optical system and the image plane. *Id.* at 1:55–58. However, there were known disadvantages to this approach. *Id.* at 1:59–67.

The '575 patent discloses systems and methods to provide a relatively compact projection optical system that is “corrected for various aberrations, such as chromatic aberration and curvature of field, and being capable of securing a large effective image-side numerical aperture while well suppressing the reflection loss on optical surfaces.” *Id.* at 2:3–9. A medium

having a refractive index larger than 1.1, such as deionized water, is interposed in the optical path between the boundary lens and the image plane, thereby increasing the image-side numerical aperture. *Id.* at 5:9–21. The projection optical system is catadioptric, comprising at least two reflecting mirrors, in which every transmitting member and every reflecting member with a refracting power are arranged along a single optical axis and in which the projection optical system has an effective imaging area that does not include the optical axis. *Id.* at 5:39–45. By arranging the transmitting members and the reflecting members along a single axis, the system is easier to produce than a system wherein the optical members are arranged along multiple optical axes. *Id.* at 5:52–59.

B. Illustrative Claim

Claim 1 is illustrative and is reproduced below:

1. A catadioptric projection optical system, which forms a reduced image of a first surface on a second surface, comprising:
 - at least two reflecting mirrors; and
 - a boundary lens whose surface on the first surface side has a positive refractive power,wherein where a refractive index of an atmosphere in an optical path of the projection optical system is 1, an optical path between the boundary lens and the second surface is filled with a medium having a refractive index larger than 1.1,
 - wherein every transmitting member and every reflecting member with a refractive power constituting the projection optical system are arranged along a single optical axis; and
 - the projection optical system having an effective imaging area of a predetermined shape not including said optical axis.

C. Prior Art Supporting the Instituted Challenges

Carl Zeiss relies on the following prior art references, as well as the Declaration of Richard C. Juergens (Ex. 1016):

Terasawa	US 2002/0024741 A1	Feb. 28, 2002	Ex. 1008
Suwa	US 5,825,043	Oct. 20, 1998	Ex. 1009
Switkes	M. Switkes & M. Rothschild, <i>Resolution Enhancement of 157 nm Lithography by Liquid Immersion</i> , 4691 PROC. SPIE 459–465 (2002)	2002	Ex. 1010
Ulrich	Willi Ulrich et al., <i>The Development of Dioptric Projection Lenses for DUV Lithography</i> , 4832 PROC. SPIE 158–169 (2002)	2002	Ex. 1011
Fukami ²	WO 99/49504	Sept. 30, 1999	Ex. 1012
Asai	Satoru Asai et al., <i>Resolution Limit for Optical Lithography Using Polarized Light Illumination</i> , 32 JAPAN J. APPL. PHYS. 5863–5866 (1993)	Dec. 1993	Ex. 1013

Carl Zeiss refers to Suwa, Switkes, Ulrich, and Fukami collectively as the “Immersion References.” Pet. 4.

² Fukami is a Japanese language document. Ex. 1012. Unless indicated otherwise, all subsequent references to Fukami in this decision will refer to its certified English language translation. Ex. 1015.

D. The Instituted Challenges of Unpatentability

We instituted trial based on the following grounds of unpatentability:

References	Basis	Claim[s] challenged
Terasawa and the Immersion References	§ 103	1–3, 8–12, 16–20, 23–26, 29, and 31–33
Terasawa, the Immersion References, and Asai	§ 103	30

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are interpreted according to their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); Office Patent Trial Practice Guide, 77 Fed. Reg. 48,756, 48,766 (Aug. 14, 2012). Also, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Carl Zeiss contends that the words in the challenged claims generally should have their plain meaning. Pet. 13. However, Carl Zeiss provides its own interpretations of five terms—“boundary lens,” “a refractive index . . . is 1,” “effective imaging area,” “every effective imaging area,” and “the second imaging optical system.” Pet. 13–15. Nikon provides an interpretation only for “boundary lens.” PO Resp. 16–19. For this decision, we construe each of these claim terms in turn.

1. “*boundary lens*” (*claim 1*)

Claim 1 requires a “boundary lens.” Carl Zeiss contends that “when an immersion liquid is introduced between the last lens element of the projection optical system and the wafer (as in limitation [1d]), the last lens element becomes a ‘boundary lens.’” Pet. 14. This is consistent with the use of the term “boundary lens” in the ’575 patent. *See, e.g.*, Ex. 1001, 20:45–49 (“FIG. 3 is an illustration schematically showing a configuration between the boundary lens and the wafer in the first example of the present embodiment.”) (emphasis removed), Figs. 3, 4, 5, 7 (each depicting boundary lens Lb as the last lens element). Accordingly, in the Decision to Institute, we construed “boundary lens” as “the last lens element of the projection optical system.” Dec. to Inst. 8.

Nikon contends that a “boundary lens” is not merely any lens that is placed in contact with an immersion liquid, but rather “a lens of the projection optical system that has a convex object-side surface and a flat image-side surface to increase effective NA in the presence of the immersion liquid by reducing reflection loss.” PO Resp. 16 (citing Ex. 1001, 5:22–31, Tables 1–11; Ex. 2024 ¶ 66). Nikon points to Figure 3 as depicting a boundary lens, and argues that a person of ordinary skill in the art would have understood that “a boundary lens needed to be designed to not only isolate an atmosphere of the projection optical system, but also stand a higher fluence from the light source and enable higher resolution by reducing reflection losses.” *Id.* at 17–18.

Carl Zeiss counters that nothing in the portions of the ’575 patent cited by Nikon constitutes lexicography or disavowal of the plain and

ordinary meaning of “boundary lens.” Reply 1–3. Claim 1 does not require that the image-side surface be “flat,” and the passage at column 5, lines 22 to 31, merely describes what is “feasible” and “can be” secured. *Id.* Carl Zeiss also argues that Nikon’s proposed construction does not make technical sense because, as even Nikon’s expert conceded, it is the whole system, not just the boundary lens, that increases effective NA when an immersion liquid is used between the boundary lens and the image plane. *Id.*

We are not persuaded that “boundary lens” should be construed to require “a convex object-side surface.” Claim 1 already requires that the “surface on the first surface side [of the boundary lens] has a positive refracting power.” To construe the term “boundary lens” to include this limitation would render this language of the claim limitation superfluous.

We also are not persuaded that “boundary lens” should be construed to require “a flat image-side surface.” Although Figure 3 depicts boundary lens Lb with a flat image side, Figure 3 does not amount to a definition of “boundary lens.” With respect to Figure 3, the ’575 patent states that, “the boundary lens Lb in the first example has a convex surface kept toward the reticle (first surface). In other words, the reticle-side surface Sb of the boundary lens Lb has a positive refracting power.” Ex. 1001, 20:48–51. The description of Figure 3 is silent, however, with respect to whether the image-side surface must be flat. *Id.* at 20:45–54. Moreover, Nikon’s reliance on column 5, lines 22 to 31, is unavailing because it describes only a “first aspect of the embodiment.” And in describing that aspect, as in describing Figure 3, the ’575 is silent with respect to whether the image-side surface must be flat. It says only that, “the optical surface on the object side

(first surface side) of the boundary lens is provided with the positive refracting power, whereby the reflection loss is reduced on this optical surface and, in turn, the large effective image-side numerical aperture can be secured.” *Id.* at 5:23–27. Thus, whereas Nikon’s proposed construction would require a convex object-side surface *and* a flat image-side surface, this passage of the ’575 patent suggests that a boundary lens needs only a positive refracting power—i.e., convex object-side surface—to reduce reflection loss and, in turn, increase effective NA in the presence of an immersion liquid.

Finally we are not persuaded that “boundary lens” should be construed to include a purpose—i.e., “to increase effective NA in the presence of the immersion liquid by reducing reflection loss.” Although this purpose is referenced in column 5 of the ’575 patent, we decline to import a description of a “first aspect of the embodiment” into the construction of a claim term.

Accordingly, we maintain our construction of “boundary lens” as “the last lens element of the projection optical system.”

2. “a refractive index . . . is 1” (claim 1)

Carl Zeiss contends that “a refractive index . . . is 1” should be interpreted as “equal to 1 to within at least the first decimal place.” Pet. 14. Carl Zeiss’s proposal is consistent with the ’575 patent’s use of the first decimal place later in claim 1 (“having a refractive index la[r]ger than 1.1”). Specifically, the use of the first decimal place—i.e., “1.1”—elsewhere in the claim implies that the recited “1” means “1.0;” otherwise the first decimal place—i.e., the first digit to the right of the decimal—would have been

specified there as well. Carl Zeiss's proposal is also consistent with the examples in the Specification of the atmosphere in the projection optical system being an inert gas, such as helium or nitrogen, which has a refractive index close to, but not exactly, equal to 1. Ex. 1001, 20:24–44; *see also* Ex. 1016 ¶¶ 86–92. Accordingly, we construe “a refractive index . . . is 1” as “a refractive index . . . equal to 1 within at least the first decimal place.”

3. *“effective imaging area” (claim 1)*

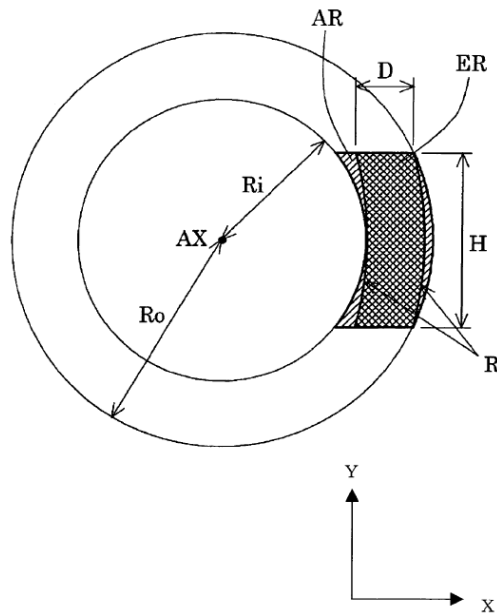
Carl Zeiss contends that “effective imaging area” should be interpreted to mean the same thing as “effective exposure area” and “effective exposure region ER.” Pet. 15. The '575 patent states that “FIG. 2 is an illustration showing a positional relation between the optical axis and an effective exposure area of arcuate shape,” and that “an effective exposure region (effective imaging area) ER is set in an arcuate shape.” Ex. 1001, 19:65–20:9 (emphasis removed). Based on our review of the Specification, we agree that these terms are used interchangeably.

4. *“every effective imaging area” (claim 18)*

Carl Zeiss contends that “every effective imaging area” should be interpreted to mean “the effective imaging area formed on the second surface as the final image, as well as effective imaging areas corresponding to any intermediate images.” Pet. 15. The term “every effective imaging area” is not used in the '575 patent outside of claim 18. As support for its position, Carl Zeiss cites only to the Declaration of Richard C. Juergens. *Id.* (citing Ex. 1016 ¶ 93). The '575 patent describes an “effective imaging area” and describes “intermediate images,” but does not describe “effective imaging areas corresponding to any intermediate images.” Specifically, the

“effective imaging area” is the arcuate shape formed on a wafer, as depicted in Figure 2, reproduced below.

Fig.2



Ex. 1001, Fig. 2, 19:65–20:23. Figure 2 depicts the “effective imaging area” as an arcuate shape formed on a wafer. In contrast, “intermediate images” are images of the reticle formed on various components of the first imaging optical system and second imaging optical system. *See, e.g.*, Ex. 1001, 21:56–67. Because the ’575 patent refers only to an area on a wafer as the “effective imaging area,” and never once refers to an intermediate image as having a corresponding effective imaging area, Carl Zeiss has not presented sufficient and credible evidence that patentee intended “every effective imaging area” to encompass “effective imaging areas corresponding to any intermediate images.” Based on our review of the Specification, “every effective imaging area” refers to all of the effective imaging areas of the claimed projection optical system, of which there is only one: the “effective imaging area” recited in claim 1. Accordingly, we construe “every effective

imaging area” as commensurate in scope with the “effective imaging area” recited in claim 1.

5. “the second imaging optical system” (claim 25)

Carl Zeiss contends that “the second imaging optical system” should be interpreted to mean the “second lens unit” recited in claim 10. Pet. 15–16. We disagree. Claim 25 recites “wherein the second imaging optical system is a dioptric system consisting of only a plurality of transmitting members.” Claim 25 depends from claims 1 and 10. However, neither claim 1 nor claim 10 recites a “second imaging optical system.” The Specification is ambiguous. The ’575 patent does not describe *only* a “second imaging optical system” or *only* a “second lens unit” as “consisting of only a plurality of transmitting members.” All described embodiments of the “second lens unit” described in the ’575 patent “consist[] only of a plurality of transmitting members.” Ex. 1001, Figs. 5, 7, 9, 14, 15, 16. Some, but not all, embodiments of the “second imaging optical unit” are “dioptric systems consisting of only of a plurality of transmitting members.” See, e.g., Ex. 1001, Fig. 5 (second imaging optical system G2 consisting only of lenses), Fig. 7 (second imaging optical system G2 consisting only of lenses), Fig. 14 (second imaging optical system G2 consisting only of lenses), Fig. 15 (second imaging optical system G4 consisting only of lenses), Fig. 16 (second imaging optical system G6 consisting only of lenses). At least one embodiment of the “second imaging optical system” is not. Ex. 1001, Fig. 9 (second imaging optical system G2 including two reflecting mirrors M3 and M4).

Claims 20, 21, 22, 23, 24, and 26 all depend, directly or indirectly, from claim 19. Claim 19 recites a “first imaging optical system” and a “second imaging optical system.” Claim 20 depends from claim 19 and defines further limitations on the “first imaging optical system” recited in claim 19. In this context, claim 25’s recitation of “[t]he projection optical system according to claim 10” (emphasis removed) appears to be a typographical error in which “10” should be “19” or “20.” Accordingly, we construe “the second imaging optical system” to mean the “second imaging optical system” recited in claim 19.

B. Whether Mr. Juergens is an Expert

Nikon contends that, “[b]ecause of the highly specialized nature of projection optical systems,” the level of ordinary skill in the art would have required at least two years of experience in the lithography optics industry and experience in the specification of projection optical systems. PO Resp. 15–16. Nikon further contends that Mr. Juergens is not an expert in the relevant field because he does not have the experience required to be a person of even ordinary skill in the art.³ *Id.* at 35–38.

Carl Zeiss counters that Nikon’s expert, Dr. Jose Sasian, invites Mr. Juergens to guest lecture Dr. Sasian’s class on lens design, and that Dr. Sasian conceded that Mr. Juergens is an expert on many aspects of optical design. Reply 13, n.2.

³ Nikon also asserts that exclusion of Mr. Juergens’ testimony would be justified. PO Resp. 38. Nikon does not, however, move to exclude either the Declaration of Mr. Juergens submitted with the Petition (Ex. 1016) or the Declaration of Mr. Juergens submitted with the Reply (Ex. 1036). Paper 32.

Having considered the parties' arguments and evidence, we are not persuaded that the level of ordinary skill in the art required at least two years of experience in the lithography optics industry and experience in the specification of projection optical systems. The claims are not limited to the field of lithography. Rather, based on the art of record, we find that the relevant field is projection optical systems. Mr. Juergens holds an M.A. in Physics and has more than 40 years of experience in the field of optical system design, including catoptric, dioptric, and catadioptric systems. Ex. 1016 ¶¶ 3–9. Accordingly, we are persuaded that Mr. Juergens is a person of at least ordinary skill in the art in the art of projection optical systems.

*C. Claims 1–3, 8–12, 16–20, 23–26, 29, and 31–33 –
Obvious over Terasawa and the Immersion References*

Carl Zeiss alleges that claims 1–3, 8–12, 16–20, 23–26, 29, and 31–33 are unpatentable under 35 U.S.C. § 103(a) over Terasawa and the Immersion References. Pet. 31–50, 55–56. Carl Zeiss cites Terasawa as teaching every limitation, but acknowledges that Terasawa does not disclose expressly “an optical path between the boundary lens and the second surface is filled with a medium having a refractive index larger than 1.1,” as recited in claim 1. *Id.* at 34, 55. For that limitation, Carl Zeiss cites to the Immersion References (Suwa, Switkes, Ulrich, and Fukami). *Id.* at 36, 44–50, 55–56.

Nikon counters that (1) Terasawa and the Immersion References do not teach, suggest, or otherwise render obvious a “boundary lens,” as properly construed; (2) a person of ordinary skill in the art would not have had a reasonable expectation of success in combining the references; and (3) secondary considerations demonstrate nonobviousness. PO Resp. 38–47.

Upon consideration of the parties' contentions and supporting evidence, we determine that Carl Zeiss has demonstrated by a preponderance of the evidence that claims 1–3, 8–12, 16–20, 23–26, 29, and 31–33 are unpatentable as obvious over Terasawa and the Immersion References. Pet. 31–50, 55–56. In our discussion below, we address Nikon's arguments presented in the Patent Owner Response.

Terasawa (Ex. 1008)

Terasawa describes a projection optical system and a projection exposure apparatus for projecting a pattern of a mask onto a substrate through the projection optical system. Ex. 1008 ¶ 1. Figure 1 of Terasawa, reproduced below, depicts a catadioptric projection optical system including a first imaging system G1 and a second imaging system G2 for projecting an image of reticle 101 illuminated with illumination system (not shown) onto wafer 102:

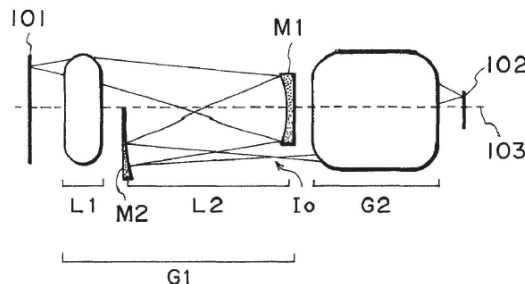


FIG. 1

Figure 1 of Terasawa depicts a catadioptric projection optical system. *Id.* ¶¶ 55, 102, 103. “The first imaging optical system G1 comprises, in order from the object side, at least a first mirror M1, having a refracting element L1, [and] a second mirror M2.” *Id.* ¶ 103. Light from reticle 101 is imaged by first imaging optical system G1, whereby intermediate image Io is formed. *Id.* Intermediate image Io, as imaged by first imaging optical

system G1, is then imaged on wafer 102 by second imaging optical system G2, comprising a refracting element, at a predetermined magnification. *Id.* In the structure described above, the optical system of the first embodiment has one optical axis 103, and produces a multiple-number imaging optical system wherein abaxial light, without light interception of a pupil, is imaged. *Id.* With the structure described above, light can be directed to the second imaging optical system without a void in a pupil and without bend of the optical axis. *Id.* ¶ 105. The region of the object plane from which the light reaches the image plane, and which is attributable to the imaging, is a semi-arcuate zone. *Id.* at Fig. 3, ¶ 117.

Suwa (Ex. 1009)

Suwa describes “a means for improving the resolution without largely increasing the numerical aperture of the projection optical system,” in which “an immersion projection method may be used in which the space between the wafer and the projection optical system is filled with a liquid.” Ex. 1009, 3:18–23. Specifically:

In this immersion projection method, the air space between the wafer and the optical element constituting the projection optical system on the projection end side (image plane side) is filled with a liquid having a refractive index close to the refractive index of the photoresist layer, to increase the effective numerical aperture of the projection optical system seen from the wafer side, i.e. improving the resolution. This immersion projection method is expected to attain good imaging performance by selecting the liquid used.

Id. at 3:24–33. Figure 9 of Suwa is reproduced below:

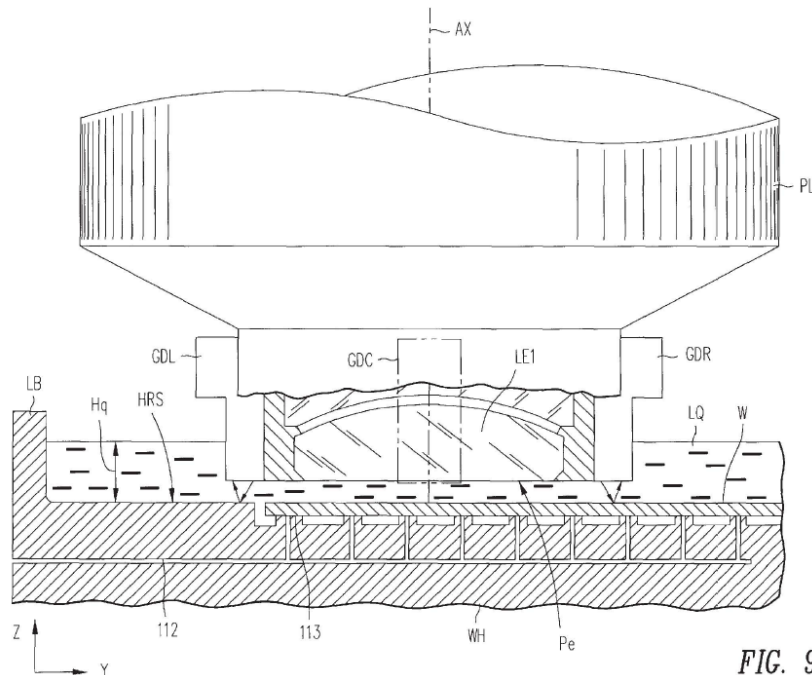


FIG. 9

Figure 9 of Suwa depicts a projection optical system (PL) with an immersion fluid (LQ). *Id.* at 23:59-65. Suwa discloses that the last lens element, LE1, is a “positive lens element [] having a flat lower surface Pe and a convex upper surface,” and “is fixed on the end of the projection lens system PL inside the lens barrel.” *Id.* at 23:9–11. Suwa also discloses that the projection optical system can be catadioptric. *Id.* at 20:13–21. Carl Zeiss acknowledges that Suwa does not disclose expressly that the liquid has a refractive index greater than 1.1, but contends that:

[A person of ordinary skill in the art] would know that “a refractive index close to the refractive index of the photoresist” would be a refractive index greater than 1.1. For example, U.S. Patent No. 4,346,164 (“Tabarelli”), to which the passage from Suwa cited above expressly refers, identifies the refractive index of the photoresist as 1.6, and goes on to list nine immersion liquids with refractive indices between 1.5 and 1.66. (ZEISS 1016; ¶¶ 199-201; ZEISS 1025, 3:57-60, 5:36-50.)

Pet. 45. We are persuaded by Carl Zeiss’s reasoning.

Switkes (Ex. 1010)

Switkes teaches that immersion lithography can be used to enhance resolution by increasing numerical aperture and also can be used to increase depth of focus. Ex. 1010, 459 (“Immersion lithography is a technique which can enhance the resolution of projection lithography by permitting exposures with numerical aperture (NA) greater than one, the theoretical maximum for conventional ‘dry’ systems. . . . Liquid immersion also increases the wafer depth of focus, i.e. the tolerable error in the vertical position of the wafer, by the index of the immersion liquid compared to a dry system *with the same numerical aperture.*”) (footnotes omitted). Switkes describes several immersion liquids for use at 157 nm and 193 nm whose refractive indexes are greater than 1.2. *Id.* at 461. Switkes describes how immersion can be used with “much of conventional designs.” *Id.*

Ulrich (Ex. 1011)

Ulrich describes the application of immersion lithography to prior art “dry” designs to achieve increased numerical aperture. Ex. 1011, 166–167. Ulrich expressly teaches that “immersion designs can be applied to other design concepts such as catadioptric designs with similar results.” *Id.* at 167.

Fukami (Ex. 1015)

Fukami describes the use of liquid immersion to improve the resolution of conventional projection exposure apparatuses. Ex. 1015, 3:13–28.⁴ Fukami expressly describes the applicability of immersion techniques

⁴ Page numbers refer to the bottom number on the page.

to a catadioptric optical projection system having two mirrors and a single optical axis. *Id.* at 21:13–16 (“Furthermore, the projection optical system PL can be a dioptric, catoptric, or catadioptric system, for example an optical system which has a plurality of dioptric elements and two catoptric elements (at least one of which is a concave mirror) disposed on an optical axis extending straight without being bent . . .”).

Boundary lens

Nikon contends that Terasawa’s last lens immediately prior to wafer 102 is not a “boundary lens” as construed by Nikon because it does not increase numerical aperture by reducing reflection loss. PO Resp. 38–39. We decline to adopt Nikon’s proposed construction of “boundary lens” for the reasons discussed above. Based on our construction of boundary lens, Terasawa’s last lens immediately prior to wafer 102 is a “boundary lens” because it is the last lens element of the projection optical system. Pet. 36.

Reason to combine and reasonable expectation of success

Carl Zeiss contends that “Ulrich demonstrates that the level of ordinary skill in this art is high and how, at the time of the alleged invention, there was not only express teaching to modify prior art ‘dry’ catadioptric projection optical system to include the immersion limitation to thereby increase NA, but also the skill necessary to do so.” Pet. 48 (citing Ex. 1016 ¶¶ 22–24, 77–81, 223–224).

Nikon contends that a person of ordinary skill in the art would not have had a reasonable expectation of success in combining the references because introducing an immersion liquid into a dry projection optical system such as Terasawa’s would create technical problems that would render it

inoperative. *Id.* at 39 (citing Ex. 2024 ¶¶ 119, 120). Specifically, Nikon argues that neither increasing NA nor increasing DOF would have led a person of ordinary skill in the art to combine the references because (1) adding an immersion liquid to Terasawa would cause technical problems that would have required undue experimentation and design to solve; and (2) a person of ordinary skill in the art would not have increased DOF at the expense of NA. *Id.* at 40–43. Carl Zeiss counters that nothing in claim 1 or the '575 patent addresses the problems identified by Nikon, and that Nikon's expert, Dr. Sasian, conceded that a person of ordinary skill in the art could have addressed those challenges at the time of the invention. Reply 6–7 (citing Ex. 1033).

Having reviewed the parties' contentions and evidence, we are persuaded that a person of ordinary skill in the art would have had a reasonable expectation of success in combining the references. Nikon's argument assumes that a person of ordinary skill in the art would introduce an immersion liquid into the dry projection optical system of Terasawa without any further modification. In the Petition, however, Carl Zeiss argued that "Ulrich also demonstrates that a POSITA at the time of the alleged invention *would have been able to modify* the systems . . . to include the immersion liquid to increase NA." Pet. 52 (emphasis added). Ulrich teaches, for example, that "the high-NA dry projection lenses were not taken as a straight forward starting point but well-known and proven know-how of design history was fallen back on," and that routine optimizations ("scaling of the two partial focus widths," "splitting thick lenses," and "adding aspheres") can be used to achieve the level of performance desired for

projection microlithography. Ex. 1011, 166; Reply 10 (citing Ex. 1016 ¶¶ 220, 221). Thus, Nikon's assumption is improper. In any event, the technical problems identified by Dr. Sasian relate to the need to characterize the optical properties of an immersion fluid, and Dr. Sasian concedes that the experiments necessary to do so were "comparable" to the techniques known and used to characterize materials such as silica glass. *See, e.g.*, Ex. 1033, 80:13–87:13. Accordingly, we are persuaded that a person of ordinary skill in the art at the time would have had a reasonable expectation of success in combining Terasawa and the Immersion References.

Secondary considerations

Factual inquiries for an obviousness determination include secondary considerations based on evaluation and crediting of objective evidence of nonobviousness. *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17 (1966). Notwithstanding what the teachings of the prior art would have suggested to one with ordinary skill in the art at the time of the '575 patent's invention, the totality of the evidence submitted, including objective evidence of nonobviousness, may lead to a conclusion that the challenged claims would not have been obvious to one with ordinary skill in the art. *In re Piasecki*, 745 F.2d 1468, 1471–72 (Fed. Cir. 1984). Secondary considerations may include any of the following: long-felt but unsolved needs, failure of others, unexpected results, commercial success, copying, licensing, and praise. *See Graham*, 383 U.S. at 17; *Leapfrog Enters., Inc. v. Fisher-Price, Inc.*, 485 F.3d 1157, 1162 (Fed. Cir. 2007).

To be relevant, evidence of nonobviousness must be commensurate in scope with the claimed invention. *In re Kao*, 639 F.3d 1057, 1068 (Fed. Cir.

2011) (citing *In re Tiffin*, 448 F.2d 791, 792 (CCPA 1971)); *In re Hiniker Co.*, 150 F.3d 1362, 1369 (Fed. Cir. 1998). In that regard, in order to be accorded substantial weight, there must be a nexus between the merits of the claimed invention and the evidence of secondary considerations. *In re GPAC Inc.*, 57 F.3d 1573, 1580 (Fed. Cir. 1995). “Nexus” is a legally and factually sufficient connection between the objective evidence and the claimed invention, such that the objective evidence should be considered in determining nonobviousness. *Demaco Corp. v. F. Von Langsdorff Licensing Ltd.*, 851 F.2d 1387, 1392 (Fed. Cir. 1988). The burden of showing that there is a nexus lies with the patent owner. *Id.*; see *In re Paulsen*, 30 F.3d 1475, 1482 (Fed. Cir. 1994).

Nikon alleges that there was a long-felt need in the semiconductor industry for higher resolution, and that the ’575 patent met that need. PO Resp. 43–45. Specifically, Nikon cites Figure 53 of the 2003 Edition of the International Technology Roadmap for Semiconductors, and asserts that “there is no evidence of record that the industry need for [the 65 nm and 45 nm technology nodes] had been met prior to the invention in the 575 Patent.” *Id.* at 44. Nikon, however, bears the burden of establishing that the long-felt need for higher resolution was unmet. Figure 53 indicates that development was underway for the 65 nm and 45 nm technology nodes, but does not provide any indication of the state of immersion lithography. Accordingly, Nikon has not provided persuasive evidence that the alleged need was long-felt and unmet prior to the invention of the ’575 patent.

Nikon also alleges that the initial skepticism toward immersed catadioptric systems is evidence of the nonobviousness of claim 1. *Id.* at

45–46. Nikon’s argument is predicated on the “surprise” expressed in a paper authored by employees of Carl Zeiss. *Id.* at 46 (citing Ex. 2005, 3:9, 3:12, 5:28). Carl Zeiss counters that the “surprise” expressed in the article relates to a folded design that Nikon’s expert, Dr. Sasian, concedes is outside the scope of claim 1, and to the introduction of intermediate images without increasing the volume and weight of the lens, which Dr. Sasian concedes is not a limitation of claim 1. Reply 11 (citing Ex. 2005, 3, 5). Having reviewed the parties’ contentions and evidence, we are not persuaded that the “surprise” expressed in the paper is evidence of initial skepticism towards the immersed catadioptric projection optical system recited in claim 1.

Finally, Nikon alleges acceptance and copying on the grounds that a 2003 paper by Nikon employees is cited in a 2005 paper by Carl Zeiss employees. PO Resp. 46 (citing Ex. 2005, 8:19–20). None of the evidence submitted by Nikon, however, demonstrates that a Carl Zeiss product falls within the scope of any claim of the ’575 patent, that Carl Zeiss was aware of the ’575 patent prior to developing its product, or that Carl Zeiss developed its product by copying the ’575 patent.

After weighing all of the evidence of obviousness and nonobviousness of record, on balance, we conclude that the strong evidence of obviousness outweighs the weak evidence of non-obviousness.

Whether Terasawa and the Immersion References are enabling

Nikon contends that the combination of Terasawa and the Immersion References fails to enable a person of ordinary skill in the art to make and use the subject matter of claim 1 of the ’575 patent. PO Resp. 25–35.

Specifically, Nikon argues that the proposed combination does not enable claim 1 because (1) a significant quantity of experimentation was necessary, as evidenced by the lapse of more than one year from the publication of Ulrich to the filing of Carl Zeiss's first provisional application directed to a catadioptric immersion system; (2) the Immersion References do not provide adequate direction or guidance because none of them contain prescription tables for an immersed catadioptric projection optical system; (3) the nature of the invention is such that in 2003 the industry projected that development of an immersion lithography system would take two more years; (4) a person with at least two years of experience in lithography optics and projection optical systems would not have been able to make and use the claimed invention because even a much more experienced person—Mr. Wilhelm Ulrich of Carl Zeiss—had not done so before the subject matter of the '575 patent was invented; and (5) projection optical systems present unpredictable design problems, such as beam separation, field height, and color correction, as evidenced by the 2005 paper authored by employees of Carl Zeiss. *Id.*

Carl Zeiss counters that the prior art need enable only a single embodiment within the scope of claim 1, not the full scope of the claim, and that Nikon and Dr. Sasian's arguments about the alleged shortcomings are not commensurate with the limitations recited in claim 1. Reply 5–6.

We have reviewed Nikon's argument and supporting evidence, as well as the responsive argument and supporting evidence of Carl Zeiss, and are unpersuaded that the combined teachings of Terasawa and the Immersion References would not have enabled one with ordinary skill in the art to make a catadioptric projection optical system with a single optical axis in which

the optical path between the boundary lens and the surface on which the image is projected is filled with a medium having a refractive index larger than 1.1 without undue experimentation.

The issue is whether the amount of required experimentation is undue, not whether any experimentation is necessary. *In re Vaeck*, 947 F.2d 488, 495 (Fed. Cir. 1991). *In re Angstadt*, 537 F.2d 498, 504 (CCPA 1976). The factors suitable for consideration include (1) the quantity of experimentation necessary, (2) the amount of direction or guidance presented, (3) the presence or absence of working examples, (4) the nature of the invention, (5) the state of the prior art, (6) the relative skill of those in the art, (7) the predictability or unpredictability of the art, and (8) the breadth of the claims. *See In re Wands*, 858 F.2d 731, 737 (Fed. Cir. 1988).

With respect to quantity of experimentation, neither Nikon nor Dr. Sasian explain with sufficient specificity what and how much experimentation would have been required by one with ordinary skill, and why that amount of experimentation should be regarded as undue. PO Resp. 31 (citing Exs. 2020; 2024 ¶¶ 106, 107). Nikon argues that more than one year passed between the publication of Ulrich in 2002 and the filing of Carl Zeiss's first provisional application directed to a catadioptric immersion system. We understand Nikon to be arguing that the amount of experimentation should be inferred to be undue based on the passage of more than one year. Even assuming that Carl Zeiss was experimenting during that time period, however, there is not sufficient evidence that the amount of experimentation was undue; it may have been only complex. The fact that experimentation may be complex does not necessarily make it

undue if those of skill in the art typically engage in such experimentation. *In re Wands*, 858 F.2d at 737.

With respect to the amount of direction or guidance, Nikon's argument that none of the Immersion References include prescription tables for a projection optical system is not persuasive. PO Resp. 31. The Immersion References are not relied upon to teach a catadioptric projection optical system so those references would not be expected to include a prescription table for a catadioptric projection optical system. Moreover, claim 1 does not recite a prescription table and Nikon does not explain persuasively why a person of ordinary skill in the art could not have modified a prescription table taught in Terasawa.

With respect to the nature of the invention and the state of the prior art, Nikon argues that Figure 53 of the 2003 International Technology Roadmap for Semiconductors (Ex. 2003) indicates that "for the 65 nm node, the narrowing of options for immersion lithography was not expected until 2004, and the qualification and pre-production states were not expected until 2005." PO Resp. 32. Figure 53 depicts, however, a narrowing of options for the 65 nm node generally, not for immersion lithography in particular. Moreover, the Roadmap takes into account challenges beyond just the construction of a projection optical system. Many of the "Difficult Challenges" identified by the Technology Roadmap, for example, relate to factors other than the projection optical system, such as mask requirements and resist requirements. Ex. 2003, 4. Accordingly, there is not sufficient evidence that the narrowing of options and the move to qualification and pre-production states shown in Figure 53 was driven by the amount of

experimentation required by a person of ordinary skill in the art to make and use an immersed catadioptric projection optical system.

With respect to the relative skill of those in the art, the fact that Mr. Ulrich recognized in 2002 that “parallel work must be performed on solving the technological challenges” (Ex. 1011, 167) does not establish that such work required undue experimentation. Even assuming that the experimentation required to solve the technological challenges referred to would be complex, it is not necessarily undue if those of skill in the art typically engage in such experimentation. *In re Wands*, 858 F.2d at 737.

Finally, with respect to the predictability of the art, the Carl Zeiss paper does not establish sufficiently that resolution of the problems identified required undue experimentation. In some cases the paper describes how each of the design problems was resolved by known techniques, such as a “concept that has already been studied for lithography” (Ex. 2005, 2), or “the rule [to] ‘separate the beams directly at intermediate images’” (*id.* at 5). Although the authors expressed “surprise” at results with folded designs, such designs are outside the scope of claim 1. Reply 11. The only surprise expressed by the authors with respect to inline systems (like claim 1 of the ’575 patent) is that “the introduction of additional intermediate images, which enhances the system complexity at the first glance, *does not increase volume or weight of the lens*. In some cases, the results even surpass the ‘simpler’ designs.” Ex. 2005, 5 (emphasis added). The surprise, therefore, related to the volume and weight of the lens, not to whether an immersed catadioptric projection optical system could be made. Moreover, with respect to design challenges identified elsewhere in Nikon’s

Patent Owner Response, Dr. Sasian conceded that the experiments necessary to characterize the optical properties of an immersion fluid were “comparable” to the techniques known and used to characterize materials such as silica glass. *See, e.g.*, Ex. 1033, 80:13–87:13.

For all of the foregoing reasons, Nikon has not demonstrated adequately that Terasawa and the Immersion References are non-enabling prior art.

Conclusion

For the foregoing reasons, we determine that Carl Zeiss has demonstrated by a preponderance of the evidence that claims 1–3, 8–12, 16–20, 23–26, 29, and 31–33 are unpatentable under 35 U.S.C. § 103(a) as obvious over Terasawa and the Immersion References.

D. Claim 30 – Obvious over Terasawa, the Immersion References, and Asai

Carl Zeiss alleges that claim 30 is unpatentable under 35 U.S.C. § 103(a) over Terasawa, the Immersion References, and Asai. Pet. 59–60. Carl Zeiss acknowledges that Terasawa does not disclose expressly “illumination light which is s-polarized with respect to the second surface,” as recited in claim 30 (*id.* at 59), but cites Asai for teaching that feature. *Id.* at 59–60.

Nikon counters that claim 30 would not have been obvious over Terasawa, the Immersion References, and Asai because Asai does not cure the alleged deficiencies of Terasawa and the Immersion References with respect to independent claim 1, from which claim 30 depends ultimately. PO Resp. 47.

Asai describes the use of S-polarized light in a high-numerical-aperture optical stepper system. Ex. 1013, Abstract. Specifically, Asai describes how “[l]ight polarized parallel to the plane of incidence, or P polarization, gives lower contrast images than light polarized perpendicular to the plane of incidence, or S polarization, because destructive interference between diffracted waves does not occur when the electric-field vectors are perpendicular.” *Id* at 5863 (footnotes omitted).

Upon consideration of the parties’ contentions and supporting evidence, we determine that Carl Zeiss has demonstrated by a preponderance of the evidence that claim 30 is unpatentable as obvious over Terasawa, the Immersion References, and Asai. Pet. 59–60.

As discussed above, we are not persuaded by Nikon’s arguments that Terasawa and the Immersion References do not teach the limitations of independent claim 1, from which claim 30 depends ultimately.

For the foregoing reasons, we determine that Carl Zeiss has demonstrated by a preponderance of the evidence that claim 30 is unpatentable under 35 U.S.C. § 103(a) as obvious over Terasawa, the Immersion References, and Asai.

E. Carl Zeiss’s Motion to Exclude

The party moving to exclude evidence bears the burden of proof to establish that it is entitled to the relief requested—namely, that the material sought to be excluded is inadmissible under the Federal Rules of Evidence. *See* 37 C.F.R. §§ 42.20(c), 42.62(a). For the reasons discussed below, Carl Zeiss’s Motion to Exclude is denied.

Carl Zeiss's Motion to Exclude seeks to exclude (1) Exhibits 2036–2039; (2) the portions of Mr. Juergens' second cross-examination (Ex. 2040) directed to those exhibits; (3) the Second Declaration of Dr. Sasian (Ex. 1054); and (4) portions of Patent Owner's Motion for Observation Regarding Second Cross Examination of Richard C. Juergens (Paper 30) as lacking authentication (FRE 901), inadmissible hearsay (FRE 802), and untimely. Paper 33.

We decline to assess the merits of Carl Zeiss's Motion to Exclude. As discussed above, even without excluding the identified evidence, we have concluded that Carl Zeiss has demonstrated by a preponderance of the evidence that the challenged claims are unpatentable. Accordingly, Carl Zeiss's Motion to Exclude is *dismissed* as moot.

F. Nikon's Motion to Exclude

Nikon's Conditional Motion to Exclude seeks to exclude Exhibits 1036 and 1038–1049 only if we grant Carl Zeiss's Motion to Exclude Nikon's Exhibits 2036–2039. Paper 32, 1. As discussed above, Carl Zeiss's Motion to Exclude is dismissed as moot. Accordingly, we need not reach Nikon's Conditional Motion to Exclude.

III. CONCLUSION

Carl Zeiss has met its burden of proof by a preponderance of the evidence in showing that claims 1–3, 8–12, 16–20, 23–26, and 29–33 of the '575 patent are unpatentable based on the following grounds of unpatentability:

References	Basis	Claim[s] challenged
Terasawa and the Immersion References	§ 103	1–3, 8–12, 16–20, 23–26, 29, and 31–33
Terasawa, the Immersion References, and Asai	§ 103	30

IV. ORDER

Accordingly, it is

ORDERED that claims 1–3, 8–12, 16–20, 23–26, and 29–33 of the '575 patent are held unpatentable;

FURTHER ORDERED that Carl Zeiss's Motion to Exclude is *denied*;

FURTHER ORDERED that Nikon's Motion to Exclude is *dismissed*;
and

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

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