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FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte JOHANNES RUOFF
and HEIKE FELDMANN

Appeal 2016-005906
Application 13/789,773
Technology Center 2800

Before LINDA M. GAUDETTE, JEFFREY R. SNAY, and MERRELL C. CASHION, JR., *Administrative Patent Judges*.

GAUDETTE, *Administrative Patent Judge*.

DECISION ON APPEAL[1]

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[1] This Decision includes citations to the following documents: Specification filed Mar. 8, 2013 ("Spec."); Final Office Action dated July 14, 2015 ("Final"); Appeal Brief filed Sept. 15, 2015 ("Appeal Br."); Examiner's Answer dated Apr. 4, 2016 ("Ans."); and Reply Brief filed May 12, 2016 ("Reply Br.").

Appellant[2] appeals under 35 U.S.C. § 134(a) from the Examiner's decision finally rejecting claims 1–3 and 7–24 under 35 U.S.C. § 103(a) as unpatentable over Murakami et al. (US 6,522,717 B1, issued Feb. 18, 2003 (hereinafter "Murakami")) in view of Bleeker et al. (US 2008/0137053 A1, published June 12, 2008 (hereinafter "Bleeker")). We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM-IN-PART.

The invention relates to "a mirror for [extreme ultra-violet (EUV)[3]] radiation which results in improved optical quality when used in an EUV projection exposure system." Spec. 1:25–26. An EUV projection exposure system is shown in Figure 1, reproduced below.

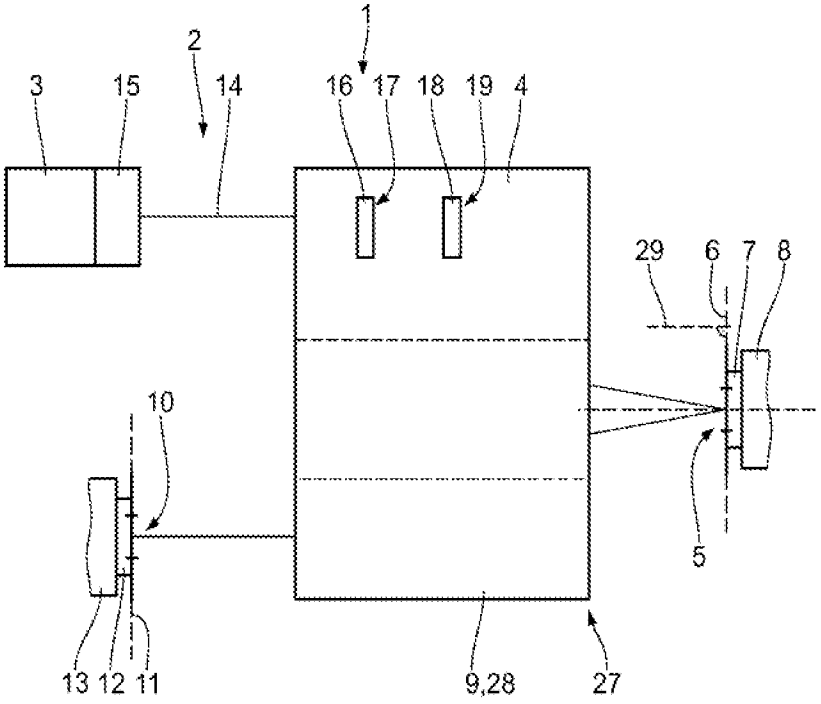

Fig. 1

[2] Appellant is the Applicant and real party in interest, Carl Zeiss SMT GmbH. *See* Appeal Br. 1.

[3] *See* Bleeker ¶ 39.

"Fig[ure] 1 schematically shows, in a meridional section, the components of a projection exposure system 1 for microlithography." Spec. 7:26–27. Projection exposure system 1 includes illumination system 2 and projection optical system 9. *See id.* at 7:26–33. Illumination system 2 includes beam source 3 which emits EUV radiation 14, and illumination optical system 4 for exposing object field 5, having reticle 7 arranged therein. *Id.* at 7:27–29, 8:4. Illumination optical system 4 includes field facet mirror 16 having a large number of field facets 17, and is arranged in a plane of illumination optical system 4, which is optically conjugated to object plane 6. *Id.* at 8:15–17. EUV radiation 14 is reflected by field facet mirror 16 to pupil facet mirror 18 of illumination optical system 4. *Id.* at 8:17–18. Pupil facet mirror 18 has a large number of pupil facets 19, each of which is associated with one of field facets 17. *Id.* at 8:18–23. Projection optical system 9 is used to image object field 5 in image field 10, having wafer 12 arranged therein. *Id.* at 7:32–8:1. Projection optical system 9 includes at least three projection mirrors. *Id.* at 9:18–29. Mirror 20 has mirror body 21 with mirror face 24 with a large number of EUV radiation-permeable regions 22, configured as through-openings in mirror body 21, and respective associated EUV radiation-reflecting regions 23. *Id.* at 9:25–27, 10:9–10. EUV radiation 14 from a light channel configured between one of field facets 17 and pupil facets 19 passes through an associated one of EUV radiation-permeable regions 22 of mirror 20, is reflected on reticle 7 and impinges in the region of pupil plane 26 (which is an exit pupil plane of illumination optical system 4 and an entry pupil plane of projection optical system 9) on one of radiation-reflecting regions 23 that is conjugated to the associated one of EUV radiation-permeable regions 22, from which EUV radiation is further reflected via projection optical system 9. *Id.* at 12:17–23.

The Specification discloses that, "[a]s an alternative to use in a projection exposure system, the mirror 20 . . . can also be used in an inspection device, in particular for inspecting reflective lithography masks or to inspect exposed wafer substrates. *Id.* at 15:5–7. Figure 8, reproduced below, shows mirror 20 in combination with Schwarzschild lens system 30. *Id.* at 15:10–12.

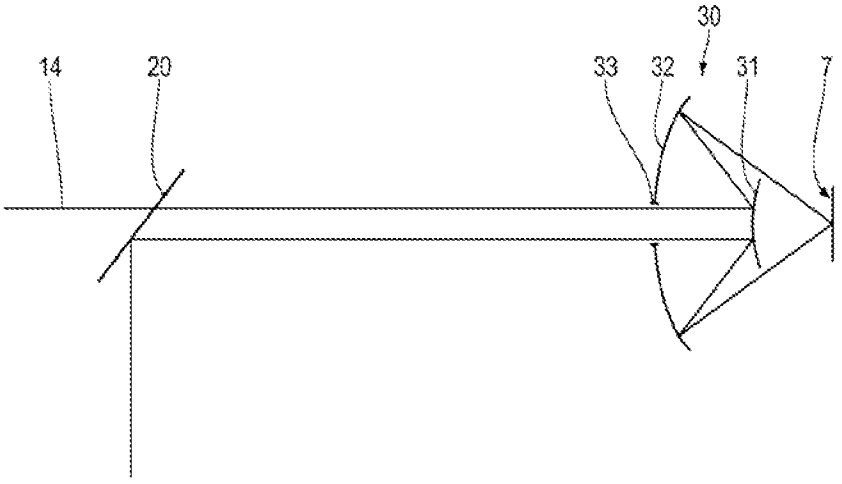

Fig. 8

As shown in Figure 8, above, Schwarzschild lens system 30 includes convex, primary mirror 31 and concave, secondary mirror 32. *Id.* at 15:12–14. Secondary mirror 32 has a through-opening 33 for EUV radiation 14. *Id.* at 15:14. In this system, mirror 20 may be provided as a folding mirror that can be arranged as part of the illumination optical system 4 in the beam path of projection optical system 9 or as part of projection optical system 9 in the beam path of illumination optical system 4. *Id.* at 15:16–19.

Of the appealed claims, claims 1 and 15 are independent. Claims 2, 3, 7–14, 20–22 and 24 depend from claim 1. Claims 16–19 and 23 depend from claim 15. Claims 1 and 15 are reproduced below.

1. A mirror, comprising:

a mirror body comprising a mirror face,

wherein:

the mirror face consists of at least one EUV radiation-reflecting region and at least five EUV radiation-permeable regions,

the radiation-permeable regions are arranged disconnectedly in the mirror face; and

the mirror is an EUV mirror.

15. An optical system, comprising:

a first optical system configured to illuminate an object field with EUV radiation, the first optical system comprising at least one pupil facet mirror, the EUV radiation in the first optical system having at least one specific beam course to produce a specific illumination setting; and

a second optical system configured to image the object field into an image field,

wherein:

the optical system comprises a mirror comprising at least five EUV radiation permeable regions in the beam path of the other optical system so that at least a part of the EUV radiation in this optical system is guided through the at least five EUV radiation-permeable regions; and

the mirror is close to a plane which is both an exit pupil plane of the first optical system and an entry pupil plane of the second optical system.

Appeal Br., Claims Appendix, 17–19.

The Specification cites Murakami as disclosing a known, X-ray microscope. Spec. 1:21–22. Murakami "relates to a reflective-type soft X-ray microscope in which reflected images of samples are observed using soft X-rays." Murakami 1:12–14. Murakami "also relates to a mask inspection device in which reflective

masks used in soft X-ray reduction projection exposure are inspected for defects using the . . . reflective-type soft X-ray microscope." *Id.* at 1:14–18. A schematic, structural diagram of a reflective type soft X-ray microscope according to Murakami's invention is illustrated in Figure 5, reproduced below. *Id.* at 6:48–50.

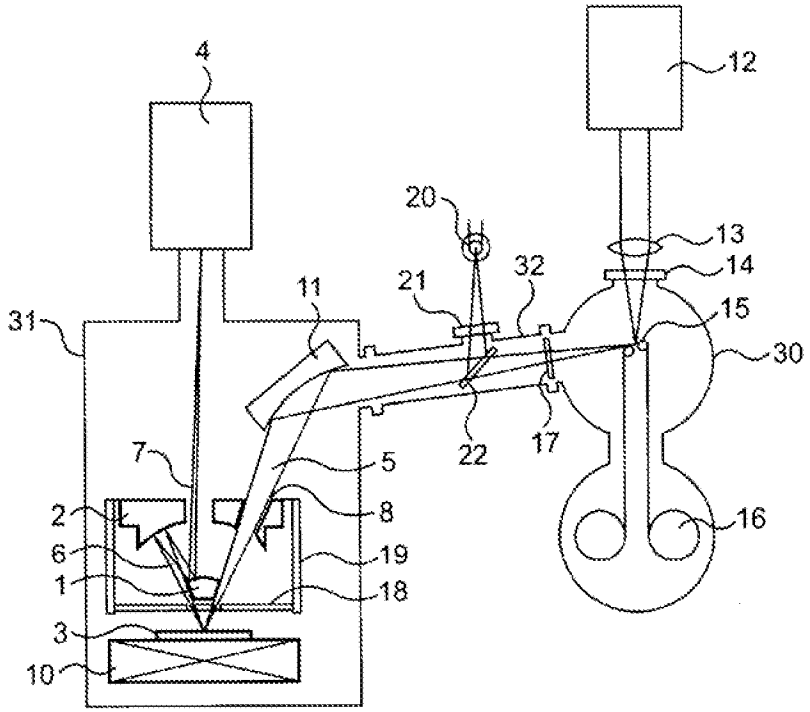

FIG. 5

Figure 5 shows a reflective-type X-ray microscope equipped with an image-focusing optical system constructed of a Schwarzschild optical system including convex mirror 1 and concave mirror 2, having concentric, spherical surface shapes. *Id.* at 10:44–48. The microscope further comprises an illumination optical system that includes laser light source 12 for generating pulsed laser light which is focused through lens 13, and directed via window 14 towards a target installed inside first vacuum chamber 30 to generate plasma 15, thereby generating soft X-rays. *Id.* at 10:55–60. The illumination optical system includes filter 17 and focusing reflective mirror 11. *Id.* at 10:48–50. The reflective-type, X-ray

microscope also includes sample stage 10, which carries and moves observation sample 3, and image detector 4. *Id.* at 10:45–54.

> The illuminating light 5 that illuminates the sample 3 is reflected by the surface of the sample 3, and becomes reflected light 6. After being further reflected by the concave mirror 2 and convex mirror 1, which constitute the Schwarzschild optical system, his reflected light passes through the opening part 7 formed in the center of the concave mirror 2, and is focused on the image detector 4 to form an image.

Id. at 11:48–55. Concave mirror 2 may have an opening part formed in only one location or a plurality of opening parts. *Id.* at 13:54–58

An embodiment of concave mirror 2 is illustrated in Figure 7, reproduced below:

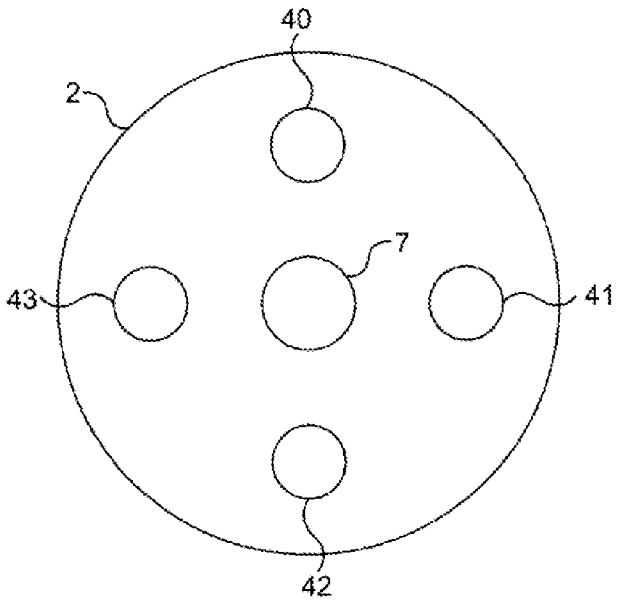

FIG. 7

Figure 7, above, shows concave mirror 2 having two opening parts [40, 41]. *Id.* at 13:58–59. Soft X-rays are introduced via opening part 40, and visible light or ultraviolet light is introduced via opening part 41. *Id.* at 13:59–62. "As a result of

this arrangement, switching between soft X-rays of the observation wavelength and visible light or ultraviolet light is facilitated. Furthermore, it is also possible to observe the sample simultaneously with soft X-rays of different wavelengths by introducing soft X-rays of different wavelengths via the respective opening parts." *Id.* at 13:62–67. "[A]n Mo/Si multi-layer reflective film that reflects soft X-rays with a wavelength of 13 nm is formed in the region 42 where the soft X-rays introduced via the opening part 40 are incident on the concave mirror 2 after being reflected by the sample." *Id.* at 14:6–10. "[A]n Mo/Be multi-layer reflective film that reflects soft X-rays with a wavelength of 11 nm is formed in the region 43 where the soft X-rays introduced via the opening part 41 are incident on the concave mirror 2 after being reflected by the sample." *Id.* at 14:11–15. "[R]eflected light passes through the opening part 7 formed in the center of the concave mirror 2, and is focused on [an] image detector 4 to form an image." *Id.* at 11:52–55.

Bleeker relates to a lithographic apparatus, i.e., a machine that applies a desired pattern onto a target portion of a substrate. Bleeker ¶ 5. The apparatus includes a radiation system for supplying a beam of radiation, which may be EUV radiation, a substrate table, a projection system for projecting an image onto a target portion of the substrate, and an array of individually controllable elements for applying a pattern to the beam. *Id.* ¶¶ 39, 45–48. A concave mirror reflects the radiation beam toward the front side of the individually controllable elements. *Id.* ¶ 63. In an embodiment shown in Figure 15, an illuminator directs radiation onto a folding mirror, which then directs radiation onto the patterning array. *Id.* ¶ 85. The folding mirror has a plurality of apertures corresponding to the plurality of individually controllable elements in the patterning array to allow the beamlets reflected by the elements to pass into the projection system. *Id.*

Independent claims 1 and 15; dependent claims 7, 8, 10, 12, 13, 16, 17 and 24

The Examiner finds Murakami discloses the invention as claimed in independent claim 1 with the exception of a mirror comprising "*at least five* EUV radiation-permeable regions" (Appeal Br. 17–18, Claims Appendix). Final 3–4. Murakami only explicitly discloses mirrors having up to three EUV radiation-permeable regions. Murakami, Figs. 1–4, 7; *see* Ans. 3; Appeal Br. 5; Final 3. The Examiner finds, however, that "providing a mirror with at least five EUV radiation-permeable regions is a mere function of the amount of beams or the amount of times, at different locations, the beams may need to pass through the mirror." Final 3. In support of this finding, the Examiner relies on Bleeker's disclosure of a lithographic system comprising a mirror having "a plurality of apertures corresponding to the plurality of individually controllable elements in the patterning array to allow the beamlets reflected by the elements to pass into the projection system" (Bleeker ¶ 85). Final 3. The Examiner determines "it would have been obvious to one of ordinary skill in the art to use the concept of providing a mirror with a plurality of apertures that corresponds to its desired function in [Murakami's] EUV projection optical system." *Id.* at 4.

Appellant asserts that "compared to Murakami, . . . Bleeker discloses a very different system with a very different mirror used for a very different reason." Appeal Br. 5. Appellant thus contends the Examiner neither has identified sufficient evidence nor adequately explained why the ordinary artisan would have modified Murakami based on Bleeker's disclosure. *Id.*

Appellant's argument is not persuasive for the reasons explained by the Examiner in the Answer. *See* Ans. 2–4. As an initial matter, as noted by the Examiner "claim 1 merely requires a mirror that is useable with EUV radiation and comprises at least five apertures and at least one reflecting region." *Id.* at 2. As

found by the Examiner, both Murakami and Bleeker disclose imaging systems comprising mirrors with various numbers of apertures and various numbers of reflecting regions that are usable with EUV radiation. *Id.* at 2–3. Although Murakami only explicitly discloses three apertures, two (40, 41) for receiving light of two different wavelengths and one (7) through which reflected light passes, we agree with the Examiner that Murakami clearly suggests the use of additional EUV radiation-permeable regions for receiving light having different wavelengths. *See* Murakami 13:64–67; Ans. 3 ("Murakami . . . establishes that providing a mirror with at least five EUV radiation-permeable regions is a mere function of the amount of beams or the amount of times, at different locations, the beams may need to pass through the mirror." (citing Murakami Figs. 1, 4)). Moreover, one of ordinary skill in the art would have had a reasonable expectation of success in modifying Murakami's mirror to include additional apertures as needed based on Bleeker's disclosure of an EUV mirror (92) that has at least five EUV radiation-permeable regions. Ans. 3–4. We are not persuaded by Appellant's argument that the Examiner has not explained how the mirror depicted in Bleeker Figure 15 could be incorporated into Murakami's system (*see* Reply Br. 3), because the rejection is not based on such modification and, even it were, "[i]t is well-established that a determination of obviousness based on teachings from multiple references does not require an actual, physical substitution of elements," *In re Mouttet*, 686 F.3d 1322, 1332 (Fed. Cir. 2012) (citations omitted). Accordingly, we are not persuaded of reversible error in the Examiner's conclusion of obviousness as to claim 1.

With respect to the additional limitations recited in independent claim 15, as well as the limitations in claim 13, which depends from claim 1, the Examiner finds Murakami Figure 5 shows a first optical system comprising pupil facet mirror

11, and configured to illuminate object field 3 with EUV radiation. Final 7. The Examiner further finds Murakami Figure 5 shows a second optical system configured to image object field 3 into image field 4. *Id.* The Examiner finds the second optical system comprises mirrors 1, 2 comprising at least one EUV radiation-permeable region (7, 8, 108, 105, 106, 40, 41) in the beam path of the first optical system. *Id.* at 7 (citing Murakami Figs. 1, 4, 5); Ans. 5 (citing Fig. 6). The Examiner further finds "mirrors 1 and 2 are close to the plane where the light exits the first optical system and enters the second optical system." Final 7–8 (citing Murakami Fig. 5).

Appellant argues the Examiner failed to identify evidence to support findings that Murakami's mirror 11 is a "pupil facet mirror," Murakami's mirror 1 has at least one EUV radiation permeable region, and Murakami's mirror 2 "is close to a plane which is both an exit pupil plane of the first optical system and an entry pupil plane of the second optical system" (claim 15). Appeal Br. 12–13; *see also*, *id.* at 8–9 (making a similar argument with respect to claim 13's requirement that "the mirror is close to a pupil"). Responsive to the additional explanation provided by the Examiner in the Answer (*see* Ans. 4–5), Appellant continues to assert that it does not agree with the Examiner's findings and that the Examiner did not point to concrete evidence in the record in support of those findings. Reply Br. 3.

We find the Examiner's explanation and citations to Murakami support the Examiner's findings with respect to claims 13 and 15. *See* Ans. 5 (citing Murakami Figs. 5, 6). Appellant has not identified error in these findings with any degree of specificity. As such, we are not persuaded that the Examiner reversibly erred in concluding claims 13 and 15 are obvious over Murakami and Bleeker.

Appellant does not present separate arguments in support of patentability of

dependent claims 7, 8, 10, 12, 16, 17 and 24. Therefore, we sustain the rejection of claims 1, 7, 8, 10, 12, 13, 15–17, and 24.

Claims 2, 3, and 9

Claim 2 depends from claim 1 and recites "wherein the mirror face has a conjugated EUV radiation-reflecting region for each EUV radiation-permeable region, and each EUV radiation-permeable region is transferrable by a rotation about an axis of symmetry into its corresponding conjugated EUV radiation-reflecting region." Appeal Br. 17, Claims Appendix. Claim 3 depends from claim 2 and recites "wherein each EUV radiation-permeable region is arranged symmetrically with respect to the axis of symmetry to its respective conjugated EUV radiation-reflecting region." *Id.*

The Examiner finds Murakami's mirror face 2 has conjugated EUV radiation-reflecting regions 9 in the Figure 2 embodiment, and 42 and 43 in the Figure 7 embodiment that correspond to each of EUV radiation-permeable regions 7 and 8 in the Figure 2 embodiment, and 7, 40 and 41 in the Figure 7 embodiment. Final 4. Appellant argues the Examiner failed to identify a disclosure or suggestion of a conjugated EUV radiation-reflecting region corresponding to Murakami's EUV radiation-permeable region 7 as required by claims 2 and 3. Appeal Br. 7. The Examiner does not respond to this argument. *See generally* Ans. 2–5.

The Examiner identifies three radiation-reflecting regions as corresponding to four radiation-permeable regions. Final 4. We agree with Appellant that the Examiner has not indicated, nor is it apparent from Murakami's written description and drawings, which of the three EUV radiation-reflecting regions is intended to correspond to EUV radiation-permeable region 7 in each of the Figure 2 and Figure 7 embodiments. Moreover, the Examiner has not explained, nor is it

apparent from a review of Murakami, which of EUV radiation reflecting regions 9, 42, and 43 meets the recited symmetry requirements with respect to EUV radiation-permeable region 7. *See* claims 2 and 3.

Accordingly, we do not sustain the rejection of claims 2 and 3. Because claim 9 depends from claim 2, we also do not sustain the rejection of this claim.

Claims 11, 14, 19, and 20

With respect to claims 11, 14, 19, and 20, Appellant argues the rejection cites Murakami as the primary reference and, therefore, it is improper for the Examiner to reject the claims over Bleeker as modified by Murakami. Appeal Br. 8–10, 14–15. We do not agree with Appellant's characterization of the Examiner's rejection of these claims as relying on Bleeker as the primary reference. We note, however, that the case law supports the Examiner's reliance on either Murakami or Bleeker as the primary reference. *See In re Bush*, 296 F.2d 491, 496 (CCPA 1961) ("[W]here a rejection is predicated on two references each containing pertinent disclosure which has been pointed out to the applicant, we deem it to be of no significance, but merely a matter of exposition, that the rejection is stated to be on A in view of B instead of on B in view of A, or to term one reference primary and the other secondary.").

Because Appellant has not identified reversible error in the Examiner's obviousness determination as to claims 11, 14, 19, and 20, we sustain the rejection of these claims.

Claim 18

Claim 18 depends indirectly from claim 15 and requires the mirror is in an illumination optical system. Appeal Br. 19, Claims Appendix. Appellant argues "Figure 5 of Murakami clearly shows that mirrors 1 and 2 are downstream of the object 3. Hence, neither mirror 1 nor mirror 2 of Murakami are in an illumination

optical system." Appeal Br. 14 (footnote omitted). Appellant's argument is not persuasive for the reasons explained on page 5 of the Answer.

Accordingly, we sustain the rejection of claim 18.

Claim 21

Claim 21 depends from claim 1, and recites "wherein an entire reflective area of the mirror face is configured to reflect EUV radiation having the same wavelength." Appeal Br. 19, Claims Appendix. The Examiner relies on column 8, lines 56–67 of Murakami for a teaching of this feature. Final 9. In the relied-upon disclosure, Murakami describes forming an Mo/Si multi-layer film "which reflects soft X-rays of a specified wavelength . . . on the surface of [a low-thermal-expansion glass] substrate." Murakami 8:56, 59–61. Appellant argues the cited disclosure in Murakami describes a mirror during an intermediate manufacturing step, and is not a description of the mirror used by Murakami. Appeal Br. 11. Appellant cites, without further explanation, the description in column 8, line 52 through column 10, line 38 of Murakami as evidence that in the mirror used by Murakami, "the entire reflective area of the mirror face is not configured to reflect EUV radiation having the same wavelength." *Id.*

We have reviewed the disclosure in Murakami relied on by Appellant, but are not persuaded of reversible error in the Examiner's rejection of claim 21. Murakami discloses a working example in which "[a]n Mo/Si multi-layer film, which is used to reflect soft X-rays with a wavelength of 13 nm, *is formed on the reflective surfaces* of the respective reflective mirrors." Murakami 11:61–64 (emphasis added). Murakami discloses that the invention is not limited to mirrors having films that reflect a single wavelength; rather the mirror face may have, for example, a region with an Mo/Si multi-layer reflective film that reflects soft X-rays with a wavelength of 13 nm, and another region with an Mo/Be multi-layer

reflective film that reflects soft X-rays with a wavelength of 11 nm. *Id.* at 14:6–13. In our view, this disclosure supports the Examiner's finding that Murakami discloses an embodiment "wherein an entire reflective area of the mirror face is configured to reflect EUV radiation having the same wavelength" (claim 21).

Accordingly, we sustain the rejection of claim 21.

Claims 22 and 23

Claim 22 depends from claim 1, and recites "wherein a center of the mirror face is not EUV radiation-permeable." Appeal Br. 19, Claims Appendix. Clam 23 depends from claim 15, and recites the same limitation. *Id.*

In rejecting claim 22, the Examiner cites Figure 15 and paragraph 85 of Bleeker for a teaching of this feature. Final 10. Appellant contends the Examiner reversibly erred in failing to explain the reason why one of ordinary skill in the art would have modified Murakami's mirror to eliminate its EUV radiation-permeable center, noting that "[t]he mere fact that Bleeker may teach something does not mean that it would have been obvious to a person of ordinary skill in the art to implement that teaching in Murakami's system." Appeal Br. 12. We agree.

The Examiner relies on Murakami's mirror 2 for a teaching of a mirror as recited in claim 1 and relies on Bleeker as evidence that it would have been obvious to modify Murakami to include additional (i.e., at least five) EUV radiation-permeable regions. Final 3–4. Murakami, however, clearly describes mirror 2 as having hole 7 in the center that allows light to pass through. *See* Murakami 2:20–22. The Examiner has not explained why one of ordinary skill in the art would have modified Murakami's mirror 2 to eliminate this hole.

Accordingly, we reverse the rejection of claim 22.

In rejecting claim 23, the Examiner finds Figure 6 of Murakami, which depicts mirror 1, discloses a mirror having a center that is not EUV radiation-

permeable. Final 10. Appellant argues "[t]he Examiner has not pointed to any information in Murakami that establishes that his mirror 1 has a center that is not EUV radiation-permeable." Appeal Br. 16.

We are not persuaded by Appellant's argument. Murakami describes Figure 6 as follows: "supporting columns 18 that support the convex mirror 1 of the Schwarzschild optical system are positioned in such a way as not to block the region 105 through which the illuminating light 5 passes or the region 106 through which the reflected light 6 reflected by the sample 3 passes." Murakami 12:22–27. Figure 6 appears to illustrate supporting columns 18 as blocking the center of mirror 1 and, unlike regions 105, 106, Murakami does not expressly describe the center of mirror 1 as unobstructed to allow for passage or reflection of light. Accordingly, it was reasonable for the Examiner to find that only regions 105 and 106, which are not located in the center of mirror 1, are not EUV radiation-permeable.

Therefore, we sustain the rejection of claim 23.

ORDER

The rejection of claims 1, 7, 8, 10–21, 23 and 24 is AFFIRMED.

The rejection of claims 2, 3, 9, and 22 is REVERSED.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED-IN-PART