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Datasheet for the decision of 19 June 2018

Case Number: T 0665/13 - 3.4.03

Application Number: 05768370.8

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Title of invention:
Illumination optical apparatus, method of adjusting the illumination optical apparatus, exposure system and method

Patent Proprietor:
Nikon Corporation

Opponent:
Carl Zeiss SMT GmbH

Headword:

Relevant legal provisions:
EPC 1973 Art. 54, 56, 84
EPC Art. 52(1), 123(2)

Keyword:
Amendments - added subject-matter (yes)
Inventive step - after amendment - (yes)

Decisions cited:
G 0003/14, T 2197/09

Catchword:

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Beschwerdekammern

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Case Number: T 0665/13 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 19 June 2018

Appellant: (Patent Proprietor)	Nikon Corporation 15-3, Konan 2-chome Minato-ku Tokyo 108-6290 (JP)
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Appellant: (Opponent)	Carl Zeiss SMT GmbH Rudolf-Eber-Strasse 2 73447 Oberkochen (DE)
Representative:	Ostertag & Partner Patentanwälte mbB Epplestraße 14 70597 Stuttgart (DE)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 8 January 2013 concerning maintenance of the European Patent No. 1798758 in amended form.**

Composition of the Board:

Chairman	G. Eliasson
Members:	S. Ward
	T. Bokor

Summary of Facts and Submissions

I. This is an appeal by both the patent proprietor and the opponent against the interlocutory decision of the Opposition Division in the case of European patent No. 1 798 758. On the basis of the requests then on file, the Opposition Division decided that:

- the claimed subject-matter of the main request (patent as granted) and of auxiliary requests 6, 16 and 17 was not new (Articles 100(a), 52(1) and 54 EPC);

- the claimed subject-matter of auxiliary requests 1-5 and 7-15 failed to meet the requirements of Article 123(2) EPC; and

- on the basis of auxiliary request 18 filed in oral proceedings before the Opposition Division, the patent and the invention to which it related met the requirements of the EPC.

II. The opposition was filed against the patent in its entirety. Grounds for the opposition were: lack of novelty, lack of inventive step, insufficient disclosure and unallowable extension of subject-matter (Articles 100(a), 100(b), 100(c), 52(1), 54 and 56 EPC).

III. The following documents are referred to in this decision:

D2: US 6 366 341 B1
D5: US 2003/0067591 A1

IV. At the end of the oral proceedings held before the Board the parties requests were as follows:

The appellant-proprietor (hereinafter, the proprietor) requested that the decision under appeal be set aside and the patent maintained as granted (main request), or in an amended form on the basis of auxiliary request 21 (ARXXI, filed with the statement of grounds of appeal), auxiliary request 22 (ARXXII, filed with the statement of grounds of appeal), or auxiliary request 46 (ARXXXXVI). All other requests were withdrawn.

The exact content of ARXXXXVI was that the decision under appeal be set aside and the patent maintained on the basis of the following documents:

Description:
pages 3-6,10-15 of the patent specification,
pages 2,7,8,9 as filed in the oral proceedings before the Board;
Claims:
Claims 1-27 of the forty-sixth auxiliary request as filed with letter dated 2 October 2013;
Drawings:
Figures 1-14 of the patent specification.

The appellant-opponent (hereinafter, the opponent) requested that the decision under appeal be set aside and that the patent be revoked.

V. (i) Claim 1 of the main request reads as follows:

"An illumination optical apparatus for illuminating a surface to be illuminated (M, W), in particular with a light beam from a light source (1), the illumination optical apparatus comprising:

a first adjustment surface (8) disposed in an optical path between an illumination pupil plane (5) of the illumination optical apparatus and the surface to be illuminated and in an optical path on the light source side with respect to a conjugate plane (7) optically conjugate with the surface to be illuminated, and having a first transmittance distribution or first reflectance distribution of transmittances or reflectances different according to incidence positions or according to incidence angles; and
a second adjustment surface (9) having a second transmittance distribution or second reflectance distribution of transmittances or reflectances different according to incidence positions or according to incidence angles,
characterized in that the second adjustment surface (9) is disposed in the optical path between the illumination pupil plane and the surface to be illuminated and in an optical path on the surface-to-be-illuminated side with respect to the conjugate plane optically conjugate with the surface to be illuminated."

The wording of claim 2 of the main request is very similar to that of claim 1, but the reference signs (8) and (9) are replaced by (8a) and (9a), and the conjugate plane is defined to be a conjugate plane (10a) optically conjugate with the *illumination pupil plane*.

(ii) Claim 1 of auxiliary request 21 reads as follows:

"An illumination optical apparatus for illuminating a surface to be illuminated (M, W), in particular with a light beam from a light source (1), the illumination optical apparatus comprising:

a first adjustment surface (8) disposed in an optical path between an illumination pupil plane (5) of the illumination optical apparatus and the surface to be illuminated and in an optical path on the light source side with respect to a conjugate plane (7) optically conjugate with the surface to be illuminated, and having a first transmittance distribution or first reflectance distribution of transmittances or reflectances different according to incidence positions or according to incidence angles; and
a second adjustment surface (9) disposed in the optical path between the illumination pupil plane and the surface to be illuminated and in an optical path on the surface-to-be illuminated side with respect to the conjugate plane optically conjugate with the surface to be illuminated, and having a second transmittance distribution or second reflectance distribution of transmittances or reflectances different according to incidence positions or according to incidence angles, characterised in that the second transmittance distribution or the second reflectance distribution is substantially complementary to the first transmittance distribution or the first reflectance distribution.

Claim 2 of auxiliary request 21 is identical to claim 2 of the main request except that "incidence positions or according to" has been deleted (twice), and a characterising part identical to the characterising part of claim 1 of auxiliary request 21 has been added.

(iii) The wording of claims 1 and 2 of auxiliary request 22 is identical to that of claims 1 and 2 of auxiliary request 21, except that the following feature is added before the final full stop:

"over an effective region of each of the first and second adjustment surfaces that intersects the optical axis".

(iv) The wording of claim 1 of auxiliary request 46 is identical to that of claim 1 of auxiliary request 22, except that "or according to incidence angles" has been deleted (in relation to both the first and second adjustment surfaces). Independent claim 2 of auxiliary request 22 has been entirely omitted in auxiliary request 46.

VI. The opponent's arguments, in so far as they are relevant to the present decision, were essentially as follows:

(a) Article 123(2) EPC: Main Request

In claim 1 of the main request, the first and second adjustment surfaces were located on either side of a plane conjugate to the surface to be illuminated, and each adjustment surface had a distribution of transmittances or reflectances different according to incidence positions or incidence angles. Claim 1 therefore comprised four "constellations" (K1-K4) of adjustment surfaces which could be summarised as follows:

K1: position/position
K2: angle/angle
K3: position/angle
K4: angle/position

While constellations K1 and K2 were disclosed in original claims 24 and 27, respectively, there was no

basis for the "mixed" (position/angle and angle/position) constellations K3 and K4.

In claim 2, the first and second adjustment surfaces were located on either side of a plane conjugate with the illumination pupil plane, and similar constellations (K1'-K4') were present, none of which had an unambiguous basis in the application as filed.

Claims 14-17 had no counterpart in the claims as originally filed, and no adequate basis in the original application.

(b) Article 123(2) EPC: Other Requests

In claim 1 of auxiliary request 21, the fact that the first and second transmittance or reflectance distributions were defined to be "substantially complementary" was not sufficient to unambiguously exclude the mixed position/angle constellations K3 and K4, and hence the corresponding objections raised against the main request applied to this request also.

In claim 1 of auxiliary request 22, the first and second distributions were substantially complementary "over an effective region of each of the first and second adjustment surfaces that intersects the optical axis". The (possibly small) region intersecting the optical axis displaying complementarity was merely "an" effective region, meaning that there might be other effective regions in which the transmittance/reflectance distributions were not complementary. There was no basis for this in the application as filed.

Claim 2 of auxiliary request 22 was clearly based on the arrangement shown in Fig. 5. In this embodiment,

however, there was no disclosure that light was actually propagating along the axis (AX), and hence no basis for the feature: "that intersects the optical axis".

(c) Novelty over D2

The Opposition Division had correctly concluded that the subject-matter of claim 1 of the main request lacked novelty over D2. The blades (40a, 40b) depicted in Fig. 17 (shape 2) were located in the plane conjugate to the mask, and the neutral density filters (41a, 41b), which corresponded to the claimed adjustment surfaces, were therefore located on either side of the conjugate plane. This was evident from the sharpness of the edges of the graph at the bottom of the figure and from the arrowhead extending from the reference "S" (opening) in Fig. 17, which clearly pointed to the plane of the blades (40a, 40b). Imaging the field stop onto the mask was the normal practice in such illumination systems. The proprietor's argument that the skilled person would conclude that the blades do not need to be placed precisely at the conjugate plane was irrelevant to the question of novelty. What was important was what was disclosed in D2, and not the extent to which a skilled person would consider departing from that teaching.

Claim 1 of auxiliary Request 21 also lacked novelty, since the additional feature that the first and second transmittances were "substantially complementary" was also disclosed in D2. A neutral density filter on one side of the opening had a complementary effect to that on the opposite side of the opening, so that exposure through one filter and then the other in sequential

steps resulted in a constant level of exposure in the effective overlap region.

(d) Inventive Step starting from D5

The problem-solution approach required the identification of a problem which is solved by essentially all embodiments falling under the claim. Of the eight constellations defined in claims 1 and 2 of the main request, only K1 would solve the technical problem defined in the contested patent. The others would not result in any useful technical effect.

In the case of those auxiliary requests in which the first and second transmittance or reflectance distributions were substantially complementary, the angle/angle distributions (K2 and K2') would have no effect whatsoever, apart from a uniform dimming of the intensity. Hence, even the broader problem formulated by the proprietor ("correcting combinations of inhomogeneity in the angle and spatial distribution at the illuminated plane") would not be solved by all embodiments of the claims.

VII. The proprietor's arguments, in so far as they are relevant to the present decision, were essentially as follows:

(a) Article 123(2) EPC: Main Request

It was undisputed that the constellations K1 and K2 of claim 1 were satisfactorily based on original claims 24 and 27, and the constellations K3 and K4 were mainly based on paragraph [0056] of the originally filed description, in which the term "correction filter" was a synonym for the claimed "adjustment surface".

Paragraph [0057] also alludes to "mixed" constellations.

The constellation K2' was directly based on the embodiment of Fig. 5, and the variations defined in the other constellations of claim 2 found a basis at least in paragraphs [0056] and [0057].

Claims 14-17 found a basis in the modification of the embodiment of Fig. 6 set out in paragraph [0062] as originally filed, in which correction filter 11(c) might be located between the mask blind and the surface to be illuminated.

(b) Article 123(2) EPC: Other Requests

According to the sense in which the word "complementary" was used in the patent, a position dependent distribution could only be complementary to another position dependent distribution, and an angle dependent distribution could only be complementary to another angle dependent distribution. Hence, the use of "complementary" in claim 1 excluded the mixed constellations K3 and K4. A statement to this effect could be inserted in an amended description if necessary.

The term "effective region" in claim 1 of auxiliary request 22 was explicitly disclosed in paragraphs [0033], [0034], [0047] and [0048] in connection with the examples of Figs. 3 and 4, and was clearly intended to mean the whole surface interacting with the beam. In all embodiments the effective region intersected the optical axis.

(c) Novelty over D2

The subject-matter of claim 1 of the main request was new. D2 did not explicitly disclose that the blades (40a, 40b) of the dose adjusting device in Fig. 17 were located in a plane conjugate to the mask plane, and it followed that there was no explicit disclosure that the neutral density filters (identified in the contested decision as corresponding to the claimed adjustment surfaces) would be located on either side of this plane.

Neither was this requirement an inevitable consequence of the disclosure of D2. The function of the dose adjusting device was to limit a ray bundle travelling from the fly-eye integrator to the lens system, and it could be placed anywhere between these components.

It was not possible to form a perfect image on the mask of both neutral density filters, since they had a finite thickness and were axially separated. Some defocus therefore had to be tolerated, and the skilled person would understand that the small amount of defocusing resulting from the pair of blades being on one side of the conjugate plane would also be equally acceptable.

The effect of the graded neutral density filters was equivalent to blurring the edges of the illuminated region on the mask, and imaging a blurring filter did not require perfect focusing of the blades onto the mask. Arranging the blades either side of the conjugate plane would require special effort and precise alignment, which would serve no purpose in the light of the function of the dose adjusting device.

The arguments of the opponent on the basis of the sharpness of the graph at the bottom of Fig. 17 were not pertinent, since this merely showed the transmittance of the neutral density filters, and not the resulting exposure on the mask. No information concerning the location of the filters could be derived from this graph.

The feature that the first and second transmittances were "substantially complementary", as defined in claim 1 of auxiliary request 21, was also undisclosed in D2, since there was no disclosure of any configuration in which the neutral density filters overlapped, as would be required to have complementary transmittance. The filters were therefore not complementary, since they did not achieve a uniform transmittance in areas where the filters had effect.

(d) Inventive Step starting from D5

The objective problem solved by the invention was to adjust the illuminance distributions on a surface to be illuminated independently of the point-wise pupil luminance distributions on that surface. This problem was solved by all constellations of claims 1 and 2 of the main request rather than merely by a subset as the opponent alleged.

Constellation Kl provided the ability to independently adjust the illuminance distribution and the illumination angle distribution as a result of positioning the filters on either side of the conjugate plane. By taking advantage of the inversion of the light cones as they passed through the intervening plane, independent control was achieved. Such control could not be achieved by a single filter, or by a

combination of filters placed on one side of the conjugate plane only.

As one skilled in the art of optics understood, adjusting the angle-dependent distribution at the pupil plane was equivalent to adjusting the position-dependent distribution at the field plane (the Fourier transform plane of the pupil plane), and vice versa. Therefore, by adjusting the transmittance or reflectance based on angles either side of a pupil plane, similar effects were achieved to adjusting position-dependent transmittances or reflectances on either side of a field plane. The opposite also applied, since changing angle-dependent transmittances or reflectances either side of a field plane was equivalent to changing position-dependent transmittances or reflectances either side of a pupil plane.

The configurations shown in the opponent's annexes OA3 (for K2) and OA6 (for K2') represented special choices by the opponent of particular angle-dependent distributions which led, in the cases chosen, merely to a dimming of intensity. However, for more general choices for the angle-dependency of the distribution, the point-wise pupil distribution might be influenced independently of the field luminance distribution. The mixed constellations K3, K4, K3' and K4' also achieved this effect. Accordingly, all constellations, aside from certain specific anomalous configurations, solved the technical problem.

D5 did not disclose that the filters (14a, 14b) might be arranged on either side of the conjugate plane, and, as the Opposition Division correctly recognised, none

of the cited prior art documents taught or suggested this feature.

Reasons for the Decision

1. The appeal is admissible.

2. *Procedural Requests*

The procedural requests made in the written proceedings by the proprietor (reimbursement of the appeal fee, apportionment of costs) and the opponent (remission to the department of first instance pursuant to Article 11 RPBA, reimbursement of the appeal fee) were all withdrawn at oral proceedings before the Board.

3. *Terminology*

For convenience of reference, the following terminology is used:

- an adjustment surface having a transmittance distribution or reflectance distribution of transmittances or reflectances different according to incidence positions will be referred to as a *position dependent adjustment surface*; and
- an adjustment surface having a transmittance distribution or reflectance distribution of transmittances or reflectances different according to incidence angles will be referred to as an *angle dependent adjustment surface*.

4. *Article 123(2) EPC: Main Request*

4.1 Claim 1 of the main request defines an illumination optical apparatus comprising, *inter alia*, first and second adjustment surfaces disposed either side of a plane optically conjugate with the surface to be illuminated. The first adjustment surface may be either a position dependent or an angle dependent adjustment surface, and the second adjustment surface may also be either a position dependent or an angle dependent adjustment surface. The four "constellations" K1-K4 identified by the opponent (see point VI(a), above) are therefore defined as alternative possibilities in claim 1. It is not disputed by the opponent that K1 and K2 were disclosed in original claims 24 and 27.

4.2 The constellations K3 and K4 have "mixed" adjustment surfaces (i.e. both a position dependent and an angle dependent type) located either side of the plane optically conjugate with the surface to be illuminated. Symbolically, K3 and K4 may be written as follows:

K3: position/conjugate plane/angle
K4: angle/conjugate plane/position.

Such mixed constellations are not disclosed in the claims as originally filed.

4.3 The proprietor cited, as the main basis for K3 and K4, the following passage from paragraph [0056] of the originally filed description:

"It is also possible to use a correction filter with a transmittance distribution of transmittances different according to incidence positions, in combination with a correction filter with a transmittance distribution of transmittances different according to incidence angles ..."

4.4 At oral proceedings it was uncontested that the terms "correction filter" and "adjustment surface" are used synonymously in the contested patent (see e.g. paragraph [0058], first sentence, of the originally filed description). It was equally undisputed that the mixed arrangement mentioned in the cited passage is intended to refer to a combination of a position dependent correction filter of the type disclosed in the embodiment of Fig. 1 with an angle dependent correction filter of the type disclosed in the embodiment of Fig. 5.

There is, however, no explicit disclosure in this passage, or elsewhere, of the locations of the respective adjustment surfaces in the case of a mixed combination, and hence no explicit disclosure of the constellations K3 or K4.

4.5 Whether the application as filed provides any implicit indication of the locations of the adjustment surfaces in the case of a mixed combination is questionable. In the opinion of the Board, the most that could plausibly be argued is that the skilled person would infer that the respective locations would correspond to those locations actually disclosed in Figs. 1 and 5, i.e. that a position dependent correction filter (8 or 9) located as depicted in Fig. 1 could be combined with an angle dependent correction filter (8a or 9a) located as depicted in Fig. 5.

However, the constellation K4 would require an angle dependent correction filter to be located essentially at the position of the filter (8) in Fig. 1 in combination with a position dependent correction filter essentially located in the position of filter (9) in

Fig. 1. The Board finds no disclosure - explicit or implicit - of such an arrangement in the application as filed. The same conclusion is reached in the case of K3 for the same reasons *mutatis mutandis*.

4.6 The Board therefore finds that the subject-matter of claim 1 extends beyond the content of the application as filed, and for this reason alone, the patent cannot be maintained according to the main request.

The Board also considered claims 2 and 14-17 of the main request, and decided that the subject-matter of these claims also extended beyond the content of the application as filed. However, in the light of the conclusion of the previous paragraph, it is unnecessary for the Board to provide further reasoning in relation to the main request.

5. *Auxiliary Request 21: Article 123(2) EPC*

5.1 Claim 1 of auxiliary request 21 comprises the feature that the second transmittance or reflectance distribution is "substantially complementary" to the first transmittance or reflectance distribution. The proprietor argued that this formulation was sufficient to rule out the mixed position/angle constellations K3 and K4; the opponent argued that this remained unclear. However, both parties agreed that, if necessary, this matter could be dealt with by an appropriate statement in the description that constellations K3 and K4 were not part of the invention.

5.2 No other objections were raised under Article 123(2) EPC against auxiliary request 21.

6. *Auxiliary Request 21: Novelty over D2*

6.1 The subject-matter of claim 1 of auxiliary request 21 corresponds to that of auxiliary request 16 rejected by the Opposition Division for lack of novelty over D2.

6.2 D2 discloses an exposure apparatus (Figs. 1 or 15) comprising an illumination optical system (2) for illuminating a mask (M), and a projection optical system 3 by means of which a pattern image on the mask is projected onto a specific area on a substrate (W). As shown in Figs. 2-4 or 16-17, the illumination optical system has a dose adjusting device (4, 40) comprising a pair of L-shaped light-shielding sections or blades (4a, 4b, 40a, 40b) forming a rectangular opening (S). In Fig. 17 (shape 2), the blades support respective neutral density filters (41a, 41b), which may be identified with the claimed first and second adjustment surfaces.

6.3 The opponent argued (and the Opposition Division accepted) that D2 anticipates all features of claim 1. The proprietor's view was that the following two features are not disclosed in D2:

(a) the adjustment surfaces are located on either side of a plane conjugate to a surface to be illuminated; and

(b) the adjustment surfaces have complementary transmittance distributions.

6.4 Concerning feature (a), the relationship between the opening (S) and the mask (M) is described as follows:

"a dose adjusting device 4, provided in this illumination optical system 2, for adjusting the area

of an opening S where a bundle of rays or light passes, thereby defining the illumination range of the light on the mask M" (column 5, lines 5-9);

"*The exposure light that has been defined by the opening S illuminates a specific area of the mask M via the lens system 29*" (column 5, lines 61-63);

"*The projection optical system 3 serves to form a pattern image, located in the illumination range of the mask M that is defined by the opening S, on the substrate W*" (column 6, lines 26-28);

"*The dose adjusting device 40, disposed in the illumination optical system 2, adjusts the area of the opening S that passes light to thereby define illumination range for the mask M. The dose adjusting device 40 sends only that light emerging from the fly-eye integrator 26 which has passed the opening S to the lens system 29. The pattern image that is defined by the opening S of the dose adjusting device 40 is formed on the mask M via the lens system 29, so that the pattern image on the mask M is exposed on a specific area on the substrate W*" (column 15, lines 10-19).

6.5 In the opinion of the Board, the skilled person would understand these (and similar) passages to mean that an *image* of the opening (S) is formed onf the mask (M) via the lens system 29, and that the part of the pattern image on the mask which is thereby illuminated (i.e. which falls within the image of the opening) is projected onto an area on the substrate (W) by the projection system (3). On this understanding, the opening (S) must be located at a plane conjugate to the mask (M).

6.6 The proprietor argued that since the arrangement of D2 required a reduced level of illumination at the peripheral portion of the illumination area on the mask, the skilled person would realise that it would also be possible to locate the opening near to, but slightly displaced from, the plane conjugate to the mask, as the resultant blurring at the periphery of the illuminated region would be entirely consistent with the aim of the apparatus of D2.

The Board agrees, and points out that this possibility is in fact disclosed in D2. In a section setting out alternative embodiments, the following is stated (column 17, lines 60-62):

"Light reduction can be achieved by blurring the edge images of the opening S by shifting the focus of the lens."

The implication is clear: in the principal embodiments (Figs. 1 and 15), the edge images of the opening (S) are not blurred, implying that the opening (S) and the mask (M) are in conjugate planes. However, in an alternative arrangement, the edge images of the opening (S) may be slightly blurred by shifting the focus of the lens, thereby departing from a strict conjugate relationship. It would be implicit to the skilled person that an equivalent way of departing from a conjugate relationship would be to slightly shift the position of the opening.

6.7 Hence, for the principal embodiments, the Board believes that D2 discloses that the opening (S) is located at a plane conjugate to the mask.

6.8 The proprietor is correct in pointing out that, in practice, the opening (S) is formed by two blades (4a, 4b, 40a, 40b) which would have finite thicknesses, as shown in Fig. 4, so that the opening itself would have a small but finite thickness. By contrast, a plane conjugate to the surface of the mask is essentially a mathematical construct of infinitesimal thickness.

In the Board's view, it is quite normal in optics to refer to a field or aperture stop being located at a particular plane in an optical system, even though the physical implementation of such a stop would have a small but finite thickness. The skilled person would understand that D2 teaches that the opening must be located at a plane conjugate to the mask, and that this means, in practice, that the notional plane optically conjugate to the surface of the mask should lie within the finite thickness of the opening.

As a consequence, the neutral density filters (41a, 41b) of Fig. 17 (shape 2) are necessarily located on either side of a plane conjugate to the mask (i.e. the surface to be illuminated), and hence feature (a) is judged by the Board to be disclosed in D2.

6.9 Concerning feature (b), the opponent accepted that, in the light of decision G 3/14, its earlier clarity objection to the term "complementary" is moot, and the term cannot be objected to under Article 84 EPC 1973.

Although the term "substantially complementary" is not explicitly defined in the patent, it is clear (for example, from paragraph [0043]) that the intended meaning is that the two adjustment surfaces have a combined effect such that "the illuminance distribution on the surface to be illuminated is maintained almost

uniform without substantial change". The term "substantially complementary" is therefore interpreted in this sense in the present decision.

6.10 In the case where the surface to be illuminated is exposed via the two adjustment surfaces simultaneously (as in the embodiments of the patent), the above definition means that the "respective distributions across the filters substantially multiply to a constant" (see proprietor's letter dated 30 April 2014, page 12, fourth paragraph).

6.11 In the case of D2, a region of the mask corresponding to a peripheral portion of the pattern image ("the overlying portion") is exposed via one of the neutral density filters in a first exposure step, and via the other neutral density filter in a second exposure step (column 16, lines 21-33). These regions are therefore exposed via the respective first and second neutral density filters *sequentially*, and not simultaneously. This is not excluded by claim 1 of auxiliary request 21, which contains no limitation in this respect. In the case of sequential exposure, the Board's view is that the term "substantially complementary" means that the two exposure steps have the combined effect that the "overlying portion" of the surface to be illuminated is substantially uniformly exposed.

6.12 The combined result of the two exposure steps of D2 is explained as follows (column 16, lines 30-33):

"In this manner, exposure is carried out with the light exposure quantity at the overlying portion of the substrate W set equal to the light exposure quantity to the portion other than the overlying portion, as per the first embodiment."

In other words, the doubly-exposed peripheral portion receives the same exposure as the singly-exposed non-peripheral portion. Since the exposure of the non-peripheral portion is constant over the image of the opening, the combined exposure over the peripheral portion is also constant.

6.13 This is also clear from the first embodiment, which is referred to in the cited passage above ("as per the first embodiment"). Fig. 5C schematically depicts the transmission in the light reducing areas R1 and R2, which correspond to the light reduction obtained in the second embodiment by the neutral density filters 41a and 41b. Fig. 5D shows the combined exposure quantity to be constant over the overlying region, and equal to the constant exposure in the non-overlapping region.

6.14 The argument that the arrangements of D2 would result in corner regions (e.g. the overlap regions shown in Fig. 4) where the claimed distributions would not be complementary fails to convince the Board. Claim 1 does not require that complementary transmittance distributions should extend over the entire first and second adjustment surfaces.

6.15 The Board therefore concludes that the neutral density filters of D2 are disclosed to have transmittances which are substantially complementary, and hence that feature (b), referred to above, is also disclosed in D2.

The subject-matter of claim 1 of auxiliary request 21 is therefore not new within the meaning of Article 52(1) EPC and Article 54 EPC 1973, and the patent cannot be maintained according to this request.

7. *Auxiliary Request 22: Article 123(2) EPC*

7.1 Claim 1 of auxiliary request 22 adds the feature that the first and second distributions are substantially complementary:

"over an effective region of each of the first and second adjustment surfaces that intersects the optical axis".

The term "effective region" is explicitly disclosed in paragraphs [0033], [0034], [0047] and [0048] in connection with the examples of Figs. 3 and 4.

7.2 In the opinion of the Board, the skilled person would understand the "effective region" of a correction filter to mean the region of the filter producing the optical effects aimed for, as opposed to regions which have no filtering effect, e.g. regions used for mounting.

The added feature therefore defines firstly, that the correction filters have transmittance distributions which are complementary to each other over those regions of each filter which are designed to have an optical effect on the incident light, and secondly, that these regions intersect the optical axis. This interpretation is consistent with what is disclosed in examples of Figs. 3 and 4.

7.3 While the precise functional forms of the transmittance distributions of Figs. 3 and 4 are clearly exemplary, the skilled person would, in the opinion of the Board, understand that where complementary transmittance distributions are employed, complementarity is intended

to extend over the effective region, and the effective region is intended to include the optical axis.

7.4 The opponent argued that claim 1 defines "an" effective region, implying that there may be other effective regions in which the transmittance distributions are not complementary. The Board, however, believes that a skilled person would understand the term "effective region" as explained above. The use of the indefinite article simply corresponds to the normal way of introducing a new feature into a claim.

The opponent raised a further argument that claim 2 corresponded to the arrangement shown in Fig. 5, in which it was not clearly disclosed that light was propagating along the axis (AX). This objection appears to be based on the observation that systems for illuminating a mask are known in the art in which the light beam intersects the pupil plane at off-axis positions. The Board does not dispute that such systems exist, but simply notes that the systems actually disclosed in the application as originally filed are not of this type, but clearly correspond to on-axis arrangements.

7.5 Auxiliary Request 22 is therefore found to comply with the requirements of Article 123(2) EPC.

8. *Auxiliary Request 22: Novelty*

The novelty of the subject-matter of auxiliary request 22 was not contested by the opponent.

9. *Auxiliary Request 22: Inventive Step*

9.1 There was no dispute that, as in the contested decision, the closest prior art may be taken as document D5. D5 discloses an exposure apparatus 50 including an illumination optical system, having *inter alia* filters 14a and 14b located on the same side of a movable blind (field stop) 16a, the filters having transmittance distributions dependent on position transverse to the optical axis (paragraph [0090]), and represented by curves L11 and L21 in Figs. 4(a) and 4(b). When there is no transverse shift between the filters, the combined (product) transmittance is "more or less constant" (paragraph [0112]), as shown in curve L31 of Fig. 4(c). Hence D5 discloses first and second adjustment surfaces (filters 14a and 14b) having position dependent transmittance distributions which are substantially complementary over an effective region of the adjustment surfaces that intersects the optical axis.

9.2 In comparing claim 1 of auxiliary Request 22 with D5, the two claimed alternative constellations, K1 and K2, need to be separately analysed.

9.3 *Alternative K1*

9.3.1 Alternative K1 differs from D5 only in that the first and second adjustment surfaces are disposed *on either side* of a plane optically conjugate with the surface to be illuminated. In D5, filters 14a and 14b are located on the same side of the corresponding plane (the plane containing movable blind 16a).

9.3.2 The objective problem may be seen as that stated in paragraph [0007] of the patent (paragraph [0006] of the application as filed), or alternatively as the slightly more general problem stated by the proprietor as

follows: to adjust the illuminance distributions on a surface to be illuminated independently of the point-wise pupil luminance distributions on that surface.

9.3.3 The opponent did not dispute that the distinguishing feature of K1 solved the above problem (in either form), and did not, in fact, raise any inventive step objection against the claimed alternative K1.

The analysis of K1 could therefore stop at this point. Nevertheless, the Board believes that it is important to understand *how* the problem is solved by K1 in order to be able to determine whether K2 may also be regarded as solving the (or at least a) problem. The proprietor provided an explanation of the functioning of alternative K1, and the Board's understanding of this explanation is now given.

9.3.4 In Fig. 2, each ray arriving at, for example, point P2 passes through filter 8, mask blind plane 7 and filter 9. The filters 8, 9 have transmittances which are substantially complementary. As noted above (point 6.10), in a case such as K1 where the surface to be illuminated is exposed via two position dependent adjustment surfaces simultaneously, "substantially complementary" means that the respective distributions across the filters substantially multiply to a constant. This may be represented as follows:

$T_1(x).T_2(x) = A,$

Where T1 and T2 are the transmittance distributions of the respective adjustment surfaces, x is a positional coordinate perpendicular to the optical axis (which may be scaled so that $-1<x<1$) and A is a constant ($0<A<1$), independent of x.

9.3.5 All rays which are incident on P2 cross the plane 7 at the same position coordinate, x, and if the filters 8 and 9 were both placed essentially at the plane 7, the effect on all such rays would be to modulate the intensities by the product $T_1(x).T_2(x)$, which is simply equal to the constant A. The result would be merely an equal reduction in intensity for all rays.

However, by placing the filters at a certain distance on either side of the plane 7, a position dependent effect is achieved. For example, the two rays depicted in Fig. 2 as arriving at point P2 are incident on the filter 8 at different positions, which may be written $(x+\delta)$ and $(x-\delta)$, where δ represents a small shift in the x coordinate. For the symmetrical arrangement of Fig. 2, the same rays would be incident on the filter 9 at positions $(x-\delta)$ and $(x+\delta)$.

The effect of the filters on the rays would therefore be to modulate the intensities by the following factors respectively:

$T_1(x+\delta).T_2(x-\delta)$; and
$T_1(x-\delta).T_2(x+\delta)$.

These two factors are different, and hence, *as a result of the crossing of the rays at plane* 7, locating the filters at a certain distance on either side of plane 7 generates a differential effect which is key to solving the above problem, namely to allow the uniformity of the field illumination and the uniformity of the pupil luminance distribution (angle distribution) to be independently adjusted. The Board finds this explanation plausible.

9.4 *Alternative K2*

9.4.1 No angle dependent filters are disclosed in D5; hence alternative K2 differs from D5 in the following features:

- the first and second adjustment surfaces are disposed on either side of a plane optically conjugate with the surface to be illuminated;
- the first and second adjustment surfaces have incidence angle dependent transmittance or reflectance distributions; and
- the first and second transmittance or reflectance distributions are substantially complementary (i.e. in the incidence angle domain).

For example, at an incidence angle α, the first and second adjustment surfaces may have transmittances $T_1(\alpha)$ and $T_2(\alpha)$ respectively, and the complementarity condition is $T_1(\alpha).T_2(\alpha) = B$, where B is a constant.

9.4.2 For the subject-matter of a claim (or a claimed alternative) to be acknowledged as involving an inventive step, essentially all embodiments falling within it should solve the objective problem. Clearly, one embodiment falling under K2 would be the arrangement of Fig. 1 with the position dependent adjustment surfaces 8 and 9 replaced by angle dependent adjustment surfaces 8a and 9a (corresponding to the layout shown in the opponent's annex OA3).

9.4.3 As may be clearly seen in Fig. 1, the only element positioned between the adjustment surfaces is the field stop (mask blind) at plane 7 (see paragraph [0022] of the patent), which obviously either allows rays to pass

or blocks them, but does not produce any angular deviation of their paths, as is evident from Fig. 2.

Hence, *any* ray which is incident on filter 8 at an angle α, and which passes through the field stop, will arrive, undeviated, at the filter 9 at the same incident angle α. The technical effect of the filters in this embodiment would therefore be to modulate the intensity by the factor $T_1(\alpha).T_2(\alpha)$, which, as a direct consequence of complementarity, would mean that all rays passing through the field stop would have their intensities reduced by the same constant factor B. This would not correspond to a solution of the objective problem.

9.4.4 The proprietor argued that this would only be the case for certain anomalous transmittance distributions. The Board does not agree. The above conclusion follows directly from the complementarity of the angle dependent distributions.

9.4.5 The proprietor's argument based on Fourier optics is also not persuasive. It is true that effects obtained by a position dependent filter located at the field plane (i.e. the plane optically conjugate with the surface to be illuminated) should also be obtainable by an angle dependent filter located at the pupil plane (the Fourier plane to the field plane). The gist of the proprietor's argument appears to be that if a particular configuration is accepted as solving the objective problem, the Fourier equivalent should also be acknowledged as solving the problem. As an argument that K2 solves the objective problem, this fails for two reasons:

(a) The only configuration which has been demonstrated to solve the objective problem is K1, the Fourier equivalent of which is K2' (i.e. the arrangement of Fig. 5), and not K2, in which the angle dependent adjustment surfaces are placed (as in K1) on either side of a field plane.

(b) Constellation K1 does not solve the objective problem by locating a position dependent filter at the field plane, but by means of a differential effect obtained by locating complementary position dependent filters on either side of the field plane. The Board sees no reason, based on Fourier optics or otherwise, to suppose that an equivalent differential effect necessarily occurs with angle dependent filters either side of the field or pupil plane. Hence, this argument would not be persuasive in relation either to K2 or K2'.

9.4.6 The Board therefore concludes that the claimed alternative K2 would not solve the objective problem, either as stated in paragraph [0007] of the patent or as formulated more generally by the proprietor as allowing the illuminance distributions on a surface to be illuminated to be adjusted independently of the point-wise pupil luminance distributions on that surface.

9.4.7 In the light of the above analysis, the only technical effect which can be seen to result from the arrangement of K2 is the reduction of the intensity of all rays by a fixed constant factor.

9.4.8 The arrangement of the closest prior art already provides means for uniformly attenuating the intensity of the illuminating radiation. In D5 the beam from

light source 1 is incident on a variable optical attenuator 3 under the control of an exposure control unit 23 which may also control, for example, the pulse energy (paragraph [0085], Fig. 1). By this means the exposure dose on the wafer can be controlled, for example by increasing the attenuation when the exposure is to be limited, and by providing little or no attenuation when a maximum exposure dose is to be employed.

The Board fails to see what possible effect would be achieved in the arrangement of D5 by incorporating complementary angle dependent adjustment surfaces on either side of movable blind 16a, other than the introduction of a fixed and invariable beam attenuation, which would be undesirable and detrimental to the functioning of the system of the closest prior art, as it would needlessly limit the range of possible exposure doses.

9.4.9 The distinguishing features of K2 are therefore seen as a purely disadvantageous modification of the closest prior art, and no inventive step can be acknowledged on this basis (see T 2197/09, Reasons, point 5.4). Claim 1 of auxiliary request 22 does not therefore involve an inventive step within the meaning of Article 52(1) EPC and Article 56 EPC 1973. As a result, the patent cannot be maintained on the basis of this request.

A similar conclusion was reached in relation to claim 2. However, in the light of the conclusion of the previous paragraph, it is unnecessary for the Board to provide further reasoning in relation to this request.

10. *Auxiliary Request 46: Article 123(2) EPC*

10.1 Auxiliary request 46 comprises a single independent claim for an apparatus which is restricted to the constellation K1. The only objection raised under Article 123(2) EPC which can be seen to apply to this subject-matter concerns the feature: "over an effective region ... that intersects the optical axis", which was raised in relation to auxiliary request 22 (see point 7.1, above).

10.2 Since the Board found this feature to have a basis in the application as filed, auxiliary request 46 is considered to meet the requirements of Article 123(2) EPC.

11. *Auxiliary Request 46: Substantive Issues*

11.1 The objection raised under Article 100(b) EPC in the notice of opposition concerned claims 14-17 of the granted patent. This subject-matter has been omitted in auxiliary request 46. The objection raised in appeal against claims 1 and 2 under Article 100(b) EPC was subsequently withdrawn (and in any event did not relate to constellation K1, to which claim 1 of auxiliary request 46 is restricted).

11.2 In the oral proceedings the opponent stated that no novelty objection was maintained against auxiliary request 22. The same clearly must apply to claim 1 of auxiliary request 46, which is more restricted than claim 1 of auxiliary request 22.

11.3 It has been shown above (point 9.3) that constellation K1 solves the objective problem. Moreover, the available prior art does not disclose the distinguishing feature of this constellation, and the opponent stated at oral proceedings that no inventive

step objection was raised against claim 1 of auxiliary request 46. The Board therefore judges that, having regard to the state of the art, the subject-matter of claim 1 of auxiliary request 46 would not be obvious to a person skilled in the art.

No objection was raised against any of the other claims of auxiliary request 46, and the description of the patent specification was suitably adapted to this request at the oral proceedings.

11.4 Consequently, taking into consideration the amendments made to the patent according to auxiliary request 46, the patent and the invention to which it relates meet the requirements of the EPC, and the patent as so amended can therefore be maintained (Article 101(3)(a) EPC).

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to maintain the patent as amended in the following version:

Description:
pages 3-6,10-15 of the patent specification,
pages 2,7,8,9 as filed in the oral proceedings before the Board;
Claims:
Claims 1-27 of the forty-sixth auxiliary request as filed with letter dated 2 October 2013;
Drawings:
Figures 1-14 of the patent specification.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated