BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

Internal distribution code:
(A) [ ] Publication in OJ
(B) [ ] To Chairmen and Members
(C) [X] To Chairmen
(D) [ ] No distribution

D E C I S I O N
of 14 May 2003

Case Number: T 0910/00 - 3.4.2

Application Number: 92301476.5

Publication Number: 0500393

IPC: G03B 27/53

Language of the proceedings: EN

Title of invention:
Imaging method for manufacture of microdevices

Patentee:
CANON KABUSHIKI KAISHA

Opponent:
ASM Lithography B.V./Carl Zeiss

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (appellant's main and first auxiliary requests: no; second auxiliary request: yes)"

Decisions cited:
-

Catchword:
-

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0910/00 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 14 May 2003

Appellant: (Proprietor of the patent)
CANON KABUSHIKI KAISHA
30-2, 3-chome, Shimomaruko
Ohta-ku
Tokyo (JP)

Representative:
Beresford, Keith Denis Lewis
BERESFORD & Co.
2-5 Warwick Court
High Holborn
London WC1R 5DH (DE)

Respondents: (Opponents)
ASM Lithography B.V./Carl Zeiss
De run 1110/
5503 LA Veldhoven/89518 Heidenheim/Benz (NL)

Representative:
Leeming, John Gerard
J.A. Kemp & Co.
14 South Square
Gray's Inn
London WC1R 5JJ (GB)

Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 28 June 2000 revoking European patent No. 0 500 393 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: E. Turrini
Members: A. G. Klein
M. J. Vogel

Summary of Facts and Submissions

I. European patent No. 0 500 393 (application No 92 301 476.5) was revoked by decision of the opposition division on the ground under Article 100(a) EPC that its subject-matter did not involve an inventive step within the meaning of Article 56 EPC.

II. The appellant (proprietor of the patent) filed an appeal against the decision revoking its patent.

III. Oral proceedings were held on 14 May 2003 at which the appellant as its main request requested that the decision under appeal be set aside and that the patent be maintained on the basis of a set of claims, of which independent claim 5 reads as follows:

"5. A projection exposure apparatus for projecting an image of a pattern of an original (30) on a workpiece (32) for the manufacture of microdevices, said apparatus comprising:

an X-Y stage (34) for supporting thereon the workpiece (32) and being movable along X and Y directions in an X-Y coordinate system defined in said apparatus;

means (11-19) for forming a light source having an intensity distribution such that the portions at a centre thereof and on first and second axes defined to intersect with each other at the centre and defined along the X and Y directions, respectively is decreased in comparison with the portions of the light source other than the centre portion and the portions along the first and second axes;

an illumination optical system (20-28) for illuminating the pattern of the original (30) with

light from said light source; and

a projection optical system (31) for projecting on the workpiece (32) an image of the pattern illuminated with the light from said light source,

wherein said intensity distribution of said light source is such that said light source comprises four sections (2a, 2b, 2c, 2d) having substantially the same light intensity and being distributed in four quadrants defined by the centre and the first and second axes, and

wherein an image of the secondary light source is projected onto a pupil (1) of said projection optical system (31), and wherein, on the assumption of a coordinate system defined by X and Y axes extending along the first and second directions and intersecting at a centre of the pupil, and that the radius of the pupil is 1, coordinates of the effective centres of intensity of the four sections (2a, 2b, 2c, 2d) are (p, p), (-p, p), (-p, -p) and (p, -p), wherein $0.25 < p < 0,6$; and

wherein each of the sections has a radius q, and $0.15 < q < 0.3$".

As its first auxiliary request the appellant requested that the patent be maintained on the basis of a set of claims of which independent claim 5 corresponds to independent claim 5 of the main request after addition, at the end of the claim, of the following features:

"and wherein the four sections of the light source are such that the apparatus may be arranged for use with an original having a fine pattern with linear features extending orthogonally in said X and Y directions in a manner in which said linear features produce from the light from said four sections diffracted light in which

the zero orders travel obliquely relative to the pattern and of which only light of zero order and of one first order passes through the pupil of the projection optical system for formation of an image of said linear features on said workpiece."

As its second auxiliary request the appellant requested that the patent be maintained in amended form on the basis of a set of 5 claims consisting of claims 1 to 4 and claim 35 of the main request. Claims 1 and 35, the only independent claims of the set of claims in accordance with the appellant's second auxiliary request, read as follows:

"l. A method of forming an image of a fine pattern having linear features extending in orthogonal first and second directions, for the manufacture of microdevices, said method comprising the steps of: illuminating the pattern (30) with light from a light source (11-19), said light source having an intensity distribution such that the portions at a centre thereof and on first and second axes defined to intersect with each other at the centre and defined along the first and second directions respectively is decreased in comparison with portions of the light source other than the centre portion and the portions along the first and second axes;

wherein said light source comprises four sections (2a, 2b, 2c, 2d) having substantially the same light intensity and being distributed in four quadrants defined by the centre and the first and second axes;

wherein an image of the light source is projected onto a pupil (1) of a projection optical system (7), and

wherein on the assumption of a coordinate system defined by X and Y axes extending along the first and second directions and intersecting at a centre of the pupil, and that the radius of the pupil is 1, coordinates of the effective centres of intensity of the four sections are (p, p), (-p, p) (-p, -p) and (p, -p), wherein $0.25 < p < 0.6$;

wherein each of the sections has a radius q, and $0.15 < q < 0.3$, and wherein

the intensity distribution of the light source, the fine pattern and the optical system being arranged so that said linear features produce diffracted light in which the zero order light travels obliquely relative to the pattern and of which only light of zero order and of one of the first orders passes through the pupil for the formation of said image of said fine pattern."

"35. A microdevice manufacturing method, including a step of printing a device pattern on a workpiece using a method of forming an image as defined in any of claims 1 to 4, and manufacturing a microdevice from the printed workpiece."

The respondents (opponents) for their part requested that the appeal be dismissed.

The following documents were discussed at the oral proceedings:

D0: Optical Lithography-Thirty years and three orders of magnitude; J.H. Bruning; SPIE Vol. 3049; pages 14 to 27;

D1: JP-A-61-91662, and an English translation thereof to which reference will be made hereafter for convenience;

D2: US-A-4 931 830;

D4: Effect of central obscuration on image formation in projection lithography; S.T. Yang et al.; SPIE Vol. 1264 Optical/Laser Microlithography III (1990); pages 477 to 485; and

D6: US-A-3 776 633.

The Board announced its decision at the end of the oral proceedings.

IV. In support of its request the appellant stressed that the patent was dedicated to a technical problem which had been the object of intense research and development by eminent scientists and companies for decades, as was evidenced by document D0, namely improving resolution in the manufacture of semiconductor devices by optical lithography.

A. Suzuki, the present inventor, who was acknowledged on the last page of document D0 as one of the most influential people in this industry, proposed a unique conception which could not be derived from any prior art citation, namely the idea of getting rid in projection lithography of one of the first orders of diffraction using a particular light source arrangement which allowed for a substantial reduction of the angle of incidence of light rays onto the wafer surface and a consequential increase of the depth of focus. The symmetry of the light source arrangement relatively to

axes extending along the orthogonal directions of extension of the linear features of a fine pattern to be imaged achieved high brightness of the image obtained, by the composition of diffracted light of zero order and of one of the first orders from one side with light of zero order and of the other first order from the other side.

This conception was quite different from the teaching of document D2, which only proposed rejection of light of the second order and above.

Document D1 explicitly recommended annular light sources, or light sources having the effect of an annular source. It did not therefore provide any obvious incentive to modify the arrangement of Figure 3 by reducing the number of holes from eight to only four as in the invention.

Document D4 disclosed the result of a study of the effect of central obscuration by simulating various illumination conditions and it explicitly proposed the use of a full ring annular illumination design to optimise the performance of a centrally-obscured projection system for use in lithography.

Finally, document D6, published 20 years before the priority date of the patent, related to the different technology of proximity printing, which at the latter date had already been abandonned. The technical problem to which this document was dedicated, namely the avoidance of ghost lines due to undesirable diffraction effects produced by the edges of narrow strips provided in a mask arranged at a short distance from the wafer, did not arise with projection printing. This problem

was solved in D6 by rendering diffraction ineffective altogether. In projection printing, however, diffraction did not constitute a problem to be eliminated, but a necessary phenomenon.

V. The respondents' arguments can be summarised as follows:

Independent apparatus claims 5 of the appellant's main and first auxiliary requests are directed to a projection exposure apparatus which does not actually comprise the technical feature, stressed by the appellant, that only light of zero order and of one of the first orders passes through the pupil for the formation of an image, because diffraction is closely determined by the geometry of a given pattern to be imaged, which is no part of the claimed apparatus.

Moreover, the claims do not specify that the intensity distribution of the light source is such that the portions on the axes along the directions of the linear features of the fine pattern to be imaged are completely dark, so that the use of annular light source configurations is not actually excluded from their scope.

Concerning inventive step, the patent relies on a conception which gave rise to several patent applications filed almost contemporarily by different applicants, which shows that it cannot be considered a unique achievement, as was suggested by the appellant.

Figure 3 of document D1 shows a stop which produces a light source arrangement which is distinguished from the one proposed in the patent only in that there are

additional illuminating portions along the X and Y axes. The document however clearly teaches that light which does not contribute to the production of a fine image should be cut off. Having in mind the teaching of document D4 that oblique illumination along axes which are parallel to the directions of extension of the pattern to be imaged produces poor images, getting rid of the illuminating portions along these directions in the arrangement of Figure 3 of document D1 so as to achieve the claimed construction does not involve an inventive step. The less so since document D1 in conjunction with Figure 3 explicitly states that the stop shown there could comprise either "several" or "many" openings, the first alternative clearly suggesting the use of less than the eight openings shown on the figure.

The numerical ranges set out in the independent claims for the coordinates of the effective centres of intensity of the four illuminated sections of the light source and for radius of these sections are absolutely trivial and they cover almost every reasonably conceivable arrangement.

Document D6 relates to the technology of proximity printing, which historically is the precursor of projecting printing. Projection printing in effect translates directly to the surface of the resist to be imaged what happens at the mask in proximity printing. Since ideal focusing is almost impossible in projecting printing, the optical considerations valid in proximity printing almost identically apply to projection

printing. Accordingly, the mere transfer of the particular light source design disclosed in document D6 to a projection printing apparatus and method cannot be considered inventive.

Finally, the arrangement of document D2 provides for interception of high-order diffracted light and transmission of light of zero and of the first orders only. For illumination light rays which are not perfectly orthogonal to the plane of the patent, only one of the first orders would pass through the pupil in addition to light of zero order, exactly as in the claimed method.

Reasons for the Decision

1. The appeal is admissible.

2. *Appellant's main request*

The subject-matter of independent apparatus claim 5 will be considered first for convenience.

2.1 Novelty

Document D1 discloses a projection exposure apparatus for projecting an image of a pattern of an original on a workpiece for the manufacture of microdevices, which comprises most of the features set out in claim 5 except for the design of the light source which defines four illuminating sections on the pupil of the projection optical system, said sections having symmetrical coordinates and a radius in the ranges set out in the claim. In contrast, the secondary light

source of the apparatus of documents D1 comprises a special stop 10 which defines an annular opening as shown in Figures 1 and 4, or a disc-shaped opening having a higher optical transmittance closer to the peripheral areas as shown in Figure 2, or "several or many" small openings in the peripheral area as illustrated in Figure 3, which actually shows eight such openings (see the last paragraph on page 7 of document D1).

Document D2 shows a projection exposure apparatus with a light source comprising a central opening of an adjustable diameter, instead of the claimed four sections around a central portion of decreased light intensity (see Figure 1 and the abstract).

Document D4 is a scientific article on the effect of central obscuration on image formation in projection lithography. Contrary to the patent in suit the article proposes full ring annular illumination (see page 485, the paragraph "4. CONCLUSIONS"). For the assessment of oblique illumination, the experimental set up comprises a single illumination source mounted onto a rotatable carriage (see the first paragraph on page 483 and Figures 5 and 6).

Document D6 discloses an apparatus for forming an image of a fine pattern of an original mask on a workpiece for the manufacture of microdevices, which comprises a light source having four illuminating sections disposed substantially as set out in claim 5. However, the pattern is disposed in close proximity to the workpiece for achieving proximity printing, and the apparatus therefore does not comprise any projection optical system.

The remaining prior art citations on the file do not come closer to the claimed subject-matter.

Accordingly, the subject-matter of claim 5 is novel within the meaning of Article 54 EPC.

2.2 Inventive step

Independent claim 5 in substance defines an optical projection lithography apparatus of the type known for instance from documents D1 or D2, with the illumination means being replaced by that recommended in document D6 in conjunction with proximity printing. The Board in particular concurs with the respondents' view that the ranges set out in the claim for the coordinates and radius of the four illuminating sections cover trivial values at which the skilled person would have arrived by mere experimentation. The appellant did not show nor even suggest that the claimed values resulted in any unexpected technical effect.

The respondents submitted that, due to an unavoidably imperfect focussing of the image of a pattern as formed by the projection system in an optical projection apparatus, substantially the same optical conditions prevailed in proximity printing and in optical projection apparatuses. The skilled person would therefore have readily envisaged using an illumination design disclosed in conjunction with proximity printing also in an optical projection apparatus.

In the absence of any evidence supporting this submission, the Board is not convinced that optical projection systems of the type disclosed in documents D1 or D2 give rise to deviations of the focus

position in a range comparable to the distance between the mask and the workpiece in the proximity printing technique of document D6, which is between 10 and 20 micrometers (see D6, column 3, lines 11 to 13 and 40 to 44), and that the technical problem underlying the disclosure of document D6, which is to avoid the formation of ghost lines between the images of adjacent slits, also arises in optical projection.

It is not clear however which technical effect the specific light source arrangement set out in claim 5 and known from document D6 actually achieves in the claimed optical projection apparatus. The appellant in this respect only submitted that the fact that this light source arrangement produced oblique illumination such as to allow only diffracted light of zero order and of one of the first orders to pass through the pupil constituted an essential characteristic of the unique conception proposed by the patent. The precise selection of specific diffraction orders is however closely dependent on the geometry of the illuminated pattern, which is not specified in the claim, and it cannot accordingly provide any support for the patentability of its subject-matter.

Independent claim 5 in accordance with the appellant's main request therefore in the Board's opinion defines no more than an arbitrary use of a known light source arrangement in a known projection exposure apparatus, which in the absence of any technical advantage lacks an inventive step within the meaning of Article 56 EPC.

The appellant's main request cannot be allowed accordingly.

3. *Appellant's first auxiliary request*

As compared to independent claim 5 of the appellant's main request, independent claim 5 of the first auxiliary request has been supplemented with an indication that the four sections of the light source are such that the apparatus may be arranged for use with an original having a fine pattern with linear features extending orthogonally in said X and Y directions in a manner in which said linear features produce from the light from said four sections diffracted light in which the zero orders travel obliquely relative to the pattern and of which only light of zero order and of one first order passes through the pupil of the projection optical system for formation of an image of said linear features on said workpiece.

The feature that the four sections of the light source are "such that the apparatus may be arranged for use with an original having a fine pattern with linear features ... in a manner in which said linear features produce ..." does not however in the Board's view define any clear additional limitation to the projection exposure apparatus defined in independent claim 5 of the main request, because whether only light of zero order and of one first order passes through the pupil of the projection optical system entirely depends on the geometry of the fine pattern provided on the original, which is still not defined in the claim.

The subject-matter of independent claim 5 of the first auxiliary request therefore also lacks an inventive step within the meaning of Article 56 EPC, for the reasons set out above in relation to the allowability

of claim 5 of the main request.

4. *Appellant's second auxiliary request*

4.1 Compliance of the amended claims with the requirements of Article 123(2) and (3) EPC

Independent method claim 1 corresponds to a combination of claims 1 and 2 as granted, together with an indication that the intensity distribution of the light source, the fine pattern and the optical system are arranged so that linear features produce diffracted light in which the zero order light travels obliquely relative to the pattern and of which only light of zero order and of one of the first orders passes through the pupil for the formation of an image, as disclosed in the paragraph bridging pages 12 and 13 of the description as originally filed.

The remaining claims 2 to 4 and 35 correspond to claims 3 to 5 and 37 as granted.

For these reasons, the amendments effected to the claims as granted do not offend against the requirements of Article 123(2) and (3) EPC.

4.2 Novelty

Claim 1 of the appellant's second auxiliary request defines a method of forming an image of a fine pattern having linear features extending in orthogonal first and second directions by optical projection, the pattern being illuminated with light from a light source having four sections distributed in four quadrants defined by axes extending along the two

directions of the linear features of the pattern such that the latter produces diffracted light in which the zero order light travels obliquely relatively to the pattern and of which only light of zero order and of one of the first orders passes through the pupil for the formation of the image.

This method is undisputedly novel, since in particular a light source as defined in the claim is known only from document D6, but in connection with proximity printing, not optical projection.

4.3 Inventive step

The opposition division started its reasoning denying an inventive step to the subject-matter of an independent claim of a similar scope from document D6 which it considered to represent the closest prior art. Document D6 however was published around 18 years before the priority date of the patent in suit and it relates to proximity printing which, as is evidenced for instance by Figure 19 of document D0, is a technology which was no longer in use in optical lithography at the priority date of the patent. Accordingly, in the Board's view, document D6 is not a realistic starting point for a development made in the early 90's in the field of optical projection lithography. The Board cannot therefore concur to the opposition division's view that document D6 discloses closer prior art then those documents on the file which actually relate to optical projection lithography, like in particular document D1 which is the only citation to disclose a secondary light source providing oblique illumination of a pattern through several sections distributed around a dark centre (see Figure 3).

As compared to the embodiment illustrated in Figure 3 of document D1, which comprises eight illuminating sections, the method of the patent in suit involves the use of a light source comprising only four sections disposed in four quadrants delimited by axes which extend along two orthogonal directions defined by linear features of a pattern to be imaged. The technical effect of the claimed arrangement of the light source is to warrant that light is diffracted by the orthogonal linear features such that only light of zero order and of one of the first orders passes through the pupil for the formation of an image, which improves resolution and depth of focus.

This conception cannot in the Board's view be considered to result in an obvious manner from the state of the art.

Document D1 does not in particular establish any link between the preferential directions of the linear features of the pattern to be imaged and the angular position of the illuminating sections of the light source.

As was correctly stressed by the respondents, document D4, which is specifically dedicated to assessing the effect of central obscuration on image formation in projection lithography, clearly recognises that a single, axially off-set illumination section disposed along the direction of extension of linear features of an imaged pattern actually causes deterioration of the resolution for features extending in that direction and improvement of the resolution for features extending in the orthogonal direction. Instead of suggesting the four-section arrangement set out in

present claim 1 the document however explicitly recommends the use of annular illumination like in document D1 for improving uniformity of the image (see Figures 5 and 6 and the paragraph bridging pages 482 and 483).

Document D2 only recommends optical projection using central illumination through a diaphragm which is so controlled as to eliminate diffracted light of second order and above. This teaching is not compatible with the central obscuration techniques of documents D1 and D4, and no combination of these can lead to using the illumination arrangement set out in claim 1.

Finally, whilst a light source arrangement as set out in claim 1 is known from document D6, this document only relates to proximity printing. In contrast with the claimed method, this arrangement is used there to eliminate the effect of diffraction, which causes undesired ghost lines between the lines to be formed on the substrate, rather than to select those order of diffraction which shall pass through the pupil of an optical projection system for the formation of an image.

The other documents of the file do not come closer to the claimed method.

For these reasons, the subject-matter of claim 1 in accordance with the appellant's second auxiliary request involves an inventive step within the meaning of Article 56 EPC.

The same conclusion applies to the subject-matter of claims 2 to 4 by virtue of their appendance to claim 1

and to the subject-matter of independent claim 35, which comprises the features of independent claim 1.

4.4 Further prosecution

After deletion of all the claims between claim 4 and claim 35, independent claim 35 must be renumbered claim 5.

The description must still be adapted to the amended wording of the claims and be supplemented with a short summary of the relevant content of the closest prior art document D1, (see Rule 27(1)(b) and (c) EPC).

For these reasons, the Board deems it appropriate to remit the case to the opposition division for further prosecution as provided for in Article 111(1) 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 the first instance with the order to maintain the patent in amended form on the basis of the appellant's second auxiliary request, i.e. with claims 1 to 4 and 35 of the main request, filed as first auxiliary request with the letter dated 9 May 2003, and the description and drawings to be adapted.

The Registrar: The Chairman:

P. Martorana E. Turrini