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Datasheet for the decision of 20 November 2014

Case Number: T 2197/09 - 3.4.03

Application Number: 06004927.7

Publication Number: 1679551

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Language of the proceedings: EN

Title of invention:
Lithographic apparatus and device manufacturing method

Applicant:
ASML Netherlands B.V.

Headword:

Relevant legal provisions:
EPC 1973 Art. 56, 83, 84
EPC 1973 R. 71(2)
RPBA Art. 15(3), 15(5), 15(6)

Keyword:
Sufficiency of disclosure - (no)
Inventive step - auxiliary request (no)

Decisions cited:
T 0994/95, T 0891/02, T 0157/03, T 0578/06

Catchword:

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Case Number: T 2197/09 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 20 November 2014

Appellant: (Applicant)	ASML Netherlands B.V. De Run 6501 5504 DR Veldhoven (NL)
Representative:	Slenders, Petrus J. W. ASML Netherlands B.V. Corporate Intellectual Property P.O. Box 324 5500 AH Veldhoven (NL)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 26 June 2009 refusing European patent application No. 06004927.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

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

Summary of Facts and Submissions

I. The appeal is against the decision of the Examining Division refusing European patent application No. 06 004 927 on the grounds that "claim 1 lacks support in the description (Article 84 EPC) and its subject-matter is not sufficiently disclosed for it to be carried out by a person skilled in the art (Article 83 EPC)."

II. The following documents cited in the description of the present application (page 3, lines 28-29) are referred to:

D1: WO 99/57596
D2: WO 99/57606
D3: US 5 686 728
D4: US 5 815 310.

In addition, in the statement of grounds of appeal the appellant cited an excerpt (pages 51-57) from the PhD thesis of one of the inventors. The complete thesis has been retrieved from the internet and is cited as follows:

D5: M F Bal, Next-generation extreme ultraviolet lithographic projection, PhD Thesis, Technical University Delft.

III. Oral proceedings before the Board were held in the absence of the appellant, the appellant having previously stated in writing that "the Applicant will not be attending the oral proceedings."

IV. The appellant requested in writing that the decision under appeal be set aside and that a patent be granted in the following version:

Main request

Description, pages	
1-3,7-35	as originally filed
4-6	received on 7 September 2007
Claims, number	
2-11	as originally filed
1	received on 7 September 2007
Drawings, sheets	
1-10	as originally filed

Auxiliary request

Description, pages	
1-3,7-35	as originally filed
4-7	received on 7 September 2007
Claims, number	
2-11	as originally filed
1	received with the grounds of appeal dated 29 October 2009
Drawings, sheets	
1-10	as originally filed

The Board considered that for the auxiliary request, the description pages 4-7 received on 7 September 2007 should read as pages 4-6.

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

1. A lithographic projection apparatus comprising:
a radiation system for providing a projection beam of radiation;

a support structure for supporting patterning means, the patterning means serving to pattern the projection beam according to a desired pattern;
a substrate table for holding a substrate;
a projection system for projecting the patterned beam onto a target portion of the substrate,

characterized in that:

said projection system has precisely six imaging mirrors in the optical path of the projection beam and has an incidence angle classification, C, of 5(+), 6(-), 9(+), 13(+), 18(-), 21(+), 22(-), 25(+), 29(+), 34(-), 38(-), or 54(-), where:

$$C = \sum_{i=1}^{6} a_i . 2^{(6-i)} \quad \left(\frac{M}{|M|} \right)$$

a_i = 1 if the angle of incidence of the chief ray at mirror i is negative,
a_i = 0 if the angle of incidence of the chief ray at mirror i is positive,
M is the magnification of the projection system, and the index i numbers the mirrors from object to image when said projection system is viewed along a positive X direction, the X, Y, Z directions making up a right-handed orthogonal coordinate system,
wherein a positive z-axis is set along the optical axis and oriented towards the image plane,
wherein the object height is positive along a Y-axis.

Claim 1 of the auxiliary request is the same as claim 1 of the main request except that the incidence angle classification, C, has been limited to 9(+) only.

VI. The Examining Division argued (by reference to the annex to the summons to oral proceedings) essentially as follows:

In Figure 12 and Table 7 the application disclosed an optical layout for a 6-mirror projection system with an incidence angle classification of 9(+). The application did not disclose an optical layout for 6-mirror projection systems according to any of the other claimed incidence angle classifications. Compliance with Article 84 and 83 EPC could only be acknowledged if a skilled person would be able to determine a workable layout for any such systems (apart from 9(+)) using general knowledge and the material contained in the present application.

For a given incidence angle classification the skilled person would be able to determine the sign of the angle of incidence of a chief ray at each mirror and the sign of the magnification of the system. A workable layout would require the skilled person to determine, in addition, the position of each mirror and the radii of curvature of each mirror. In the course of the procedure, other design parameters would need to be determined, such as the number of intermediate images or the position of the aperture stop.

The procedure proposed by the applicant involved using the generally-known equations of the paraxial approximation and then performing iterative variations to find the suitable design parameters. The description (on page 29, line 8 to page 30, line 4) also disclosed a procedure to ensure that the beam is not obscured in its zigzag course. This procedure allowed possible obscuration of the extreme rays in the optical system to be checked.

However, if this test failed (i.e. in the case of partial obscuration), the mirror system must be modified or rejected. In such a case, the description did not give any other indication that would help the skilled person to appropriately modify the mirror system or to choose another more appropriate starting point. Since the skilled person would not have adequate information leading necessarily and directly towards success through the evaluation of initial failures, an undue burden was imposed.

The present application was therefore not supported by the description (Article 84 EPC) and not sufficiently disclosed in the sense of Article 83 EPC.

VII. The appellant argued essentially as follows:

In relation to the main request, the Examining Division appeared to base its conclusions on the argument that the description did not give any indication that would help the skilled person to appropriately modify a mirror system which failed the test for obscuration or to choose another more appropriate starting point.

However, such an indication was not necessary because it was possible to thoroughly search through the entire solution space (the realistic ranges for the mirror curvatures and the distances between the mirrors for a certain angle classification) for obscuration within a reasonable amount of time. For purposes of illustration, such a systematic paraxial search was described in document D5.

According to document D5 (page 64, section 4.2.2), it would take several personal computers about a week to

evaluate 20 billion systems. For a six-mirror system, typically 2.6 X 10^{12} configurations needed to be evaluated. Although this was a factor of 130 more, this could be compensated for by choosing a lower sample rate. Also, a higher percentage of six-mirror systems would be obscured compared to four-mirror systems, and because unobstructed systems tended to cost more time to evaluate, this would further compensate for the increased number of six-mirror configurations. Even without taking such compensation into account, a more powerful computer could be used, for example a supercomputer.

Accordingly, the skilled person would obtain a suitable starting point. It had not been contested by the Examining Division that, from such a starting point, the skilled person would use routine and well-known optimization techniques to derive a functioning optical system. There was therefore no undue burden for the skilled person in carrying out the invention and no insufficient disclosure of the invention in the sense of Article 83 EPC or lack of clarity and conciseness in the sense of Article 84 EPC.

In relation to the auxiliary request, claim 1 had been amended to specify an incidence angle classification of 9(+). The Examining Division had regarded this subject-matter as being sufficiently disclosed.

Reasons for the Decision

1. The appeal is admissible.

2. As announced in advance, the duly summoned appellant did not attend the oral proceedings. According to Rule 71(2) EPC 1973, the proceedings could however continue without the appellant. In accordance with Article 15(3) RPBA, the board relied for its decision only on the appellant's written submissions. The board was in a position to decide at the conclusion of the oral proceedings, since the case was ready for decision (Article 15(5) and (6) RPBA), and the voluntary absence of the appellant was not a reason for delaying a decision (Article 15(3) RPBA).

3. The document D5

3.1 In support of its position that there is no insufficiency of disclosure, the appellant cited an excerpt from the PhD thesis of one of the inventors, for which no publication date was given. The complete thesis may, however, easily be found online (document D5), and on a page bearing the heading "Proefschrift" it is stated (in Dutch) that the author defended the thesis in public on 10 February 2003. As there is no evidence that the thesis was available to the public before that date, and as the priority date of the present application is 7 November 2000, document D5 is regarded as a post-published document.

Although the disclosure requirement of Article 83 EPC 1973 has to be met at the filing date, or, if applicable, at the priority date (see e.g. T 891/02, Reasons, point 3, first paragraph), post-published documents can be used as evidence in deciding whether the invention was indeed reproducible without undue burden at the relevant filing date (see T 994/95, Reasons, point 8; T 157/03, Reasons, point 9).

It is clear that from the appellant's submissions that document D5 has been cited for this purpose, i.e. to support the contention that "there is no undue burden for the skilled person in carrying out the invention". The evidential significance of document D5 in this respect will be considered in the following.

4. Main Request: Articles 83 and 84 EPC 1973

4.1 Claim 1 is directed to a lithographic projection apparatus comprising *inter alia* a projection system having precisely six imaging mirrors; an "incidence angle classification, C" is introduced, and the projection system is defined to correspond to one of twelve alternative classifications listed in the claim.

To produce such a projection system it is not disputed that a skilled person, following normal optical design procedures, would firstly have to arrive at a suitable first-order layout (mirror spacings, curvatures etc.) subject to the system constraints. The further stages would involve optimization of the initial design to conform to the design objectives, followed by manufacturing, testing etc. It has never been alleged that a skilled person would be unable to carry out these further stages using standard procedures, and the Board also sees no reason to doubt this.

Hence, in relation to Article 83 EPC 1973, the point at issue is whether a skilled person would be able to arrive at a workable initial layout for each of the systems corresponding to the claimed incidence angle classifications (apart from 9(+), which was not objected to) on the basis of the disclosure of the

application, and having regard to the common general knowledge in the art.

4.2 It is undisputed that, with the exception of incidence angle classification 9(+) (see Table 7), the application does not explicitly disclose starting layouts for the claimed incidence angle classifications. The only other layouts explicitly disclosed for six mirror systems (Tables 8 and 9) concern the non-claimed classification 37(+).

4.3 In the absence of explicit prescriptions, it is reasonable to enquire whether it would be a trivial matter for the skilled person to arrive at the required starting layouts. This is, in the opinion of the Board, essentially a question of fact, and hence it is permissible to consider evidence on this matter even if it appears in a post-published document such as document D5.

In the first paragraph on page 51 of document D5 it is stated that:

- *"due to the large number of variables and constraints involved [in EUV reflective ring-field projection systems], choosing unobstructed starting configurations for subsequent optimization is a nontrivial issue."*

In the third paragraph on the same page (page 51) the difficulties are explained as follows:

- *"The use of mirrors may lead to obstruction. The absence of obstructions is an essential and, as we will show, a very restrictive demand. Geometrical obstruction confines the possible system*

configurations to small domains of the parameter space."

Post-published document D5, cited by the appellant, is therefore considered by the Board to provide clear evidence that, as a matter of fact, the determination of a suitable starting layout is not a trivial matter.

4.4 Despite the above conclusions, the requirements of Article 83 EPC could still be met if the application disclosed a method by which the skilled person could reliably arrive at the required layouts without undue burden.

According to the method set out in the application (see page 19, lines 5–7), a six mirror system is represented as having 13 variables, i.e. 6 curvatures (c1–c6) and 7 distances (d0–d6). The stop position is defined as being on one of the mirror surfaces.

Imposing a number of constraints on the system (e.g. constraints G1–G4, see page 14, lines 8–20) reduces the number of independent variables. For example, four equations may be derived for d0, d1, d5 and d6 in terms of the other variables (equations 45–48, 51–54, 57–60 and 63–66), thus reducing the number of independent variables from 13 to 8.

The pertinent question, therefore, is whether a skilled person, using the information disclosed in the application and common general knowledge in the art, would be able to proceed from this point to a fully worked out starting layout (similar to that of Table 7) for the classification classes other than 9(+).

4.5 In the statement of grounds, the appellant suggests that the skilled person could find starting layouts without undue burden by searching through the entire solution space, i.e. the realistic ranges for the mirror curvatures and the distances between the mirrors, using sampling.

The only mention of sampling in the application, however, appears on page 12 (lines 12-13), where it is stated that "the paraxial approach and the constraints yield a limited number of variables that are sampled to identify solutions." Whether the skilled person would understand this brief comment to imply the exhaustive systematic search described by the appellant and disclosed in the post-published document D5 is open to question.

4.6 However, even if a skilled person did arrive at an understanding that the starting layouts are to be found by a systematic search of solution space, the task facing the skilled person would, in the opinion of the Board, be formidable.

4.7 Even for a single sampled point of solution space, it is doubtful that the suggested procedure would be an entirely straightforward matter.

A skilled person could reasonably be expected to be able to operate commercially available optical design software (e.g. as suggested on page 10, lines 30-33), which would enable the basic ray tracing to be carried out. However, a "particular problem in designing mirror systems" is obscuration (page 29, lines 7-16), and each configuration would have to be evaluated for this, for example by the procedure suggested on page 29, line 17 - page 30, line 4). In addition, according to document

D5 (page 64, first paragraph) "workspace" and "feasibility" (i.e. no unrealistic values) need to be checked also. No evidence has been provided that commercial software would, without modification, be capable of providing such evaluations.

4.8 Furthermore, even with appropriate software the appellant concedes that, according to document D5, "it takes several personal computers about a week to evaluate 20 billion systems" (page 64, section 4.2.2), and that for a six-mirror system, typically 2.6×10^{12} configurations need to be evaluated, a factor of 130 more. Although the appellant suggests ways in which the time required could be reduced (e.g. using a lower sample rate or a supercomputer), it can hardly be denied that the skilled person would be faced with a significant, lengthy and burdensome research project.

4.9 In the present case, the burden placed on the skilled person is, in the opinion of the Board, particularly unwarranted. The claimed invention concerns the 12 classification classes out of all possible 6-mirror systems which the inventors determined to be "feasible" (page 11, lines 5-10). The applicant (now the appellant) must be presumed to have derived workable starting solutions with no obscuration, no unrealistic parameters etc. for the 12 classes of "feasible" 6-mirror systems before the priority date of the present application. If this were not the case, how would the applicant have known that precisely these classes are "feasible"?

In the application as filed, however, the applicant chose to disclose a working layout for only one (9(+)) of the claimed 12 incidence angle classifications, thereby obliging the skilled person to perform a

laborious and time-consuming research project to arrive at workable layouts for the other 11 claimed classes. In the opinion of the Board, this amounts to a failure to discharge the duty of disclosure set out in Article 83 EPC 1973.

4.10 In the light of the above, the Board judges that the subject-matter of claim 1 of the main request does not meet the requirements of Article 83 EPC 1973.

Consequently, the Board does not consider it necessary to decide on the separate objection of the Examining Division that the subject-matter of claim 1 of the main request fails to meet the requirements of Article 84 EPC 1973.

5. Auxiliary Request: Inventive Step

5.1 Claim 1 of the auxiliary request is restricted to the incidence angle classification 9(+). The Board concurs with the finding of the Examining Division that this subject-matter is adequately disclosed.

5.2 The closest prior art is considered to be one of the six-mirror EUV lithography systems referred to in the application (page 3, final paragraph), for example those of documents D1 (class 41(+)), D2 (class 41(+)), D3 (class 41(+)) or D4 (class 45(-)). Claim 1 differs in having a layout corresponding to another incidence angle classification, i.e. class 9(+).

5.3 According to the application, the technical problem is "to provide alternative and improved projection systems for EUV radiation and a methodology for designing such systems." (Page 4, lines 1–2.)

Hence, the Board's understanding is that what is aimed for is a projection system capable of delivering either an improved performance in relation to the closest prior art, or at least a level of performance broadly comparable to that of the prior art systems, achieved by means of an alternative optical design. Understood in this sense, the Board can accept that this is a reasonable technical problem to pose.

5.4 The Board stresses, however, that a convincing argument in support of inventive step could not be based on a "problem" of merely providing *any* alternative projection system for EUV radiation, even one delivering a performance inferior to systems of the prior art. An inventive step cannot be acknowledged on the basis of a purely disadvantageous modification of the closest prior art (see Case Law of the Boards of Appeal, 7th edition 2013, I.D.9.18.1).

5.5 It is therefore necessary to enquire whether modifying the closest prior art by incorporating a projection system having an incidence angle classification of 9(+) could plausibly be regarded as solving the technical problem set out under point 5.3, above.

5.6 The Board accepts that there is no general requirement under the EPC for an applicant to provide experimental proof for patentability and the establishment of plausibility in this respect is "only relevant when examining inventive step if the case at hand allows the substantiation of doubts about the suitability of the claimed invention to solve the technical problem addressed and when it is thus far from straightforward that the claimed invention solves the formulated problem." (see T 578/06, Reasons, points 13 and 15).

5.7 The Board takes the view, however, that the present case gives rise to legitimate doubts in this respect.

As mentioned above, the design of optical systems typically involves determining a suitable first-order layout, and then applying conventional optimization techniques to arrive at the finished design. The design is then assessed using performance evaluation methods familiar to the skilled person.

According to the present application, obtaining a "feasible" first-order layout for a 6-mirror system (free of obscuration, no unrealistic parameters etc.) is a particular problem, and as a result of its researches, the applicant concludes that among all possible 6-mirror systems, the only feasible layouts are those listed on page 11, lines 8-10.

These layouts therefore represent the starting points for the further stages of the procedure necessary to solve the above-mentioned problem, i.e. optimization and evaluation to determine which – if any – of the optimized systems can deliver performance superior (or at least comparable) to that of the prior art systems.

However, no performance data is presented in the application which would give credibility to the idea that at least some of these systems – and in particular 9(+) – solve the above problem. In fact, the application does not even appear to contain any assertion or claim – even an unsubstantiated one – that this is the case. Indeed, there is nothing in the application to indicate that any attempt at optimization and comparison with the prior art had even been made at the priority date.

The Board therefore concludes that the application does not make it plausible that a projection system having an incidence angle classification 9(+) could provide superior – or even equivalent – performance compared to the systems of the prior art based on incidence angle classifications 41(+) or 45(-).

5.8 The only other source of evidence available for the technical effects provided by a projection system having an incidence angle classification 9(+) is the the post-published document D5 (although cited in relation to the issue of sufficiency of disclosure in relation to the main request).

The jurisprudence of the boards of appeal on the extent to which such evidence appearing in a post-published document may be taken into account is well-established (see "Case Law", op. cit., I.D.4.6).

In the present case, however, it is not necessary examine this jurisprudence in detail, since the only evidence actually found in post-published document D5 in this respect points in exactly the opposite direction.

5.9 In particular, in document D5 two of the requirements of an EUV projection system are listed as "extremely small distortion" (page 24, line 1) and an rms "wavefront error smaller than λ/50 in image space" (page 24, "Number of mirrors", first paragraph).

In Fig 6.8 (page 89) a six mirror system in class 9(+) is shown, and the caption reads as follows:

- *"A positive six-mirror system in class 9+. Although the angles of incidence are large, the*

root-mean-squared wavefront error can decrease down to λ/2. The object heights are between 114 and 118 mm. the numerical aperture is 0.3 but the distortion is large."

This system, referred to as an "exotic design" (page 88, final paragraph) therefore has an rms wavefront error of λ/2 or greater and large distortion, and hence does not meet the requirements for a EUV projection system mentioned above.

This is further confirmed on page 127 (fourth paragraph) where it is conceded that systems in the useful six-mirror classes "are already known from the patent literature". The inference is clear: the 9(+) system is interesting as an "exotic design" but is not "useful" as an actual EUV projection system.

5.10 In summary, there is no evidence in the application or elsewhere that incorporating the the distinguishing feature of claim 1 of the auxiliary request into the closest prior art would solve the problem of providing an improved (or even equivalently performing) EUV projection system. In the absence of any other realistic technical problem credibly solved by the claimed subject-matter, it is not possible to acknowledge an inventive step.

Consequently, the Board judges that the subject-matter of claim 1 of the auxiliary request does not involve an inventive step within the meaning of Article 56 EPC 1973.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated