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Datasheet for the decision of 13 December 2007

Case Number: T 1533/05 - 3.4.03

Application Number: 02250785.9

Publication Number: 1231515

IPC: G03F 7/20

Language of the proceedings: EN

Title of invention:
Lithographic apparatus and device manufacturing method

Applicant:
ASML Netherlands B.V.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 123(2), 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 1533/05 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 13 December 2007

Appellant: ASML Netherlands B.V.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 4 August 2005 refusing European application No. 02250785.9 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. G. O'Connell
Members: G. Eliasson
T. Bokor

Summary of Facts and Submissions

I. This is an appeal against the refusal of application 02 250 785 for lack of an inventive step.

II. The following prior art documents are cited in the present decision:

D1: US 5 202 748 A
D3: US 6 078 380 A
D4: US 5 142 132 A.

III. D1 and D3 were cited in the decision under appeal; D4, a document cited in D1, was introduced by the board in a communication annexed to a summons to oral proceedings.

IV. In response to the board's communication the appellant applicant sent amended application documents with a letter dated 9 November 2007.

V. At oral proceedings before the board, the appellant applicant requested that the decision under appeal be set aside and a patent granted in the following version:

Claims 1 to 16 filed at the oral proceedings;

Description
pages 1 to 3 and 8 to 17 as originally filed,
pages 4 and 5 sent with letter dated 9 November 2007,
pages 6 and 7 filed at the oral proceedings;

Drawings as originally filed.

VI. Independent claims 1 and 12 of the above request read as follows (board's emphasis marking amendments with respect to corresponding claims before the examining division):

"1. A lithographic projection apparatus comprising:
a radiation system (EX, IN, CO) for supplying a projection beam of radiation;
a support structure (MT) for supporting patterning means serving to pattern the projection beam according to a desired pattern;
a substrate table (WT) for holding a substrate (W);
a projection system (PL) for projecting the patterned beam onto an exposure area of the substrate, said projection system having a focal plane and comprising at least one adjustable element (21, 23, 25) capable of changing the shape of the focal plane; and
control means (30) arranged to operate during exposure of an exposure area by projection of said patterned beam thereon to control said adjustable element to change the shape of said focal plane so as to be less flat and to more closely conform to the surface contour of said exposure area;
characterised in that
said adjustable element is a **refractive** lens element (21,23,25)."

"12. A device manufacturing method comprising the steps of:
providing a substrate (W) that is at least partially covered by a layer of radiation-sensitive material;

providing a projection beam of radiation using a radiation system (EX, IN, CO);
using patterning means (MA) to endow the projection beam with a pattern in its cross-section;
projecting the patterned beam of radiation onto an exposure area of the layer of radiation-sensitive material using a projection system (PL), said projection system having a focal plane and comprising at least one adjustable element (21, 23, 25) capable of changing the shape of the focal plane; and
controlling said adjustable element (21, 23, 25), during the step of projecting the patterned beam onto an exposure area, to change the shape of said focal plane so as to be less flat and to more closely conform to the surface contour of said exposure area;
characterised in that:
said adjustable element is a **refractive** lens element (21, 23, 25)."

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

Claim 1 is based on claim 1 as originally filed with the added feature that the adjustable element is a refractive lens element. Similarly, independent claim 12 is based on claim 13 as originally filed with the same limitation of the adjustable element to a refractive lens element as in claim 1. This feature is based on eg Figure 8 and accompanying text of the application as originally filed.

Dependent claims 2 to 11 and 13 to 16 correspond to claims 2 to 11 and 14 to 17, respectively, of the application as originally filed.

In the board's judgement, the application complies with Article 123(2) EPC.

3. *Inventive step*

3.1 D4 discloses a lithographic projection apparatus comprising a radiation system 2, a support structure for a reticle 20, a substrate table for a wafer 24, a projection system 6, 8 and 10 comprising a deformable mirror 6 and a control system 12 which controls the shape of the mirror 6 to adjust the focus to project a focused, distortion-free image onto the wafer (column 5, lines 46 to 58 and Figure 1). The light reflected by the wafer is used for the interferometric control of the shape of the deformable mirror 6. The surface

contour of the wafer is therefore automatically taken into account in this process when the focus is adjusted.

3.1.1 The device of claim 1 differs from that of document D4 in that the adjustable element is a refractive lens element, whereas in document D4, the adjustable optical element is a deformable mirror.

3.2 Document Dl discloses a lithographic projection apparatus (column 3, line 48 to column 5, line 6; Figure 1), which in addition to the features of the apparatus of document D4 (reference to document D4 at column 1, line 63 to column 2, line 3) further comprises a second interferometric system 2 and an adjustable wafer chuck 38. The second interferometric system analyses light emitted from a reference light source 4 and reflected from the wafer for analysing the flatness of the wafer and for controlling an adjustable wafer chuck 38. The adjustable wafer chuck 38 is adjusted so as to flatten the wafer, whereas the deformable mirror 48 compensates for aberrations in the optical system (column 4, lines 59 to 65).

3.2.1 The subject matter of claim 1 differs from the apparatus of document Dl in that the control means is operative to control said adjustable element "so as to be less flat and to more closely conform to the surface contour of said exposure area", and in that the adjustable element is a refractive lens. In the apparatus of document D1, the adjustable element is a deformable mirror 48, and a deformable wafer chuck 38 is used for flattening the wafer.

3.3 Document D3 discloses a refractive lithographic projection system for the manufacture of integrated circuit devices (column 1, lines 23 to 29; Figure 1). Document D3 also discloses field curvature correction means (column 3, line 59 to column 4, line 1; column 21, line 35 to column 22, line 61), which are suitable for performing field curvature correction during exposure (column 11, lines 1 to 29; column 65, line 25 to column 68, line 67; Figures 19, 34, 35). The lithographic projection apparatus of document D3 further comprises (see also Figures 1, 19, 34, 35) in particular a radiation system for supplying a projection beam IL of radiation; a support structure RS for supporting patterning means R serving to pattern the projection beam IL to a desired pattern. A projection system PL projects the patterned beam onto a target portion of a substrate (wafer) W on a substrate table WS, where the projection system PL has a focal plane at the substrate W and comprises at least one adjustable refractive lens element (20 to 23) capable of changing the shape of the focal plane.

3.3.1 The subject matter of claim 1 differs from the device of document D3 in that it comprises control means (50, 53) controlling the adjustable refractive lens element (20, 21 a, 21 b, 22, 23) to change the shape of said focal plane so as to be less flat and to more closely conform to the surface contour of said exposure area. In the device of document D3, the adjustable refractive lens elements 20-23 have the purpose of adjusting the focal plane to be as flat as possible while maximising the focal depth (column 10, lines 41 to 50; column 11, lines 24 to 29).

3.4 Document D3 is considered closest prior art as it relates to a lithographic projection apparatus using refractive lens elements. The characterising features with respect to document D3 have the technical effect of allowing a wafer, which has become warped during a previous processing step, to be exposed properly. In the apparatus of document D3, the control means control the adjustable refractive lens elements so that the focal depth is maximised while removing aberrations, thereby accommodating unevenness of the wafer surface to a certain extent. As the focal depth --even after being optimised-- remains very small, the apparatus of document D3 cannot properly expose warped wafers.

Thus, the objective technical problem having regard to document D3 relates to exposing a warped wafer.

3.5 In the decision under appeal, the examining division was of the opinion that the skilled person would be well-acquainted with the problem of warped wafers, as this commonly occurs in a semiconductor chip factory. He would also understand that the solution to this problem would entail matching the field curvature to the wafer curvature. As the field curvature correction means present in the apparatus of document D3 were suitable for performing field curvature correction during exposure, it would be obvious for the skilled person to modify the control means of the apparatus of document D3 to make the shape of the focal plane less flat during exposure to match the surface contour of the wafer to be exposed. The suggestion made in document D1 to use a deformable wafer chuck in order to flatten the wafer surface was not considered to be a realistic alternative.

3.6 The board agrees however with the appellant applicant that none of the available prior art documents teaches adjusting the focal plane of a lithographic projection apparatus so as to follow the existing surface contour of the wafer to be exposed. All conventional prior art lithographic projection systems work on the premise that the wafer should be made as flat as possible before it enters the lithographic projection apparatus, and that the projection system should be optimised for making the focal plane on the wafer surface as flat and as free from distortions as possible. Although the apparatus of document D4 does undisputedly have the effect of compensating for non-flat wafer surfaces, there is no teaching in document D4 that this was intended or recognised: the adjustable mirror is taught as having the purpose of reducing focus errors resulting from "distortions induced mechanically, thermally and by vibration of the system", that is distortions originating from the optical system itself (column 3, lines 53 to 56; column 2, line 63 to column 3, line 2; column 5, lines 46 to 58). Therefore, the skilled person reading document D4 at the priority date of the application would consider this teaching in the context of other known lithographic projection systems. In the absence of any explicit teaching that the apparatus of document D4 could be used with warped wafers, the skilled person would therefore assume that the wafers to be exposed in the apparatus of document D4 would have to be flat. This is also more clearly illustrated in document D1 which discloses an apparatus developed from that of document D4 and explicitly addresses the problem of warped wafers (column 2, lines 29 to 34). In addition to the deformable mirror

known from document D4 which is adjustable in response from signals from a first interferometer, a second interferometer and a deformable wafer chuck 38 are added. In the apparatus of document D1, the deformable wafer chuck 38 has the purpose of flattening the wafer and the deformable mirror removes distortions in the optical system (D1, column 4, line 59 to 65; column 5, line 6).

Even if - as suggested by the examining division - the solution suggested in document D1 of using an adjustable wafer chuck should turn out not to be successful in removing the effect of wafer warp, in the judgement of the board it nevertheless could not be inferred without hindsight that the skilled person would, without further ado, proceed to solve this problem by instead using a suitably controlled adaptive optical system in the lithographic projection apparatus.

The board cannot find any indication in the prior art that would lead the skilled person to the insight that the apparatus of document D3 could be operated in such a way as to adjust the shape of the focal plane to the surface contour of the wafer.

3.7 Starting from the apparatus of document D4, the skilled person would also not arrive at the claimed device without employing inventive skills, since D4 explicitly teaches the use of a deformable mirror also for a purely refractive optic system (column 6, lines 23 to 27), thereby leading the skilled person away from replacing the deformable mirror with a series of adjustable refractive lens elements.

Furthermore, as mentioned above, and most importantly, document D4 lacks any explicit teaching that it would be useful for compensating for wafer warp and none of the conventional lithographic projection apparatuses in use at the priority date of the application appears to have used adaptive optics for this purpose. Therefore, the skilled person reading document D4 would only consider its teaching relevant for the purpose of compensating for aberrations in the optical system. In other words, D4 is an accidental anticipation of claim 1 as originally filed whose relevance on inventive step can only be seen with hindsight.

3.8 For the above reasons, in the board's judgement, the subject matter of claim 1 involves an inventive step within the meaning of Article 56 EPC.

3.9 The subject matter of independent claim 12 involves an inventive step for the same reasons as given above.

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 grant a patent in the following version:

Claims

1 to 16 filed at the oral proceedings;

Description

pages 1 to 3 and 8 to 17 as originally filed,
pages 4 and 5 sent with letter dated 9 November 2007,
pages 6 and 7 filed at the oral proceedings;

Drawings as originally filed.

Registrar | Chair

S. Sánchez Chiquero | R. G. O'Connell