(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 October 2012 (04.10.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/134292 A4

(51) International Patent Classification:
G01B 9/02 (2006.01) *G03F 7/20* (2006.01)

(21) International Application Number:
PCT/NL2012/050211

(22) International Filing Date:
30 March 2012 (30.03.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2006496 30 March 2011 (30.03.2011) NL

(71) Applicant *(for all designated States except US)*: **Mapper Lithography IP B.V.** [NL/NL]; Computerlaan 15, NL-2628 XK Delft (NL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **DE BOER, Guido** [NL/NL]; Recht van ter Leede 31, NL-4145 LN Leerdam (NL). **OOMS, Thomas Adriaan** [NL/NL]; Laan der Zeven Linden 16, NL-2645 GS Delfgauw (NL). **VERGEER, Niels** [NL/NL]; Schiebroeksestraat 12a, NL-3037 RV Rotterdam (NL). **COUWELEERS, Godefridus Cornelius Antonius** [NL/NL]; Otterlaan 2, NL-2623 CX Delft (NL).

(74) Agent: **DE HOOP, Eric**; Octrooibureau Vriesendorp & Gaade B.V., Dr. Kuyperstraat 6, NL-2514 BB Den Haag (NL).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *with amended claims and statement (Art. 19(1))*

Date of publication of the amended claims and statement: 29 November 2012

WO 2012/134292 A4

(54) **Title**: ALIGNMENT OF AN INTERFEROMETER MODULE FOR AN EXPOSURE TOOL

(57) **Abstract**: The invention relates to alignment of an interferometer module (60) for use in an exposure tool. An alignment method is provided for aligning an interferometer to the tool while outside of the tool. Furthermore, the invention provides a dual interferometer module, an alignment frame use in the alignment method, and an exposure tool provided with first mounting surfaces for cooperative engagement with second mounting surfaces (62, 63, 64) of an interferometer module.

AMENDED CLAIMS
received by the International Bureau on 08 October 2012 (08.10.2012)

1. Method of pre-aligning an interferometer module for use in an exposure tool comprising a frame provided with first mounting surfaces and a mirror for reflecting an interferometer beam, wherein said module comprises an interferometer head for emitting the interferometer beam, and wherein said module is connected to second mounting surfaces for cooperative engagement with said first mounting surfaces, said method comprising the step of:

aligning the orientation of said module relative to said second mounting surfaces outside of said exposure tool, wherein said orientation of said module relative to said second mounting surfaces is aligned based on a pre-determined orientation of said first mounting surface relative to said mirror.

2. Method according to claim 1, further comprising a step of mounting said aligned module in said exposure tool.

3. Method according to claim 1 or claim 2, wherein said step of aligning comprises:

providing an alignment frame spaced apart from said exposure tool and comprising third mounting surfaces for cooperative engagement with said second mounting surfaces, and a sensor for sensing whether a beam emitted by said interferometer head is emitted to a pre-determined position,

mounting said module with said second mounting surfaces on said third mounting surfaces of said alignment frame,

emitting a beam with said interferometer head, and

adjusting the orientation of said module relative to said second mounting surfaces to position said beam on

said pre-determined position.

4. Method according to claim 3, further comprising using a knife-edge arranged for partially blocking said beam from reaching said sensor when said module is mounted in said alignment frame, wherein said step of adjusting comprises determining that said beam is in said predetermined position when the energy of said beam sensed by said sensor is substantially equal to a predetermined fraction of a total beam energy of said beam.

5. Method according to claim 3, wherein said interferometer is a differential interferometer adapted for emitting said beam as a measurement beam and for emitting a corresponding reference beam, wherein said alignment frame comprises a sensor for sensing the position of said reference beam, said method comprising adjusting the orientation of said module relative to the direction into which said measurement and reference beams are emitted such that the sum of energy of said beams sensed by said beam sensing surfaces is substantially equal to a predetermined fraction of a total beam energy of said beams.

6. Method according to claim 4 or claim 5, wherein said predetermined fraction is substantially 50%.

7. Method according to any one of the claims 3-6, wherein said first mounting surfaces of said exposure tool and/or said third mounting surfaces of said alignment frame are adapted for forming a kinematic mount with said second mounting surfaces of said interferometer module.

8. Method according to any one of the preceding claims, wherein said module comprises a further interferometer head arranged for emitting a further beam substantially perpendicular to said beam, wherein said aligning further comprises the steps of:

aligning the orientation of said further interferometer head relative to said second mounting surfaces outside of said exposure tool based on a pre-determined orientation of said first mounting surfaces,

wherein the orientations of said interferometer

head and said further interferometer head are adjusted such that said beams emitted by said interferometer head and said further interferometer head are inclined at a substantially pre-determined angle to each other.

9. Method according to claim 8, wherein said predetermined angle is 90 degrees.

10. Method according to claim 8 or claim 9, wherein said aligning comprises aligning said beam and said further beam such that they intersect.

11. Interferometer module for use in the method according to any one of the preceding claims, wherein said interferometer module comprises an interferometer head for emitting a beam, second mounting surfaces for cooperative engagement with said first mounting surfaces of said exposure tool, and adjustment means for adjusting the orientation of said interferometer head relative to said second mounting surfaces.

12. Interferometer module according to claim 11, wherein said interferometer head is a first interferometer head, said module further comprising a second interferometer head arranged for emitting a beam substantially perpendicular to a beam emitted by said first interferometer head, and second adjustment means for adjusting an orientation of said second interferometer head relative to said second mounting surfaces.

13. Interferometer module according to claim 12, wherein said interferometer module is substantially L-shaped, with said first and second interferometer head each arranged on different legs of said L-shaped module for emitting a beam towards each other.

14. Interferometer module according to claim 13, wherein said second mounting surfaces are arranged at corners of said L-shaped module.

15. Interferometer module according to any one of the claims 11-14, wherein said adjustment means comprise a number of adjustment plates.

16. Alignment frame for use in the method of any

one of the claims 1 to 10 for the pre-alignment of an interferometer module, wherein said module comprises an interferometer head for emitting a beam, second mounting surfaces for cooperative engagement with first mounting surfaces of an exposure tool spaced apart from said alignment frame, said alignment frame comprising third mounting surfaces for cooperative engagement with said second mounting surfaces and a sensor for sensing a position of a beam emitted by said interferometer head.

17. Alignment frame according to claim 16, wherein said third mounting surfaces are adapted to form a kinematic mount with said second mounting surfaces.

18. Alignment frame according to claim 16 or 17, wherein said sensor is arranged for having said emitted beam directly incident thereon when said second mounting surfaces are engaging said third mounting surfaces.

19. Alignment frame according to any one of claims 16-18, wherein said sensor is arranged at a predetermined position relative to said third mounting surfaces.

20. Alignment frame according to any one of the claims 16-19, wherein said sensor comprises a beam sensing surface for sensing a beam incident thereon.

21. Alignment frame according to claim 20, further comprising a knife-edge arranged between said module and said beam sensing surface and proximate to said beam sensing surface.

22. Alignment frame according to claim 20 or claim 21, wherein said beam sensing surface is greater than or equal to the area of a perpendicular cross-section of said beam.

23. Alignment frame according to any one of the claims 16-22, further comprising one or more additional sensors spaced apart from said sensor and adapted for sensing positions of one or more additional beam spots of one or more additional beams emitted by said interferometer module.

24. Exposure tool comprising:

projection optics for projecting one or more exposure beams onto a target,

a target positioning system comprising a target carrier adapted for moving said target relative to said projection optics,

wherein said target carrier is provided with a mirror,

first mounting surfaces having a substantially pre-determined orientation,

an interferometer module according to any one of claim 11-15 adapted for measuring a displacement of said target within said tool, said interferometer module comprising second mounting surfaces adapted for cooperative engagement with said first mounting surfaces,

wherein said target positioning system is adapted for moving said target based on said measured displacement,

wherein said exposure tool and interferometer module are adapted for releasably mounting said second mounting surfaces of said interferometer module on said first mounting surfaces of said exposure tool such that said second mounting surfaces are aligned relative to said first mounting surfaces.

25. Exposure tool according to claim 24, further comprising releasable clamping means for releasably clamping said second mounting surfaces of said interferometer module against said first mounting surfaces.

26. Exposure tool according to claim 25, wherein said clamping means are quick-release clamping means.

27. Exposure tool according to claim 25 or claim 26, wherein said releasable clamping means comprises a leaf-spring adapted for biasing said second mounting surfaces against said first mounting surfaces.

28. Exposure tool according to any on of the claim 24-27, wherein said exposure tool comprises an accommodating section for receiving said interferometer module, said accommodating section comprising said first

mounting surfaces.

29. Exposure tool according to claim 28, wherein said accommodating section comprises a wall provided with a passage for allowing a beam emitted by said interferometer to pass through.

30. Exposure tool according to any one of the claims 24-29, wherein said first mounting surfaces comprise three spaced apart planar abutment surfaces for abutting said second mounting surfaces, wherein said planes of said abutment surfaces intersect at a position having a distance to said projection optics which is substantially greater than a distance of said interferometer head to said projection optics along the direction of the beam emitted by said interferometer head.

31. Exposure tool according to claim 30, wherein said first mounting surfaces comprise grooves extending parallel to said abutment surfaces.

STATEMENT UNDER ARTICLE 19 (1)

Claim 1 discloses a method of pre-aligning an interferometer module for use in an exposure tool comprising a frame provided with first mounting surfaces and a mirror for reflecting an interferometer beam. The module comprises an interferometer head for emitting the interferometer beam, wherein said module is connected to second mounting surfaces for cooperative engagement with said first mounting surfaces. The method comprises the step of: - aligning the orientation of said module *relative to* said second mounting surfaces **outside of** said exposure tool, wherein said orientation of said module relative to said second mounting surfaces is aligned based on a pre-determined orientation of said first mounting surface relative to said mirror. To this end the interferometer module is provided with adjustment means for adjusting the orientation of said interferometer head relative to the second mounting surface (see claim 11). Also, the interferometer comprises a second mounting surface for engaging with the first mounting surface in a predetermined and fixed manner. Furthermore, an alignment frame may be used comprising third mounting surfaces for cooperative engagement with said second mounting surfaces and a sensor for sensing a position of a beam emitted by said interferometer head (see claim 16).

It must be stressed that none of the documents D1 (EP1,174,679A2), D2 (US2005/0225770A1), D3 (US2005/0105855A1) disclose a method of pre-aligning an interferometer module for use in an exposure tool as in claim 1. Logically said documents neither disclose an interferometer nor an alignment frame for use in such method. Novelty of the claims is therefore evident. The argumentation of the Examiner in the Written Opinion, which resembles a problem-solution approach, goes wrong as it is based upon hind-sight.

The method of claim 1 is far from conventional. In conventional exposure tools interferometers are aligned while mounted in the machine, which is a cumbersome way of working, requiring highly specialized professionals which need access to cleanrooms, where the exposure tools are located. Apart from reducing the down-time of the exposure tool, the invention circumvents this problem in a very clever way. Alignment-in-place is substituted with a method of pre-alignment outside the cleanroom. Furthermore, said pre-alignment has been reduced to an activity which may be carried out by less specialized engineers without requiring clean-room access. A key insight behind the invention is that the pre-alignment is possible if it can be guaranteed that a mechanical fit between the first and second mounting surfaces produces a predictable and reproducible orientation of the interferometer with respect to the exposure tool. Without the insight as here described it is far from trivial to arrive at something falling within the scope of the claims, and therefore the invention is believed to involve an inventive step. The fact that the Examiner did not find any documents teaching or giving hints towards the solution underlines the applicant's point-of-view.