

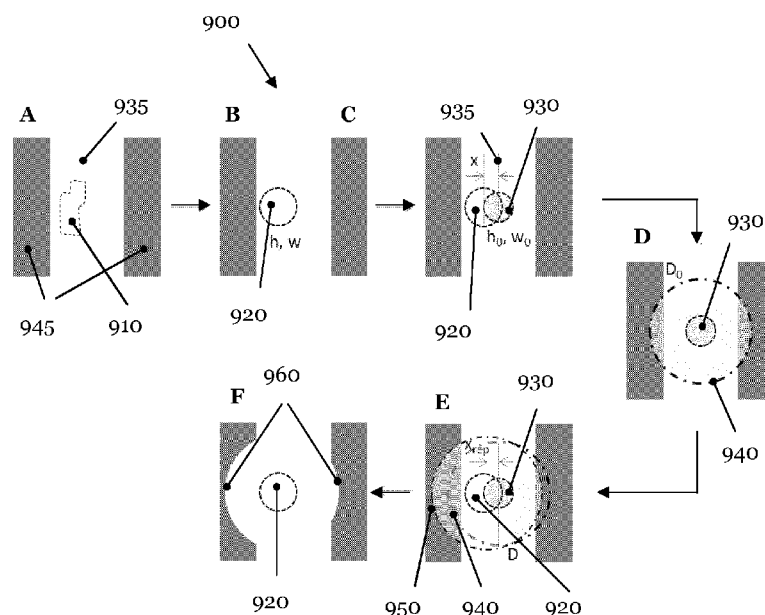


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61/509,206 19 July 2011 (19.07.2011) US
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- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, 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, 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).

[Continued on next page]

(54) **Title:** METHOD AND APPARATUS FOR ANALYZING AND FOR REMOVING A DEFECT OF AN EUV PHOTOMASK

Fig. 9



(57) **Abstract:** The invention refers to a method for analyzing a defect of an optical element for the extreme ultra-violet wavelength range comprising at least one substrate and at least one multi-layer structure, the method comprising the steps: (a) determining first data by exposing the defect to ultra-violet radiation, (b) determining second data by scanning the defect with a scanning probe microscope, (c) determining third data by scanning the defect with a scanning particle microscope, and (d) combining the first, the second and the third data.

**Published:****(88) Date of publication of the international search report:**

14 March 2013

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/063881

A. CLASSIFICATION OF SUBJECT MATTER

INV. G03F1/22 G03F1/84 G03F1/86
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G03F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	RIK JONCKHEERE ET AL: "Evidence of printing blank-related defects on EUV masks missed by blank inspection", PROCEEDINGS OF SPIE, 2 February 2011 (2011-02-02), page 79850W-1, XP55043311, ISSN: 0277-786X, DOI: 10.1117/12.883854 cited in the application	1,2, 7-10,25, 26
Y	the whole document	1-7, 9-14,16, 17,24-26
	----- -/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 January 2013

Date of mailing of the international search report

31/01/2013

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/063881

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	VAN DEN HEUVEL D ET AL: "Natural EUV mask blank defects: evidence, timely detection, analysis and outlook", PROCEEDINGS OF THE SPIE - THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING SPIE - THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING USA, vol. 7823, 13 September 2010 (2010-09-13), pages 78231T-1-78231T-12, XP55043306, ISSN: 0277-786X, DOI: 10.1117/12.865812 cited in the application abstract; figures 5, 8-10 page 1 - page 12 -----	1,7-10
Y	WO 2004/015496 A2 (FEI CO [US]; FERRANTI DAVID C [US]; RAY VALERY [US]; SMITH GERALD [US]) 19 February 2004 (2004-02-19) abstract; figures 2, 4A, 4B, 5-8 paragraph [1022] - paragraph [1026] paragraph [1044] - paragraph [1050] -----	1-7, 9-14,16, 17,24-26
A	TSUNEO TERASAWA ET AL: "Actinic phase defect detection and printability analysis for patterned EUVL mask", SPIE PROCEEDINGS, THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING - SPIE, BELLINGHAM, WASHINGTON, USA, vol. 7636, 1 March 2010 (2010-03-01), pages 763602-1-763602-10, XP002659237, ISSN: 0277-786X, DOI: 10.1117/12.846678 ISBN: 0-8194-2351-3 the whole document -----	1-13,25, 26
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/063881

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CLIFFORD CHRIS ET AL: "Compensation methods for buried defects in extreme ultraviolet lithography masks", JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY: PART B, AVS / AIP, MELVILLE, NEW YORK, NY, US, vol. 29, no. 1, 11 January 2011 (2011-01-11), pages 11022-1-11022-6, XP012144469, ISSN: 1071-1023, DOI: 10.1116/1.3531927	14,15, 20-23
Y	the whole document	16,17,24
X	US 2008/318138 A1 (HOLFELD CHRISTIAN [DE]) 25 December 2008 (2008-12-25) abstract; figures 1A, 1B, 5A-5E, 6 paragraph [0005] - paragraph [0041] paragraph [0083] - paragraph [0087]	14,18,19
X	M. WAIBLINGER ET AL: "E-beam induced EUV photomask repair: a perfect match", PROCEEDINGS OF SPIE, vol. 7545, 3 February 2010 (2010-02-03), pages 75450P-1-75450P-8, XP055050034, ISSN: 0277-786X, DOI: 10.1117/12.863542 the whole document	14,16,17
Y	US 2010/154521 A1 (BUDACH MICHAEL [DE]) 24 June 2010 (2010-06-24) the whole document	1,2,7, 9-11,14, 16,17, 24-26

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2012/063881

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-13, 25, 26

Method for analyzing a defect of an optical element by determining first, second and third data and combining those data.

Technical effect: defect analysis.

2. claims: 14-24

Method for determining a repairing form to compensate at least one defect of an EUV photolithographic mask.

Technical effect: mask repair.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/063881

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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