**Title:** METHOD AND SYSTEM DETECTING PHASE DEFECTS IN PHOTOMASKS AND WAFERS

**Abstract:** Provided are apparatus and methods for detecting phase defects. The invention relies generally on the distortion of light as it passes through defects in phase shift masks to detect these defects. Light traveling through a defect, such as a bump in an etched area will travel at a different angle than light traveling through air. In order to enhance the signals generated from the defects, the invention in several embodiments provides a multiple element detector (700) having at least four elements (701-716), arranged in a radially symmetric configuration. Individual elements of the detector (700) are selected to form a differential signal based on the configuration of pattern lines in the area proximate to the defect. The resulting differential signal is used to generate an image signal and to identify phase defects.
INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/29789

A. CLASSIFICATION OF SUBJECT MATTER
IPC(T7) : G02B 09/02
US CL : 250/559.45; 348/125
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)
U.S. : 250/559.45; 348/125

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
None

Electronic database consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US 6,249,988 B1 (KRANTZ) 19 June 2001 (19.06.2001), see entire document.</td>
<td>1-3,21-23,40-42</td>
</tr>
<tr>
<td></td>
<td>document.</td>
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</tr>
</tbody>
</table>

☐ 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 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
- "F" 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
- "A" document member of the same patent family

Date of the actual completion of the international search
10 January 2004 (10.01.2004)

Date of mailing of the international search report
24 MAR 2004

Name and mailing address of the ISA/US
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Stephne B. Allen
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Form PCT/ISA/210 (second sheet) (July 1998)
INTERNATIONAL SEARCH REPORT

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

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

1. □ Claim Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. ◐ Claim Nos.: 4-20, 24-39 and 43 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:
   Claims 4-20, 24-39 and 43 are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a) in that they are improper multiple dependent claims.

3. □ Claim Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

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

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 fee, this Authority did not invite payment of any additional fee.

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.
□ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1)) (July 1998)
Continuation of B. FIELDS SEARCHED Item 3:
USPTO EAST DATABASE
search terms: phase near$5$ defect$4$ and (mask$1$ or photomask$1$ or wafer$1$) and (reflected or transmitted)