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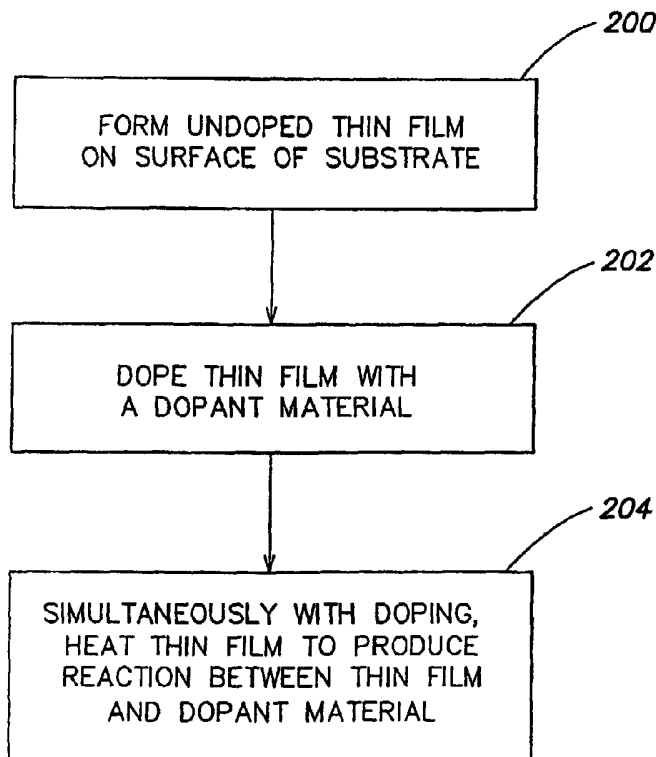
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- (51) International Patent Classification⁷: **H01L 21/314**, 21/285, 21/28 (74) Agent: **McCLELLAN, William, R.**; Wolf, Greenfield & Sacks, P.C., 600 Atlantic Avenue, Boston, MA 02210 (US).
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- (71) Applicant: **VARIAN SEMICONDUCTOR EQUIPMENT ASSOCIATES, INC.** [US/US]; 35 Dory Road, Gloucester, MA 01930 (US). (88) Date of publication of the international search report: 18 December 2003
- (72) Inventor: **DOWNEY, Daniel, F.**; 8 Ryan Road, Magnolia, MA 01930 (US). For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD FOR FORMING THIN FILM LAYERS BY SIMULTANEOUS DOPING AND SINTERING



(57) Abstract: The method includes the steps of doping a thin surface layer on the substrate with low energy ions of a dopant material, and heating the thin surface layer sufficiently to produce a reaction between the dopant material and the surface layer. The heating step is performed simultaneously with at least part of the doping step. The doping step may utilize plasma doping of the thin surface layer. In one embodiment, the doping step includes plasma doping of a silicon oxide layer with nitrogen ions. The heating step may utilize thermal conduction or heating with radiation, such as heating with optical energy. The process may be used for forming dielectric layers having a thickness of 50 angstroms or less.

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INTERNATIONAL SEARCH REPORT

International Application No
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<p>A. CLASSIFICATION OF SUBJECT MATTER IPC 7 H01L21/314 H01L21/285 H01L21/28</p>		
<p>According to International Patent Classification (IPC) or to both national classification and IPC</p>		
<p>B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 7 H01L</p>		
<p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p>		
<p>Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, PAJ</p>		
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 824 268 A (TEXAS INSTRUMENTS INC) 18 February 1998 (1998-02-18) abstract column 3, line 19 - line 23 -----	1-22
X	WO 00 65631 A (APPLIED MATERIALS INC) 2 November 2000 (2000-11-02) page 21, line 16 - page 22, line 21; figures 10,16 -----	1-22
A	WO 02 17372 A (MICRO C TECHNOLOGIES INC) 28 February 2002 (2002-02-28) the whole document -----	1-22
A	US 6 168 980 B1 (ZHANG HONGYONG ET AL) 2 January 2001 (2001-01-02) the whole document -----	1-22
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<p><input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.</p>		
<p>° Special categories of cited documents :</p>		
<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p>		<p>"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</p>
<p>"E" earlier document but published on or after the international filing date</p>		<p>"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</p>
<p>"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)</p>		<p>"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.</p>
<p>"O" document referring to an oral disclosure, use, exhibition or other means</p>		<p>"&" document member of the same patent family</p>
<p>"P" document published prior to the international filing date but later than the priority date claimed</p>		
<p>Date of the actual completion of the international search 23 May 2003</p>		<p>Date of mailing of the international search report 30 SEP 2003</p>
<p>Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016</p>		<p>Authorized officer Nesso, S.</p>

INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2001/021588 A1 (MISIUM GEORGE R ET AL) 13 September 2001 (2001-09-13) the whole document -----	1-22
A	US 6 069 054 A (CHOI JEONG Y) 30 May 2000 (2000-05-30) the whole document -----	1-22
A	EP 0 973 189 A (TEXAS INSTRUMENTS INC) 19 January 2000 (2000-01-19) the whole document -----	1-22
A	US 6 268 296 B1 (MISIUM GEORGE R ET AL) 31 July 2001 (2001-07-31) the whole document -----	1-22

INTERNATIONAL SEARCH REPORT

International application No.
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Box I Observations where certain claims were found unsearchable (Continuation of item 1 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.: **1-3 9-16 18**
because they relate to subject matter not required to be searched by this Authority, namely:
see FURTHER INFORMATION sheet PCT/ISA/210
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 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:

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 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.:
1-22

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
 No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.1

Claims Nos.: 1-3 9-16 18

The second invention defined in Form PCT/ISA/206 relating to a method of forming a metal film has not been searched because it is not supported by the description. Indeed, it is unclear how a reaction between a dopant material and a surface layer could bring to the formation of a metal film. Since the description gives no further explanation or example about how this metal film is formed, this second invention is not supported by the description and thus it has not been searched.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

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

1. claims: 1-22

A method of forming a thin film layer on a substrate, comprising the steps of: doping a thin surface layer with low energy atoms of dopant material; and heating the thin surface layer to produce a reaction between the dopant material and the surface layer to form a dielectric film having a thickness of 50 angstroms or less, the heating step being performed simultaneously with the doping step.

Claims 1-3, 9-16, 18

A method of forming a thin film layer on a substrate, comprising the steps of: doping a thin surface layer with low energy atoms of dopant material; and heating the thin surface layer to produce a reaction between the dopant material and the surface layer to form a metal film having a thickness of 50 angstroms or less, the heating step being performed simultaneously with the doping step.

2. claims: 1-3 9-16 18

A method of forming a thin film layer on a substrate, comprising the steps of: doping a thin surface layer with low energy atoms of dopant material; and heating the thin surface layer to produce a reaction between the dopant material and the surface layer to form a silicide film having a thickness of 50 angstroms or less, the heating step being performed simultaneously with the doping step.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 03/06840

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