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(54) Title: METHODS OF FORMING SEMICONDUCTOR CONTACTS AND RELATED SEMICONDUCTOR DEVICES

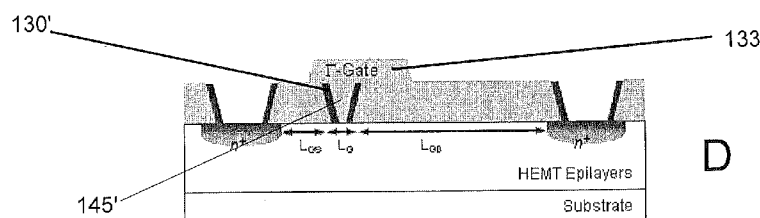


FIGURE 1

(57) **Abstract:** Methods of forming semiconductor devices having customized contacts are provided including providing a first insulator layer and patterning the first insulator layer such that the first insulator layer defines at least one contact window. A second insulator layer is provided on the first insulator layer and in the at least one contact window such that the second insulator layer at least partially fills the at least one contact window. A first portion of the second insulator layer is etched such that a second portion of the second insulator layer remains in the at least one contact window to provide at least one modified contact window having dimensions that are different than dimensions of the at least one contact window. Related methods and devices are also provided.



INTERNATIONAL SEARCH REPORT		International application No. PCT/US11/42933															
A. CLASSIFICATION OF SUBJECT MATTER IPC: H01L 29/778(2006.01),21/306(2006.01) USPC: 257/194,E29.246,E21.215;438/172,738 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. : 257/194, E29.246, E21.215; 438/172, 738 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) Please See Continuation Sheet																	
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category *</th> <th style="width: 60%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width: 30%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">X</td> <td>US 2010/0025730 A1 (HEIKMAN et al) 04 February 2010 (04.02.2010); figures 7A, 7B, 8 and paragraphs 0092-0093.</td> <td>1-12, 14-18, 20-22, 26-35, 37, and 39</td> </tr> <tr> <td style="text-align: center;">X</td> <td>US 2007/0249119 A1 (SAITO) 25 October 2007 (25.10.2007); figures 14B and 15A-15B.</td> <td>40-42 and 46-57</td> </tr> <tr> <td style="text-align: center;">X</td> <td>PING, A.T. et al; A High-Performance 0.13um AlGaAs/InGaAs pHEMT Process Using Sidewall Spacer Technology, GaAs MANTECH 2005 International Conference on Compound Semiconductor Manufacturing; April 11-14, 2005; 4 pages, especially Abstract, figures 1(a)-1(d), and figure 2.</td> <td>59-61</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US 2007/0018199 A1 (SHEPPARD et al) 25 January 2007 (25.01.2007); figures 1E-1H and paragraph 0046.</td> <td>1-12, 14-18, 20, 22, 26-35, 37, 39-42, 46-57, and 59-61</td> </tr> </tbody> </table>			Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	US 2010/0025730 A1 (HEIKMAN et al) 04 February 2010 (04.02.2010); figures 7A, 7B, 8 and paragraphs 0092-0093.	1-12, 14-18, 20-22, 26-35, 37, and 39	X	US 2007/0249119 A1 (SAITO) 25 October 2007 (25.10.2007); figures 14B and 15A-15B.	40-42 and 46-57	X	PING, A.T. et al; A High-Performance 0.13um AlGaAs/InGaAs pHEMT Process Using Sidewall Spacer Technology, GaAs MANTECH 2005 International Conference on Compound Semiconductor Manufacturing; April 11-14, 2005; 4 pages, especially Abstract, figures 1(a)-1(d), and figure 2.	59-61	A	US 2007/0018199 A1 (SHEPPARD et al) 25 January 2007 (25.01.2007); figures 1E-1H and paragraph 0046.	1-12, 14-18, 20, 22, 26-35, 37, 39-42, 46-57, and 59-61
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☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.																	
<table style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> * 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 </td> <td style="width: 50%; vertical-align: top;"> "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 </td> </tr> </table>			* 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	"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													
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Date of the actual completion of the international search 14 February 2013 (14.02.2013)		Date of mailing of the international search report 14 FEB 2013															
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201		Authorized officer Marcos D. Pizarro Telephone No. 571-272-1705															

INTERNATIONAL SEARCH REPORT		International application No. PCT/US11/42933
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	2008/0157121 A1 (OHKI et al) 03 July 2008 (03.07.2008); figures 7A-7B and paragraph 0055.	1-12, 14-18, 20, 22, 26-35, 37, 39-42, 46-57, and 59-61
A	US 2009/0189187 A1 (BRIERE et al) 30 July 2009 (30.07.2009); figures 2, 3A-3C and paragraph 0020.	1-12, 14-18, 20, 22, 26-35, 37, 39-42, 46-57, and 59-61
A	US 2010/0171150 A1 (SMITH et al) 08 July 2010 (08.07.2010); figures 13-18.	1-12, 14-18, 20, 22, 26-35, 37, 39-42, 46-57, and 59-61

INTERNATIONAL SEARCH REPORT	International application No. PCT/US11/42933
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.: 23-25,38 and 43-45 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: because they are dependent claims and are not drafted in accordance with the first sentence of Rule 6.4(a).
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: Please See Continuation 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 additional fees, this Authority did not invite payment of any 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.: 1-12,14-18,20-22,26-35,37,39-42,46-57 and 59-61
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.

INTERNATIONAL SEARCH REPORTInternational application No.
PCT/US11/42933**BOX III. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING**

This International Search Authority has found 4 inventions claimed in the International Application covered by the claims as indicated below.

REQUIREMENT FOR UNITY OF INVENTION

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1.

Group I, claim(s) 1-12, 14-18, 20-24, 26-35, 37-57, and 59-61, drawn to a method comprising the combination of steps of etching a first layer of the second insulator at a slower rate than a second layer of the second insulator, and etching the first insulator at a slower rate than the second insulator.

Group II, claim(s) 1-12, 14-17, 19-24, 26-34, 36-56, and 58-61, drawn to a method comprising the combination of steps of etching a first layer of the second insulator at a slower rate than a second layer of the second insulator, and etching the first insulator at a faster rate than the second insulator.

Group III, claim(s) 1-11, 13-18, 20-23, 25-35, 37-57, and 59-61, drawn to a method comprising the combination of steps of etching a first layer of the second insulator at a faster rate than a second layer of the second insulator, and etching the first insulator at a slower rate than the second insulator.

Group IV, claim(s) 1-11, 13-17, 19-23, 25-34, 36-56, and 58-61, drawn to a method comprising the combination of steps of etching a first layer of the second insulator at a faster rate than a second layer of the second insulator, and etching the first insulator at a faster rate than the second insulator.

This International Searching Authority considers that the international application does not comply with the requirements of unity of invention (Rules 13.1, 13.2 and 13.3) for the reasons indicated below:

The groups of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical feature of the Group I invention is the claimed combination of steps of etching a first layer of the second insulator at a slower rate than a second layer of the second insulator, and etching the first insulator at a slower rate than the second insulator, and this feature is not present in Groups II-IV.

The special technical feature of the Group II invention is the claimed combination of steps of etching a first layer of the second insulator at a slower rate than a second layer of the second insulator, and etching the first insulator at a faster rate than the second insulator, and this feature is not present in Groups I, III, and IV.

The special technical feature of the Group III invention is the claimed combination of steps of etching a first layer of the second insulator at a faster rate than a second layer of the second insulator, and etching the first insulator at a slower rate than the second insulator, and this feature is not present in Groups I, II, and IV.

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The special technical feature of the Group IV invention is the claimed combination of steps of etching a first layer of the second insulator layer at a faster rate than a second layer of the second insulator, and etching the first insulator at a faster rate than the second insulator, and this feature is not present in Groups I-III.

Therefore, since there is no special technical feature common to Groups I-IV, unity of invention is lacking.

Continuation of B. FIELDS SEARCHED Item 3:

EAST database

search terms: gate, source, drain, HEMT, SiC, GaN, channel, barrier, buffer