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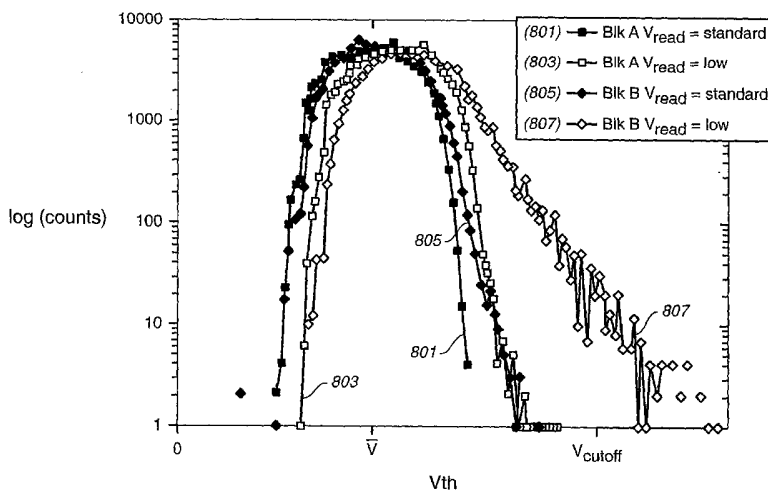
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(54) Title: METHODS FOR IDENTIFYING NON-VOLATILE MEMORY ELEMENTS WITH POOR SUBTHRESHOLD SLOPE OR WEAK TRANSCONDUCTANCE



(57) Abstract: The present invention presents a number of methods for identifying cells with poor subthreshold slope and reduced transconductance. A first set of techniques focuses on the poor subthreshold behavior of degraded storage elements by cycling cells and then programming them to a state above the ground state and the reading them with a control gate voltage below the threshold voltage of this state to see if they still conduct. A second set of embodiments focuses on weak transconductance behavior by reading programmed cells with a control gate voltage well above the threshold voltage. A third set of embodiments alters the voltage levels at the source-drain regions of the storage elements. The current-voltage curve of a good storage element is relatively stable under this shift in bias conditions, while degraded elements exhibit a larger shift. The amount of shift can be used to differentiate the good elements from the bad.

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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US2004/030493

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 G11C16/34 G11C29/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) IPC 7 G11C		
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 practical, search terms used) EPO-Internal, WPI Data, PAJ		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A A A	EP 0 686 979 A (ST MICROELECTRONICS SRL) 13 December 1995 (1995-12-13)  column 4, line 15 - column 5, line 58; figures 3,4  ----- US 6 128 219 A (PIO ET AL) 3 October 2000 (2000-10-03) column 1, line 47 - line 51  ----- US 5 909 398 A (TANZAWA ET AL) 1 June 1999 (1999-06-01) column 6, line 43 - line 51  ----- -/---	1-3, 20, 26, 38 14-17, 22-24, 33 4-6, 28-31  12  12
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <span style="margin-left: 200px;"><input checked="" type="checkbox"/> Patent family members are listed in annex.</span>		
° 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 document 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  <p style="text-align: center; font-size: 1.2em;">2 June 2005</p>	Date of mailing of the international search report  <p style="text-align: center; font-size: 1.2em;">22.06. 2005</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	Authorized officer  <p style="text-align: center; font-size: 1.2em;">Ramcke, T</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.
Y	US 5 428 621 A (MEHROTRA ET AL) 27 June 1995 (1995-06-27) column 10, line 19 - line 20 column 12, line 4 - line 10 -----	14,16, 17,33
P,Y	US 2004/111553 A1 (CONLEY KEVIN M) 10 June 2004 (2004-06-10) claim 24 -----	15
P,Y	US 2003/210573 A1 (LEE CHANG-HYUN) 13 November 2003 (2003-11-13) paragraph '0031! -----	22-24
Y	US 6 236 609 B1 (TANZAWA TORU ET AL) 22 May 2001 (2001-05-22) column 8, line 61 - line 67 -----	22-24
Y	US 5 675 546 A (LEUNG ET AL) 7 October 1997 (1997-10-07) column 2, line 22 - line 33 -----	22

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2004/030493

## Box 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 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 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.:  
1-6, 12, 14-17, 20, 22-24, 26, 28-31, 33, 38
  
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.

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

1. claims: 1-6,20,26,28-31,38

Claims 4 and 28: Source drain voltage levels differ for first and second bias conditions  
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2. claim: 7

Determine whether the distribution developed a tail in response to second bias conditions  
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3. claims: 8-11

Determine whether a shift of the distribution has exceeded a predetermined criterion  
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4. claim: 12

Compare shift for first population with shift for second population  
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5. claims: 13,32

Perform method as part of initial test  
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6. claims: 14-17,33

Perform method subsequent to operation of memory  
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7. claims: 18,36

Select population at random  
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8. claims: 19,37

Logically remap population in response to determining  
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9. claims: 21,25

Second set control gate voltage is lower than first set control gate voltage  
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10. claims: 22-24

Number of program and erase cycles prior to said method  
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11. claim: 27

Second set control gate voltage is twice the first set  
control gate voltage  
---

12. claim: 34

Perform method in response to ECC error  
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13. claim: 35

Perform method in response to a number of operations  
---

14. claims: 39,40

Memory transistors connected in series (NAND string)  
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## INTERNATIONAL SEARCH REPORT

International Application No

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