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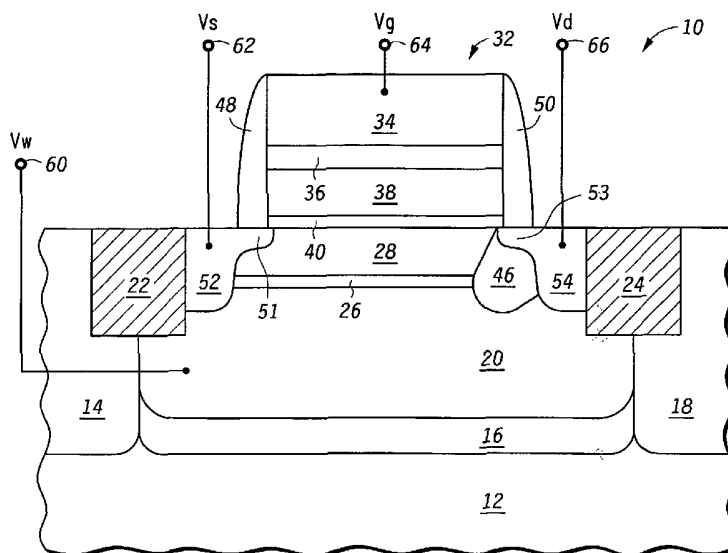
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- (54) Title: NON-VOLATILE MEMORY DEVICE AND METHOD FOR FORMING
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[Continued on next page]



(57) Abstract: In one embodiment, a semiconductor device (10) has a highly doped layer (26) having a first conductivity type uniformly implanted into a semiconductor substrate (20), where a channel region (28) is located between a top surface of the substrate (20) and the highly doped layer (26). In an alternate embodiment, a semiconductor device (70) has a counterdoped channel (86) and an anti-punch through region (74) below the channel. A gate stack (32) is formed over the substrate (20). A source (52) and drain (54, 53) having a second conductivity type are implanted into the substrate. The resulting non-volatile memory cell provides a low natural threshold voltage to minimize threshold voltage drift during a read cycle. In addition, a halo region (46), having the second conductivity type and implanted at an angle in the drain side, may be used to assist in hot carrier injection which allows a higher programming speed.

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SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

*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.*

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12 August 2004

INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 03/30588

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H01L29/10 H01L21/8234

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)  
IPC 7 H01L

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, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 513 923 A (PHILIPS NV) 19 November 1992 (1992-11-19) column 4, line 30 - column 9, line 14; figures 1-10	1-5
A	----- US 2002/024078 A1 (HORIUCHI MASATADA ET AL) 28 February 2002 (2002-02-28) paragraphs [0013] - [0107]; figures 1-15	1-4
A	----- PATENT ABSTRACTS OF JAPAN vol. 007, no. 226 (E-202), 7 October 1983 (1983-10-07) & JP 58 115863 A (MATSUSHITA DENKI SANGYO KK), 9 July 1983 (1983-07-09) abstract -----	1,3,5

Further documents are listed in the continuation of box C.

Patent family members are listed in 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 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

24 March 2004

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02/07/2004

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## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/30588

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0513923	A	19-11-1992	US 5424567 A	13-06-1995
			DE 69205060 D1	02-11-1995
			DE 69205060 T2	15-05-1996
			EP 0513923 A2	19-11-1992
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US 2002024078	A1	28-02-2002	JP 2002076332 A	15-03-2002
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JP 58115863	A	09-07-1983	NONE	
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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 03/30588

## 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.:  
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 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.:

1-5

### 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

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

1. claims: 1-5

Transistor with a halo implant in the drain and an anti-punch-through layer in the channel that contains dopants of a single conductivity type

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2. claims: 6-10

Transistor with an anti-punch-through layer in the channel that contains dopants of two conductivity types

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