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*G11C 16/10* (2006.01)    *G11C 16/04* (2006.01)
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- (71) **Applicant:** SANDISK TECHNOLOGIES, INC.  
[US/US]; Two Legacy Town Center, 6900 North Dallas Parkway, Plano, TX 75024 (US).
- (72) **Inventors; and**
- (71) **Applicants (for US only):** MIHNEA, Andrei [US/US]; 951 Sandisk Drive, Milpitas, CA 95035 (US). COSTA, Xiyang [US/US]; 951 Sandisk Drive, Milpitas, CA 95035 (US). ZHANG, Yanli [CN/US]; 951 Sandisk Drive, Milpitas, CA 95035 (US).
- (74) **Agent:** MAGEN, Burt; Vierra Magen Marcus LLP, 575 Market Street, Suite 3750, San Francisco, CA 94105 (US).

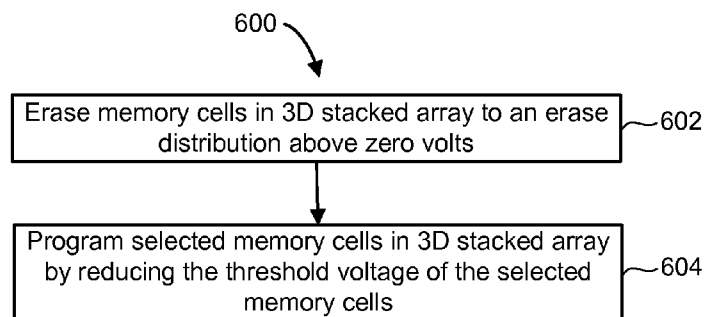
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**Published:**

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

[Continued on next page]

(54) **Title:** 3D NAND STACKED NON-VOLATILE STORAGE PROGRAMMING TO CONDUCTIVE STATE



**Fig. 6**

(57) **Abstract:** Programming NAND strings in a 3D stacked storage device to a conductive state is disclosed. Storage elements may be erased by raising their  $V_t$  and programmed by lowering their  $V_t$ . Programming may include applying a series of increasing voltages to selected bit lines until the selected memory cell is programmed. Unselected bit lines may be held at about ground, or close to ground. The selected word line may be grounded, or be held close to ground. Unselected word lines between the selected word line and the bit line may receive about the selected bit line voltage. Unselected word lines between the source line and the selected word line may receive about half the selected bit line voltage. Programming may be achieved without boosting channels of unselected NAND strings to inhibit them from programming. Therefore, program disturb associated with leakage of boosted channel potential may be avoided.



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INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2013/068041

A. CLASSIFICATION OF SUBJECT MATTER  
INV. G11C11/56 G11C16/10 H01L27/115  
ADD. G11C16/04

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)  
G11C 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 practicable, search terms used)  
EPO-Internal, COMPENDEX, INSPEC, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/195128 A1 (FUJIWARA TOMOKO [JP] ET AL) 2 August 2012 (2012-08-02)	1,15
Y	paragraph [0121]; figures 3-6,11	4,5,11,12
X	US 2009/109761 A1 (JIN YOUNG-GU [KR] ET AL) 30 April 2009 (2009-04-30)	1,15
Y	paragraph [0030]; figures 1-4,6	
Y	TW I 220 526 B (MACRONIX INT CO LTD [TW]) 21 August 2004 (2004-08-21)	4,5,11,12
A	figures 2A-B, 3A-B	
	US 2009/279360 A1 (LEE PETER WUNG [US] ET AL) 12 November 2009 (2009-11-12)	1-5,8-12,15
	paragraphs [0158] - [0159]	
	-/--	

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 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)

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"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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European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040,  
Fax: (+31-70) 340-3016

Authorized officer:  
Havard, Corinne

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2013/068041

## 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.:  
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 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:

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 fees, this Authority did not invite payment of 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.:  
  
1-6, 8-13, 15
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 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 REPORT

International application No  
PCT/US2013/068041

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 2006/140000 A1 (LIAO YI Y [TW] ET AL LIAO YI YING [TW] ET AL) 29 June 2006 (2006-06-29) paragraph [0033]; figures 3B, 4, 6, 7B -----	6,13
Y	EP 1 638 110 A1 (MACRONIX INT CO LTD [TW]) 22 March 2006 (2006-03-22) paragraphs [0047], [0068]; figure 11 -----	6,13
Y	US 4 939 690 A (MOMODOMI MASAKI [JP] ET AL) 3 July 1990 (1990-07-03) figure 5 -----	6,13

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/068041

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US 2012195128 A1	02-08-2012	JP 2012160222 A US 2012195128 A1	23-08-2012 02-08-2012
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**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, 8-12, 15

3D NAND non-volatile memory and programming method with erase threshold voltage being the highest positive threshold voltage wherein the bit line voltage increases in magnitude between the programming steps until a first storage element is programmed

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2. claims: 6, 13

3D NAND non-volatile memory and programming method with erase threshold voltage being the highest positive threshold voltage wherein during programming, the unselected word lines between the bit line and the selected word line are at a first voltage and the already programmed unselected word lines between the selected word line and the source line are at a second voltage, the second voltage preventing programming of an already programmed memory cell by being less than the first voltage

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3. claims: 7, 14

3D NAND non-volatile memory with two select gate transistors in series on the drain side and programming method with erase threshold voltage being the highest positive threshold voltage with specific voltages applied to an unselected block during programming

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