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PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference see form PCT/ISA/220	**FOR FURTHER ACTION** See paragraph 2 below	
International application No. PCT/GB2019/053257	International filing date *(day/month/year)* 15.11.2019	Priority date *(day/month/year)* 30.11.2018

International Patent Classification (IPC) or both national classification and IPC
INV. H01L27/24 H01L45/00

Applicant
ARM LIMITED

1. This opinion contains indications relating to the following items:

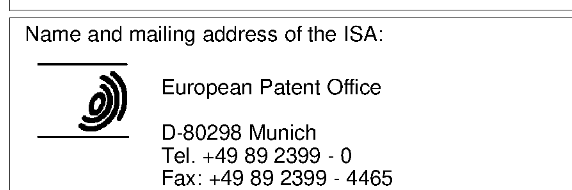
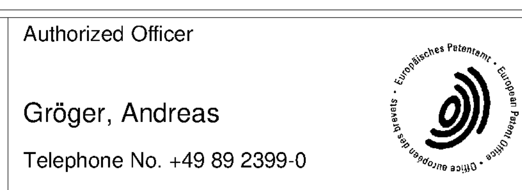
- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
 European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Fax: +49 89 2399 - 4465	see form PCT/ISA/210	Gröger, Andreas Telephone No. +49 89 2399-0 

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	3-5, 8, 9, 11, 17, 19, 20, 22, 23, 25-28, 30
	No:	Claims	1, 2, 6, 7, 10, 12-16, 18, 21, 24, 29, 31
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-31
Industrial applicability (IA)	Yes:	Claims	1-31
	No:	Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Item V

1 Reference is made to the following documents:

D1 : US 2014 / 0252295 A1

D2 : WO 2017 / 222525 A1

D3 : WO 2009 / 114796 A1

2 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 1, 10, 15 and 29 is not new in the sense of Article 33(2) PCT.

2.1 **Claim 1:**

Document D1, [0023]-[0049], Figs. 2-16 discloses

a method - *cf. D1, [0023], Figs. 2-16,*

comprising:

forming a structure 1005, 1003 1001, 703, 705, 1201 on a first portion 301 of a substrate 307 while maintaining a second portion 303 of the substrate exposed, the structure comprising at least a conductive film 1005 formed on the substrate and a correlated electron material (CEM) film 1003 formed over the conductive film 1005 - *Document D1, [0029], discloses nickel oxide as a material of resistive switching layer 1003. Nickel oxide is a known CEM, cf. e.g. D3, p. 32, l. 3-5, reference to D3 is made as technical background document giving evidence of implicit disclosure.* -

depositing a sealing layer 1301 over the structure and at least a portion of the second portion of the substrate 303 - *cf. D1, [0040], [0042], [0045], Fig. 13* ;

forming an insulative filling material 1303 over at least a portion of the sealing layer 1301 disposed over the second portion 303 of the substrate 307;

and

removing a portion of the insulative filling material - *formation of via 1401 according to D1, [0045], Fig. 14* - prior to removal of the at least a portion of the sealing layer 1301 disposed over the second portion 303 of the substrate 307 - *formation of via 1501 according to D1, [0046], Fig. 15.*

Therefore, the subject-matter of claim 1 of the present application is anticipated by D1.

2.2 **Claim 10:**

Document D1, [0023]-[0049], Figs. 2-16 discloses

a switching device - *cf. e.g. D1, [0040] : "RRAM", the method steps of D1 implying the disclosure of the corresponding resulting device features* -

comprising:

a structure 1005, 1003 1001, 703, 705, 1201 disposed over a first portion 301 of a substrate 307, the structure comprising at least a conductive film 1005 disposed over the substrate 307, a correlated electron material (CEM) film 1003 - *Nickel oxide as disclosed by D1, [0029] being a CEM as discussed above* - disposed over the conductive film 1005 and a conductive overlay disposed 705 over the CEM film 1003;

a sealing layer 1301 disposed over the structure and at least a second portion 301 of the substrate 307;

and

a conductive via 1603 extending through a discontinuity in the sealing layer 1301 over the second portion 303 of the substrate 307, the conductive via 1301 being electrically connected to a metal layer 311 disposed under the substrate 307.

Therefore, the subject-matter of claim 10

2.3 **Claim 15:**

Document D1, [0023]-[0049], Figs. 2-16 discloses

a method - *cf. D1, [0023]*

comprising:

forming an etch-stop control layer 1301 - *cf. D1, [0040], [0042], [0045]* over a device - *The stacked structure 1005, 1003 1001, 703, 705, 1201 as shown in D1, Fig. 13 is a device in the sense of the claim.* ;

forming a first layer of insulative filling material 1303 over the etch-stop control layer 1301 - *cf. D1, [0045]*;

initiating a process to etch a localized portion of the first layer of insulative material 1303 - *Forming the via 1401 as shown in D1, Fig. 14 and described in D1, [0045].* -

and

altering the process to etch the localized portion responsive to detection of removal of at least a portion of the etch-stop control layer. - *In accordance with D1, [0045], the etching is stopped before the via reaches the top electrode. On the other hand, the via is etched until reaching the etch stop layer 1301 as also described by D1, [0045] and shown in D1, Fig. 1303. Stopping the process is an act of altering the process as defined by the claim. The location of stopping implies that it occurs in response to starting etching the etch-stop control layer 1301, i.e. removing at least a portion thereof.*

Therefore, the subject-matter of claim 15 of the present application is anticipated by D1.

2.4 **Claim 29:**

Document D2, p. 18, l. 11 - p. 20, l. 4, Fig. 6B discloses

a switching device - *cf. e.g. D2, p. 18, l. 11 : "RRAM"* -

comprising:

a first metal contact 4380 disposed over a switching device 120 comprising a correlated electron material - *cf. D2, p. 21, l. 9-29; p. 24, l. 10-25 : "Mott transition", which is a correlated electron effect* -

a second metal contact 4580 disposed over a via 4520, 4560;

the first and second metal contacts 4380, 4580 being coplanar - *Both metal contacts are located within the same dielectric layer 4420*;

and

at least a portion of an etch-stop control layer 4360 disposed between the first and second metal contacts - *According to D2, p. 19, l. 1-6, layer 4360 is an etch-stop layer and, as shown in D2, Fig. 6B, located as defined.*

Therefore, the subject-matter of claim 29 of the present application is anticipated by D2. of the present application is anticipated by D1.

3 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of **claim 25** does not involve an inventive step in the sense of Article 33(3) PCT.

3.1 Document D1, [0023]-[0049], Figs. 2-16 discloses

a method of coupling to a switching device - *The structure 1005, 1003 1001, 703, 705, 1201 is an MRAM and, hence, a switching device. The claim comprises all possible types of coupling, including electric coupling to contact 1605 through via 1601 as disclosed by D1. -*

comprising:

forming an etch-stop control layer 1301 on an insulative filling material and on a switching device adjacent to the insulative filling material;

forming, over the etch-stop control layer 1301, a layer of insulative filling material 1303 ~~having a thickness of between about 5.0 nm to about 20.0 nm~~;

initiate a process to remove at least a portion of the layer of insulative filling material formed over the etch-stop control layer - *forming opening 1401 according to D1, [0045], Fig. 14*;

and

alter the process to remove the at least the portion of the layer of insulative filling material responsive to removal of at least a portion of the etch-stop control layer - *disclosed by D1 as further discussed with respect to the subject-matter of claim 15 above.*

3.2 Therefore, the subject-matter of claim 25 of the present application is distinguished from the disclosure of D1 in that the layer of insulating filling material has a thickness of between about 5.0 nm to about 20.0 nm.

3.3 Document D1 is silent about a thickness of the insulative filling material and, thereby, leaves the selection of a thickness as a problem to be solved by the skilled person.

3.4 The range defined would be chosen by the skilled person in a standard design procedure ensuring the desired functionality of the layers.

3.5 Thereby, the skilled person would obtain the subject-matter of claim 25 of the present application without resort to an inventive step.

4 Dependent claims 2, 6, 7, 12-14, 16, 18, 21, 24, 31 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty, the reasons being as follows:

4.1 **Claim 2:**
Metal via 1603 of D1, Fig. 16 is formed and located as defined by the claim.

4.2 **Claim 6:**
A single etching step concerning all layers defined is disclosed by D1, [0046], Fig. 15.

4.3 **Claims 7, 21:**
Silicon nitride is disclosed by D1, [0040].

4.4 **Claim 12:**
A conductivity between different levels as defined is realised by via 1603 as shown in D1, Fig. 16.

4.5 **Claim 13:**
In the structure of D1, Fig. 16, via 1603 is adjacent to insulative filling material 1303.

4.6 **Claim 14:**
Angles as defined occur in the structure of D1, Fig. 16 as parts of the rounded upper rim.

4.7 **Claim 16:**
In D1, [0023]-[0049], Figs. 2-16

the device comprises a conductive overlay layer 705 - *cf. D1, [0035]-[0036], [0039],*

the method further comprises, prior to the forming of the etch-stop control layer 1301:

depositing a second layer of insulative filling material 1101 over the conductive overlay 705 - *cf. D1, [0039], Fig. 11*;

and

removing a portion of the second layer of insulative filling material 1101 to reveal a top surface of the conductive overlay 705 that is coplanar with a top surface of a remaining portion 1201 of the second layer of insulative filling material 1101 adjacent to the device - *cf. D1, [0039], Fig. 12*,

wherein

the etch-stop control layer 1301 is formed over the top surface of the conductive overlay 705 and the remaining portion 1201 of the second layer of insulative material 1101 - *cf. D1, [0040], Fig. 13.*

4.8 **Claim 18:**
In the method of D1, etch-stop control layer 1301 is formed over conductive overlay 705 and the process is continued to reveal a part 1601 of top contact 705, cf. D1, [0048]-[0049], Fig. 16.

4.9 **Claim 24:**
Deposition of metal 1603, 1605, 1607 as defined is disclosed by D1, [0048]-[0049], Fig. 16.

4.10 **Claim 31:**
In the structure of D2, Fig. 6B, there are at least one contact 4380 and one contact 4580 in a mutual next-neighbours-relation so that the portion of 4360 located between these two next neighbours is arranged as defined by the claim.

5 Dependent claims 3-5, 8, 9, 11, 17, 19, 20, 22, 23, 26-28, 30 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step, the reasons being as follows:

5.1 **Claims 3-5:**
The claims define standard etching techniques in the art which would be considered by the skilled person in carrying out the method of D1 as such and without resort to an inventive step.

5.2 **Claims 8, 23, 28:**
The ranges defines usual thicknesses of etch stop or sealing layers which the skilled person would obviously select to ensure their functionality.

5.3 **Claim 9:**
In the method of D1, conductive film 501 is formed over a metal layer 311 in 301 - cf. D1, [0026] - depositing one or more layers of CEM 601 on the conductive film 1005 to form the CEM film, forming a conductive overlay 605 over the CEM film 601, forming a conductive overlay 705 over the CEM film 601 and removing a portion of the one or more layers of CEM film 601, a portion of the conductive overlay 605 and a portion of conductive film 501 to expose the second portion 303 of substrate 307 - cf. D1, [0034]-[0038], Figs. 6-10.

5.4 **Claim 11:**
Silicon nitride is disclosed by D1, [0040]. The thickness range defined is a range of obvious selections which the skilled person would make to ensure the functionality of the device.

5.5 **Claim 17:**
Chemical-mechanical polishing (CMP) is a standard method in the art which the skilled person would consider as such in a standard design procedure to implement the method of D1.

5.6 **Claims 19, 20:**
Materials having a dielectric constant with the range defined are well-known in the art and would be selected as such in a design procedure to implement the method of D1. Likewise, the skilled person is aware of the basic physical phenomenon of capacitive coupling and its correlation with dielectric constant since the latter determines the capacitance when geometric parameters are fixed.

5.7 **Claims 22, 27:**
Document D1, [0035] describes the general availability of techniques to detect when a level is reached and to avoid over-etching. The skilled person would obviously apply such techniques in etching all layers of D1, detecting etching products as defined being an obvious selection from such known techniques.

5.8 **Claim 26:**
A hard mask is disclosed by D1, [0033].

5.9 **Claim 30:**
Document D2 does not disclose any specific thickness of the etch stop layer and, thereby, leaves the selection of a thickness thereof as a problem to be solved by the skilled person. The range defined by the claim corresponds to usual thicknesses of such a layer the skilled person would know as part of general technical knowledge and select, therefore, as an obvious design option. It is noted that the present application, in particular paragraph [0085] of the description, does not attribute any specific effect to this thickness that would go beyond mere suitability for performing its intended function.

Item VII

6 Other than preferred by R. 5.1(a)(ii) PCT, the present application does not mention D1, D2, D3.