

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

PCT

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

To:

see form PCT/ISA/220

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/US2018/047524

International filing date (day/month/year)
22.08.2018

Priority date (day/month/year)
29.08.2017

International Patent Classification (IPC) or both national classification and IPC
INV. H01L43/12

Applicant
EVERSPIN TECHNOLOGIES, INC.

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 43bis.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 notified the International Bureau under Rule 66.1bis(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:



European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0
Fax: +49 89 2399 - 4465


Date of completion of this opinion

see form PCT/ISA/210

Authorized Officer

Köpf, Christian

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 43bis.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 13ter.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 13ter.1(a)).
 - on paper or in the form of an image file (Rule 13ter.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 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>20</u>
	No: Claims	<u>1-19</u>
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-20</u>
Industrial applicability (IA)	Yes: Claims	<u>1-20</u>
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

- 1 Reference is made to the following documents:
- D1 US 2013/244344 A1 (MALMHALL ET AL) 19 September 2013
 - D2 US 2014/217527 A1 (GUO) 7 August 2014
 - D3 US 2010/240151 A1 (BELEN ET AL) 23 September 2010
- 2 Notwithstanding the lack of clarity and conciseness mentioned under Item VIII, the present application does not meet the criteria of Article 33(2) PCT because the subject-matter of (independent) claims 1, 12, and 19 is not novel.
- 2.1 D1 (paragraphs [0018]-[0027]; figures 3-9) discloses a method of fabricating a magnetoresistive bit (MTJ array) from a magnetoresistive (TMR) stack (11, 12) including at least an intermediate region (tunnel barrier) positioned between two magnetic regions (free and fixed layers), and a multi-layer surface region (three-layer hardmask 13, 14, 15), the method comprising:
- a. (figures 3, 4) etching through at least a portion of a thickness of the surface region (layer 15) to create a first set of exposed areas in the form of multiple parallel strips (lines 15b) extending in a first direction;
 - b. (figures 5, 6) etching through at least a portion of a thickness of the surface region to create a second set of exposed areas in the form of multiple parallel strips extending in a second direction transverse to the first direction, wherein the first set of exposed areas and the second set of exposed areas have multiple areas that overlap (pads 15c); and
 - c. (figures 7-9) etching the magnetoresistive stack through the first and second sets of exposed areas.
- D2 (paragraphs [0021]-[0025]; figures 1-6) and D3 (paragraphs [0043]-[0063], [0077]-[0080]; figures 5-10, 18) describe similar MTJ array fabrication methods, including multi-step etching (carbofluoride RIE) of orthogonal sets of parallel strips into a single- or multi-layer hardmask (e.g. of Ta or Ta/NiCr/MnPt) followed by TMR stack etching, thereby anticipating the subject-matter of claims 1 and 12 as well.

- 2.2 D2 (paragraphs [0021]-[0025]) also discloses a surface region including a first layer (hardmask 140, e.g. of Ta) having a higher etch rate to a chemical reagent (e.g. CF_4) disposed over a second layer (capping layer) having a lower etch rate to the chemical reagent, the method comprising:
- a. (figure 3) etching through the first layer using a (reactive ion) etching process (RIE) utilizing the chemical reagent to create the first set of parallel strips in the first direction;
 - a. (figure 4) etching through the first layer using a similar RIE process utilizing the chemical reagent to create the second set of parallel strips in the second transverse direction; and
 - b. (figures 5, 6) etching through at least the second layer (capping layer and TMR stack 130) using a physical (ion beam) etching process (IBE) through the first set and second sets of exposed areas,
- thereby anticipating the subject-matter of claim 19.
- 3 Dependent claims 2-11, 13-18, 20 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step.
- 3.1 Claims 2, 3, 6-9, 13, 17, 18: D1-D3 already teach two transverse sets of parallel equidistant lines etched into two- or multi-layer (hardmask) surface regions having different RIE etch rates to form square/rectangular cell arrays. Further cell corner rounding is mentioned at least in D1 (paragraph [0027]) and D3 (paragraph [0062]).
- 3.2 Claims 4, 5, 20: In an advantageous embodiment of D1 (paragraphs [0028]-[0032]; figure 10) two equally spaced apart sets of parallel strips per patterning direction (self-aligned double patterning method using mask spacers) have already been used in order to obtain MTJ cells of half pitch dimensions ($F/2$), thereby anticipating the subject-matter of claims 4 and 5.
- The skilled person would apply said teaching with corresponding effect obviously also to the method known from D2, thereby arriving at a method according to claim 20 without any inventive activity.
- 3.3 Claims 10, 16: A dielectric/metal/dielectric hardmask, e.g. of SiO_2 or SiN dielectric layers (13, 15) sandwiching a Cu layer (14), is already disclosed in D1 (paragraph [0021]; figure 3).

- 3.4 Claims 11, 14, 15: D2 (paragraph [0027]) describes a third physical etching step for the second (capping) layer and TMR stack (130), e.g. using an Ar or Kr IBE process.

Re Item VIII

Certain observations on the international application

The application does not meet the requirements of Article 6 PCT because (independent) claims 1, 12, and 19 are neither clear nor concise.

1. The term "surface region" used in said claims is vague and unclear and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear.

It is evident from the description (e.g. paragraphs [037]-[048]; figures 1-4) that said objected feature in fact is, or at least comprises, a hardmask region (20) which is essential to the definition of the invention.

Since the claims do not contain this feature they do not meet the requirement following from Article 6 PCT taken in combination with Rule 6.3(b) PCT that any independent claim must contain all the technical features essential to the definition of the invention.

2. Although said claims have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each other only with regard to the definition of the subject-matter for which protection is sought and/or in respect of the terminology used for the features of that subject-matter.

Claim 12 apparently comprise a combination of the features of claims 1, 3 (two transverse sets of parallel lines), 6 (multi-layer surface region), and is in fact a dependent claim.

Claim 19 combines features of claims 3, 8 (two-layer surface region of different etch rates), and 11 (physical etching of lower layer).