PATENT COOPERATION TREATY

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INTERNATIONAL SEARCHING AUTHORITY

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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.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GE2019/050002	17.05.2019	22.05.2018

International Patent Classification (IPC) or both national classification and IPC
INV. C23C14/35 H01J37/34

Applicant
BERISHVILI, Zaur

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.

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WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/GE2019/050002

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	3-12
	No:	Claims	1, 2
Inventive step (IS)	Yes:	Claims	3-12
	No:	Claims	1, 2
Industrial applicability (IA)	Yes:	Claims	1-12
	No:	Claims	

2. Citations and explanations

see separate sheet

1 Prior art documents

Reference is made to the following documents:

D1 WO 2016/189337 A1 (BERISHVILI ZAUR [GE]) 1 December 2016 (2016-12-01) cited in the application

D2 US 2006/222780 A1 (GUREVICH SERGEY A [RU] ET AL) 5 October 2006 (2006-10-05)

D3 Z. V. BERISHVILI ET AL: "Planar Magnetron Sputtering Device: A New Generation of Magnetron Sputtering Design and Technology", JOURNAL OF PHYSICAL SCIENCE AND APPLICATION, vol. 7, no. 5, 28 May 2017 (2017-05-28), XP055620208, ISSN: 2159-5348, DOI: 10.17265/2159-5348/2017.05.003

D4 SU 2018 016 288 A3 (Z.V. BERISHVILI, I.I GADAKHABADZE) 15 May 1993 (1993-05-15)

D5 US 2011/203734 A1 (KOJI TSUNEKAWA [JP]) 25 August 2011 (2011-08-25)

Re Item V

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

2 Patentability of claim 1

2.1 **Claim 1** reads as follows (feature labelling added):

(A) The method of production of nanomaterial in a vacuum

(A1) using a magnetron sputtering device in the vacuum chamber of which over the disk target, coaxially to it there is located a magnetic system, which forms a magnetic field with a configuration of a loop composed of the line of involutes of circumference of circle of a certain radius, which contains consequently grouped permanent magnets, made with the option of rotation and regulation of the distance between its poles;

(a) at that, the method provides for the formation of a rotating magnetic field in the plane parallel to the surface of the disk target with a configuration of a loop composed of the line of involutes of circumference of circle of a certain radius, which rotation axis passes through the center of the target, thus forming an active sputtering zone between the inputs and outputs of magnetic field power lines on the disk target surface by applying an electric field and a rotating magnetic field to the disk target surface;

(b) formation on the disk target surface, of a gas discharge in the form of a closed loop, consisting of the involutes of the circumference of a circle of specific radius, and magnetron plasma of the shape of a torus over the active sputtering region by manipulating the values of working gas pressure in the vacuum chamber and the power applied to the disk target;

(c) formation and dispersion of cathode spots in the dark cathode region of the glow discharge plasma in close proximity to the ionization of the working gas atoms and the disk target surface in the magnetron toroidal plasma region by their acceleration;

(d) cascading decay of the produced liquid material macrodroplets of the disk target in the toroidal magnetron plasma region and curing of the nanoparticles formed as a result of such decay,

is characterized in that

(d1) additionally provides for creation of a nanoparticles forming reactor that in the process of sputtering of the disk target material additionally provides a compact location of the regions of macrodroplet flow with a configuration of a closed loop in the active sputtering zone and the regions of cascading decay of toroidal plasma;

(d2) continuous movement of the created reactor over the disk target surface, with regulation of the distance between the inputs and outputs of magnetic field power lines on the disk target surface and automatic control of the rotation rate of the rotating magnetic field taking into account its current values and specific parameters characterizing the processes in the created reactor;

(d3) at that, the formation and dispersion of the cathode spots additionally provides for the bombardment of the disk target by working gas ions and supply of the macrodroplets flow of the liquid disk target material, formed as a result of the formation and dispersion of cathode spots to the toroidal magnetron plasma region;

(d4) and the cascading decay of the formed liquid material of the disk target additionally provides for the carrying out of the decay process under conditions of recharging of liquid macrodroplets in the toroidal magnetron plasma and development of the Rayleigh or capillary instability, and carrying out of the process of cooling and curing of the nanoparticles formed as a result of the cascading decay - outside the toroidal plasma region.

2.2 As disclosed in the description of the present international application (cf. page 7, lines 1-20), document **D1** discloses (cf. abstract; figures 1-4; page 1, lines 1-6; page 3, line 29 - page 9, line 21) a planar magnetron sputtering device comprising a vacuum chamber (19) in which an anode (5) and a cathode assembly (4) are arranged. Said cathode assembly includes a disk target (3), a magnetic system (6) consisting of many pairs of permanent magnets (7) mounted on a rotating disk (9) of soft magnetic material, and a system (18) for both cooling the cathode assembly and rotating the magnetic system (i.e. under the action of a stream of a cooling liquid). The magnetic system's permanent magnets (7) are placed around a contour of defined radius of the circumference of an involute, wherein a first group of said magnets of a first polarity is arranged outside of said contour and a second group of said magnets of the opposite polarity is arranged inside of said contour. A discharge is ignited in the inert gas present over the disk target (3), the configuration of said discharge following the shape of the closed loop formed by the rotating magnetic system (6). The resulting toroidal plasma (20) subjects said target to ion sputtering and to the dispersion of target material. In D1, in order to adjust the sputtering parameters of the disk target, both the distance between the pole tips of the magnets (7) having opposite polarities and the rotation speed of the magnetic system (6) may be controllably changed. Hence, D1 discloses, at least implicitly, the aforementioned features (A1, a - c, d2, d3).

2.3 Although D1 remains silent about using the planar magnetron sputtering device to intentionally generate nanomaterial (i.e. there is no indication that the electrons' temperature and density in D1's toroidal plasma are controlled so as to controllably ignite a cascaded decay of the droplets of target material into nanoparticles following's Rayleigh instability), it is considered, *on the balance of probabilities,* that such cascaded fission occurs in D1's device, even if only in an unpredictable and uncontrollable manner. Hence, D1 also discloses the aforementioned features (A, d, d1, d4).

2.4 Therefore, the method of production of nanomaterial defined in claim 1 is not new in the sense of Article 33(2) PCT.

3 Patentability of claim 9

3.1 **Claim 9** reads as follows (feature labelling added):

(A) A magnetron sputtering device as claimed to produce a nanomaterial in a vacuum containing

(a) a vacuum chamber where

(a1) an anode,

(a2) a disk target made of non-magnetic material,

(a3) a cathode assembly and

(a4) a liquid cooling system of the cathode assembly are placed;

(a31) at that, the cathode assembly has a hollow cylinder shape and

(a32) has a disk target carrier in its inner part with the disc target placed in it,

(a33) a magnetic system which contains the disc made of soft magnetic material on which permanent magnet groups are fixed.

(a331) The disk made of soft magnetic material is fixed on the disc carrier with blades, which has the shape of a hollow cylinder and is made with the option of rotation with the assistance of the liquid jet for cooling of the cathode assembly on those blades.

(a332) the like poles of the permanent magnets of each group are located along the corresponding closed loop composed of the involutes of circumference of the circle a certain radius;

(a333) at that one of the groups of magnets is placed outside the specified loop and the other group of magnets is placed inside the loop;

(a334) opposite the poles of one of the groups of magnets placed along the closed loop, the poles of the magnets of the second group with opposite polarity are located.

(a335) The magnetic system is made with the option of working in both stationary and rotational modes, as well as with the option of regulating the distance between adjacent magnets with opposite polarity,

is characterized in that

(b) it additionally contains the disc target lock made of non-magnetic material and

(c) a magnetic system rotation rate control unit,

(c1) which is installed in the inner part of the cathode assembly, above the magnetic system and

(c2) is connected to the software control device;

(d) at that, the disk target placed in the disk target carrier with the disk target lock placed and fixed in the disk target lock, the cathode assembly with the disk target lock placed in it, with the magnetic system, the magnetic system rotation rate control unit placed in it, and the cathode assembly liquid cooling system create a sequence consisting of these assemblies and elements, located coaxially to each other in a vertical direction from bottom to top, which is installed over the objects subject to treatment placed in the working zone of the vacuum chamber, and/or other objects required for production process;

(c3) the magnetic system rotation rate control unit contains the dielectric housing in the form of the hollow cylinder with the central end apertures, motionlessly fixed in an internal part of the disk lock on internal surface of which at the specified level there are installed constant magnets and a brake ring , accordingly;

(c31) the fixed disk made of dielectric material and attached to the cathode assembly,

(c32) where a magnetic sensor is installed with the possibility to interact with the magnets installed in the housing, and

(c33) piezoelectric elements with the possibility to fix a mechanical contact in the working process that causes friction with the brake ring,

(c34) at that the outputs of the sensor and piezoelectric elements are connected to the said software control device.

3.2 In the light of section 2 above, document D1 *clearly* discloses the above-mentioned features (A, a - a335, c, c2), and *clearly* fails to disclose the structural details of the magnetic system rotation rate control unit, according to features (c1, c3 - c34).

3.3 The **difference** between claim 9 and D1 hence *at least* consists in features (c1, c3 - c34).

3.4 The **technical effect** of said difference consists in that the number of revolutions of the magnetic system is more efficiently controlled.

3.5 Said difference solves the **objective problem** of increasing the magnetron sputtering device productivity and of improving the quality of the sputtering control.

3.6 Faced with said objective problem, the person skilled in the art would find no motivation in D1 to modify the magnetic system rotation rate control unit, in accordance with features (c1, c3 - c34) of the difference, because D1 already successfully manages to regulate the sputtering process by controlling the speed of the magnetic system (6) via the drive rod (40; cf. page 7, lines 18-37). Should the skilled person nonetheless consider that the speed of the magnetic system is inaccurately controlled, there would be no reason why said skilled person would in particular choose to mount the magnetic system rotation rate control unit inside of the cathode assembly (i.e. inside of the vacuum chamber), according to feature (c1) of the difference, and provide such control unit with the brake ring, the magnetic sensor and the piezoelectric elements, according to features (c3 - c34) of the difference, all the more when considering that alternative configurations exist, such as one based on encoders and disclosed in document **D5**.

3.7 It is considered that the person skilled in the art would require an active intent to construct a magnetic system rotation rate control unit, according to features (c1, c3 - c34) of the aforementioned difference, in order to arrive at the configuration of claim 9.

3.8 None of the available prior art documents discloses the difference between claim 9 and D1, or anything within an obvious modification of said part. The skilled person's general knowledge would further also not provide any motivation to specifically use a magnetic system rotation rate control unit, according to features (c1, c3 - c34) of the aforementioned difference, in order to increase D1's magnetron sputtering device productivity and to improve the quality of the control of D1's sputtering process.

3.9 Therefore, the magnetron sputtering device defined in claim 9 involves an inventive step in the sense of Article 33(3) PCT.

4 Claims 2-8 and 10-12

4.1 Document D1 discloses the additional steps of forming and dispersing the cathode spots, according to **claim 2** (cf. page 5, line 34 to page 6, line 2).

4.2 None of the available prior art documents discloses the additional features defined in dependent **claims 3-8**, which are thus considered to meet the PCT requirements. **Claims 10-12** depend on claim 9, and, as such, also meet the PCT requirements for patentability.

5 Industrial applicability

Since the present application relates to the generation of nanoparticles being used in ultrafast switches and memory cells, the subject matter of the claims is considered to be industrially applicable in the sense of Article 33(4) PCT.