

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 320903-2160		FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/US2020/031373	International filing date (day/month/year) 04 May 2020	(Earliest) Priority Date (day/month/year) 02 May 2019	
Applicant THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS			

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out 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)).

b. This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6bis(a)).

c. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. **Certain claims were found unsearchable** (see Box No. II).

3. **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

the text is approved as submitted by the applicant.

the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

the text is approved as submitted by the applicant.

the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

a. the figure of the **drawings** to be published with the abstract is Figure No. 8

as suggested by the applicant.

as selected by this Authority, because the applicant failed to suggest a figure.

as selected by this Authority, because this figure better characterizes the invention.

b. none of the figures is to be published with the abstract.

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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 extra sheet(s).

- 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 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.:

- 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.:
1-14, 16-23

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.

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A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - B41J 2/06; B41J 2/09; C12Q 1/00; C23C 4/12; G01N 27/62; H05K 3/12 (2020.01) CPC - B41J 2/06; B41J 2/01; B41J 2/09; C12Q 1/00; C23C 4/12; G01N 27/44739; G01N 27/44791; G01N 27/62; G01N 30/6095; H05K 3/125 (2020.08)		
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) see Search History document		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched see Search History document		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) see Search History document		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/0187798 A1 (ROGERS et al) 04 August 2011 (04.08.2011) entire document	1-14, 16-23
A	US 2017/0219522 A1 (LI-COR, INC.) 03 August 2017 (03.08.2017) entire document	1-14, 16-23
A	US 2013/0287962 A1 (DENG et al) 31 October 2013 (31.10.2013) entire document	1-14, 16-23
A	US 2011/0155574 A1 (GOLOVCHENKO et al) 30 June 2011 (30.06.2011) entire document	1-14, 16-23
A	US 2018/0178174 A1 (RAINDANCE TECHNOLOGIES, INC.) 28 June 2018 (28.06.2018) entire document	1-14, 16-23
A	US 2015/0158300 A1 (UEDA et al) 11 June 2015 (11.06.2015) entire document	1-14, 16-23
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
<p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"D" document cited by the applicant in the international application</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>		
Date of the actual completion of the international search 01 August 2020		Date of mailing of the international search report 14 AUG 2020
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300		Authorized officer Blaine R. Copenheaver Telephone No. PCT Helpdesk: 571-272-4300

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International application No.

PCT/US2020/031373

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-14 and 16-23, are drawn to an atomic-to-nanoscale matter emission/flow regulation device comprising at least a first nanodroplet generation/control device.

Group II, claim 15, is drawn to a method of fabricating an atomic-to-nanoscale matter emission/flow regulation device comprising: a first substrate comprising a first semiconductor material.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: a first nanodroplet generation/control device having a front side, a back side and a first reservoir disposed in between the front side and the back side for holding matter to be extracted, the first nanodroplet generation/control device comprising at least a first nanodroplet column system comprising: an upper portion of the first reservoir; a first electrostatic lens (e-lens) disposed in between the upper portion of the first reservoir and the front side of the first nanodroplet generation/control device, the first e-lens including at least a first set of at least first and second electrodes that are laterally separated from one another by a first lateral gap having a gap width; and a first nozzle disposed in between the first e-lens and the upper portion of the first reservoir and being separated from the first e-lens by a first e-lens-to-filament gap, the first nozzle having a first nanodroplet orifice through which nanodroplets generated from matter held in the first reservoir are extracted out of the first reservoir through the first nanodroplet orifice when a first set of preselected voltage signals are applied to the first set of at least first and second electrodes, the first nozzle being precisely aligned with the first lateral gap and having a first nozzle width equal to a distance between innermost edges of side walls of the first nozzle, the first nozzle and the first lateral gap having a common central axis that ensures that the nanodroplets extracted through the first nanodroplet orifice self-align with the first lateral gap as claimed therein is not present in the invention of Group II. The special technical feature of the Group II invention: forming one or more first layers of insulation on the front side of the first substrate, said one or more first layers of insulation having a thickness equal to a length of a first electrostatic lens (e-lens)-to-filament gap; forming one or more first patterned metal layers on a top surface of said one or more first layers of insulation, said one or more first patterned metal layers having at least a first gap therein that extends through said one or more first metal layers and has a first gap width, wherein opposite sides of said one or more metal layers that define the first gap comprise first and second electrodes of a first e-lens of the atomic-to-nanoscale matter emission/flow regulation device; using said one or more first patterned metal layers having said at least a first gap therein as a mask during an etching process to etch at least a second gap in said one or more first layers of insulation, the second gap extending through said one or more layers of insulation and having a width equal to the gap width, the first and second gaps being laterally aligned; and using said one or more first metal layers and said one or more first layers of insulation having the first and second gaps therein, respectively, as a mask during an etching process to etch a nozzle in the front side of the first substrate that extends into the first reservoir, the nozzle having an inlet side disposed inside of the first reservoir and an exit side disposed in the second gap, the nozzle and the first and second gaps having a common central axis, said one or more layers of insulation separating the nozzle from the e-lens by a distance equal to the length of the e-lens-to-filament gap as claimed therein is not present in the invention of Group I.

Groups I and II lack unity of invention because even though the inventions of these groups require the technical feature of an atomic-to-nanoscale matter emission/flow regulation device comprising: a first reservoir for holding matter to be extracted, this technical feature is not a special technical feature as it does not make a contribution over the prior art.

Specifically, US 2011/0155574 to Golvochenko teaches an atomic-to-nanoscale matter emission/flow regulation device comprising: a first reservoir for holding matter to be extracted (Paras. [0033], [0037-0038]).

Since none of the special technical features of the Group I or II inventions are found in more than one of the inventions, unity of invention is lacking.