

## SEARCH REPORT

Application Number

LH 30  
LT 2021567

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	HYART T ET AL: "Possible THz Bloch gain in dc-ac-driven superlattices", MICROELECTRONICS JOURNAL, MACKINTOSH PUBLICATIONS LTD. LUTON, GB, vol. 40, no. 4-5, 1 April 2009 (2009-04-01), pages 719-721, XP026038649, ISSN: 0026-2692, DOI: 10.1016/J.MEJO.2008.11.038 [retrieved on 2008-12-31]	1-4, 8, 11-15	INV. G02F1/017 H01L29/15 H01L31/0352 H03B7/14
Y	* the whole document *	5-7, 9, 10	
Y	EP 0 759 640 A1 (PAUL DRUDE INST FUER FESTKOERP [DE]) 26 February 1997 (1997-02-26) * abstract; figure 1 * * column 2, lines 50-59 * * column 5, lines 7-44 * * column 7, line 40 - column 8, line 45 *	5-7, 9, 10	
A	APOSTOLOS APOSTOLAKIS ET AL: "Controlling the harmonic conversion efficiency in semiconductor superlattices by interface roughness design", ARXIV.ORG, CORNELL UNIVERSITY LIBRARY, 201 OLIN LIBRARY CORNELL UNIVERSITY ITHACA, NY 14853, 9 January 2019 (2019-01-09), XP081012852, * the whole document *	1-15	TECHNICAL FIELDS SEARCHED (IPC)  H01L H03B G02F H03D
The present search report has been drawn up for all claims			
The Hague		Date of completion of the search 10 June 2022	Examiner Beugin, Anne
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

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EPO FORM 1503 11.08 (P04C80)

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A	<p><b>TIMO HYART ET AL:</b> "Bloch gain in dc-ac-driven semiconductor superlattices in the absence of electric domains", ARXIV.ORG, CORNELL UNIVERSITY LIBRARY, 201 OLIN LIBRARY CORNELL UNIVERSITY ITHACA, NY 14853, 19 December 2007 (2007-12-19), XP080342974, DOI: 10.1103/PHYSREVB.77.165330</p> <p>* the whole document *</p> <p>-----</p>	1-15	
A	<p><b>US 7 170 085 B2 (STEVENS INST TECHNOLOGY [US])</b> 30 January 2007 (2007-01-30)</p> <p>* abstract; figure ,8 *</p> <p>* column 5, line 36 - column 6, line 16 *</p> <p>-----</p>	1-15	
The present search report has been drawn up for all claims			<p><b>TECHNICAL FIELDS SEARCHED (IPC)</b></p>
<p><b>The Hague</b></p>		<p>Date of completion of the search</p> <p><b>10 June 2022</b></p>	<p>Examiner</p> <p><b>Beugin, Anne</b></p>
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone  Y : particularly relevant if combined with another document of the same category  A : technological background  O : non-written disclosure  P : intermediate document</p> <p>T : theory or principle underlying the invention  E : earlier patent document, but published on, or after the filing date  D : document cited in the application  L : document cited for other reasons  .....  &amp; : member of the same patent family, corresponding document</p>			

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EPO FORM 1503 11.08 (P04C80)

**ANNEX TO THE SEARCH REPORT  
ON LITHUANIAN PATENT APPLICATION NO.**

**LH 30  
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

**10-06-2022**

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
EP 0759640	A1	26-02-1997	NONE			
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US 7170085	B2	30-01-2007	US	2005093023	A1	05-05-2005
			WO	2005017494	A2	24-02-2005
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## WRITTEN OPINION

File No. LH30	Filing date ( <i>day/month/year</i> ) 27.10.2021	Priority date ( <i>day/month/year</i> )	Application No. LT2021567
International Patent Classification (IPC) INV. G02F1/017 H01L29/15 H01L31/0352 H03B7/14			
Applicant Valstybinis mokslini tyrim institutas Fizini ir technologijos moksl centras			

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 the opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the application
- ☒ Box No. VIII Certain observations on the application

	Examiner Beugin, Anne
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**WRITTEN OPINION****Box No. I Basis of this opinion**

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application, this opinion has been established on the basis of:
  - a. type of material:
    - ☐ a sequence listing
    - ☐ table(s) related to the sequence listing
  - b. format of material:
    - ☐ on paper
    - ☐ in electronic form
  - c. time of filing/furnishing:
    - ☐ contained in the application as filed.
    - ☐ filed together with the application in electronic form.
    - ☐ furnished subsequently for the purposes of search.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

**Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

## 1. Statement

Novelty (N)	Yes: Claims	5-7, 9, 10, 14, 15
	No: Claims	1-4, 8, 11-13
Inventive step (IS)	Yes: Claims	
	No: Claims	1-15
Industrial applicability (IA)	Yes: Claims	1-15
	No: Claims	

## 2. Citations and explanations

**see separate sheet**

**WRITTEN OPINION**

Application number  
LT2021567

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**Box No. VIII    Certain observations on the application**

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**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 HYART T ET AL: "Possible THz Bloch gain in dc-ac-driven superlattices", MICROELECTRONICS JOURNAL, MACKINTOSH PUBLICATIONS LTD. LUTON, GB, vol. 40, no. 4-5, 1 April 2009 (2009-04-01), pages 719-721, XP026038649, ISSN: 0026-2692, DOI: 10.1016/J.MEJO.2008.11.038 [retrieved on 2008-12-31]

D2 EP 0 759 640 A1 (PAUL DRUDE INST FUER FESTKOERP [DE]) 26 February 1997 (1997-02-26)

2 The present application does not meet the criteria of patentability, because the subject-matter of claim1 is not new.

D1 discloses (references in parentheses applying to this document):

A broadband high-frequency radiation generating/amplifying device (abstract: "amplification and generation of THz radiation in dc-ac-driven semiconductor superlattices "), which is based on semiconductor superlattices, characterized in that the device comprises:

- a superlattice (see the abstract and part 1), which is a periodic structure having at least two layers of different materials;
- a first unit for generating an alternating pumping electric field with a selected frequency and for inputting it into the superlattice along the superlattice axis, wherein said superlattice is configured to generate alternating output electric field, its harmonics, subharmonics, and fractional frequencies (AC field is applied see section 3, the axis in which it is applied is the same that the DC field in view of equation 5);
- a second unit for applying a homogenous static electric field across the superlattice along said superlattice axis to ensure negative differential mobility of charge carriers within the superlattice and ensuring that said alternating pumping electric field in the superlattice generates slow, preferably 1000 slower than the speed of light, longitudinal space charge wave along said superlattice axis, which in turn generates said alternating output electric field (see also part 3 in which Dc field and Ac field are applied to the superlattice);
- the parameters of said alternating pumping electric field and said homogenous static electric field are selected in such a way that said alternating output electric

field comprises a plurality of harmonics, sub-harmonics, and/or fractional harmonics of said alternating pumping electric field (generating harmonics and subharmonics is also disclosed in D1 see in par 3 the last paragraph).

3 Moreover document D1 also discloses (references in parentheses applying to this document):

Claim 2: The device of claim 1, wherein the first unit comprises:

- a source for generating said alternating pumping electric field with a selected frequency (implicit as AC is injected, see equation 5 and part 3);
- an input device for inputting said alternating pumping electric field to said superlattice, thereby to generate said longitudinal space charge wave (see part 3 equation 5).

Claim 3: The device of claim 1 or 2, wherein the second unit provides a constant voltage along said superlattice (DC is applied see equation 5 and part 3).

Claim 4: The device of any one of claims 1-3, wherein the second unit is configured for providing broadband radiation generation/amplification conditions (device of D1 suitable for amplification, see in D1 the abstract: "amplification and generation of THz radiation in dc-ac-driven semiconductor superlattices" ), ~~preferably by using non-ohmic contacts.~~

Claim 8: The device of any of the preceding claims, wherein the upper operational frequency of said superlattice being limited by the Bloch frequency criterion (Bloch frequency criterion and Bloch gain, see figure 2 of D1 and corresponding description).

Claim 11: The device of any of the preceding claims, wherein the frequency of said alternating pumping electric field or fields correspond to microwave frequency range or THz range (see in D1 the introduction the last sentence).

Claim 12: The device of claim 11, wherein the device is used within room temperature range (in D1 part 1 introduction and all through D1).

Claim 13: The device of claims 11 and 12, wherein the strengths of said alternating pumping electric field and said homogeneous static electric field exceed thresholds of critical fields, calculated for said superlattice (D1 part 2).

Claim 14: D1 shows amplification to a "desirable level", thus even if not explicitly disclosed, the amplification is implicitly disclosed in D1.

Claim 15: The device of any of the preceding claims, wherein by the employment of slow light, said alternating pumping electric field or longitudinal electrostatic wave in the structure, enables significant, ~~preferably 1000x~~ power gain of said alternating pumping electric field (see in D1 figure 2 and corresponding description).

Consequently the subject-matter of claims 2-4, 8, 12, 13, 14 and 15 is not new.



- 4 Dependent claims 5-7, 9 and 10 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of inventive step. Indeed document D2 discloses:

Claim 5: The device of claim 2, wherein the first unit for inputting said oscillating pumping electric field into said superlattice along to said superlattice axis is arranged on top of said superlattice (figure 1 and corresponding description).

Claim 6: the device of any of the preceding claims, wherein the superlattice is a quantum well semiconductor superlattice that ensure come into being of an energy miniband (column 5 lines 7-30: quantum wells superlattice).

Claim 7: The device of any of the preceding claims, wherein the superlattice, comprising a repetition of at least 10 times, preferably 30 times or more, of a dual-layer structure, wherein each of its layers being made of different semiconductor material, enabling an energy miniband (column 2 lines 50-59 and column 5 lines 7-44).

Claim 9: The device of any of the preceding claims, wherein said superlattice is a sub-critically doped superlattice (column 5 lines 31-44).

Claim 10: The device of any of the preceding claims, wherein a relevant silicon doping level is selected based on the so-called Kroemers' criterion (column 7 line 40 - column 8 line 45).

### **Re Item VIII**

#### **Certain observations on the application**

Claims 1, 4 and 15 are not clear.

1. Claim 1 does not meet the requirement of clarity because the matter for which protection is sought is not clearly defined. Indeed it is not clear neither from the claims or from the description how and which parameters are selected in order to obtain an output electric field comprising a plurality of harmonics of said altering pumping electric field. It is also not clear how the superlattice is configured to generate alternating output electric field. Furthermore it is also not clear how is ensured negative differential mobility of charge carriers within the superlattice and ensured that the alternating pumping electric field in the superlattice generates slow longitudinal space charge wave along said superlattice axis.

The claim attempts to define the subject-matter in terms of the result to be achieved, which merely amounts to a statement of the underlying problem, without providing the technical features necessary for achieving this result.

2. The term "preferably" used in the subject-matter of claims 4 and 15 does not limit the scope of the claim and expression following this term is therefore completely optional.