

SEARCH REPORT

Application Number

LH 23
LT 2020553

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	US 7 432 142 B2 (CREE INC [US]) 7 October 2008 (2008-10-07) * figure 1 *	1	INV. H01L21/268 H01L21/76 H01L21/8252
A,D	DE 10 2013 201298 A1 (FRAUNHOFER GES ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E V [DE]) 31 July 2014 (2014-07-31) * figure 2 *	1,2	H01L21/285 H01L27/06 H01L29/08 B23K26/12 H01L21/335
A	US 2016/225889 A1 (UMENO KAZUYUKI [JP] ET AL) 4 August 2016 (2016-08-04) * figures 31, 32 *	1,3	H01L21/329 B23K26/0622 B23K26/364
			TECHNICAL FIELDS SEARCHED (IPC)
			H01L B23K
The present search report has been drawn up for all claims			
The Hague		Date of completion of the search 15 June 2021	Examiner Gélébart, Jacques
CATEGORY OF CITED DOCUMENTS		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	
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			

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

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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.

15-06-2021

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 7432142	B2	07-10-2008	CA	2567066 A1	15-12-2005
			CN	1998085 A	11-07-2007
			EP	1747589 A1	31-01-2007
			JP	5160225 B2	13-03-2013
			JP	2007538402 A	27-12-2007
			KR	20070032701 A	22-03-2007
			TW	200539264 A	01-12-2005
			US	2005258451 A1	24-11-2005
			WO	2005119787 A1	15-12-2005

DE 102013201298	A1	31-07-2014	NONE		

US 2016225889	A1	04-08-2016	JP	6133191 B2	24-05-2017
			JP	2015079923 A	23-04-2015
			US	2016225889 A1	04-08-2016
			WO	2015056797 A1	23-04-2015

WRITTEN OPINION

File No. LH23	Filing date (<i>day/month/year</i>) 29.09.2020	Priority date (<i>day/month/year</i>)	Application No. LT2020553
International Patent Classification (IPC) INV. H01L21/268 H01L21/76 H01L21/8252 H01L21/285 H01L27/06 H01L29/08 B23K26/12 H01L21/335 H01L21/329 B23K26/0622 B23K26/364			
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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 Gélébart, Jacques
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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	1-9
	No: Claims	
Inventive step (IS)	Yes: Claims	1-9
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-9
	No: Claims	

2. Citations and explanations

see separate sheet

Re Item V

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

Reference is made to the following documents:

- D1 US 7 432 142 B2 (CREE INC [US]) 7 October 2008 (2008-10-07)
- D2 DE 10 2013 201298 A1 (FRAUNHOFER GES ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E V [DE]) 31 July 2014 (2014-07-31)
- D3 US 2016/225889 A1 (UMENO KAZUYUKI [JP] ET AL) 4 August 2016 (2016-08-04)

D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses, see figure 1, a method for fabrication of recessed electrical elements, which by choice can be recessed electrical contacts and/or junctions and/or electrical components, formed in group III-N semiconductor layers heterostructure in which layer composition is selected so, that in a buffer layer (4) of a heterojunction, near boundary with the III-N barrier layer, a two-dimensional electron gas (2DEG) channel (20) is formed, and in the regions of the semiconductor layers heterostructure, in which the recessed elements would be formed, recesses are formed ~~using a laser irradiation~~, the recesses are filled with the materials, intended for the forming of selected elements, wherein the method comprises the following steps:

~~a) coating a top surface of the III-N semiconductor layers heterostructure, grown on a substrate, with at least one a protective layer, in order to form a blank,~~

~~b) placing the blank, prepared in the step a), into a chamber, vacuumed or filled with an inert or shielding gas, the chamber has a transparent window through which the laser radiation enters the chamber,~~

c) forming the recess separately for each contact and/or junction and/or electrical component ~~by directing through the transparent window in the chamber to the blank the focused ultrashort pulsed laser radiation, which has selected parameters to remove the protective layer and required thickness of the material in order to form the recess of required depth in the semiconductor layers of the heterostructure,~~

d) ~~translating the blank and focused laser beam in respect to each other in the controlled manner and after translation to the position, selected for the forming of the next recess, directing the focused laser beam similarly as in the step c) and selecting the appropriate parameters of laser irradiation to form the another recess of required shape and depth and/or required number of recesses with the same or different dimensions,~~

e) filling the recess, formed in the step c) or d), with a III-N semiconductor layer (26), which has a required doping, and/or a metal compounds, forming a recessed electrically conductive contact and/or a electrically partially conductive contact and/or the junction and/or the electrical component, comprised of the region containing 2DEG channel, and/or the conductive electrical contacts and/or the electrically partially conductive contacts and/or the junctions,

f) ~~removing the remaining protective layer after forming of required recessed contacts and/or junctions and/or components,~~

g) ~~annealing the recessed electrically conductive contacts and junctions and electrical components using the rapid thermal annealing technique to an optimal temperature in the inert gas environment until a metal to 2DEG channel contact resistance is reduced,~~

h) ~~after the forming of recessed electrical contacts and/or junctions and/or electrical components, forming the recessed isolating elements, required for a separation and/or isolation of the elements, formed in the step g).~~

The subject-matter of claim 1 therefore differs from this known method at least in that a laser is used to form the recesses and is therefore new.

The problem to be solved by the present invention may be regarded as to avoid contamination, damage to the surface, use of photolithography, see page 6, lines 3-13 of the description of the application.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step for the following reasons: Forming recesses in III-N layers using a laser is known per se, see D2, figure 2 or D3, figures 31, 32. But there is no way the person skilled in the art would combine the teachings of D1 and D2 or D3.

Claims 2-9 are dependent on claim 1 and as such also meet the requirements of novelty and inventive step.