



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/804,537	11/06/2017	Byunghoon NA	Q233725	3506
23373	7590	07/11/2019		
SUGHRUE MION, PLLC 2000 PENNSYLVANIA AVENUE, N.W. SUITE 900 WASHINGTON, DC 20006			EXAMINER NGUYEN, TUAN N	
			ART UNIT	PAPER NUMBER
			2828	
			NOTIFICATION DATE	DELIVERY MODE
			07/11/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PPROCESSING@SUGHRUE.COM
USPTO@sughrue.com
sughrue@sughrue.com

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Firstly, it is well-known a metamaterial/meta-atoms derive their properties not from the properties of the base materials, but from arrangement periodic pattern from composite materials such as metals and plastic at scales that are smaller than the wavelengths they influence, and their shape, geometry, size, orientation and arrangement gives them properties in affecting the electromagnetic waves by absorbing, enhancing, bending, or blocking to achieve the desired result output.

Claim Rejections - 35 USC § 102

(a)(2) the claimed invention was described in a patent issued under section 151, or in an application for patent published or deemed published under section 122(b), in which the patent or application, as the case may be, names another inventor and was effectively filed before the effective filing date of the claimed invention.

2. Claim 1 is rejected under 35 U.S.C. 102(a)(2) as being anticipated by Birkedal et al. (US 7,693,203)

Birkedal et al. (US 7,632,203) shows and discloses a known vertical cavity surface emitting laser (*Fig 2,3 (Prior Art): VCSEL*) comprising: a gain layer configured to generate light (*Fig 2, 3 (Prior Art): active region 304 generate light*); a distributed Bragg reflector disposed below the gain layer (*Fig 3 (Prior Art): DBR 306 below gain layer 304*); and a meta structure reflector disposed above the gain layer and comprising a plurality of nano structures having a sub wavelength dimension (*Fig 2, 3 (Prior Art): meta structure reflector/PBG 318 above gain layer and comprising a plurality of nano structures; Col 4-6: line [36-067] PBG nano structure having sub wavelength; See also Fig 4-10 and related Col 1-2*).

Claim Rejections - 35 USC § 103

3. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

4. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

Claims 1-16, 20 are rejected under 35 U.S.C. 103 as being unpatentable over Ostergaard et al. (2002/0163947)/(US 6,683,898) in view of Birkedal et al. (US 7,632,203).

With respect to claim 1, Ostergaard et al. '947 shows and discloses a vertical cavity surface emitting laser (*Fig 1A-B, 4, 8B, 8C: VCSEL*) comprising: a gain layer configured to generate light (*(Fig 1A-B, 4, 8B, 8C: gain 104 active generate light)*); a distributed Bragg reflector disposed below the gain layer (*Fig 1A-B, 4, 8B, 8C: DBR 102 below gain layer*); and a meta structure reflector disposed above the gain layer (*Fig 1A-B, 4, 8B, 8C: meta structure reflector/PBG 155/116 above gain layer*). The claim further requires the meta structure reflector comprising a plurality of nano structures having a sub wavelength dimension. Ostergaard et al. '947 did not explicitly state as the above. However, Ostergaard et al. '947 did disclose the PBG one/two/or three D periodic microstructure of different shapes being used (*Section [0026, 0053, 097, 0111] dimension of short axis 1nm-500nm, and 50-1000nm in long axis*). Therefore, it is recognize Ostergaard et al. '947 having the meta structure reflector comprising of nano structure and having a sub wavelength dimension.

Birkedal et al. '203 of analogous art shows and discloses a known vertical cavity surface emitting laser (*Fig 2,3 (Prior Art): VCSEL*) comprising: a gain layer configured to generate light (*Fig 2, 3 (Prior Art): active region 304 generate light*); a distributed Bragg reflector disposed below the gain layer (*Fig 3 (Prior Art): DBR 306 below gain layer 304*); and a meta structure reflector disposed above the gain layer and comprising a plurality of nano structures having a sub wavelength dimension (*Fig 2, 3 (Prior Art): meta structure reflector/PBG 318 above gain layer and comprising a plurality of nano structures; Col 4-6: line [36-067] PBG nano structure having sub wavelength; See also Fig 4-10 and related Col 1-2*). Therefore, before the effective filing date of the claimed invention, it would have been obvious to one of ordinary skill in the art to provide Ostergaard et al. '947 the PBG nano structure having subwavelength as taught or suggested by Birkedal et al. '203, for the benefit of having the desired output.

With respect to claim 2, Ostergaard et al. '947 shows and discloses wherein the meta structure reflector further comprises a first support layer, and wherein the plurality of nano structures are disposed on the first support layer (*Fig 1A-B, 4, 8B, 8C: meta structure reflector comprises a first support layer 105, and the plurality of nano structures are disposed on the first support layer 105*).

With respect to claims 3, 4 the claims further requires wherein a thickness of the first support layer is $1/5$ or greater of an oscillation wavelength of the vertical cavity surface emitting laser; OR wherein the first support layer has a refractive index less than a refractive index of each of the plurality of nano structures. Ostergaard et al. '947 did not explicitly state as the

above. However, Ostergaard et al. '947 did show and disclose of the support layer thickness and the variation of refractive index can be selected or affect based on the material/structure/ or method of forming (*Section [026, 083-087 0100] refractive index of microstructure based on material or formation air hole "semiconductor rods and material, or etch air hole"*). Therefore, it is recognize Ostergaard et al. '947 capable of having the above limitations.

With respect to claim 5-6 Ostergaard et al. '947 shows and discloses a second support layer disposed on the first support layer and having a plurality of through holes corresponding to shapes of the plurality of nano structures, wherein the plurality of nano structures are respectively arranged in the plurality of through hole; AND wherein a refractive index of the second support layer is less than a refractive index of each of the plurality of nano structures (*Fig 2A-2E; Section [052-053]; See also Fig 6-15*).

With respect to claims 7-11 the claims further requires wherein at least one of a thickness, a width, and an arrangement interval of the plurality of nano structures is less than half of an oscillation wavelength of the vertical cavity surface emitting laser; OR wherein the plurality of nano structures has a size distribution that allows the meta structure reflector to operate as a concave mirror; OR wherein the plurality of nano structures has a size distribution that allows the meta structure reflector to operate as a convex mirror; OR wherein the plurality of nano structures has a size distribution that allows the meta structure reflector to operate as a beam deflector; OR wherein the plurality of nano structures has a shape distribution that allows the meta structure reflector to operate as a polarization beam splitter. Ostergaard et al. '947 did not explicitly state as the above. However, Ostergaard et al. '947 did show and disclose a typical circular shape, triangular, or different shapes, distribution, and relative potion will determined

the far field of the array, or affect the beam in polarization, of the support layer thickness and the variation of refractive index can be selected or affect based on the material/structure/ or method of forming (*Section [007, 026-027, 044, 075, 081, 110-111] regular polygon, rectangular, trapezium, ellipse, etc. where shapes and positions determined the far field of the array; See also Section [0114-0119]). Therefore, it is recognize Ostergaard et al. '947 capable of having the above limitations where desired thickness, arrangement, distribution, etc. to operate as a concave mirror, convex mirror, deflector or splitter (i.e. it is well-known a metamaterial/meta-atoms derive their properties not from the properties of the base materials, but from arrangement periodic pattern from composite materials such as metals and plastic at scales that are smaller than the wavelengths they influence, and their shape, geometry, size, orientation and arrangement gives them properties in affecting the electromagnetic waves by absorbing, enhancing, bending, or blocking to achieve the desired result output).*

With respect to claim 12-13, Ostergaard et al. '947 shows and disclose wherein the plurality of nano structures have asymmetric shapes; AND wherein the plurality of nano structures have shapes and arrangements that allow a ratio of a width in a first direction to a width in a second direction perpendicular to the first direction to change according to a position of the plurality of nano structures (*Fig 2C; Section [080] PBG asymmetric*).

With respect to claim 14, the claim further requires wherein a reflectance of the distributed Bragg reflector is greater than a reflectance of the meta structure reflector. Ostergaard et al. '947 did not explicitly state as the above. However, it is well-known and recognize reflectance at the output side/top DBR meta structure in the VCSEL is lower than

the bottom mirror - so that the resonating wavelength would output at the lower side/the meta structure reflector.

With respect to claims 15-16, Ostergaard et al. '947 shows and discloses wherein the gain layer comprises: an active layer; and an upper clad layer and a lower clad layer respectively disposed above and below the active layer; AND wherein each of the active layer, the upper clad layer, and the lower clad layer comprises a semiconductor material (*Fig 1A-B, Fig 4-15: active layer 104 between upper and lower clad layer 103 and comprising of semiconductor material; Section [082-084]).*

With respect to claim 20, an optical device comprising: the vertical cavity surface emitting laser of claim 1 (*See claim 1*). The claim further requires the vertical cavity surface emitting laser being configured to emit light toward an object; a sensor configured to receive the light reflected from the object; and an analyzer configured to analyze the light received by the sensor and analyze at least one of a property, a shape, a location, and a motion of the object. Ostergaard et al. '947 in view of Birkedal et al. '203 did not explicitly state the above, however it is recognize the existence of known system with sensor/detector that analyze the light output from metamaterial VCSEL to assessed whether the design has met its intended purposes or intended use.

Claims 17-19 are rejected under 35 U.S.C. 103 as being unpatentable over Ostergaard et al. (2002/0163947)/(US 6,683,898) in view of Birkedal et al. (US 7,632,203), and further in view Morel et al. (US 2014/0059830).

With respect to claim 17-19 the claims further requires a heat sink configured to dissipate heat generated from the gain layer; wherein a region of the heat sink comprises; a first region that is disposed in parallel to a direction in which the distributed Bragg reflector and the gain layer are stacked and surrounds side surfaces of the vertical cavity surface emitting laser; and a second region connected to the first region and located at an upper portion of the gain layer; AND wherein a discharge path of the heat generated from the gain layer toward the hot sink includes a first path of the heat toward the second region and a second path of the heat toward the first region, and wherein the first path is shorter than the second path in at least one position of the gain layer. Ostergaard et al. '947 in view of Birkedal et al. '203 disclose the above without teaching of a heat sink to dissipate heat from the gain layer.

Morel et al. ' 830 of analogous art shows and discloses the use of metamaterial in a VCSEL with DBR mirrors and perform dual function of the DBR and heat spreader at the same time (*TITLE; ABSTRACT; Fig 1-5; Section [013- 015]*). Therefore, before the effective filing date of the claimed invention, it would have been obvious to one of ordinary skill in the art to provide Ostergaard et al. '947 in view of Birkedal et al. '203 the metamaterial heat sink as taught or suggested by Birkedal et al. '203, for the benefit of having the metamaterial/DBR acts as a heat sink, and the heat generate from the gain layer toward the top PGB/first path is shorter than the second path in at least one potion/bottom DBR of the gain layer.

Citation of Pertinent References

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. It is cited primarily to show the product of the instant invention.

Capasso et al. (US 2011/0315898) shows and disclose a VCSEL with meta-surface where the periodic of the surface not only fine grooves but can be other sub-wavelength-sized structures such as apertures or indentation with other shapes, with the same constant or non-constant element to element distance, depth, etc. to balance the benefit of the output (*Fig 1, 2, 4, 5, 17-44; Section [94, 52-97]*); AND the measure of emission pattern detection of meta-surface (*Section [023-024, 064, 072-095]*).

Wang et al (US 2016/0307939) shows and discloses known a VCSEL with active/QW layer between DBR layer with metal microstructure above active layer (Fig 28: active 2504 above DBR 2876 with microstructure/metastructure above the active layer 2504, Section [0204-0206]; See also Figs **23-38B**, 85-90, **92-96**, 100-102, **105A-107**, 112-114).

1. Any inquiry concerning this communication or earlier communications from the examiner should be directed to TUAN N NGUYEN whose telephone number is (571)272-1948. The examiner can normally be reached on M-F.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, JESSICA MANNO can be reached on (571) 272-2339. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications

may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/TUAN N NGUYEN/
Primary Examiner, Art Unit 2828

Notice of References Cited	Application/Control No. 15/804,537		Applicant(s)/Patent Under Reexamination NA et al.	
	Examiner TUAN N NGUYEN		Art Unit 2828	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20020163947-A1	11-2002	Ostergaard, John Erland	H01S5/18355	372/43.01
*	B	US-6683898-B2	01-2004	.O slashed.stergaard; John Erland	H01S5/18355	372/43.01
*	C	US-20110315898-A1	12-2011	Capasso; Federico	B82Y20/00	250/492.1
*	D	US-20140059830-A1	03-2014	Morel; Yannick C.	H01S5/18377	29/428
*	E	US-20160307939-A1	10-2016	WANG; Shih-Yuan	H01L27/1443	1/1
*	F	US-7693203-B2	04-2010	Birkedal; Dan	H01S5/183	372/43.01
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

<i>Index of Claims</i> 	Application/Control No. 15/804,537	Applicant(s)/Patent Under Reexamination NA et al.
	Examiner TUAN N NGUYEN	Art Unit 2828

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47										
CLAIM		DATE								
Final	Original	07/03/2019								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
	12	✓								
	13	✓								
	14	✓								
	15	✓								
	16	✓								
	17	✓								
	18	✓								
	19	✓								
	20	✓								

Search Notes 	Application/Control No. 15/804,537	Applicant(s)/Patent Under Reexamination NA et al.
	Examiner TUAN N NGUYEN	Art Unit 2828

CPC - Searched*		
Symbol	Date	Examiner
H01S5/18386.cpc.; G01D5/30.cpc.; H01S5/18361.cpc.;	7/3/2019	TN

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
372	50.11.ccls.	07/03/2019	TN

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
EAST: Text search (Assignee search ;	07/03/2019	TN
EAST: Text search (257/\$\$\$ccls.; 438/\$\$\$ccls.; 372/\$\$\$ccls.; inventor search ; backward/ forward searchj	07/04/2019	TN
Update text search (372/\$\$\$ccls.; 438/\$\$\$ccls.; 372/\$\$\$ccls.; backward/ forward search	07/05/2019	TN
Update text search	7/7/2019	TN

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

--	--

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	603	H01S5/18386.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/03 12:15
S2	1522	G01D5/30.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/03 12:27
S3	1424	H01S5/18361.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/03 13:08
S4	1	("20180278023").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/03 13:32
S5	826137	SAMSUNG near3 ELECTRONICS near3 "LTD"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/03 14:28
S6	48	S5 and (meta near3 reflect\$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/03 14:29
S7	1689	372/50.11.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/03 15:17

EAST Search History (Prior Art)

S8	218	(NA or HAN) and (Byunghoon or Seunghoon)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/04 20:31
S9	27	S8 and meta	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/04 21:05
S10	22	("20040008397" "20110103742" "20120212375" "20130215483" "20130258293" "20140085693" "20140158198" "20140175546" "20140185122" "20140226195" "20160146989" "20160170237" "7787735" "8698096" "8711463" "9256113" "9261714" "9285611").PN. OR ("9632216").URPN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/04 21:21
S11	3	"63583643".FMID.	US-PGPUB; USPAT; FPRS	OR	OFF	2019/07/04 21:22
S12	0	257/\$\$.ccls. and (VCSEL and DBR and (meta near3 reflect\$4))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/04 21:23
S13	0	438/\$\$.ccls. and (VCSEL and DBR and (meta near3 reflect\$4))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/04 23:15
S14	0	372/\$\$.ccls. and (VCSEL and DBR and (meta near3 reflect\$4))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/04 23:16
S15	0	372/\$\$.ccls. and (VCSEL and DBR and (meta near3 reflect\$4))	US-PGPUB; USPAT; FPRS	OR	OFF	2019/07/05 06:04

EAST Search History (Prior Art)

S16	0	372/\$\$.ccls. and ((meta near3 reflect\$4))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/05 06:13
S18	30	372/\$\$.ccls. and (meta\$material)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/05 06:26
S17	0	257/\$\$.ccls. and (VCSEL and DBR and (metamaterial))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/05 06:26
S19	198	438/\$\$.ccls. and (meta\$material)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/05 06:49
S20	18	(VCSEL and DBR and (meta\$material))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/05 06:53
S21	15	(VCSEL and DBR and (meta\$material or metalayer) and (gain or active))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/05 08:15

EAST Search History (Prior Art)

S22	48	("20050092925" "20050184354" "20070092192" "20070190434" "20080047604" "20080102582" "20080218740" "20080229941" "20080248608" "20080265449" "20090188557" "20090267049" "20100029067" "20100126548" "20100193768" "20100197068" "20100221866" "20100313941" "20120193676" "20120292676" "20130207222" "20140001528" "20150041965" "20160225631" "4571559" "4637129" "4716449" "5451767" "5457327" "5625636" "5757057" "5886374" "6027956" "6177289" "6667528" "7115971" "7397101" "7495306" "7601597" "7674563" "7772615" "7795064" "7893348" "7898052" "7972934" "8114695" "8129710" "8436370").PN. OR ("9496435").URPN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/05 08:24
S23	19	("4790635" "4991179" "5031012" "5340998" "5404373" "5557117" "5574738" "6285704" "6396083" "6611539" "7075954" "7105866" "7369583").PN. OR ("7772615").URPN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/05 08:27
S24	31	(US-20190056246-\$ or US-20180278023-\$ or US-20180080758-\$ or US-20170211951-\$ or US-20180062353-\$ or US-20190115725-\$ or US-20180316155-\$ or US-20190155124-\$ or US-20190154503-\$ or US-20190137856-\$ or US-20190103727-\$ or US-20190086579-\$ or US-20190057512-\$ or US-20190034035-\$ or US-20190011535-\$ or US-20190004312-\$ or US-20190139243-\$ or US-20190137665-\$ or US-20180158856-\$ or US-20160307939-\$ or US-20180129866-\$ or US-20180131160-\$).did. or (US-9632216-\$ or US-9496435-\$ or US-7772615-\$ or US-8634078-\$ or US-7369583-\$).did. or (WO-2017217035-\$ or CA-2878975-\$).did. or (US-20140059830-\$ or US-20140348191-\$).did.	US-PGPUB; USPAT; FPRS; DERWENT	OR	OFF	2019/07/05 08:28
L1	19	(("7693203") or ("6683898") or ("20160156883") or ("20120128019") or ("4944788") or ("4275948") or ("106058642") or ("1020120061514")).PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2019/07/07 23:32
L2	4	L1 and (meta or metamaterial or meta\$atom or nm)	US-PGPUB; USPAT	OR	OFF	2019/07/07 23:45
L3	168	VCSEL and ((meta or metamaterial or meta\$atom) and nm)	US-PGPUB; USPAT	OR	OFF	2019/07/07 23:50

EAST Search History (Interference)

		<This search history is empty>			
--	--	--------------------------------	--	--	--

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	Not Yet Assigned
	Confirmation Number	Not Yet Assigned
	Filing Date	November 6, 2017
	First Named Inventor	Byunghoon NA
	Art Unit	Not Yet Assigned
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	Q233725

U.S. PATENTS						
Examiner Initials*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, where Relevant Passages or Relevant Figures Appear
	1.	7693203	B2	2010-04-06	Birkedal et al.	
	2.	6683898	B2	2004-01-27	Østergaard et al.	

U.S. PATENT APPLICATION PUBLICATIONS						
Examiner Initials*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, where Relevant Passages or Relevant Figures Appear
	3.	2016/0156883	A1	2016-06-02	HAN et al.	
	4.	2012/0128019	A1	2012-05-24	Chang-Hasnain et al.	

FOREIGN PATENT DOCUMENTS								
Examiner Initials*	Cite No	Foreign Document Number ³	Country Code ²	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, where Relevant Passages or Relevant Figures Appear	T ⁵
	5.	4944788	JP	B2	2012-06-06			Corresponds to US 7693203
	6.	4275948	JP	B2	2009-06-10			Corresponds to US 6683898
	7.	106058642	CN	A	2016-10-26	UNIV BEIJING TECHNOLOGY		Abstract
	8.	10-2012-0061514	KR	A	2012-06-13	Pusan National University Industry-University Cooperation Foundation		Machine Translation

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city, and/or country where published.	T ⁵
	9.	J. Piprek et al., "Thermal Conductivity Reduction in GaAs-A1As Distributed Bragg Reflectors", IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 10, NO. 1, JANUARY 1998, (Pages 81 - 83)	
	10.	H.K. Lee et al., "Thermal analysis of asymmetric intracavity-contacted oxide-aperture VCSELs for efficient heat dissipation", Elsevier Ltd., Solid-State Electronics 53, (July 26, 2009), (Pages 1086-1091)	
	11.	A N AL-Omari et al., "Improved performance of top-emitting oxide-confined polyimide-planarized 980 nm VCSELs with copper-plated heat sinks", 2012 IOP Publishing Ltd, JOURNAL OF PHYSICS D: APPLIED PHYSICS, J. Phys. D: Appl. Phys. 45 (Nov. 19, 2012) 505101 (9 Pages Total), doi:10.1088/0022-3727/45/50/505101	
	12.	Toshihiko OUCHI., "Thermal Analysis of Thin-Film Vertical-Cavity Surface-Emitting Lasers Using Finite Element Method", The Japan Society of Applied Physics, Jpn. J. Appl. Phys., Vol. 41 (2002), Part 1, No. 8, August 2002, (Pages 5181-5186)	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

1 See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. 2 Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). 3 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 4 Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 5 Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /T.N.N/ 06/11/2019

/TUAN N NGUYEN/

[Page 1 of 3]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	Not Yet Assigned
	Confirmation Number	Not Yet Assigned
	Filing Date	November 6, 2017
	First Named Inventor	Byunghoon NA
	Art Unit	Not Yet Assigned
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	Q233725

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city, and/or country where published.	T ⁵
	13.	MICHAEL C.Y. HUANG et al., "A surface-emitting laser incorporating a high-index-contrast subwavelength grating", nature photonics, VOL 1, FEBRUARY 2007, www.nature.com/naturephotonics, (5 Pages Total), February 1, 2007, doi:10.1038/nphoton.2006.80	

EXAMINER SIGNATURE			
Examiner Signature	/TUAN N NGUYEN/	Date Considered	06/11/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

1 See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. 2 Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). 3 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 4 Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 5 Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /T.N.N/

[Page 2 of 3]