US00D876504S

(12) United States Design Patent

Lee et al.

(10) Patent No.: US D876,504 S
(45) Date of Patent: ** Feb. 25, 2020

(54) **EXHAUST FLOW CONTROL RING FOR SEMICONDUCTOR DEPOSITION APPARATUS**

(71) Applicant: **ASM IP Holding B.V.**, Almere (NL)

(72) Inventors: **Julll Lee**, Chungcheongnam-do (KR); **Sung Hoon Jun**, Gyeonggi-do (KR); **Dong Rak Jung**, Chungcheongnam-do (KR); **Seung Wook Kim**, Gyeongsangnam-do (KR)

(73) Assignee: **ASM IP Holding B.V.**, Almere (NL)

(**) Term: **15 Years**

(21) Appl. No.: **29/604,101**

(22) Filed: **May 15, 2017**

(30) **Foreign Application Priority Data**

Apr. 3, 2017 (KR) 30-2017-0015304

(51) **LOC (12) Cl.** **15-09**

(52) **U.S. Cl.**
USPC **D15/138**

(58) **Field of Classification Search**
USPC D13/182; D15/122, 138
CPC H01L 21/6831; H01L 21/67109; H01L 21/68735
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,266,416	A	12/1941	Duclos
D142,841	S	11/1945	D'Algodt
3,263,502	A	8/1966	Springfield
3,913,058	A	10/1975	Nishio et al.
4,721,533	A	1/1988	Phillippi et al.
4,749,416	A	6/1988	Greenspan
5,002,632	A	3/1991	Loewenstein et al.
5,053,247	A	10/1991	Moore
5,069,591	A	12/1991	Kinoshita

(Continued)

FOREIGN PATENT DOCUMENTS

CN	102373440	7/2014
DE	3836696	12/1989

(Continued)

OTHER PUBLICATIONS

CNIPA; Office Action dated Dec. 14, 2018 in Application No. 201410331047.6.

(Continued)

Primary Examiner — Patricia A Palasik
(74) *Attorney, Agent, or Firm* — Snell & Wilmer L.L.P.

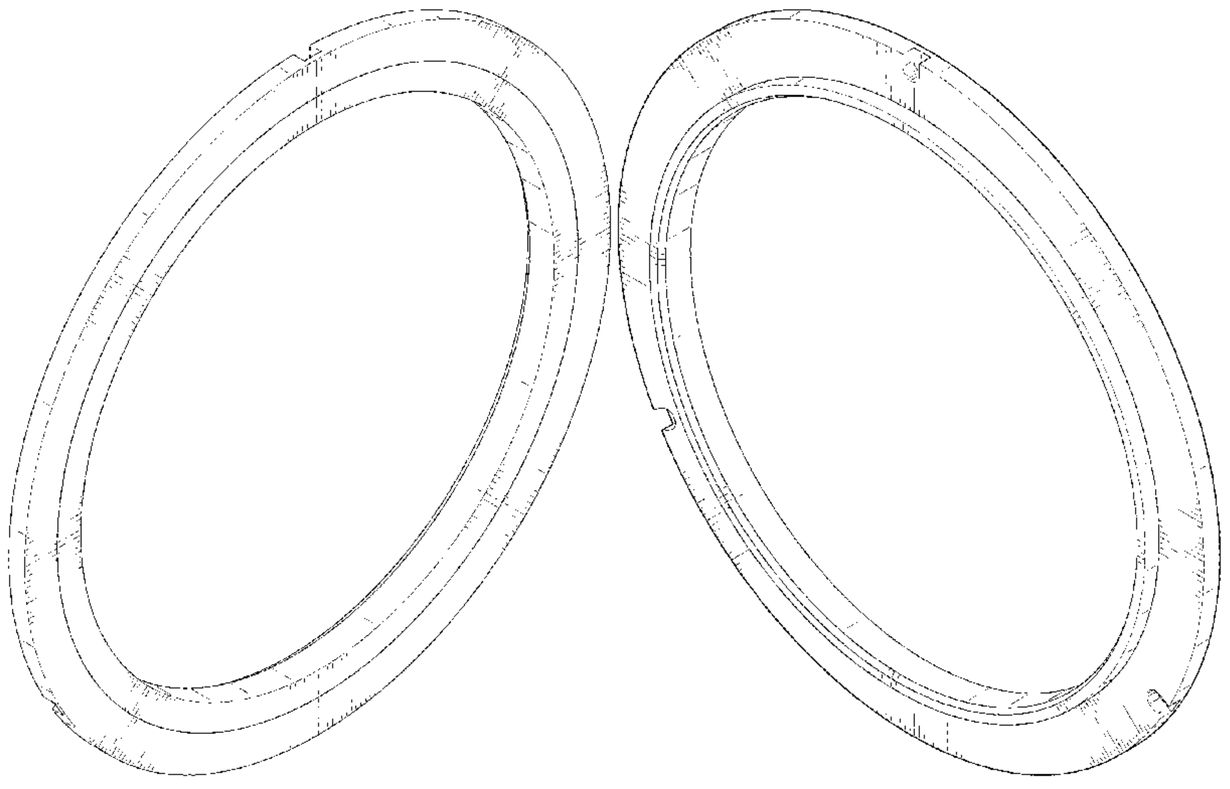
(57) **CLAIM**

The ornamental design for an exhaust flow control ring for semiconductor deposition apparatus, as shown and described.

DESCRIPTION

FIG. **1** is a perspective view of an exhaust flow control ring for semiconductor deposition apparatus,
FIG. **2** is a front elevational view of the exhaust flow control ring for semiconductor deposition apparatus,
FIG. **3** is a rear elevational view of the exhaust flow control ring for semiconductor deposition apparatus,
FIG. **4** is a left side elevational view of the exhaust flow control ring for semiconductor deposition apparatus,
FIG. **5** is a right side elevational view of the exhaust flow control ring for semiconductor deposition apparatus,
FIG. **6** is another view of the exhaust flow control ring for semiconductor deposition apparatus,
FIG. **7** is another view of the exhaust flow control ring for semiconductor deposition apparatus; and,
FIG. **8** is a rear perspective view of the exhaust flow control ring for semiconductor deposition apparatus.

1 Claim, 7 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,082,517	A		1/1992	Moslehi
5,084,126	A		1/1992	McKee
5,158,128	A		10/1992	Inoue et al.
5,273,609	A		12/1993	Moslehi
5,281,274	A		1/1994	Yoder
5,305,417	A		4/1994	Najm et al.
5,320,218	A		6/1994	Yamashita et al.
5,338,362	A		8/1994	Imahashi
5,348,774	A		9/1994	Golecki et al.
5,388,945	A		2/1995	Garric et al.
5,397,395	A		3/1995	Sano et al.
5,423,942	A		6/1995	Robbins et al.
5,431,734	A		7/1995	Chapple-Sokol et al.
5,447,294	A		9/1995	Sakata et al.
D363,464	S		10/1995	Fukasawa
5,463,176	A		10/1995	Eckert
5,480,818	A		1/1996	Matsumoto et al.
5,482,559	A		1/1996	Imai et al.
5,484,484	A		1/1996	Yamaga et al.
5,531,218	A		7/1996	Krebs
5,586,585	A		12/1996	Bonora et al.
5,667,592	A		9/1997	Boitnott et al.
D386,076	S		11/1997	Moore
5,685,912	A		11/1997	Nishizaka
5,728,425	A		3/1998	Ebe et al.
5,730,802	A		3/1998	Ishizumi et al.
5,801,945	A		9/1998	Commer
5,827,420	A		10/1998	Shirazi et al.
D404,370	S	*	1/1999	Kimura D13/182
D404,372	S	*	1/1999	Ishii D13/182
5,863,123	A		1/1999	Lee et al.
5,866,795	A		2/1999	Wang et al.
5,879,459	A		3/1999	Gadgil et al.
5,893,741	A		4/1999	Huang
5,904,170	A		5/1999	Harvey et al.
D411,516	S		6/1999	Imafuku et al.
5,915,562	A		6/1999	Nyseth et al.
5,939,886	A		8/1999	Turner et al.
5,992,453	A		11/1999	Zimmer
6,000,732	A		12/1999	Scheler et al.
6,035,804	A		3/2000	Arami et al.
6,053,983	A		4/2000	Saeki et al.
6,072,163	A		6/2000	Armstrong et al.
6,074,154	A		6/2000	Ueda et al.
6,079,356	A		6/2000	Umotoy et al.
6,079,927	A		6/2000	Muka
6,095,083	A		8/2000	Rice et al.
6,106,625	A		8/2000	Koai et al.
6,119,710	A		9/2000	Brown
6,120,008	A		9/2000	Littman et al.
6,143,082	A		11/2000	McInerney et al.
6,143,659	A		11/2000	Leem
6,190,037	B1		2/2001	Das et al.
6,190,457	B1		2/2001	Arai et al.
6,203,969	B1		3/2001	Ueda
6,231,290	B1		5/2001	Kikuchi et al.
6,238,734	B1		5/2001	Senzaki et al.
6,287,988	B1		9/2001	Nagamine et al.
6,296,710	B1		10/2001	Allen et al.
6,335,049	B1		1/2002	Basceri
6,346,419	B1		2/2002	Ryerson et al.
6,379,466	B1		4/2002	Sahin et al.
6,390,754	B2		5/2002	Yamaga et al.
6,439,822	B1		8/2002	Kimura et al.
6,450,117	B1		9/2002	Murugesh et al.
6,455,098	B2		9/2002	Tran et al.
6,481,945	B1		11/2002	Hasper et al.
6,498,091	B1		12/2002	Chen et al.
6,502,530	B1		1/2003	Turlot et al.
6,503,365	B1		1/2003	Kim et al.
6,506,009	B1		1/2003	Nulman et al.
6,527,884	B1		3/2003	Takakuwa et al.
6,558,517	B2		5/2003	Basceri
6,582,174	B1		6/2003	Hayashi
6,589,352	B1	*	7/2003	Yudovsky C23C 16/4585 118/500
6,696,367	B1		2/2004	Aggarwal
D494,552	S	*	8/2004	Tezuka D13/182
D496,008	S	*	9/2004	Takahashi D13/182
6,812,157	B1		11/2004	Gadgil
6,815,352	B1	*	11/2004	Tamura C30B 15/00 156/345.51
6,838,122	B2		1/2005	Basceri et al.
6,841,201	B2		1/2005	Shanov et al.
6,861,642	B2		3/2005	Ichiki et al.
6,867,859	B1		3/2005	Powell
6,876,191	B2		4/2005	de Ridder
6,878,206	B2		4/2005	Tzu et al.
6,883,733	B1		4/2005	Lind
6,884,475	B2		4/2005	Basceri
6,916,398	B2		7/2005	Chen et al.
6,949,204	B1		9/2005	Lenz et al.
6,963,052	B2		11/2005	Kuibira et al.
6,982,103	B2		1/2006	Basceri et al.
6,984,591	B1		1/2006	Buchanan et al.
7,049,226	B2		5/2006	Chung et al.
7,052,584	B2		5/2006	Basceri
7,109,098	B1		9/2006	Ramaswamy et al.
7,144,809	B2		12/2006	Elers et al.
7,202,512	B2		4/2007	Chen et al.
7,204,886	B2		4/2007	Chen et al.
7,208,198	B2		4/2007	Basceri et al.
7,217,617	B2		5/2007	Basceri
D556,704	S	*	12/2007	Nakamura D13/182
D557,226	S	*	12/2007	Uchino D13/182
D558,021	S		12/2007	Lawrence
D559,993	S	*	1/2008	Nagakubo D24/232
D559,994	S	*	1/2008	Nagakubo D24/232
7,326,656	B2		2/2008	Brask et al.
D571,383	S	*	6/2008	Ota D15/138
D571,831	S	*	6/2008	Ota D15/138
7,422,636	B2		9/2008	Ishizaka
7,456,429	B2		11/2008	Levy
D583,395	S	*	12/2008	Ueda D15/138
7,467,632	B2		12/2008	Lee et al.
7,504,344	B2		3/2009	Matsuki et al.
D593,585	S	*	6/2009	Ota D15/138
7,544,398	B1		6/2009	Chang et al.
D609,652	S	*	2/2010	Nagasaka D13/182
D614,593	S	*	4/2010	Lee D13/182
D616,394	S	*	5/2010	Sato D13/182
7,712,435	B2		5/2010	Yoshizaki et al.
7,758,698	B2		7/2010	Bang et al.
7,780,789	B2		8/2010	Wu et al.
7,799,706	B2		9/2010	Yeom et al.
D625,977	S		10/2010	Watson et al.
7,833,348	B2		11/2010	Wada et al.
7,894,474	B1		2/2011	Bell
7,919,142	B2		4/2011	Yeom et al.
7,994,070	B1		8/2011	Dip et al.
RE43,023	E		12/2011	Nakashima et al.
D649,986	S	*	12/2011	Fujikata D15/138
D654,882	S		2/2012	Honma et al.
D655,260	S		3/2012	Honma et al.
D655,261	S		3/2012	Honma et al.
8,206,506	B2		6/2012	Kadkhodayan et al.
8,402,918	B2		3/2013	Kadkhodayan et al.
8,419,959	B2		4/2013	Bettencourt et al.
8,465,903	B2		6/2013	Weidman et al.
8,557,712	B1		10/2013	Antonelli et al.
8,573,152	B2		11/2013	de la Llera et al.
8,573,154	B2		11/2013	Yorozuya
8,586,484	B2		11/2013	Matsuyama et al.
D694,790	S		12/2013	Matsumoto et al.
D697,038	S		1/2014	Matsumoto et al.
8,647,993	B2		2/2014	Lavoie et al.
8,728,956	B2		5/2014	Lavoie et al.
8,741,062	B2		6/2014	Lindfors et al.
D709,536	S	*	7/2014	Yoshimura D15/138
D709,537	S	*	7/2014	Kuwabara D15/138
8,828,886	B2		9/2014	Samukawa et al.
8,859,368	B2		10/2014	Deniz
D716,742	S	*	11/2014	Jang D13/182

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,876,974	B2	11/2014	Wan	
8,900,999	B1	12/2014	Wu et al.	
D724,553	S *	3/2015	Choi	D13/182
8,980,006	B2	3/2015	Huh et al.	
9,004,744	B1	4/2015	Kemp	
9,029,244	B2	5/2015	Won et al.	
D733,257	S	6/2015	Schoenherr et al.	
D733,262	S	6/2015	Kang	
9,076,726	B2	7/2015	Kauerauf et al.	
D736,348	S	8/2015	Tan	
9,127,358	B2	9/2015	Inoue et al.	
9,184,054	B1	11/2015	Huang et al.	
D745,641	S	12/2015	Blum	
9,252,238	B1	2/2016	Trevino et al.	
9,267,204	B2	2/2016	Honma	
D751,176	S	3/2016	Schoenherr et al.	
9,287,273	B2	3/2016	Ragnarsson et al.	
9,309,978	B2	4/2016	Hatch et al.	
9,337,057	B2	5/2016	Park et al.	
9,362,137	B2	6/2016	Kang et al.	
9,362,180	B2	6/2016	Lee et al.	
9,399,228	B2	7/2016	Breiling et al.	
9,523,148	B1	12/2016	Pore et al.	
9,570,302	B1	2/2017	Chang et al.	
9,576,952	B2	2/2017	Joshi et al.	
9,583,345	B2	2/2017	Chen et al.	
9,684,234	B2	6/2017	Darling et al.	
D793,976	S *	8/2017	Fukushima	D13/182
D795,208	S *	8/2017	Sasaki	D13/182
9,748,145	B1	8/2017	Kannan et al.	
9,786,491	B2	10/2017	Suzuki et al.	
9,820,289	B1	11/2017	Pawar et al.	
9,865,455	B1	1/2018	Sims et al.	
9,865,815	B2	1/2018	Hausmann	
9,868,131	B2	1/2018	Kilpi et al.	
9,875,893	B2	1/2018	Takamure et al.	
D810,705	S *	2/2018	Krishnan	D13/182
9,951,421	B2	4/2018	Lind	
D819,580	S *	6/2018	Krishnan	D13/182
9,997,357	B2	6/2018	Arghavani et al.	
9,997,373	B2	6/2018	Hudson	
10,018,920	B2	7/2018	Chang et al.	
10,047,435	B2	8/2018	Haukka et al.	
D827,592	S *	9/2018	Ichino	D13/182
10,106,892	B1	10/2018	Siddiqui et al.	
10,121,671	B2	11/2018	Fu et al.	
10,147,600	B2	12/2018	Takamure et al.	
10,177,025	B2	1/2019	Pore	
10,179,947	B2	1/2019	Fukazawa	
10,186,420	B2	1/2019	Fukazawa	
10,190,213	B2	1/2019	Zhu et al.	
D840,364	S *	2/2019	Ichino	D13/182
10,211,308	B2	2/2019	Zhu et al.	
10,229,833	B2	3/2019	Raisanen et al.	
10,236,177	B1	3/2019	Kohen et al.	
10,249,524	B2	4/2019	den Hartog Besselink et al.	
10,249,577	B2	4/2019	Lee et al.	
10,262,859	B2	4/2019	Margetis et al.	
10,269,558	B2	4/2019	Blanquart et al.	
10,276,355	B2	4/2019	White et al.	
10,283,353	B2	5/2019	Kobayashi et al.	
10,290,508	B1	5/2019	Kubota et al.	
10,312,055	B2	6/2019	Suzuki	
10,312,129	B2	6/2019	Coomer	
10,319,588	B2	6/2019	Mattinen et al.	
10,322,384	B2	6/2019	Stumpf et al.	
10,340,125	B2	7/2019	Winkler	
10,340,135	B2	7/2019	Blanquart	
10,343,920	B2	7/2019	Haukka	
10,361,201	B2	7/2019	Xie et al.	
2001/0000141	A1	4/2001	Zhou et al.	
2001/0014267	A1	8/2001	Yamaga et al.	
2001/0031541	A1	10/2001	Madan et al.	
2001/0039922	A1	11/2001	Nakahara	
2001/0039966	A1	11/2001	Walpole et al.	
2001/0041250	A1	11/2001	Werkhoven et al.	
2001/0054388	A1	12/2001	Qian	
2002/0008270	A1	1/2002	Marsh	
2002/0025688	A1	2/2002	Kato	
2002/0027945	A1	3/2002	Hirano et al.	
2002/0043337	A1 *	4/2002	Goodman	C23C 16/4581 156/345.12
2002/0048634	A1	4/2002	Basceri	
2002/0073922	A1	6/2002	Frankel et al.	
2002/0090735	A1	7/2002	Kishkovich et al.	
2002/0099470	A1	7/2002	Zinger et al.	
2002/0100418	A1	8/2002	Sandhu et al.	
2002/0104751	A1	8/2002	Drewery et al.	
2002/0123237	A1	9/2002	Nguyen et al.	
2002/0160112	A1	10/2002	Sakai et al.	
2003/0000647	A1	1/2003	Yudovsky et al.	
2003/0008528	A1	1/2003	Xia et al.	
2003/0017265	A1	1/2003	Basceri et al.	
2003/0017266	A1	1/2003	Basceri et al.	
2003/0040120	A1	2/2003	Allen et al.	
2003/0040196	A1	2/2003	Lim et al.	
2003/0041971	A1	3/2003	Kido et al.	
2003/0045961	A1	3/2003	Nakao	
2003/0049372	A1	3/2003	Cook et al.	
2003/0066482	A1	4/2003	Pokharna et al.	
2003/0072882	A1	4/2003	Niinisto et al.	
2003/0077857	A1	4/2003	Xia et al.	
2003/0077883	A1	4/2003	Ohtake	
2003/0101938	A1	6/2003	Ronsse et al.	
2003/0111013	A1	6/2003	Oosterlaken et al.	
2003/0124792	A1	7/2003	Jeon et al.	
2003/0140851	A1	7/2003	Janakiraman et al.	
2003/0170945	A1	9/2003	Igeta et al.	
2003/0176074	A1	9/2003	Paterson et al.	
2003/0190804	A1	10/2003	Glenn et al.	
2003/0213435	A1	11/2003	Okuda et al.	
2003/0213560	A1	11/2003	Wang et al.	
2003/0232511	A1	12/2003	Metzner et al.	
2004/0011504	A1	1/2004	Ku et al.	
2004/0015300	A1	1/2004	Ganguli et al.	
2004/0025787	A1	2/2004	Selbrede et al.	
2004/0035358	A1	2/2004	Basceri et al.	
2004/0043544	A1	3/2004	Asai et al.	
2004/0048452	A1	3/2004	Sugawara et al.	
2004/0056017	A1 *	3/2004	Renken	H01L 21/67109 219/444.1
2004/0065255	A1	4/2004	Yang et al.	
2004/0069226	A1	4/2004	Yoshida et al.	
2004/0083975	A1	5/2004	Tong et al.	
2004/0089236	A1	5/2004	Yokogawa et al.	
2004/0092073	A1	5/2004	Cabral et al.	
2004/0105738	A1	6/2004	Ahn et al.	
2004/0127069	A1	7/2004	Yamazaki et al.	
2004/0142577	A1	7/2004	Sugawara et al.	
2004/0185177	A1	9/2004	Basceri et al.	
2004/0187784	A1	9/2004	Sferlazzo	
2004/0202786	A1	10/2004	Wongsenakhum et al.	
2004/0223893	A1	11/2004	Tabata et al.	
2004/0228968	A1	11/2004	Basceri	
2004/0241322	A1	12/2004	Basceri et al.	
2005/0009325	A1	1/2005	Chung et al.	
2005/0017272	A1	1/2005	Yamashita et al.	
2005/0046825	A1	3/2005	Powell et al.	
2005/0056218	A1	3/2005	Sun et al.	
2005/0056780	A1	3/2005	Miller et al.	
2005/0059261	A1	3/2005	Basceri et al.	
2005/0059264	A1	3/2005	Cheung	
2005/0095859	A1	5/2005	Chen et al.	
2005/0107627	A1	5/2005	Dussarrat et al.	
2005/0109461	A1	5/2005	Sun	
2005/0115946	A1	6/2005	Shim et al.	
2005/0148162	A1	7/2005	Chen et al.	
2005/0161434	A1	7/2005	Sugawara et al.	
2005/0183827	A1	8/2005	White et al.	
2005/0186688	A1	8/2005	Basceri	
2005/0193948	A1	9/2005	Oohirabaru et al.	
2005/0208217	A1	9/2005	Shinriki et al.	
2005/0208219	A1	9/2005	Basceri	
2005/0229849	A1	10/2005	Silvetti et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0252447 A1 11/2005 Zhao et al.
2005/0252455 A1 11/2005 Moriya et al.
2005/0253061 A1 11/2005 Cameron et al.
2005/0271812 A1 12/2005 Myo et al.
2005/0284991 A1 12/2005 Saez
2006/0009044 A1 1/2006 Igeta et al.
2006/0048710 A1 3/2006 Horiguchi et al.
2006/0057799 A1 3/2006 Horiguchi et al.
2006/0108221 A1 5/2006 Goodwin et al.
2006/0113038 A1 6/2006 Gondhalekar et al.
2006/0137608 A1 6/2006 Choi et al.
2006/0141155 A1 6/2006 Gordon et al.
2006/0151117 A1 7/2006 Kasanami et al.
2006/0165892 A1 7/2006 Weidman
2006/0166428 A1 7/2006 Kamioka et al.
2006/0228898 A1 10/2006 Wajda et al.
2006/0240187 A1 10/2006 Weidman
2006/0257563 A1 11/2006 Doh et al.
2006/0275710 A1 12/2006 Yamazaki et al.
2007/0020160 A1 1/2007 Berkman et al.
2007/0026162 A1 2/2007 Wei et al.
2007/0032045 A1 2/2007 Kasahara et al.
2007/0062646 A1 3/2007 Ogawa et al.
2007/0066038 A1 3/2007 Sadjadi et al.
2007/0087296 A1 4/2007 Kim et al.
2007/0095283 A1 5/2007 Galewski
2007/0095286 A1 5/2007 Baek et al.
2007/0128858 A1 6/2007 Haukka et al.
2007/0131168 A1 6/2007 Gomi et al.
2007/0134919 A1 6/2007 Gunji et al.
2007/0148347 A1 6/2007 Hatanpaa et al.
2007/0184179 A1 8/2007 Waghray et al.
2007/0190362 A1 8/2007 Weidman
2007/0190782 A1 8/2007 Park
2007/0231488 A1 10/2007 Von Kaenel
2007/0252233 A1 11/2007 Yamazaki et al.
2007/0258855 A1 11/2007 Turcot et al.
2007/0261868 A1 11/2007 Gross
2007/0269983 A1 11/2007 Sneh
2007/0292974 A1 12/2007 Mizuno et al.
2008/0026162 A1 1/2008 Dickey et al.
2008/0044938 A1 2/2008 England et al.
2008/0063798 A1 3/2008 Kher et al.
2008/0067146 A1 3/2008 Onishi et al.
2008/0102205 A1 5/2008 Barry et al.
2008/0102208 A1 5/2008 Wu et al.
2008/0124945 A1 5/2008 Miya et al.
2008/0128726 A1 6/2008 Sakata et al.
2008/0153308 A1 6/2008 Ogawa et al.
2008/0176335 A1 7/2008 Alberti et al.
2008/0176412 A1 7/2008 Komeda
2008/0182411 A1 7/2008 Elers
2008/0193643 A1 8/2008 Dip
2008/0194105 A1 8/2008 Dominguez et al.
2008/0210278 A1 9/2008 Orii et al.
2008/0223130 A1 9/2008 Snell et al.
2008/0241052 A1 10/2008 Hooper et al.
2008/0268171 A1 10/2008 Ma et al.
2008/0272424 A1 11/2008 Kim et al.
2008/0274369 A1 11/2008 Lee et al.
2008/0277647 A1 11/2008 Kouvetakis et al.
2009/0047433 A1 2/2009 Kim et al.
2009/0053900 A1 2/2009 Nozawa et al.
2009/0056112 A1 3/2009 Kobayashi
2009/0087585 A1 4/2009 Lee et al.
2009/0104594 A1 4/2009 Webb
2009/0116936 A1 5/2009 Marubayashi et al.
2009/0117717 A1 5/2009 Tomasini et al.
2009/0124131 A1 5/2009 Breunsbach et al.
2009/0137055 A1 5/2009 Bognar
2009/0159002 A1 6/2009 Bera et al.
2009/0165721 A1* 7/2009 Pitney C23C 16/4583 118/728
2009/0165722 A1 7/2009 Ha
2009/0166616 A1 7/2009 Uchiyama
2009/0186571 A1 7/2009 Haro
2009/0197411 A1 8/2009 Dussarrat et al.
2009/0223441 A1 9/2009 Arena et al.
2009/0250004 A1 10/2009 Yamada et al.
2009/0267225 A1 10/2009 Eguchi
2009/0275210 A1 11/2009 Shanker et al.
2009/0280248 A1 11/2009 Goodman et al.
2009/0298257 A1 12/2009 Lee et al.
2009/0324989 A1 12/2009 Witz et al.
2010/0025766 A1 2/2010 Nuttinck et al.
2010/0034719 A1 2/2010 Dussarrat et al.
2010/0051584 A1 3/2010 Okita et al.
2010/0055312 A1 3/2010 Kato et al.
2010/0055316 A1 3/2010 Honma
2010/0055898 A1 3/2010 Chang et al.
2010/0075037 A1 3/2010 Marsh et al.
2010/0086703 A1 4/2010 Mangum et al.
2010/0111648 A1 5/2010 Tamura et al.
2010/0119439 A1 5/2010 Shindou
2010/0129548 A1 5/2010 Sneh
2010/0140684 A1 6/2010 Ozawa
2010/0159707 A1 6/2010 Huang et al.
2010/0166630 A1 7/2010 Gu et al.
2010/0209598 A1 8/2010 Xu et al.
2010/0279008 A1 11/2010 Takagi
2011/0021033 A1 1/2011 Ikeuchi et al.
2011/0031562 A1 2/2011 Lin et al.
2011/0042200 A1 2/2011 Wilby
2011/0065289 A1 3/2011 Asai
2011/0070740 A1 3/2011 Bettencourt et al.
2011/0089166 A1 4/2011 Hunter et al.
2011/0092077 A1 4/2011 Xu et al.
2011/0117492 A1 5/2011 Yamada et al.
2011/0143461 A1 6/2011 Fish et al.
2011/0159200 A1 6/2011 Kogure
2011/0204025 A1 8/2011 Tahara
2011/0217838 A1 9/2011 Hsieh et al.
2011/0223334 A1 9/2011 Yudovsky et al.
2011/0264250 A1 10/2011 Nishimura et al.
2012/0024223 A1 2/2012 Torres et al.
2012/0028469 A1 2/2012 Onizawa et al.
2012/0088031 A1 4/2012 Neel
2012/0108048 A1 5/2012 Lim et al.
2012/0126300 A1 5/2012 Park et al.
2012/0149207 A1 6/2012 Graff
2012/0164846 A1 6/2012 Ha et al.
2012/0180719 A1 7/2012 Inoue et al.
2012/0258257 A1 10/2012 Nguyen et al.
2012/0295449 A1 11/2012 Fukazawa
2012/0309181 A1 12/2012 Machkaoutsan et al.
2012/0318773 A1 12/2012 Wu et al.
2013/0005147 A1 1/2013 Angyal et al.
2013/0019944 A1 1/2013 Hekmatshoar-Tabai et al.
2013/0019945 A1 1/2013 Hekmatshoar-Tabai et al.
2013/0042811 A1 2/2013 Shanker et al.
2013/0059078 A1 3/2013 Gatineau et al.
2013/0078376 A1 3/2013 Higashino et al.
2013/0093048 A1 4/2013 Chang et al.
2013/0122722 A1 5/2013 Cissell et al.
2013/0168353 A1 7/2013 Okita et al.
2013/0196502 A1 8/2013 Haukka et al.
2013/0203267 A1 8/2013 Pomarede et al.
2013/0228225 A1 9/2013 Leeser
2013/0234203 A1 9/2013 Tsai et al.
2013/0280891 A1 10/2013 Kim et al.
2013/0299944 A1 11/2013 Lai et al.
2013/0302520 A1 11/2013 Wang et al.
2013/0309876 A1 11/2013 Ogawa
2013/0312663 A1 11/2013 Khosla et al.
2013/0323859 A1 12/2013 Chen et al.
2014/0017414 A1 1/2014 Fukazawa et al.
2014/0017908 A1 1/2014 Beynet et al.
2014/0034632 A1 2/2014 Pan et al.
2014/0120678 A1 5/2014 Shinriki et al.
2014/0141165 A1 5/2014 Sato et al.
2014/0162401 A1 6/2014 Kawano et al.
2014/0209976 A1 7/2014 Yang et al.
2014/0227444 A1 8/2014 Winter et al.
2014/0231922 A1 8/2014 Kim et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2014/0234992 A1 8/2014 Kubota et al.
2014/0262193 A1* 9/2014 Im H01L 21/68735 165/185
2014/0322862 A1 10/2014 Xie et al.
2015/0031218 A1 1/2015 Karakawa
2015/0056821 A1 2/2015 Ishikawa et al.
2015/0091134 A1 4/2015 Amaratunga et al.
2015/0147875 A1 5/2015 Takamure et al.
2015/0167162 A1 6/2015 Barik et al.
2015/0167165 A1 6/2015 Lindfors
2015/0167705 A1 6/2015 Lee et al.
2015/0170975 A1 6/2015 Blatchford et al.
2015/0179640 A1 6/2015 Kim et al.
2015/0203961 A1 7/2015 Ha et al.
2015/0240357 A1 8/2015 Tachibana et al.
2015/0262828 A1 9/2015 Brand et al.
2015/0287591 A1 10/2015 Pore et al.
2015/0287612 A1 10/2015 Luere et al.
2015/0311151 A1 10/2015 Chi et al.
2015/0322569 A1 11/2015 Kilpi et al.
2015/0345018 A1 12/2015 Detavernier et al.
2015/0372056 A1 12/2015 Seong et al.
2016/0002776 A1* 1/2016 Nal C23C 16/45504 427/255.28
2016/0002786 A1 1/2016 Gatineau et al.
2016/0024655 A1 1/2016 Yudovsky et al.
2016/0042954 A1 2/2016 Sung et al.
2016/0071750 A1 3/2016 de Ridder et al.
2016/0085003 A1 3/2016 Jaiswal
2016/0148800 A1 5/2016 Henri et al.
2016/0148806 A1 5/2016 Henri et al.
2016/0163558 A1 6/2016 Hudson et al.
2016/0172189 A1 6/2016 Tapily
2016/0196970 A1 7/2016 Takamure et al.
2016/0222504 A1 8/2016 Haukka et al.
2016/0273106 A1 9/2016 Kanjolia et al.
2016/0276212 A1 9/2016 Horikoshi
2016/0281223 A1 9/2016 Sowa et al.
2016/0365414 A1 12/2016 Peng et al.
2016/0372321 A1* 12/2016 Krishnan H01L 21/67103
2016/0379826 A9 12/2016 Arghavani et al.
2017/0009367 A1* 1/2017 Harris C25D 17/001
2017/0018570 A1 1/2017 Lue et al.
2017/0044664 A1 2/2017 Dussarrat et al.
2017/0051405 A1 2/2017 Fukazawa et al.
2017/0051406 A1 2/2017 Mori et al.
2017/0104061 A1 4/2017 Peng et al.
2017/0110601 A1 4/2017 Blomberg et al.
2017/0140925 A1 5/2017 Suzuki et al.
2017/0145564 A1 5/2017 Bertuch et al.
2017/0148918 A1 5/2017 Ye et al.
2017/0200622 A1 7/2017 Shiokawa et al.
2017/0226636 A1 8/2017 Xiao
2017/0278705 A1 9/2017 Murakami et al.
2017/0338111 A1 11/2017 Takamure et al.
2017/0338133 A1 11/2017 Tan et al.
2017/0338134 A1 11/2017 Tan et al.
2017/0358482 A1 12/2017 Chen et al.
2017/0373188 A1 12/2017 Mochizuki et al.
2018/0005814 A1 1/2018 Kumar et al.
2018/0019165 A1 1/2018 Baum et al.
2018/0053660 A1 2/2018 Jandl et al.
2018/0068862 A1 3/2018 Terakura et al.
2018/0090583 A1 3/2018 Choi et al.
2018/0094351 A1 4/2018 Verghese et al.
2018/0127876 A1 5/2018 Tolle et al.
2018/0151588 A1 5/2018 Tsutsumi et al.
2018/0158716 A1 6/2018 Konkola et al.
2018/0163305 A1 6/2018 Batzer et al.
2018/0174801 A1 6/2018 Chen et al.
2018/0180509 A1 6/2018 Sawachi et al.
2018/0189923 A1 7/2018 Zhong et al.
2018/0211834 A1 7/2018 Takamure et al.
2018/0258532 A1 9/2018 Kato et al.
2018/0269057 A1 9/2018 Lei et al.
2018/0286638 A1 10/2018 Susa
2018/0286672 A1 10/2018 Van Aerde et al.
2018/0294187 A1 10/2018 Thombare et al.
2018/0308701 A1 10/2018 Na et al.
2018/0323055 A1 11/2018 Woodruff et al.
2018/0323056 A1 11/2018 Woodruff et al.
2018/0323059 A1 11/2018 Bhargava et al.
2018/0325414 A1 11/2018 Marashdeh et al.
2018/0350587 A1 12/2018 Jia et al.
2018/0350588 A1 12/2018 Raisanen et al.
2018/0350620 A1 12/2018 Zaitsu et al.
2018/0350653 A1 12/2018 Jeong et al.
2018/0355480 A1 12/2018 Kondo
2018/0363131 A1 12/2018 Lee et al.
2018/0363139 A1 12/2018 Rajavelu et al.
2018/0366314 A1 12/2018 Niskanen et al.
2019/0003050 A1 1/2019 Dezelah et al.
2019/0003052 A1 1/2019 Shero et al.
2019/0013199 A1 1/2019 Bhargava et al.
2019/0019670 A1 1/2019 Lin et al.
2019/0027573 A1 1/2019 Zhu et al.
2019/0027583 A1 1/2019 Margetis et al.
2019/0027584 A1 1/2019 Margetis et al.
2019/0027605 A1 1/2019 Tolle et al.
2019/0032209 A1 1/2019 Huggare
2019/0032998 A1 1/2019 Jdira et al.
2019/0035605 A1 1/2019 Suzuki
2019/0035647 A1 1/2019 Lee et al.
2019/0035810 A1 1/2019 Chun et al.
2019/0040529 A1 2/2019 Verbaas et al.
2019/0051544 A1 2/2019 Verbaas
2019/0051548 A1 2/2019 den Hartog Besselink et al.
2019/0051555 A1 2/2019 Hill et al.
2019/0057857 A1 2/2019 Ishikawa et al.
2019/0057858 A1 2/2019 Hausmann et al.
2019/0062907 A1 2/2019 Kim et al.
2019/0066978 A1 2/2019 Um et al.
2019/0066997 A1 2/2019 Klaver et al.
2019/0067003 A1 2/2019 Zope et al.
2019/0067004 A1 2/2019 Kohen et al.
2019/0067014 A1 2/2019 Shrestha et al.
2019/0067016 A1 2/2019 Zhu et al.
2019/0067094 A1 2/2019 Zope et al.
2019/0067095 A1 2/2019 Zhu et al.
2019/0080903 A1 3/2019 Abel et al.
2019/0081072 A1 3/2019 Chun et al.
2019/0086807 A1 3/2019 Kachel et al.
2019/0088555 A1 3/2019 Xie et al.
2019/0093221 A1 3/2019 Jdira et al.
2019/0096708 A1 3/2019 Sharma
2019/0106788 A1 4/2019 Hawkins et al.
2019/0109002 A1 4/2019 Mattinen et al.
2019/0109009 A1 4/2019 Longrie et al.
2019/0115206 A1 4/2019 Kim et al.
2019/0115237 A1 4/2019 den Hartog Besselink et al.
2019/0131124 A1 5/2019 Kohen et al.
2019/0140067 A1 5/2019 Zhu et al.
2019/0148224 A1 5/2019 Kuroda et al.
2019/0148398 A1 5/2019 Kim et al.
2019/0153593 A1 5/2019 Zhu et al.
2019/0157054 A1 5/2019 White et al.
2019/0163056 A1 5/2019 Maes et al.
2019/0164763 A1 5/2019 Raisanen et al.
2019/0244803 A1 8/2019 Suzuki

FOREIGN PATENT DOCUMENTS

JP H0429313 1/1992
JP H06319177 11/1994
JP H07225214 8/1995
JP H09064149 3/1997
JP 2001015698 1/2001
JP 2001287180 10/2001
JP 2002237375 8/2002
JP 2003053688 2/2003
JP 2004163293 6/2004
JP 2006049352 2/2006
JP 2008085129 4/2008
JP 2008089320 4/2008

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

JP	2008172083	7/2008
JP	2011181681	9/2011
JP	2012164736	8/2012
JP	2016098406	5/2016
JP	2010123843	6/2016
JP	2017183242	10/2017
KR	100253664	4/2000
KR	20100079920	7/2010
SU	494614	2/1976
SU	1408319	7/1988
TW	540093	7/2003
WO	DM/048579	7/1999
WO	2004008491	7/2002
WO	2005112082	11/2005
WO	2006035281	4/2006
WO	2007131051	11/2007
WO	2008045972	4/2008
WO	2015112728	7/2015
WO	2018013778	1/2018

OTHER PUBLICATIONS

CNIPA; Notice of Allowance dated Jun. 14, 2019 in Application No. 201410331047.6.
CNIPA; Office Action dated Jun. 28, 2019 in Application No. 201510765170.3.
CNIPA; Office Action dated Oct. 19, 2018 in Application No. 201510765170.3.
CNIPA; Office Action dated Oct. 31, 2018 in Application No. 201510765406.3.
CNIPA; Office Action dated Jun. 28, 2019 in Application No. 201510765406.3.
CNIPA; Office Action dated Mar. 14, 2019 in Application No. 201610141027.1.
CNIPA; Office Action dated Dec. 20, 2018 in Application No. 201710738549.4.
CNIPA; Office Action dated Jun. 20, 2019 in Application No. 201711120632.1.
CNIPA; Notice of Allowance dated Nov. 1, 2018 in Application No. 201830397219.9.
EPO; Office Action dated Jan. 11, 2019 in Application No. 09836647.9.
JPO; Office Action dated Aug. 10, 2009 in Application No. 2003029767.
JPO; Office Action dated Apr. 13, 2010 in Application No. 2003029767.
JPO; Notice of Allowance dated Jun. 24, 2010 in Application No. 2003029767.
JPO; Office Action dated Oct. 30, 2008 in Application No. 2004558313.
JPO; Office Action dated Feb. 19, 2009 in Application No. 2004558313.
JPO; Notice of Allowance dated Jun. 30, 2009 in Application No. 2004558313.
JPO; Notice of Allowance dated Dec. 19, 2018 in Application No. 2014205548.
JPO; Office Action dated Jun. 27, 2019 in Application No. 2015034774.
JPO; Office Action dated Jan. 30, 2019 in Application No. 2015052198.
JPO; Notice of Allowance dated Apr. 5, 2019 in Application No. 2015052198.
KIPO; Office Action dated Jan. 12, 2019 in Application No. 10-2012-0064526.
KIPO; Office Action dated Mar. 27, 2019 in Application No. 10-2012-0076564.
KIPO; Office Action dated May 30, 2019 in Application No. 10-2012-7004062.
KIPO; Decision of Intellectual Property Trial and Appeal Board dated May 13, 2019 in Application No. 10-2012-7004062.
KIPO; Office Action dated Apr. 19, 2019 in Application No. 10-2013-0101944.
KIPO; Office Action dated Apr. 24, 2019 in Application No. 10-2013-0036823.
KIPO; Office Action dated May 31, 2019 in Application No. 10-2013-0050740.
KIPO; Office Action dated Mar. 27, 2019 in Application No. 10-2013-0084459.
KIPO; Office Action dated Apr. 30, 2019 in Application No. 10-2013-0088450.
KIPO; Office Action dated May 21, 2019 in Application No. 10-2013-0121554.
KIPO; Office Action dated Jan. 22, 2019 in Application No. 10-2014-7017110.
KIPO; Notice of Allowance dated Feb. 27, 2018 in Application No. 10-2017-0175442.
KIPO; Office Action dated Jan. 30, 2019 in Application No. 30-2018-0033442.
KIPO; Notice of Allowance dated Apr. 1, 2019 in Application No. 30-2018-0033442.
TIPO; Notice of Allowance dated Jan. 28, 2015 in Application No. 99114329.
TIPO; Office Action dated Jun. 20, 2017 in Application No. 102125191.
TIPO; Notice of Allowance dated Jan. 30, 2019 in Application No. 103132230.
TIPO; Office Action dated Feb. 22, 2019 in Application No. 104105533.
TIPO; Office Action dated Nov. 19, 2018 in Application No. 104105965.
TIPO; Notice of Allowance dated May 9, 2019 in Application No. 104107876.
TIPO; Notice of Allowance dated Apr. 26, 2019 in Application No. 104107888.
TIPO; Office Action dated May 6, 2019 in Application No. 104108277.
TIPO; Notice of Allowance dated May 8, 2019 in Application No. 104110326.
TIPO; Office Action dated Apr. 29, 2019 in Application No. 104122889.
TIPO; Office Action dated Jan. 30, 2019 in Application No. 104122890.
TIPO; Notice of Allowance dated Jun. 19, 2019 in Application No. 104124377.
TIPO; Office Action dated Jan. 7, 2019 in Application No. 104132991.
TIPO; Notice of Allowance dated Apr. 12, 2019 in Application No. 104132991.
TIPO; Office Action dated Apr. 25, 2019 in Application No. 104141679.
TIPO; Office Action dated Apr. 25, 2019 in Application No. 105101536.
TIPO; Notice of Allowance dated May 7, 2019 in Application No. 105104453.
TIPO; Office Action dated Dec. 26, 2018 in Application No. 106127690.
TIPO; Office Action dated Jan. 7, 2019 in Application No. 106138800.
TIPO; Office Action dated Nov. 20, 2018 in Application No. 107118271.
TIPO; Office Action dated Jun. 4, 2019 in Application No. 107123992.
TIPO; Office Action dated May 28, 2019 in Application No. 107125586.
TIPO; Notice of Allowance dated Feb. 21, 2019 in Application No. 107303723.
TIPO; Office Action dated May 31, 2019 in Application No. 108102146.
USPTO; Notice of Allowance dated Apr. 4, 2019 in U.S. Appl. No. 12/618,355.
USPTO; Advisory Action dated Feb. 4, 2019 in U.S. Appl. No. 13/169,951.
USPTO; Notice of Allowance dated Apr. 4, 2019 in U.S. Appl. No. 13/169,951.
USPTO; Final Office Action dated Dec. 28, 2018 in U.S. Appl. No. 13/184,351.
USPTO; Final Office Action dated Mar. 15, 2019 in U.S. Appl. No. 13/651,144.
USPTO; Final Office Action dated Jan. 25, 2019 in U.S. Appl. No. 14/188,760.
USPTO; Advisory Action dated Jan. 22, 2019 in U.S. Appl. No. 14/219,839.
USPTO; Non-Final Office Action dated Jul. 15, 2019 in U.S. Appl. No. 14/219,839.

(56) **References Cited**

OTHER PUBLICATIONS

USPTO; Advisory Action dated Jan. 22, 2019 in U.S. Appl. No. 14/219,879.
USPTO; Non-Final Office Action dated Jun. 24, 2019 in U.S. Appl. No. 14/219,879.
USPTO; Final Office Action dated Feb. 7, 2019 in U.S. Appl. No. 14/444,744.
USPTO; Non-Final Office Action dated Jan. 11, 2019 in U.S. Appl. No. 14/457,058.
USPTO; Final Office Action dated Jun. 25, 2019 in U.S. Appl. No. 14/457,058.
USPTO; Non-Final Office Action dated Apr. 4, 2019 in U.S. Appl. No. 14/508,489.
USPTO; Non-Final Office Action dated Dec. 28, 2018 in U.S. Appl. No. 14/752,712.
USPTO; Notice of Allowance dated Jun. 11, 2019 in U.S. Appl. No. 14/752,712.
USPTO; Final Office Action dated Feb. 25, 2019 in U.S. Appl. No. 14/793,323.
USPTO; Non-Final Office Action dated Jun. 27, 2019 in U.S. Appl. No. 14/793,323.
USPTO; Final Office Action dated Apr. 18, 2019 in U.S. Appl. No. 14/829,565.
USPTO; Advisory Action dated Jul. 22, 2019 in U.S. Appl. No. 14/829,565.
USPTO; Notice of Allowance dated Mar. 25, 2019 in U.S. Appl. No. 14/997,683.
USPTO; Non-Final Office Action dated Jun. 3, 2019 in U.S. Appl. No. 15/060,412.
USPTO; Notice of Allowance dated Dec. 21, 2018 in U.S. Appl. No. 15/067,028.
USPTO; Notice of Allowance dated Feb. 25, 2019 in U.S. Appl. No. 15/074,813.
USPTO; Final Office Action dated Mar. 14, 2019 in U.S. Appl. No. 15/135,258.
USPTO; Non-Final Office Action dated Jul. 19, 2019 in U.S. Appl. No. 15/135,258.
USPTO; Notice of Allowance dated Mar. 13, 2019 in U.S. Appl. No. 15/144,506.
USPTO; Final Office Action dated Mar. 28, 2019 in U.S. Appl. No. 15/182,504.
USPTO; Notice of Allowance dated Jul. 17, 2019 in U.S. Appl. No. 15/182,504.
USPTO; Non-Final Office Action dated Mar. 28, 2019 in U.S. Appl. No. 15/205,827.
USPTO; Notice of Allowance dated Apr. 19, 2019 in U.S. Appl. No. 15/222,780.
USPTO; Non-Final Office Action dated Jan. 30, 2019 in U.S. Appl. No. 15/262,990.
USPTO; Final Office Action dated May 13, 2019 in U.S. Appl. No. 15/262,990.
USPTO; Advisory Action dated Jul. 22, 2019 in U.S. Appl. No. 15/262,990.
USPTO; Final Office Action dated Jan. 11, 2019 in U.S. Appl. No. 15/273,488.
USPTO; Notice of Allowance dated Apr. 19, 2019 in U.S. Appl. No. 15/273,488.
USPTO; Final Office Action dated Feb. 7, 2019 in U.S. Appl. No. 15/286,503.
USPTO; Non-Final Office Action dated Jun. 27, 2019 in U.S. Appl. No. 15/286,503.
USPTO; Non-Final Office Action dated Dec. 14, 2018 in U.S. Appl. No. 15/340,512.
USPTO; Notice of Allowance dated May 24, 2019 in U.S. Appl. No. 15/340,512.
USPTO; Final Office Action dated Jun. 25, 2019 in U.S. Appl. No. 15/377,439.
USPTO; Non-Final Office Action dated May 31, 2019 in U.S. Appl. No. 15/380,909.
USPTO; Non-Final Office Action dated Feb. 25, 2019 in U.S. Appl. No. 15/380,921.
USPTO; Non-Final Office Action dated Feb. 5, 2019 in U.S. Appl. No. 15/402,993.
USPTO; Final Office Action dated May 21, 2019 in U.S. Appl. No. 15/402,993.
USPTO; Final Office Action dated Feb. 4, 2019 in U.S. Appl. No. 15/410,503.
USPTO; Non-Final Office Action dated Apr. 25, 2019 in U.S. Appl. No. 15/410,503.
USPTO; Final Office Action dated Jan. 11, 2019 in U.S. Appl. No. 15/428,808.
USPTO; Notice of Allowance dated Apr. 25, 2019 in U.S. Appl. No. 15/428,808.
USPTO; Non-Final Office Action dated Jan. 25, 2019 in U.S. Appl. No. 15/434,051.
USPTO; Notice of Allowance dated Jun. 3, 2019 in U.S. Appl. No. 15/434,051.
USPTO; Final Office Action dated Feb. 27, 2019 in U.S. Appl. No. 15/489,453.
USPTO; Non-Final Office Action dated Jun. 5, 2019 in U.S. Appl. No. 15/489,453.
USPTO; Final Office Action dated May 1, 2019 in U.S. Appl. No. 15/491,726.
USPTO; Final Office Action dated Mar. 6, 2019 in U.S. Appl. No. 15/589,849.
USPTO; Non-Final Office Action dated Jun. 28, 2019 in U.S. Appl. No. 15/589,849.
USPTO; Non-Final Office Action dated Dec. 21, 2018 in U.S. Appl. No. 15/589,861.
USPTO; Final Office Action dated Jun. 26, 2019 in U.S. Appl. No. 15/589,861.
USPTO; Advisory Action dated Mar. 15, 2019 in U.S. Appl. No. 15/592,730.
USPTO; Non-Final Office Action dated Mar. 7, 2019 in U.S. Appl. No. 15/598,169.
USPTO; Final Office Action dated Jun. 25, 2019 in U.S. Appl. No. 15/598,169.
USPTO; Ex Parte Quayle Action dated Mar. 21, 2019 in U.S. Appl. No. 15/615,489.
USPTO; Non-Final Office Action dated Feb. 1, 2019 in U.S. Appl. No. 15/627,189.
USPTO; Notice of Allowance dated May 21, 2019 in U.S. Appl. No. 15/627,189.
USPTO; Final Office Action dated Mar. 6, 2019 in U.S. Appl. No. 15/636,307.
USPTO; Non-Final Office Action dated Jul. 16, 2019 in U.S. Appl. No. 15/636,307.
USPTO; Notice of Allowance dated Jun. 24, 2019 in U.S. Appl. No. 15/650,686.
USPTO; Notice of Allowance dated Feb. 21, 2019 in U.S. Appl. No. 15/659,631.
USPTO; Non-Final Office Action dated Mar. 1, 2019 in U.S. Appl. No. 15/660,805.
USPTO; Notice of Allowance dated Feb. 21, 2019 in U.S. Appl. No. 15/662,107.
USPTO; Notice of Allowance dated Mar. 20, 2019 in U.S. Appl. No. 15/672,063.
USPTO; Non-Final Office Action dated Feb. 8, 2019 in U.S. Appl. No. 15/672,119.
USPTO; Final Office Action dated Jul. 16, 2019 in U.S. Appl. No. 15/672,119.
USPTO; Notice of Allowance dated Jan. 9, 2019 in U.S. Appl. No. 15/673,110.
USPTO; Notice of Allowance dated May 6, 2019 in U.S. Appl. No. 15/673,278.
USPTO; Notice of Allowance dated Jan. 9, 2019 in U.S. Appl. No. 15/683,701.
USPTO; Non-Final Office Action dated Mar. 19, 2019 in U.S. Appl. No. 15/691,241.
USPTO; Final Office Action dated Jan. 11, 2019 in U.S. Appl. No. 15/691,241.

(56) **References Cited**

OTHER PUBLICATIONS

USPTO; Notice of Allowance dated Apr. 16, 2019 in U.S. Appl. No. 15/705,955.
USPTO; Non-Final Office Action dated Feb. 11, 2019 in U.S. Appl. No. 15/707,786.
USPTO; Non-Final Office Action dated Jun. 25, 2019 in U.S. Appl. No. 15/719,208.
USPTO; Notice of Allowance dated Apr. 19, 2019 in U.S. Appl. No. 15/726,222.
USPTO; Notice of Allowance dated Jan. 23, 2019 in U.S. Appl. No. 15/729,485.
USPTO; Final Office Action dated Apr. 19, 2019 in U.S. Appl. No. 15/795,056.
USPTO; Non-Final Office Action dated Jun. 14, 2019 in U.S. Appl. No. 15/796,593.
USPTO; Final Office Action dated Feb. 21, 2019 in U.S. Appl. No. 15/796,593.
USPTO; Non-Final Office Action dated Dec. 21, 2018 in U.S. Appl. No. 15/798,150.
USPTO; Notice of Allowance dated May 14, 2019 in U.S. Appl. No. 15/798,150.
USPTO; Final Office Action dated Dec. 14, 2018 in U.S. Appl. No. 15/798,201.
USPTO; Final Office Action dated Mar. 7, 2019 in U.S. Appl. No. 15/815,483.
USPTO; Notice of Allowance dated Dec. 5, 2017 in U.S. Appl. No. 15/832,188.
USPTO; Non-Final Office Action dated Mar. 13, 2019 in U.S. Appl. No. 15/836,547.
USPTO; Non-Final Office Action dated Jan. 11, 2019 in U.S. Appl. No. 15/879,209.
USPTO; Non-Final Office Action dated Jan. 22, 2019 in U.S. Appl. No. 15/879,209.
USPTO; Non-Final Office Action dated Apr. 17, 2019 in U.S. Appl. No. 15/886,225.
USPTO; Final Office Action dated May 2, 2019 in U.S. Appl. No. 15/890,037.
USPTO; Notice of Allowance dated Feb. 8, 2019 in U.S. Appl. No. 15/892,756.
USPTO; Non-Final Office Action dated Apr. 24, 2019 in U.S. Appl. No. 15/896,986.
USPTO; Non-Final Office Action dated May 30, 2019 in U.S. Appl. No. 15/900,425.
USPTO; Non-Final Office Action dated Mar. 8, 2019 in U.S. Appl. No. 15/917,224.
USPTO; Non-Final Office Action dated Feb. 8, 2019 in U.S. Appl. No. 15/917,262.
USPTO; Final Office Action dated Jun. 14, 2019 in U.S. Appl. No. 15/917,262.
USPTO; Non-Final Office Action dated May 8, 2019 in U.S. Appl. No. 15/925,532.
USPTO; Non-Final Office Action dated Mar. 29, 2019 in U.S. Appl. No. 15/940,801.
USPTO; Notice of Allowance dated May 31, 2019 in U.S. Appl. No. 15/957,565.
USPTO; Non-Final Office Action dated Apr. 19, 2019 in U.S. Appl. No. 15/985,298.
USPTO; Non-Final Office Action dated Feb. 21, 2019 in U.S. Appl. No. 15/987,755.
USPTO; Non-Final Office Action dated Jul. 16, 2019 in U.S. Appl. No. 16/014,981.
USPTO; Non-Final Office Action dated Jan. 24, 2019 in U.S. Appl. No. 16/018,692.
USPTO; Notice of Allowance dated Apr. 9, 2019 in U.S. Appl. No. 16/026,711.
USPTO; Non-Final Office Action dated Apr. 25, 2019 in U.S. Appl. No. 16/038,024.
USPTO; Non-Final Office Action dated Apr. 2, 2019 in U.S. Appl. No. 16/147,047.
USPTO; Notice of Allowance dated Apr. 17, 2019 in U.S. Appl. No. 16/171,098.
USPTO; Notice of Allowance dated May 1, 2019 in U.S. Appl. No. 16/171,098.
USPTO; Non-Final Office Action dated Apr. 2, 2019 in U.S. Appl. No. 16/188,690.
USPTO; Notice of Allowance dated Jun. 13, 2019 in U.S. Appl. No. 16/396,475.
USPTO; Non-Final Office Action dated Apr. 16, 2019 in U.S. Appl. No. 29/604,101.
USPTO; Non-Final Office Action dated Feb. 20, 2019 in U.S. Appl. No. 29/646,377.
WIPO; International Search Report and Written Opinion dated Jan. 25, 2019 in Application No. PCT/IB2018/000192.
WIPO; International Search Report and Written Opinion dated Jan. 4, 2019 in Application No. PCT/IB2018/000936.
WIPO; International Search Report and Written Opinion dated Dec. 20, 2018 in Application No. PCT/IB2018/001003.
WIPO; International Search Report and Written Opinion dated Dec. 20, 2018 in Application No. PCT/IB2018/001022.
WIPO; International Search Report and Written Opinion dated May 23, 2019 in Application No. PCT/IB2019/050974.
Alen, "Atomic layer deposition of TaN, NbN and MoN films for Cu Metallizations," University of Helsinki Finland, 72 pages, (2005).
Arita et al. "Electrical and optical properties of germanium-doped zinc oxide thin films" Materials Transactions, vol. 45, No. 11, pp. 3180-3183 (2004).
Arnold et al., "Novel single-layer vanadium sulphide phases" 2D Materials, 5, 045009, 11 pages (2018).
Boscher et al., "Atmosphere Pressure Chemical Vapour Deposition of NbSe2 Thin Films on Glass" Eur. J. Inorg. Chem., pp. 1255-1259 (2006).
Carmalt et al., "Chemical Vapor Deposition of Niobium Disulfide Thin Films" Eur. J. Inorg. Chem., pp. 4470-4476 (2004).
Casey et al. "Chemical Vapor Deposition of Mo onto Si" J. Electrochem. Soc.: Solid State Science, 114 (2), pp. 201-204 (1967).
Chen et al., "Develop Gap-fill Process of Shallow Trench Isolation in 450mm Wafer by Advanced Flowable CVD Technology for Sub-20nm Node," 2016 27th Annual Semi Advanced Semiconductor Manufacturing Conference (ASMC), IEEE, May 16, 2016, pp. 157-159 (2016).
Cheng et al., "Effect of carrier gas on the structure and electric properties of low dielectric constant SiCOH film using trimethylsilane prepared by plasma enhanced chemical vapor deposition," Thin Solid Films vol. 469-470, pp. 178-183 (2004).
Closser et al., "Molecular Layer Deposition of a Highly Stable Silicon Oxycarbide Thin Film Using an Organic Chlorosilane and Water," ACS Applied Materials & Interfaces 10, pp. 24266-24274 (2018).
Conroy et al., "The Preparation and Properties of Single Crystals of the 1S and 2S Polymorphs of Tantalum Disulfide" J. Solid State Chemistry, 4, pp. 345-350 (1972).
De Silva et al., "Inorganic Hardmask Development for Extreme Ultraviolet Patterning," Journal of Micro/Nanolithography, MEMS, and MOEMS 18(1) (2018).
Duffey et al., "Raman Scattering from 1T-TaS2" Solid State Communications 20, pp. 617-621 (1976).
Elers et al. "Film Uniformity in Atomic Layer Deposition," Chemical Vapor Deposition, 12, pp. 13-24 (2006).
Fu et al., "Controlled Synthesis of Atomically Thin 1T-TaS2 for Tunable Charge Density Wave Phase Transitions" Chem. Mater. 28, pp. 7613-7618 (2016).
Gesheva et al. "Composition and Microstructure of Black Molybdenum Photothermal Converter Layers Deposited by the Pyrolytic Hydrogen Reduction of MoO_2Cl_2" Thin Solid Films, 79, pp. 39-49 (1981).
Gole et al. "Preparation of Nickel Sulfide Thin Films and Nanocrystallites Using Nickel Furfuraldehyde Thiosemicarbazone as Single-source Precursor," Advanced Materials Research, vols. 383-390, pp. 3828-3834 (2012).
Habib et al. "Atmospheric oxygen plasma activation of silicon (100) surfaces," American Vacuum Society, 28(3), pp. 476-485 (2010).

(56) **References Cited**

OTHER PUBLICATIONS

Han et al., "van der Waals Metallic Transition Metal Dichalcogenides" Chem. Rev. 118, pp. 6297-6336 (2018).
Heyne et al., "The conversion mechanism of amorphous silicon to stoichiometric WS2" J. Materials Chemistry C, 6, pp. 4122-4130 (2018).
Hossain et al., "Recent Advances in Two-Dimensional Materials with Charge Density Waves: Synthesis, Characterization and Applications" Crystals 7, 298, 19 pages (2017).
Johansson et al. "Towards absolute asymmetric synthesis. Synthesis and crystal structure of stereochemically labile MCl2 (M=CO, Ni, Cu, Zn) complexes with diamine ligands," Inorganica Chimica Acta 358, pp. 3293-3302 (2005).
Jung et al. "New Mechanisms for Ozone-Based ALO Growth of High-k Dielectrics via Nitrogen-Oxygen Species" ECS Transactions, 33(2), pp. 91-99 (2010).
Kern et al., "Chemically Vapor-Deposited Borophosphosilicate Glasses for Silicon Device Applications" RCE Review, 43, 3, pp. 423-457 (1982).
Kerrigan et al. "Low Temperature, Selective Atomic Layer Deposition of Cobalt Metal Films Using Bis(1,4-di-tert-butyl-1,3-diazadienyl)cobalt and Alkylamine Precursors," Chem. Materials, 29, pp. 7458-7466 (2017).
Kim et al., "Novel Flowable CVD Process Technology for sub-20nm Interlayer Dielectrics," IEEE International Interconnect Technology Conference (IITC 2012), San Jose, California, USA, Jun. 4-6, 2012, pp. 1-3 (2012).
Kogelschatz et al. "Ozone Generation from Oxygen and Air: Discharge Physics and Reaction Mechanisms" Ozone Science & Engineering, 10, pp. 367-378 (1998).
Kukli et al., "Influence of atomic layer deposition parameters on the phase content of Ta2O5 films" J. Crystal Growth, 212, pp. 459-468 (2000).
Kukli et al. "Properties of tantalum oxide thin films grown by atomic layer deposition" Thin Solid Films, 260, pp. 135-142 (1995).
Kwon et al., "Substrate Selectivity of (tBu-Allyl)Co(CO)3 during Thermal Atomic Layer Deposition of Cobalt," Chem. Materials, 24, pp. 1025-1030 (2012).
Lee et al., "Characteristics Of Low-K Sioc Films Deposited Via Atomic Layer Deposition," Thin Solid Films 645, pp. 334-339 (2018).
Levy et al., "Reflow Mechanisms of Contact Vias in VLSI Processing" J. Electrochem. Soc.: Solid-State Science and Technology, 133, 7, pp. 1417-1424 (1986).
Li et al., "Metallic Transition-Metal Dichalcogenide Nanocatalysts for Energy Conversion" Chem. 4, pp. 1510-1537 (2018).
Lieberman, et al., "Principles of Plasma Discharges and Materials Processing" Second Edition, 368-381 (2005).
Lim et al. "Synthesis and Characterization of Volatile, Thermally Stable, Reactive Transistion Metal Amidinates," Inorg. Chem., 42, pp. 7951-7958 (2003).
Liu et al., "Van der Waals metal-semiconductor junction: Weak Fermi level pinning enables effective tuning of Schottky barrier" Sci. Adv. 2: e1600069, 7 pages (2016).
Maeno, "Gecko Tape Using Carbon Nanotubes," Nitto Denko Gihou, 47, 48-51 (2009).
Makela et al. "Thermal Atomic Layer Deposition of Continuous and Highly Conducting Gold Thin Films," Chem. Materials, 29, pp. 6130-6136 (2017).
Mattinen et al., "Crystalline tungsten sulfide thin films by atomic layer deposition and mild annealing" J. Vac. Sci. Tech. 37, 020921, 35 pages (2019).
Nakano et al., "Layer-by-Layer Epitaxial Growth of Scalable WSe2 on Sapphire by Molecular Beam Epitaxy" Nano. Lett. 17, pp. 5595-5599 (2017).
Ngo et al. "Atomic layer deposition of photoactive CoO/SrTiO3 and CoO/TiO2 on Si(001) for visible light driven photoelectrochemical water oxidation," J. Applied Physics, 114, 9 pages (2013).
Ohchi et al. "Reducing damage to Si substrates during gate etching processes." Japanese Journal of Applied Physics 47.7R 5324 (2008).
Peters et al., "Aerosol-Assisted Chemical Vapor Deposition of NbS2 and TaS2 Thin Films from Pentakis(dimethylamido)metal Complexes and 2-Methylpropanethiol" Eur. J. Inorg. Chem., pp. 4179-4185 (2005).
Radamson et al. "Growth of Sn-alloyed Group IV Materials for Photonic and Electronic Applications" Chapter 5 pp. 129-144, Manufacturing Nano Structures (2014).
Ryu et al., "Persistent Charge-Density-Wave Order in Single-Layer TaSe2" Nano. Lett. 18, pp. 689-694 (2018).
Samal et al., "Low-Temperature (<200° C.) Plasma Enhanced Atomic Deposition of Dense Titanium Nitride Thin Films" (2012).
Sanders et al., "Crystalline and electronic structure of single-layer TaS_2" Phys. Rev. B. 94, 081404, 6 pages (2016).
Schindler, Dissertation, Next Generation High-k Dielectrics for DRAM Produced by Atomic Layer Deposition Studied by Transmission Electron Microscopy (2015).
Sellers, Making Your Own Timber Dogs, Paul Sellers blog, Published on Nov. 18, 2014, [online], [site visted Jun. 10, 2017]. Available from Internet, <URL: https://paulsellers.com/2014/11/making-your-own-timber-dogs/>.
Seshadri et al., "Ultrathin Extreme Ultraviolet Patterning Stack Using Polymer Brush As An Adhesion Promotion Layer," Journal of Micro/Nanolithography, MEMS, and MOEMS 16(3) (2017).
Simchi et al., "Sulfidation of 2D transition metals (Mo, W, Re, Nb, Ta): thermodynamics, processing, and characterization" J. Materials Science 52: 17, 9 pages (2017).
Stanley et al. "Feedgas for Modern High-Performance Ozone Generators" Ozonia Ltd., Duebendorf, Switzerland. 7 pages. Available Jul. 14, 2017 online at: http://www.degremont-technologies.com/cms_medias/pdf/tech_ozonia_feedgas.pdf (1999).
Svetin et al., "Three-dimensional resistivity and switching between correlated electronic states in 1T-TaS_2" Nature, Scientific Reports Apr. 12, 2017, 7:46048, 10 pages (2017).
Tatehaba et al., "Adhesion Energy of Polystyrene and Substrate in Function Water," 5th International Symposium of Cleaning Technology in Semiconductor Device Manufacturing, pp. 560-565 (1998).
Todi et al., "Characterization of Pt-Ru Binary Alloy Thin Films for Work Function Tuning," IEEE Electron Device Letters, vol. 27, No. 7, pp. 542-545 (2006).
Ueda et al. "Enhanced Sidewall Grown (ESG) process: towards PEALD with conformality above 100%," Extended Abstracts of the 2011 International Conference on Solid State Devices and Materials, Nagoya, pp. 34-35 (2011).
Vasilev, "Borophosphosilicate Glass Films in Silicon Microelectronics, Part 1: Chemical Vapor Deposition, Composition, and Properties" Russian Microelectronics, vol. 33, No. 5, pp. 271-284 (2004).
Xing et al., "Ising Superconductivity and Quantum Phase Transition in Macro-Size Monolayer NbSe2" Nano. Lett. 17, pp. 6802-6807 (2017).
Xu et al., "Contacts between Two- and Three-Dimensional Materials: Ochmic, Schottky, and p-n Heterojunctions" ACS Nano 10, pp. 4895-4919 (2016).
Yuan et al., "Facile Synthesis of Single Crystal Vanadium Disulfide Nanosheets by Chemical Vapor Deposition for Efficient Hydrogen Evolution Reaction" Adv. Mater. 27, pp. 5605-5609 (2015).
Zhou et al., "A library of atomically thin metal chalcogenides" Nature 556, pp. 355-361 (2018).

* cited by examiner

FIG. 1

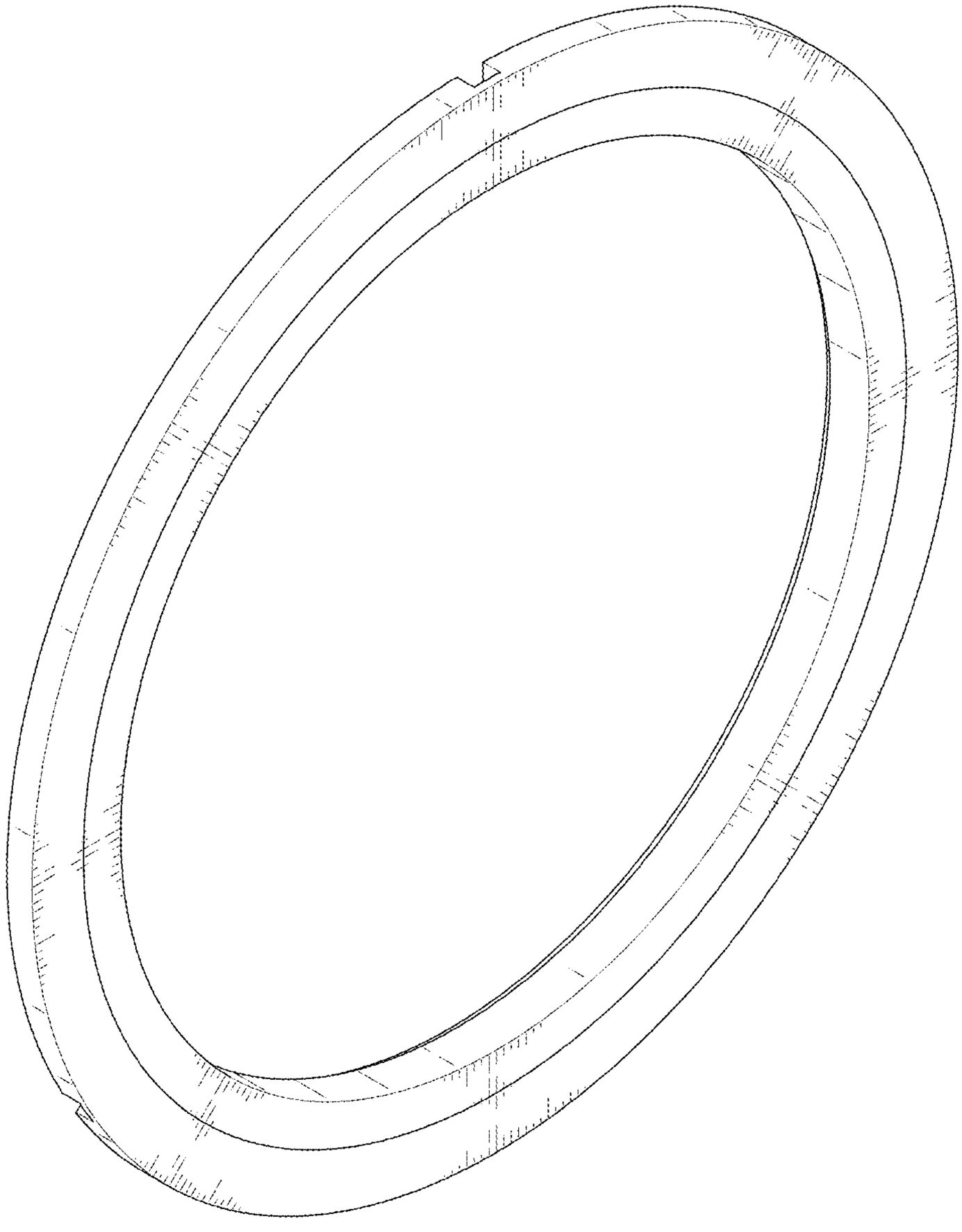


FIG. 2

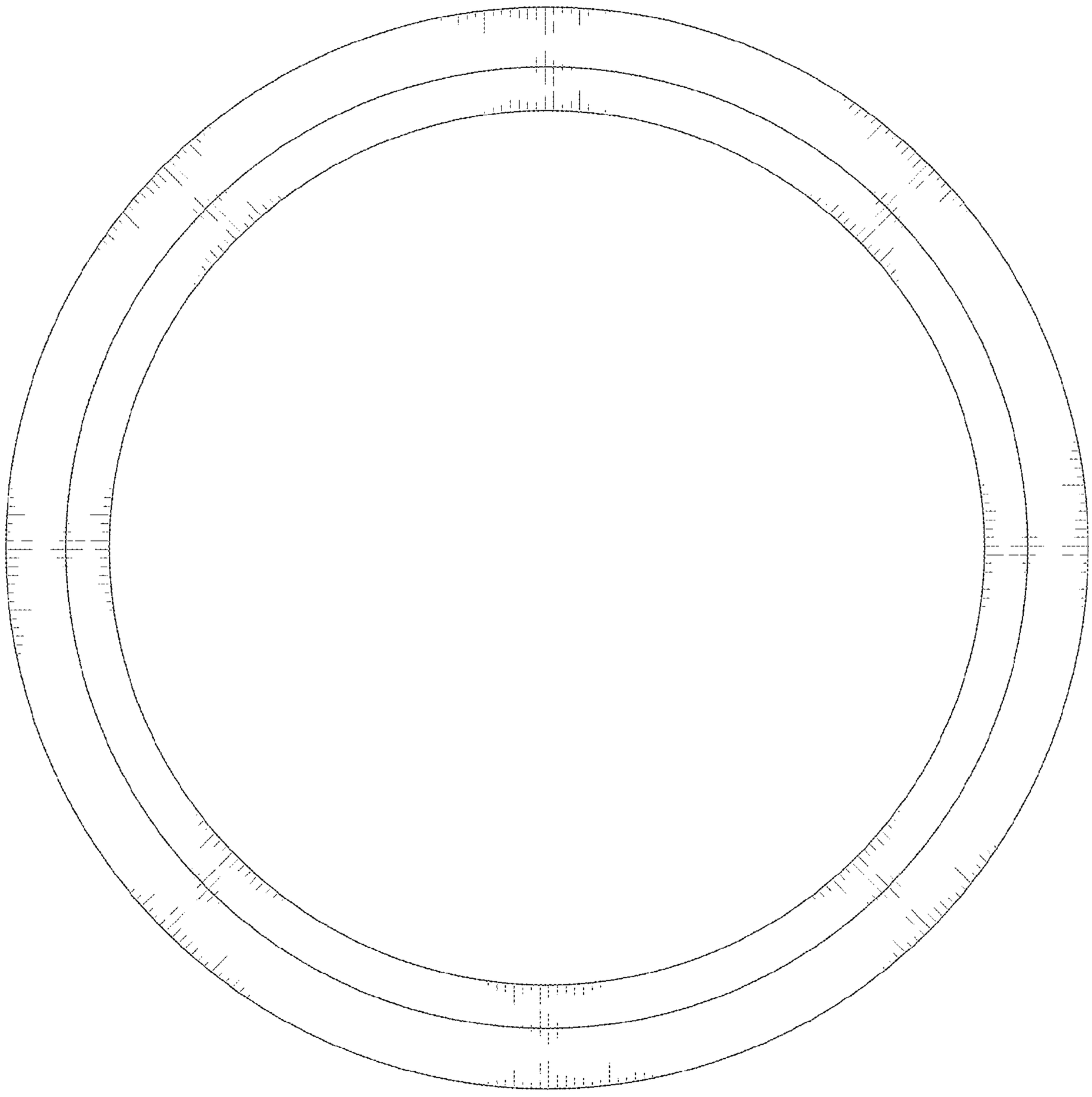


FIG. 3

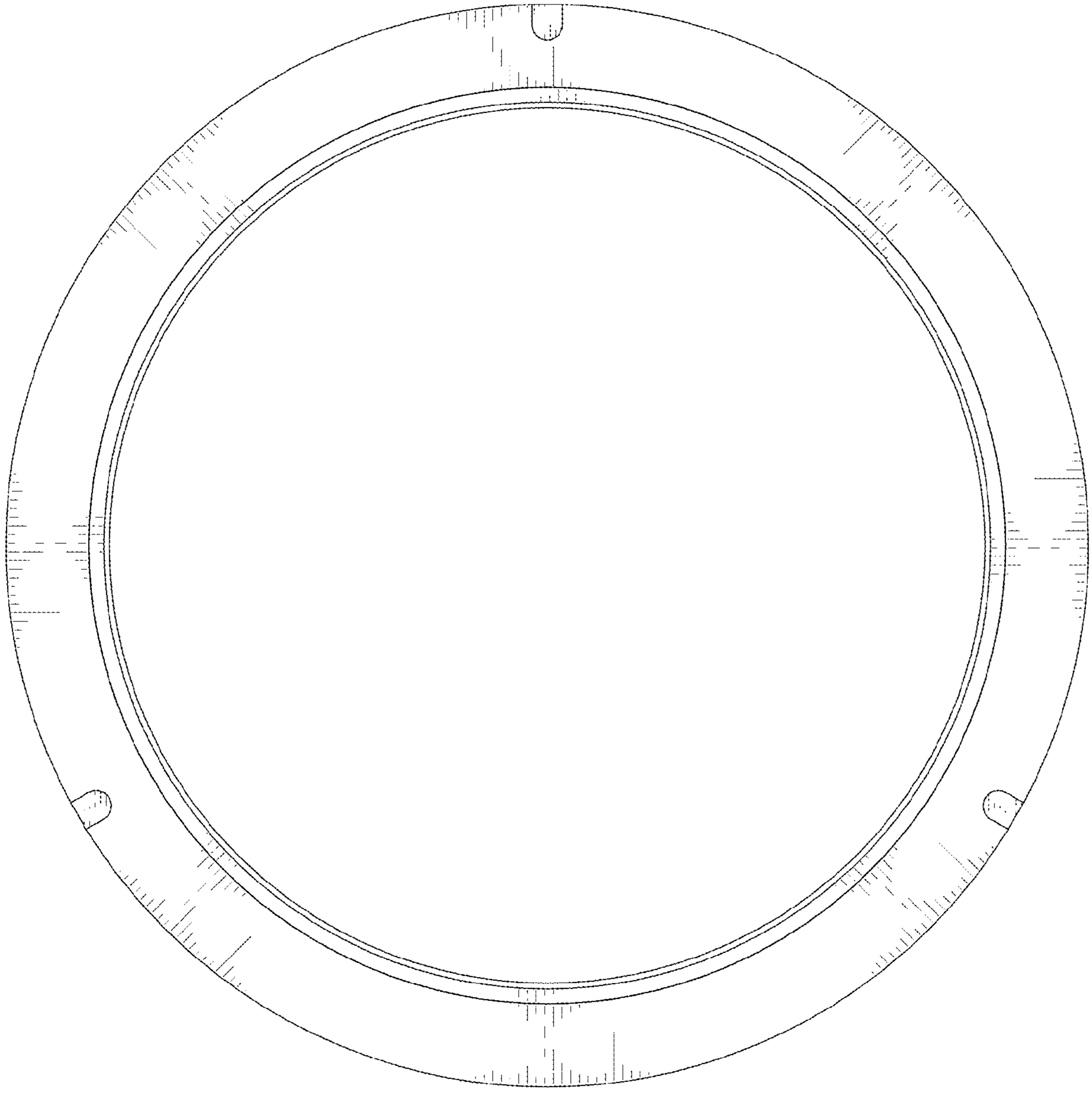


FIG. 4

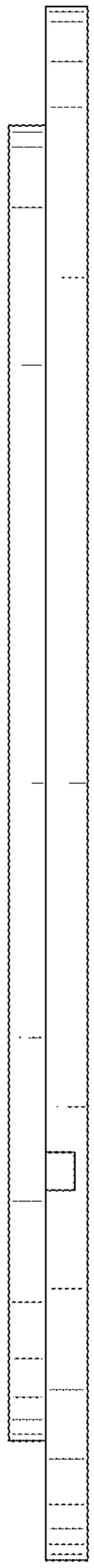


FIG. 5

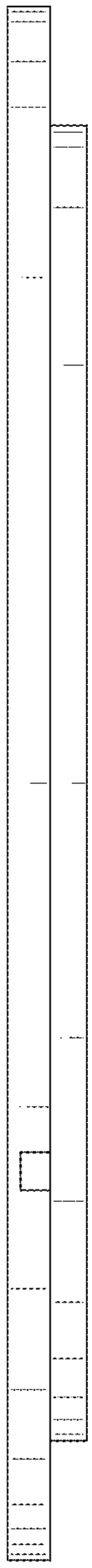


FIG. 6

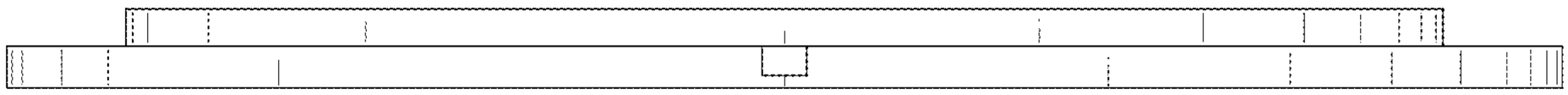


FIG. 7

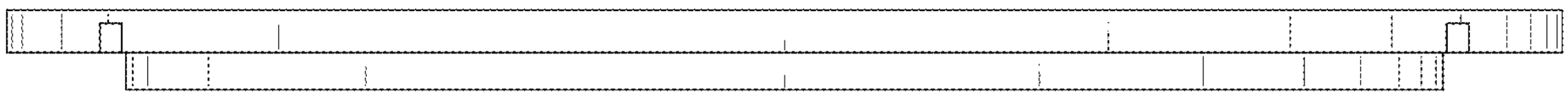


FIG. 8