

# Exhibit 2



US007544276B2

(12) **United States Patent**  
**Zhang et al.**

(10) **Patent No.:** **US 7,544,276 B2**  
(45) **Date of Patent:** **Jun. 9, 2009**

(54) **BIASED PULSE DC REACTIVE SPUTTERING OF OXIDE FILMS**

(75) Inventors: **Hongmei Zhang**, San Jose, CA (US); **Mukundan Narasimhan**, San Jose, CA (US); **Ravi B. Mullapudi**, San Jose, CA (US); **Richard E. Demaray**, Portola Valley, CA (US)

4,619,680 A 10/1986 Nourshargh et al.  
RE32,449 E 6/1987 Claussen  
4,710,940 A 12/1987 Sipes, Jr.  
4,785,459 A 11/1988 Baer  
4,915,810 A 4/1990 Kestigian et al.  
4,978,437 A 12/1990 Wirz

(73) Assignee: **SpringWorks, LLC**, Minnetonka, MN (US)

(Continued)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 529 days.

FOREIGN PATENT DOCUMENTS

EP 0 510 883 A2 10/1992

(21) Appl. No.: **11/228,834**

(Continued)

(22) Filed: **Sep. 16, 2005**

OTHER PUBLICATIONS

(65) **Prior Publication Data**

US 2006/0054496 A1 Mar. 16, 2006

Affinito et al., "PML/oxide/PML Barrier Layer Performance Differences Arising from Use of UV or Electron Beam Polymerization of the PML Layers," *Thin Solid Films* vol. 308-309, pp. 19-25 (1997).

**Related U.S. Application Data**

(Continued)

(62) Division of application No. 10/101,863, filed on Mar. 16, 2002, now Pat. No. 7,378,356.

*Primary Examiner*—Rodney G McDonald

(51) **Int. Cl.**

**C23C 14/34** (2006.01)

(74) *Attorney, Agent, or Firm*—Finnegan, Henderson, Farabow, Garrett & Dunner, LLP

(52) **U.S. Cl.** ..... **204/298.08**; 204/298.2; 204/298.06

(57) **ABSTRACT**

(58) **Field of Classification Search** ..... 204/298.2, 204/298.06, 298.08

See application file for complete search history.

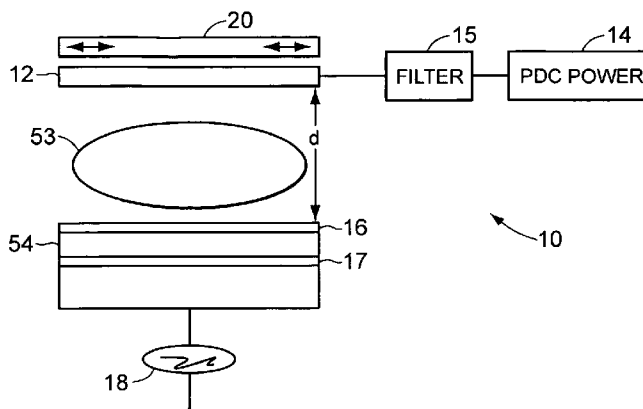
A biased pulse DC reactor for sputtering of oxide films is presented. The biased pulse DC reactor couples pulsed DC at a particular frequency to the target through a filter which filters out the effects of a bias power applied to the substrate, protecting the pulsed DC power supply. Films deposited utilizing the reactor have controllable material properties such as the index of refraction. Optical components such as waveguide amplifiers and multiplexers can be fabricated using processes performed on a reactor according to the present invention.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,309,302 A 3/1967 Heil  
3,616,403 A 10/1971 Collins et al.  
3,850,604 A 11/1974 Klein  
4,111,523 A 9/1978 Kaminow et al.  
4,437,966 A 3/1984 Hope et al.  
4,587,225 A 5/1986 Tsukuma et al.

**13 Claims, 27 Drawing Sheets**



## US 7,544,276 B2

Page 2

U.S. PATENT DOCUMENTS					
			6,004,660	A	12/1999 Topolski et al.
5,085,904	A	2/1992 Deak et al.	6,024,844	A	2/2000 Drummond et al.
5,107,538	A	4/1992 Benton et al.	6,046,081	A	4/2000 Kuo
5,119,460	A	6/1992 Bruce et al.	6,051,114	A	4/2000 Yao et al.
5,173,271	A	12/1992 Chen et al.	6,051,296	A	4/2000 McCaulley et al.
5,174,876	A	12/1992 Buchal et al.	6,052,397	A	4/2000 Jeon et al.
5,196,041	A	3/1993 Tumminelli et al.	6,057,557	A	5/2000 Ichikawa
5,200,029	A	4/1993 Bruce et al.	6,058,233	A	5/2000 Dragone
5,206,925	A	4/1993 Nakazawa et al.	6,071,323	A	6/2000 Kawaguchi
5,225,288	A	7/1993 Beeson et al.	6,077,642	A	6/2000 Ogata et al.
5,237,439	A	8/1993 Misono et al.	6,080,643	A	6/2000 Noguchi et al.
5,252,194	A	10/1993 Demaray et al.	6,088,492	A	7/2000 Kaneko et al.
5,287,427	A	2/1994 Atkins et al.	6,093,944	A	7/2000 VanDover
5,296,089	A	3/1994 Chen et al.	6,106,933	A	8/2000 Nagai et al.
5,303,319	A	4/1994 Ford et al.	6,117,279	A	9/2000 Smolanoff et al.
5,306,569	A	4/1994 Hiraki	6,146,225	A	11/2000 Sheats et al.
5,309,302	A	5/1994 Vollmann	6,154,582	A	11/2000 Bazylenko et al.
5,338,625	A	8/1994 Bates et al.	6,157,765	A	12/2000 Bruce et al.
5,355,089	A	10/1994 Treger	6,162,709	A	12/2000 Raoux et al.
5,381,262	A	1/1995 Arima et al.	6,165,566	A	12/2000 Tropsha
5,427,669	A	6/1995 Drummond	6,176,986	B1	1/2001 Watanabe et al.
5,457,569	A	10/1995 Liou et al.	6,197,167	B1	3/2001 Tanaka
5,475,528	A	12/1995 LaBorde	6,198,217	B1	3/2001 Suzuki et al.
5,478,456	A	12/1995 Humpal et al.	6,204,111	B1	3/2001 Uemoto et al.
5,483,613	A	1/1996 Bruce et al.	6,210,544	B1	4/2001 Sasaki
5,499,207	A	3/1996 Miki et al.	6,214,660	B1	4/2001 Uemoto et al.
5,512,147	A	4/1996 Bates et al.	6,232,242	B1	5/2001 Hata et al.
5,538,796	A	7/1996 Schaffer et al.	6,236,793	B1	5/2001 Lawrence et al.
5,555,127	A	9/1996 Abdelkader et al.	6,242,129	B1	6/2001 Johnson
5,563,979	A	10/1996 Bruce et al.	6,248,291	B1	6/2001 Nakagama et al.
5,565,071	A	10/1996 Demaray et al.	6,248,640	B1	6/2001 Nam
5,569,520	A	10/1996 Bates	6,261,917	B1	7/2001 Quek et al.
5,591,520	A	1/1997 Migliorini et al.	6,280,585	B1	8/2001 Obinata et al.
5,597,660	A	1/1997 Bates	6,281,142	B1	8/2001 Basceri et al.
5,603,816	A	2/1997 Demaray et al.	6,287,986	B1	9/2001 Mihara
5,607,560	A	3/1997 Hirabayashi et al.	6,288,835	B1	9/2001 Nilsson et al.
5,607,789	A	3/1997 Treger et al.	6,290,821	B1	9/2001 McLeod
5,612,152	A	3/1997 Bates	6,290,822	B1	9/2001 Fleming et al.
5,613,995	A	3/1997 Bhandarkar et al.	6,300,215	B1	10/2001 Shin
5,654,054	A	8/1997 Tropsha et al.	6,302,939	B1	10/2001 Rabin et al.
5,654,984	A	8/1997 Hershberger et al.	6,306,265	B1	10/2001 Fu et al.
5,686,360	A	11/1997 Harvey, III et al.	6,344,419	B1	2/2002 Forster et al.
5,689,522	A	11/1997 Beach	6,350,353	B2	2/2002 Gopalraja et al.
5,693,956	A	12/1997 Shi et al.	6,356,694	B1	3/2002 Weber
5,718,813	A	2/1998 Drummond et al.	6,358,810	B1	3/2002 Dornfest et al.
5,719,976	A	2/1998 Henry et al.	6,361,662	B1	3/2002 Chiba et al.
5,731,661	A	3/1998 So et al.	6,365,319	B1	4/2002 Heath et al.
5,738,731	A	4/1998 Shindo et al.	6,391,166	B1	5/2002 Wang
5,755,938	A	5/1998 Fukui et al.	6,409,965	B1	6/2002 Nagata et al.
5,757,126	A	5/1998 Harvey, III et al.	6,413,382	B1	7/2002 Wang et al.
5,762,768	A	6/1998 Goy et al.	6,413,645	B1	7/2002 Graff et al.
5,771,562	A	6/1998 Harvey, III et al.	6,416,598	B1	7/2002 Sircar
5,792,550	A	8/1998 Phillips et al.	6,423,776	B1	7/2002 Akkapeddi et al.
5,811,177	A	9/1998 Shi et al.	6,433,380	B2	8/2002 Shin
5,830,330	A	11/1998 Lantsman	6,444,750	B1	9/2002 Touhsaent
5,831,262	A	11/1998 Greywall et al.	6,452,717	B1	9/2002 Endo
5,841,931	A	11/1998 Foresi et al.	6,488,822	B1	12/2002 Moslehi
5,847,865	A	12/1998 Gopinath et al.	6,506,289	B2	1/2003 Demaray et al.
5,849,163	A	12/1998 Ichikawa et al.	6,511,615	B1	1/2003 Dawes et al.
5,853,830	A	12/1998 McCaulley et al.	6,533,907	B2	3/2003 Demaray et al.
5,855,744	A	1/1999 Halsey et al.	6,537,428	B1	3/2003 Xiong et al.
5,870,273	A	2/1999 Sogabe et al.	6,563,998	B1	5/2003 Farah et al.
5,882,946	A	3/1999 Otani	6,576,546	B2	6/2003 Gilbert et al.
5,900,057	A	5/1999 Buchal et al.	6,602,338	B2	8/2003 Chen et al.
5,930,584	A	7/1999 Sun et al.	6,605,228	B1	8/2003 Kawaguchi et al.
5,942,089	A	8/1999 Sproul et al.	6,615,614	B1	9/2003 Makikawa et al.
5,948,215	A	9/1999 Lantsman	6,632,563	B1	10/2003 Krasnov et al.
5,952,778	A	9/1999 Haskal et al.	6,673,716	B1	1/2004 D'Couto et al.
5,961,682	A	10/1999 Lee et al.	6,750,156	B2	6/2004 Le et al.
5,966,491	A	10/1999 DiGiovanni	6,760,520	B1	7/2004 Medin et al.
			6,768,855	B1	7/2004 Bakke et al.

## US 7,544,276 B2

Page 3

6,884,327	B2	4/2005	Pan et al.
7,262,131	B2	8/2007	Narasimhan et al.
2001/0027159	A1	10/2001	Kaneyoshi
2001/0031122	A1	10/2001	Lackritz et al.
2001/0034106	A1	10/2001	Moise et al.
2001/0041460	A1	11/2001	Wiggins
2002/0033330	A1	3/2002	Demaray et al.
2002/0076133	A1	6/2002	Li et al.
2002/0106297	A1	8/2002	Ueno et al.
2002/0134671	A1	9/2002	Demaray et al.
2002/0170821	A1	11/2002	Sandlin et al.
2002/0191916	A1	12/2002	Frish et al.
2003/0019326	A1	1/2003	Han et al.
2003/0022487	A1	1/2003	Yoon et al.
2003/0042131	A1	3/2003	Johnson
2003/0044118	A1	3/2003	Zhou et al.
2003/0063883	A1	4/2003	Demaray et al.
2003/0077914	A1	4/2003	Le et al.
2003/0079838	A1	5/2003	Brcka
2003/0097858	A1	5/2003	Strohhofer et al.
2003/0127319	A1	7/2003	Demaray et al.
2003/0134054	A1	7/2003	Demaray et al.
2003/0141186	A1	7/2003	Wang et al.
2003/0143853	A1	7/2003	Celii et al.
2003/0173207	A1	9/2003	Zhang et al.
2003/0173208	A1	9/2003	Pan et al.
2003/0174391	A1	9/2003	Pan et al.
2003/0175142	A1	9/2003	Milonopoulou et al.
2003/0185266	A1	10/2003	Henrichs
2004/0077161	A1	4/2004	Chen et al.
2004/0105644	A1	6/2004	Dawes
2004/0259305	A1	12/2004	Demaray et al.
2005/0000794	A1	1/2005	Demaray et al.
2005/0006768	A1	1/2005	Narasimhan et al.
2005/0048802	A1	3/2005	Zhang et al.
2005/0175287	A1	8/2005	Pan et al.
2005/0183946	A1	8/2005	Pan et al.
2006/0057283	A1	3/2006	Zhang et al.
2006/0057304	A1	3/2006	Zhang et al.
2006/0071592	A1	4/2006	Narasimhan et al.
2006/0134522	A1	6/2006	Zhang et al.
2007/0053139	A1	3/2007	Zhang et al.

## FOREIGN PATENT DOCUMENTS

EP	0 652 308	A2	10/1994
EP	0 639 655	A1	2/1995
EP	0 820 088	A2	1/1998
EP	0 867 985	B1	9/1998
EP	1068899	A1	1/2001
EP	1 092 689	A1	4/2001
EP	1 189 080	A2	3/2002
JP	2-054764	A2	2/1990
JP	6-010127	A	1/1994
JP	6-100333	A	12/1994
JP	7-224379	A	8/1995
JP	7-233469		9/1995
KR	2002-26187		4/2002
WO	WO 96/23085		8/1996
WO	WO 97/35044		9/1997
WO	WO 00/21898	A1	4/2000
WO	WO 00/22742	A2	4/2000
WO	WO 00/36665	A1	6/2000
WO	WO 01/82297	A1	11/2001
WO	WO 02/12932	A2	2/2002
WO	WO 2004/021532	A1	3/2004
WO	WO 2004/077519	A2	9/2004
WO	WO 2004/106581	A2	12/2004

WO WO 2007/027535 3/2007

## OTHER PUBLICATIONS

Affinito et al., "Polymer-Oxide Transparent Barrier Layers," Society of Vacuum Coaters, 39th Ann. Technical Conference Proceedings, May 5-10, 1996, Philadelphia, PA, pp. 392-397 (1996).

Alder, T. et al., "High-Efficiency Fiber-to-Chip Coupling Using Low-Loss Tapered Single-Mode Fiber," *IEEE Photonics Technology Letters*, 12(8):1016-1018 (2000).

Almeida, Vilson R. et al., "Nanotaper for compact mode conversion," *Optics Letters*, 28(15):1302-1304 (2003).

Asghari et al., "ASOC—A Manufacturing Integrated Optics Technology," Part of the SPIE Conference on Integrated Optics Devices III, vol. 3620, pp. 252-262 (Jan. 1999).

Barbier et al., "Amplifying Four-Wavelength Combiner, Based on Erbium/Erterbium-Doped Waveguide Amplifiers and Integrated Splitters", *IEEE Photonics Technology Letters*, vol. 9, pp. 315-317, 1997, 4 pages.

Barbier, Denis, "Performances and potential applications of erbium doped planar waveguide amplifiers and lasers," *GeO*, pp. 58-6 (date unknown).

Beach R.J., "Theory and optimization of lens ducts," *Applied Optics*, 35:12:2005-15 (1996).

Belkind et al., "Using pulsed direct current power for reactive sputtering of Al<sub>2</sub>O<sub>3</sub>," *J. Vac. Sci. Technol. A* 17(4), pp. 1934-1940 (Jul. 1999).

Bestwick, T., "ASOC silicon integrated optics technology," Part of the SPIE Conferences on Photonics Packaging and Integration, SPIE vol. 3631, pp. 182-190 (Jan. 1999).

Borsella et al., "Structural incorporation of silver insoda-lime glass by the ion-exchange process: a photoluminescence spectroscopy study", *Applied Physics A* 71, pp. 125-132 (2000).

Byer et al., "Nonlinear Optics and Solid-state Lasers," *IEEE Journal on Selected Topics in Quantum Electronics*, vol. 6, No. 6, pp. 921-929 (Nov. 2000).

Campbell et al., "Titanium dioxide (TiO<sub>2</sub>)-based gate insulators," *IBM J. Res. Develop.* 43(3), 383-391, (May 1999).

Chang, C.Y. (edited by), "ULSI Technology," The McGraw-Hill Companies, Inc., New York, 1996, Chapter 4, pp. 169-170, 226-231 (1996).

Chen et al. "Development of Supported Bifunctional Electrocatalysts for Unitized Regenerative Fuel Cells," *Journal of the Electrochemical Society*, 149(8), A1092-99, (2002).

Choi et al., "Er-Al-codoped silicate planar light waveguide-type amplifier fabricated by radio-frequency sputtering," *Optics Letters*, vol. 25, No. 4, pp. 263-265 (Feb. 15, 2000).

Cooksey et al. "Predicting Permeability & Transmission Rate for Multilayer Materials," *Foodtechnology*, vol. 53, No. 9, pp. 60-63 (Sep. 1999).

Crowder, et al., "Low-Temperature Single-Crystal Si TFT's Fabricated on Si Films Processed via Sequential Lateral Solidification," *IEEE*, vol. 19, No. 8 (Aug. 1998), pp. 306-308.

Delavaux et al., "Integrated optics erbium ytterbium amplifier system in 10 Gb/s fiber transmission experiment", 22nd European Conference on Optical Communication—ECOC' 96, Oslo, 4 pages (1996).

Distributed Energy Resources: Fuel Cells, Projects, [http://www.eere.energy.gov/der/fuel\\_cells/projects.html](http://www.eere.energy.gov/der/fuel_cells/projects.html) (2003).

DuPont Teijin Films, Mylar 200 SBL 300, Product Information (2000).

Electrometals Technologies Limited, Financial Report for the year 2002, Corporate Directory, Chairman's Review, Review of Operations (2002).

E-Tek website: FAQ, Inside E-Tek, E-Tek News, Products: <http://www.etek-inc.com/> (2003).

Flytzanis et al, "nonlinear Optics in Composite Materials," E. Wolf, Progress in Optics XXIX (c) Elsevier Science Publishers B.V., pp. 323-425 (1991).

## US 7,544,276 B2

Page 4

- Fujii et al., "1.54 mm photoluminescence of Er<sup>3+</sup> doped into SiO<sub>2</sub> films containing Si nanocrystals: Evidence for energy transfer from Si nanocrystals for Er<sup>3+</sup>", *Appl. Phys. Lett.* 71 (9), pp. 1198-1200 (Sep. 1997).
- Garcia, C. "Size Dependence of Lifetime and Absorption Cross Section of Si Nanocrystals Embedded in SiO<sub>2</sub>," *Appl. Phys. Lett.*, vol. 82, No. 10, pp. 1595-1597 (Mar. 2003).
- Goossens et al., "Sensitization of TiO<sub>2</sub> with p-type semiconductor polymers," Delft Interfaculty Research Center, Delft University of Technology Laboratory of Inorganic Chemistry, The Netherlands (1998).
- Greene et al., "Morphological and electrical properties of rf sputtered Y2O3-doped ZnO thin films," *J. Vac. Sci. Technol.*, vol. 13, No. 1 (Jan./Feb. 1976), pp. 72-75.
- Han, Hak-Seung et al. "Optical Gain at 1.54 μm in Erbium-Doped Silicon Nanocluster Sensitized Waveguide," *Appl. Phys. Lett.*, vol. 79, No. 27, pp. 4568-4570 (Dec. 2001).
- Hayakawa et al., "Enhanced fluorescence from Eu<sup>3+</sup> owing to surface plasma oscillation of silver particles in glass", *Journal of Non-Crystalline Solids*, vol. 259, pp. 16-22 (1999).
- Hayakawa et al., "Field enhancement effect of small Ag particles on the fluorescence from Eu<sup>3+</sup>-doped SiO<sub>2</sub> glass", *Appl. Phys. Lett.*, vol. 74, No. 11, pp. 1513-1515 (Mar. 1999).
- Hayfield, P.C.S., "Development of a New Material-Monolithic Ti4O7 Ebonix Ceramic," Royal Society Chemistry, (2002).
- Hehlen et al. "Spectroscopic Properties of Er<sup>3+</sup>- and Yb<sup>3+</sup>-doped Soda-Lime Silicate and Aluminosilicate Glasses," *Physical Review B*, vol. 56, No. 15, pp. 9302-9318 (Oct. 1997).
- Hehlen et al. "Uniform Upconversion in High-Concentration Er<sup>3+</sup>-doped Soda Lime Silicate and Aluminosilicate Glasses," *Optics Letters*, vol. 22, No. 11, pp. 772-774 (Jun. 1997).
- Horst et al., "Compact, Tunable Optical Devices in Silicon-Oxynitride Wave Guide Technology," IBM Research Division, 3 pages (1999).
- Hubner, J. and Guldborg-Kjaer, S., "Planar Er-and Yb-Doped Amplifiers and Lasers," COM Technical University of Denmark, 10.sup.th European Conf. On Integrated Optics, Session WeB2, pp. 71-74 (2001).
- Hwang, Man-Soo et al., "The effect of pulsed magnetron sputtering on the properties of indium tin oxide thin films," Elsevier Science B.V., p. 29-33, (2003).
- Im, et al. "Controlled Super-lateral Growth of Si Films for Microstructural Manipulation and Optimization," Materials Science Program (1998), pp. 603-617.
- Im, et al., "Crystalline Si Films for Integrated Active-Matrix LiquidCrystal Displays," *MRS Bulletin* (Mar. 1996), pp. 39-48.
- Im, et al., "Single-crystal Si films for thin-film transistor devices," American Institute of Physics (1997), pp. 3434-3436.
- Itoh, M. et al., "Large reduction of singlemode-fibre coupling loss in 1.5% delta planar lightwave circuits using spot-size converters," *Electronics Letters*, 38(2):72-74 (2002).
- Jackson et al. "An Accurate Compact EDFA Model," Dept. of Electrical and Computer Engineering, University of BC (date unknown).
- Janssen et al. "Photoinduced electron transfer from conjugated polymers onto nanocrystalline TiO<sub>2</sub>," Eindhoven University of Technology, The Netherlands (date unknown).
- Johnson, J.E. et al., "Monolithically Integrated Semiconductor Optical Amplifier and Electroabsorption Modulator with Dual-Waveguide Spot-Size Converter Input," *IEEE Journal of Selected Topics in Quantum Electronics*, 6(1):19-25, (2000).
- Jonsson L.B. et al. "Frequency response in pulsed DC reactive sputtering processes," *Thin Solid Films*, vol. 365, pp. 43-48 (2000).
- Kato et al., "Recent progress on PLC hybrid integration," Part of the SPIE Conference on Optoelectric Integrated Circuits III, SPIE. vol. 3631, pp. 28-36 (Jan. 1999).
- Kato, Kuniharu et al., "PLC Hybrid Integration Technology and Its Application to Photonic Components," *IEEE Journal of Selected Topics in Quantum Electronics*, 6(1):4-13 (2000).
- Kelly et al., "Reactive pulsed magnetron sputtering process for alumina films," *J. Vac. Sci. Technol. A* 18(6), pp. 2890-2896 (Nov. 2000).
- Kelly et al., "Control of the structure and properties of aluminum Kik, P.G. et al. "Gain Limiting Processes in Er-doped Si Nanocrystal Waveguides in SiO<sub>2</sub>," *J. Appl. Phys.*, vol. 91, No. 1, pp. 534-536 (Jan. 1, 2002).
- Kim et al. "Frequency-dependent pulsed direct current magnetron sputtering of titanium oxide films," *J. Vac. Sci. Technol. A* 19(2); 429-434 (Mar. 2001).
- Kim et al. "Mixture Behaviour and Microwave Dielectric Properties in the Low-fired TiO<sub>2</sub>-CuO System," *Jpn. J. Appl. Phys.*, 39, 2696-2700, (2000).
- Ladouceur, F. et al., "8.8 Evaluation of Results", *Silica-based Buried Channel Waveguides and Devices.*, Chapman & Hall, London, pp. 98-99 (1996).
- Ladouceur, F. et al., "Effect of side wall roughness in buried channel waveguides," *IEEE Proc.*, vol. 141, pp. 242-248 (Aug. 1994).
- Lamb, William B., "Designing Nonfoil Containing Skins for VIP Applications," DuPont VIA Symposium Presentation, (1999).
- Lamb, William et al. "Designing Non-Foil Containing Skins for Vacuum InsulationPanel (VIP) Applications," *Vuoto*, vol. XXVIII, No. 1-2—Gennaio-Giugno 1999, pp. 55-58 (1999).
- Lange et al., "High Gain Ultra-Short Length Phosphate glass Erbium-Doped Fiber Amplifier Material", OSA Optical Fiber Communications (OFC), 3 pages (2002).
- Laporta et al., "Diode-pumped cw bulk Er: Yb: glass laser", 1952 Optics Letters/vol. 16, No. 24/Dec. 15, 6 pages (1991).
- Laurent-Lund, C. et al., "PECVD Grown Multiple Core Planar Waveguides with Extremely Low Interface Reflections and Losses," *IEEE Photonics Technology Letters*, vol. 10, No. 10, pp. 1431-1433 (Oct. 1998).
- Lee et al., "Effect of size and roughness on light transmission in a S/SiO<sub>2</sub> waveguide: Experiments and model," Department of Materials Science and Engineering, Massachusetts Institute of Technology, (Jul. 12, 2000).
- Lee et al. "Effects of interfacial layer growth on the electrical characteristics of thin titanium oxide films on silicon," *Applied Physics Letters*, 74(21), 3143-3145, (May 1999).
- Love, J.D. et al., "Quantifying Loss Minimisation in Single-Mode Fibre Tapers," *Electronics Letters*, 22(17):912-914, (1986).
- Mardare et al. "On the structure of Titanium Oxide Thin Films," *Analele Stiintifice Ale Universitatii AL. I. Cuza IASA*, vol. XLV-XLVI, 201-208 (1999).
- Marques, P.V.S. et al., "Planar Silica-on-Silicon Waveguide Lasers Based in Two Layer Core Devices," 10.sup.th European Conference on Integrated Optics, Session WeB2, pp. 79-82 (2001).
- Meijerink et al, Luminescence of AG<sup>+</sup> In Crystalline and Glassy SrB<sub>4</sub>O<sub>7</sub>, *Journal of Physics and Chemistry of Solids*, vol. 54, No. 8, pp. 901-906, (1993).
- Mesnaoui et al., "Spectroscopic properties of AG<sup>+</sup> ions in phosphate glasses of NaPO<sub>3</sub>-AgPO<sub>3</sub> system", *European Journal of Solid State and Inorganic Chemistry*, vol. 29, pp. 1001-1013, 14 pages (1992).
- Mitomi, O. et al., Design of a Single-Mode Tapered Waveguide for Low-Loss Chip-to-Fiber Coupling., *IEEE Journal of Quantum Electronics*, 30(8):1787-1793, (1994).
- Mizuno et al. "Temperature dependence of oxide decomposition on titanium surfaces in UHV," submitted to *Journal of Vacuum Science and Technology*, (Oct. 28, 2001).
- Ohkubo et al., "Polarization-Insensitive Arrayed-Waveguide Grating Using Pure Si<sub>2</sub> Cladding," Fifth Optoelectronics and Communication Conference (OECC 2000) Technical Digest, 2 pages (Jul. 2000).
- Ohmi et al., "Rare earth metal oxides for high-K gate insulator," Tokyo Institute of Technology,(date unknown).
- Ohtsuki et al., "Gain Characteristics of a high concentration Er<sup>3+</sup>-doped phosphate glass waveguide", *J. Appl. Phys.* 78(6), pp. 3617-3621 (1995).
- Ono et al., "Design of a Low-loss Y-branch Optical Waveguide," Fifth Optoelectronic and Communications Conference (OECC 2000) Technical Digest, 2 pages (Jul. 2000).
- Padmini et al. "Realization of High-Tunability Barium Strontium Titanate Thin Films by RF Magnetron Sputtering," College of Engineering, University of California, Santa Barbara. (date unknown).
- Pan et al., "Planar Er<sup>3+</sup>-doped aluminosilicate waveguide amplifier

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.