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United States Patent [19]

Sproul et al.

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[45] **Date of Patent: *Aug. 24, 1999**

[54] **METHOD FOR SPUTTERING COMPOUNDS ON A SUBSTRATE**

[75] Inventors: **William D. Sproul**, Palatine; **Michael E. Graham**, Evanston, both of Ill.

[73] Assignee: **Northwestern University**, Evanston, Ill.

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/635,472**

[22] Filed: **Apr. 22, 1996**

[51] **Int. Cl.**[6] **C23C 14/34**

[52] **U.S. Cl.** **204/192.13**; 204/192.15; 204/192.16; 204/192.22; 204/192.23; 204/192.25; 204/298.03; 204/298.07; 204/298.06; 204/298.08; 204/298.14

[58] **Field of Search** 204/192.13, 192.15, 204/192.22, 192.23, 192.25, 298.03, 298.07, 298.08, 298.14, 298.26, 298.06, 192.16

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,428,811	1/1984	Sproul et al.	204/192.13
4,963,239	10/1990	Shimamura et al.	204/298.08
5,303,139	4/1994	Mark	204/298.08
5,492,606	2/1996	Stauder et al.	204/298.08
5,556,520	9/1996	Latz	204/192.13

FOREIGN PATENT DOCUMENTS

0 564 789	10/1993	European Pat. Off. .	

OTHER PUBLICATIONS

Sellers, "Asymmetric Bipolar Pulsed DC—The Enabling Technology for Reactive PVD", ENI Tech Note, pp. 1–8, Feb. 1996.

William D. Sproul, HIgh Rate Reactive Sputtering Process Control, *Surface and Coatings Technology*, 33 (1987) 73–81.

William D. Sproul and Paul J. Rudnik, The Effect of Target Power on the Nitrogen Partial Pressure Level and Hardness of Reactively Sputtered Titanium Nitride Coatings, *Thin Solid Films*, 171 (1989) 171–181.

W. D. Sproul and P. J. Rudnik, Advances in Partial–Pressure Control Applied to Reactive Sputtering, *Surface and Coatings Technology*, 39/40 (1989) 499–506.

(List continued on next page.)

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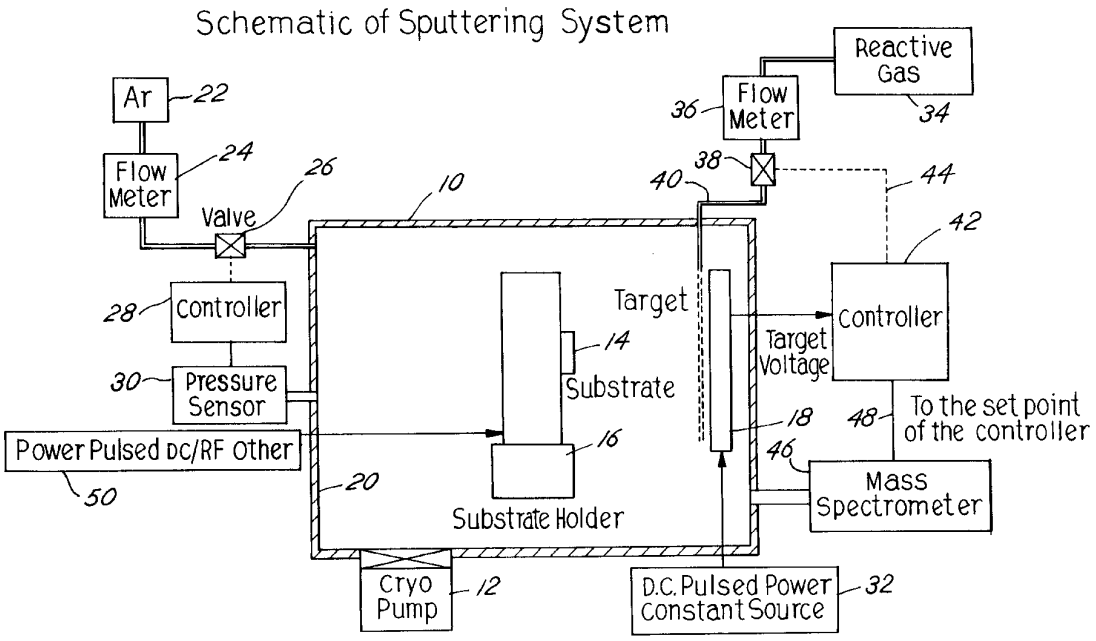
[57] **ABSTRACT**

A method and apparatus for monitoring and controlling deposition of metal, insulating compounds or other compounds on a substrate by sputtering techniques includes maintaining pulsed, constant, direct current power to the target, sensing the voltage of the target material used in the process, simultaneously rapidly sensing the partial pressure of the reactive gas, and simultaneously biasing the substrate to activate the reactive gas or otherwise energizing the reactive gas in the vicinity of the substrate. An apparatus for practicing the invention is also disclosed.

13 Claims, 5 Drawing Sheets



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OTHER PUBLICATIONS

W. D. Sproul, P. J. Rudnik and M. E. Graham, The Effect of N_2Partial Pressure, Deposition Rate and Substrate Bias Potential on the Hardness and Texture of Reactively Sputtered TiN Coatings, *Surface and Coatings Technology*, 39/40 (1989) 355–363.

X. Chu, M.S. Wong, W. D. Sproul, S. L. Rohde and S. A. Barnett, Deposition and Properties of Polycrystalline TiN/NbN Superlattice Coatings, *J. Vac Sci. Technol. A 10*(4), Jul./Aug. 1992.

William D. Sproul, *Control of A Reactive Sputtering Process For Large Systems*, Presented at the Society of Vacuum Coaters 36th Annual Technical Conference, Dallas, Texas, Apr. 30, 1993.

J. Affinito and R. R. Parsons, Mechanisms of Voltage Controlled, Reactive, Planar Magnetron Sputtering of Al in Ar/N_2 and AR/O_2 Atmospheres, J. Vac. Sci. Technol. A 2(3), Jul.–Sep. 1984.

S. Schiller, K. Goedicke, J. Reschke, V. Kirchhoff, S. Schneider and F. Milde, Pulsed Magnetron Sputter Technology, *Surface and Coatings Technology*, 61 (1993) 331–337.

P. Frach, U. Heisig, Chr. Gottfried and H. Walde, Aspects and Results of Long–Term Stable Deposition of Al_2O_3 With High Rate Pulsed Reactive Magnetron Sputtering, *Surface and Coatings Technology*, 59 (1993) 177–182.

W. D. Sproul, M. E. Graham, M. S. Wong, S. Lopez, and D. Li, Reactive Direct Current Magnetron Sputtering of Aluminum Oxide Coatings. J. Vac. Sci. Technol. A 13(3), May/Jun. 1995.

William D. Sproul, Michael E. Graham, Ming–Show and Paul J. Rudnik, Reactive DC Magnetron Sputtering of the Oxides of Ti, Zr, and Hf, Presented at the International Conference on Metallurgical Coatings and Thin Films, Town and Country Hotel, San Diego, California, Apr. 24–28, 1994 and Submitted for publication in *Surface and Coatings Technology*.

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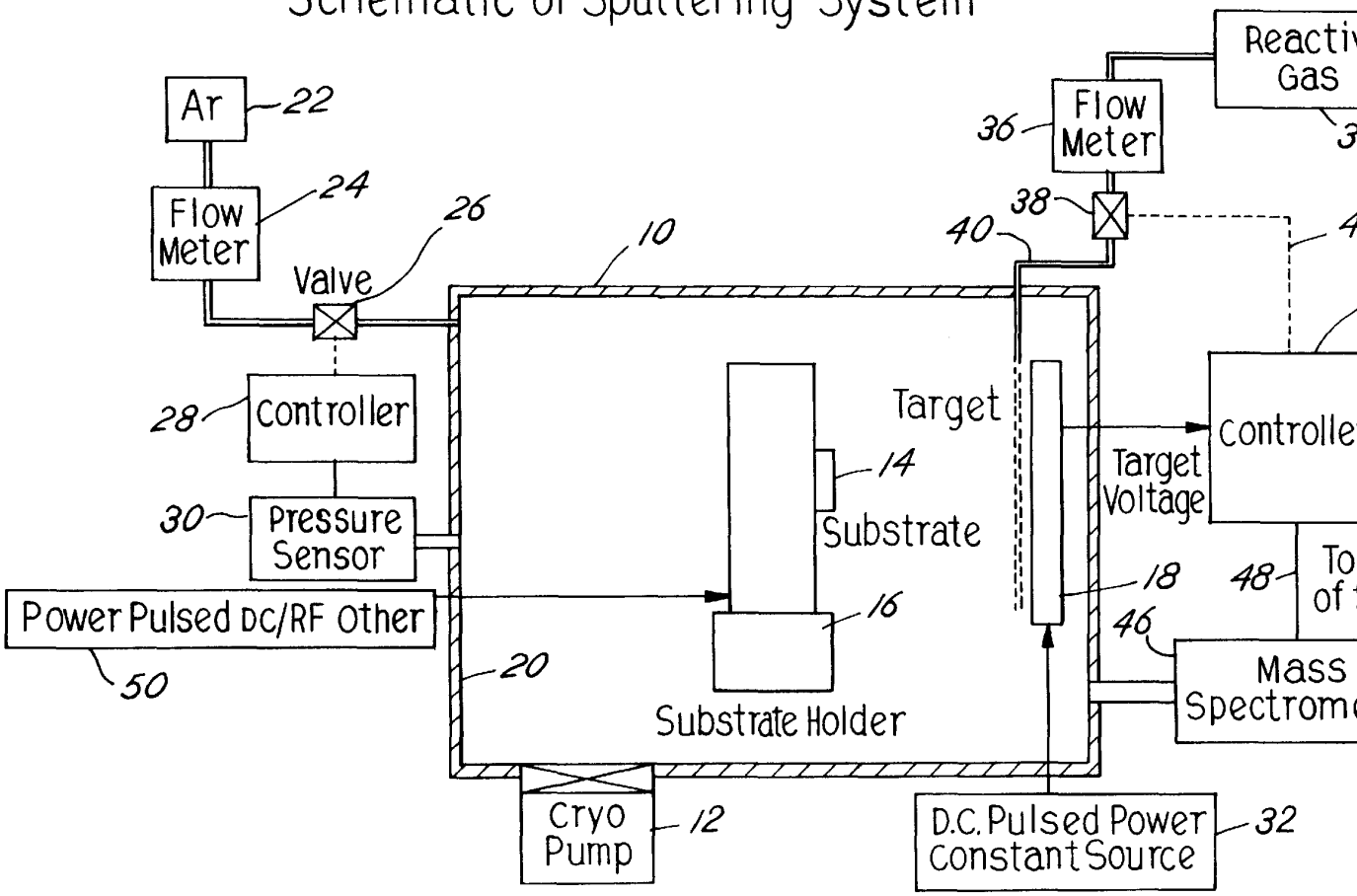
FIG.1

Schematic of Sputtering System



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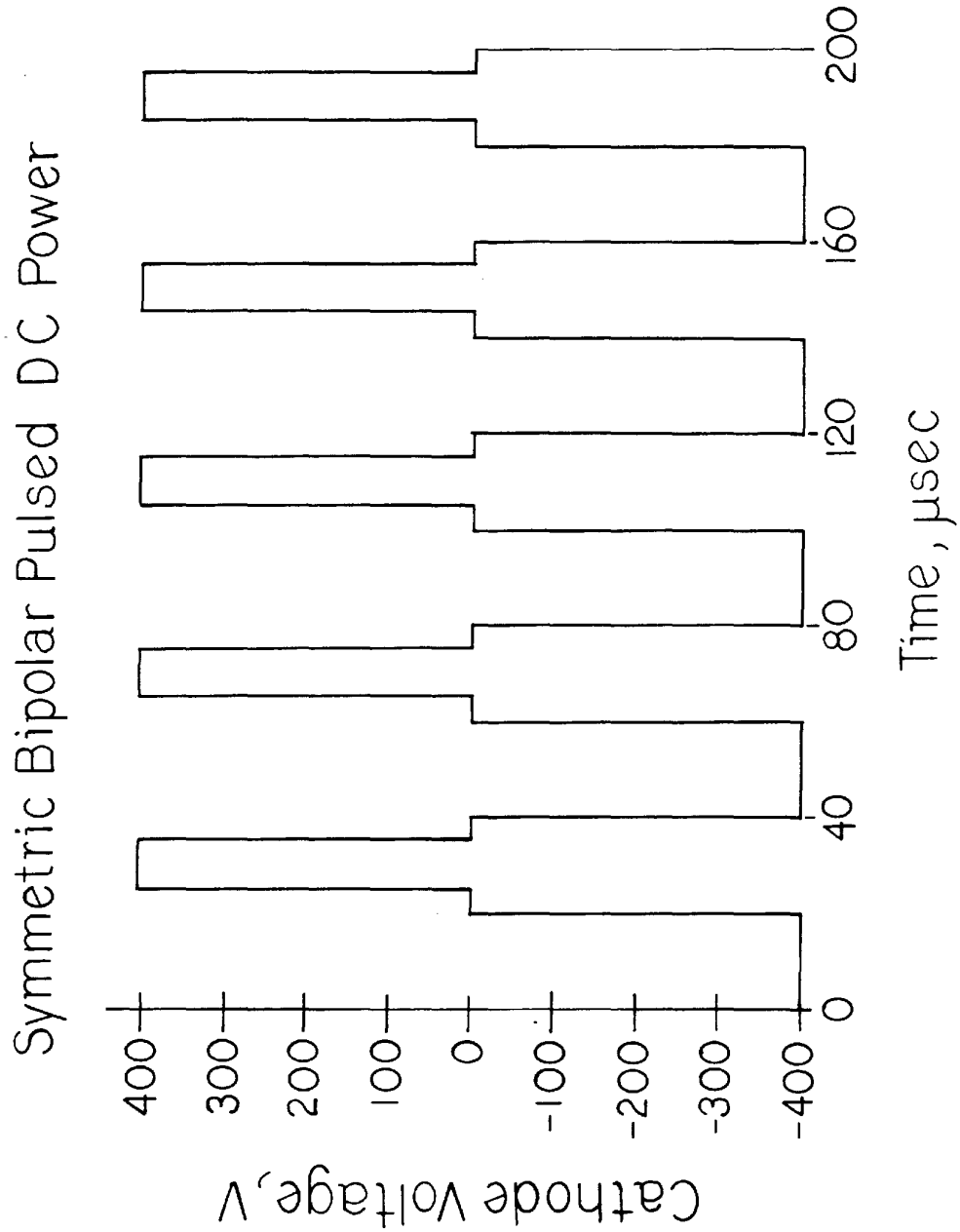

FIG.2

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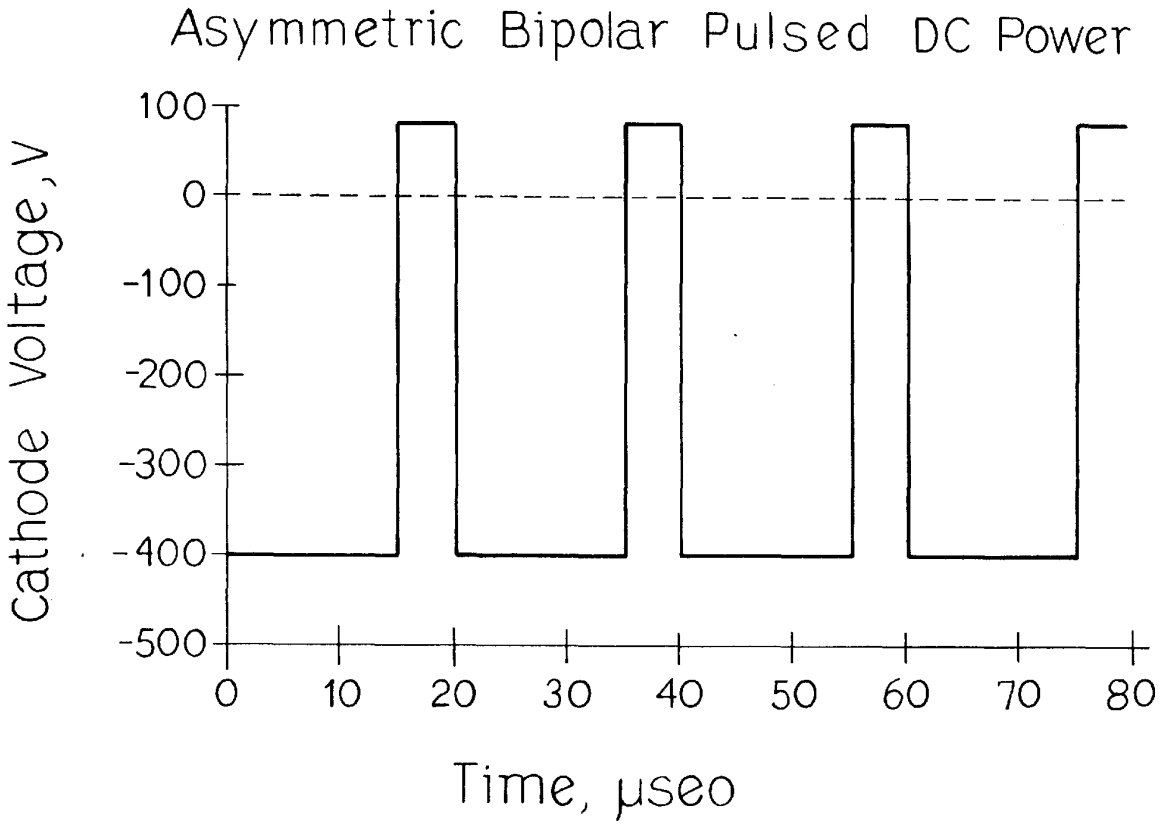
FIG.3



Source : J. Sellers, "Asymmetric Bipolar Pulsed
ENI Tech Note, ENI, Rochester, NY

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