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

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(54) **INTEGRATED PROCESS FOR COPPER VIA FILLING USING A MAGNETRON AND TARGET PRODUCING HIGHLY ENERGETIC IONS**

**FOREIGN PATENT DOCUMENTS**

WO 00/48226  
A1 8/2000 (WO) ..... H01J/37/34

**OTHER PUBLICATIONS**

Kitamoto et al., "Compact sputtering apparatus for depositing Co-Cr alloy thin films in magnetic disk," Proceedings: The Fourth International Symposium on Sputtering & Plasma Processes, Kanazawa, Japan, Jun. 4-6, 1997, pp. 519-522.

(List continued on next page.)

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(57) **ABSTRACT**

A target and magnetron for a plasma sputter reactor. The target has an annular trough facing the wafer to be sputter coated. Various types of magnetic means positioned around the trough create a magnetic field supporting a plasma extending over a large volume of the trough. For example, the magnetic means may include magnets disposed on one side within a radially inner wall of the trough and on another side outside of a radially outer wall of the trough to create a magnetic field extending across the trough, to thereby support a high-density plasma extending from the top to the bottom of the trough. The large plasma volume increases the probability that the sputtered metal atoms will become ionized. The magnetic means may include a magnetic coil, may include additional magnets in back of the trough top wall to increase sputtering there, and may include confinement magnets near the bottom of the trough sidewalls. The magnets in back of the top wall may have an outer magnet surrounding an inner magnet of the opposite polarity. The high aspect ratio of the trough also reduces asymmetry in coating the sidewalls of a deep hole in the wafer. An integrated copper via filling process includes a first step of highly ionized sputter deposition of copper, a second step of more neutral, lower-energy sputter deposition of copper to complete the seed layer, and electroplating copper into the hole to complete the metallization.

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(22) Filed: **Mar. 2, 2000**

**Related U.S. Application Data**

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(51) **Int. Cl.**<sup>7</sup> ..... **C23C 14/35**; C23C 14/00; C23C 14/34

(52) **U.S. Cl.** ..... **204/192.12**; 204/298.19; 204/298.2; 204/298.21; 204/298.22; 204/298.16; 204/298.17; 204/298.18; 204/298.12; 204/192.17; 204/192.15

(58) **Field of Search** ..... 204/298.19, 298.2, 204/298.21, 298.22, 298.16, 298.17, 298.18, 298.12, 192.12, 192.15, 192.17

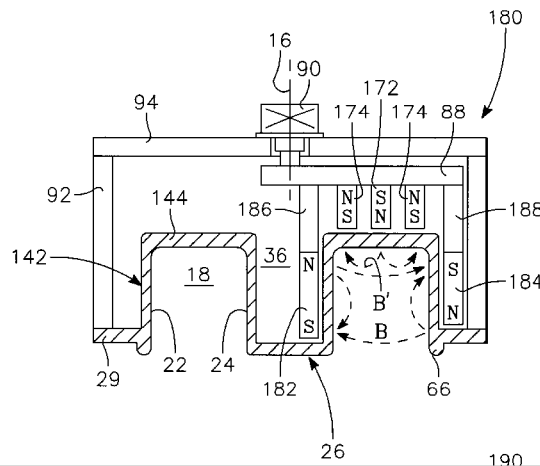
(56) **References Cited**

**U.S. PATENT DOCUMENTS**

5,069,770 \* 12/1991 Glocker ..... 204/192.12  
5,178,739 1/1993 Barnes et al. .... 204/192.12  
5,482,611 1/1996 Helmer et al. .... 204/298.17

(List continued on next page.)

**27 Claims, 11 Drawing Sheets**



**GILLETTE 1109**

## U.S. PATENT DOCUMENTS

5,512,150	*	4/1996	Bourez et al. ....	204/298.19
5,589,041		12/1996	Lantsman .....	204/192.33
5,685,959	*	11/1997	Bourez et al. ....	204/298.2
5,685,961		11/1997	Bourez et al. ....	204/192.2
5,865,961		2/1999	Yokoyama .....	204/192.12
5,897,752	*	4/1999	Hong et al. ....	204/192.12
6,080,284		6/2000	Miyaura .....	204/192.12

## OTHER PUBLICATIONS

Yamazato et al., "Preparation of TiN thin Films by facing targets magnetron sputtering," Proceedings: The Fourth International Symposium on Sputtering & Plasma Processes, Kanazawa, Japan Jun. 4-6, 1997, pp. 635-638.

Musil et al., "Unbalanced magnetrons and new sputtering systems with enhanced plasma ionization," *Journal of Vacuum Science and Technology A*, vol. 9, No. 3, May/Jun. 1991, pp. 1171-1177.

Matsuoka et al., "Dense plasma production and film deposition by new high-rate sputtering using an electric mirror," *Journal of Vacuum Science and Technology A*, vol. 7, No. 4, Jul./Aug. 1989, pp. 2652-2657.

Ivanov et al., "Electron energy distribution function in dc magnetron sputtering discharge," *Vacuum*, vol. 43, No. 8, 1992, pp. 837-842.

\* cited by examiner

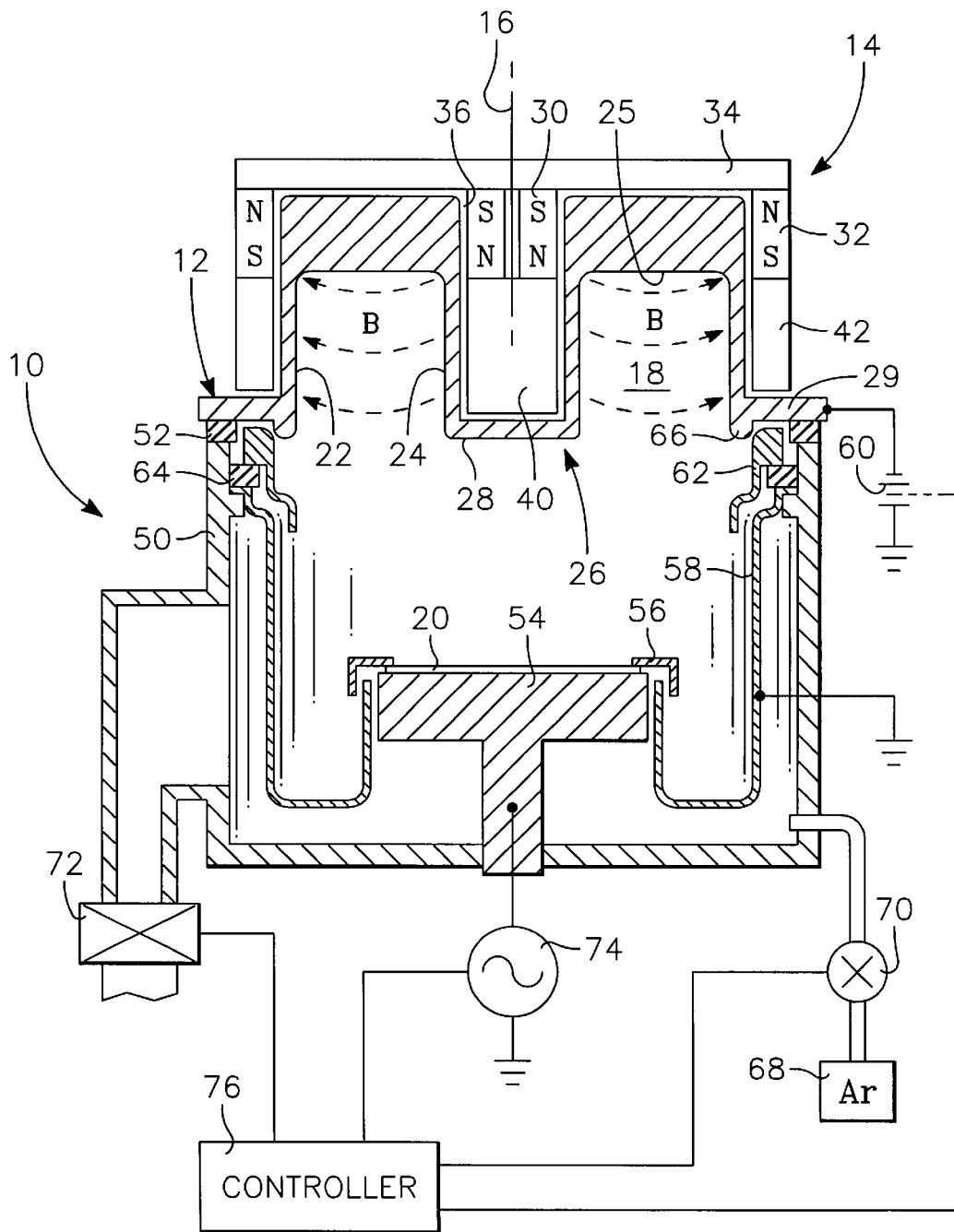
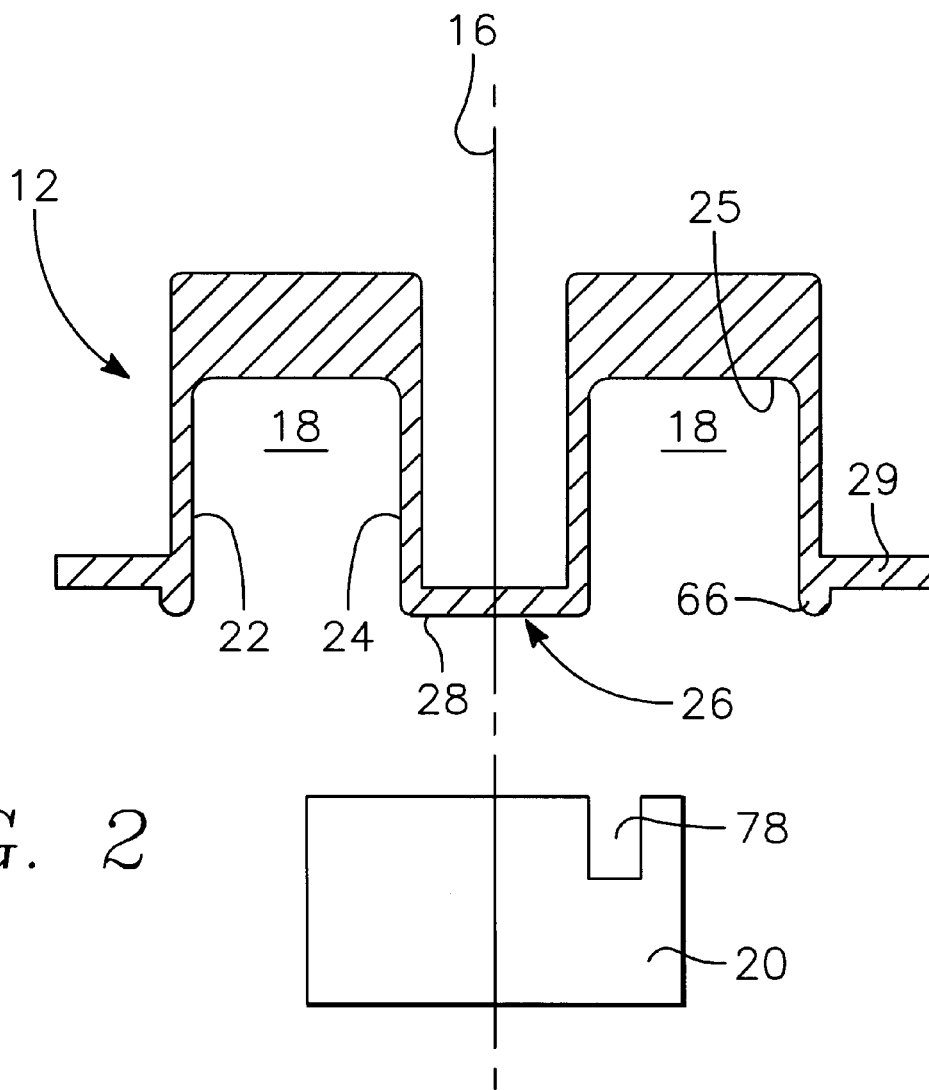


FIG. 1



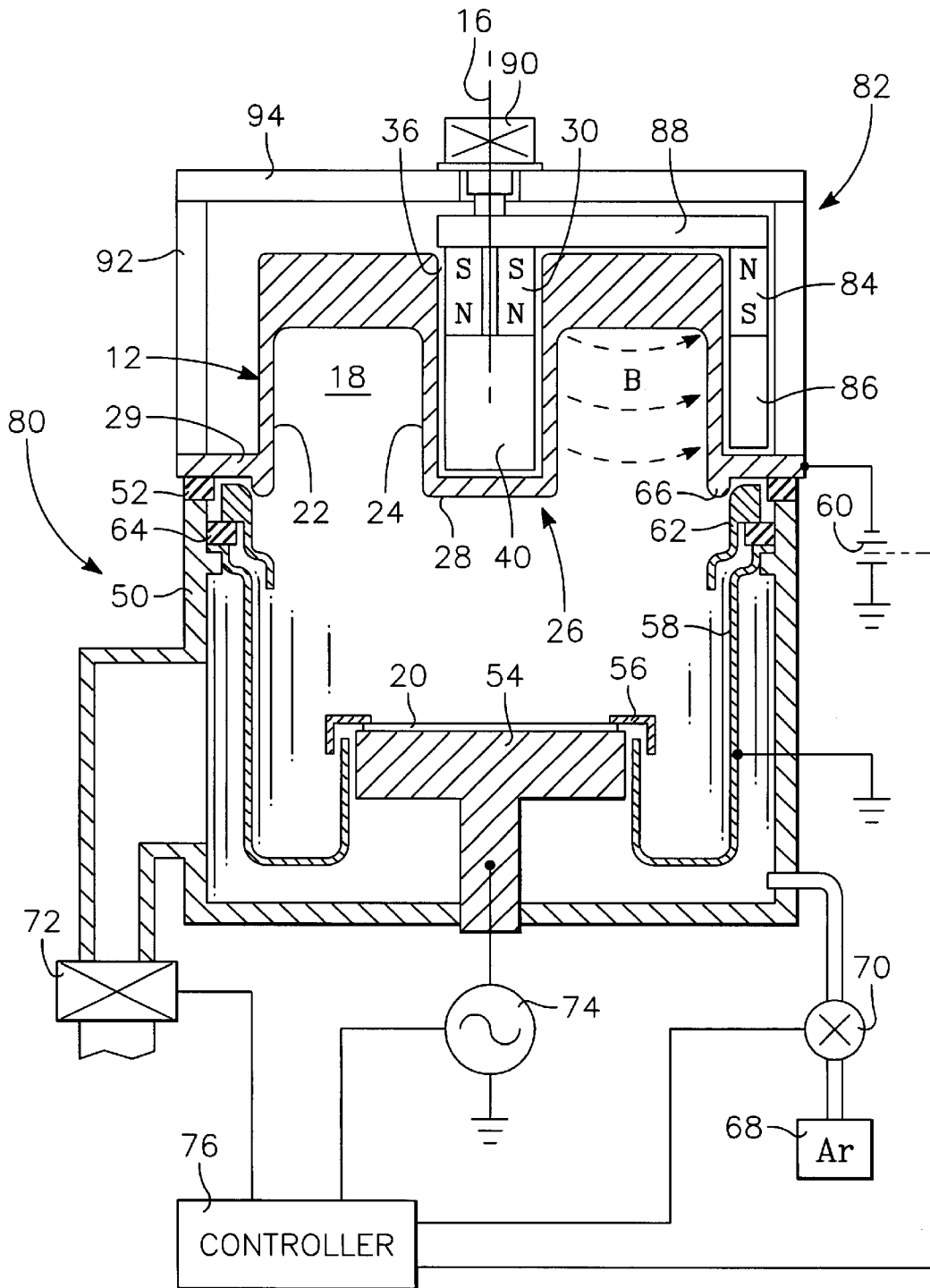


FIG. 3

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