US005893752A

United States Patent [19]

Zhang et al.

[11] Patent Number: 5,893,752

[45] Date of Patent: Apr. 13, 1999

[54] **PROCESS FOR FORMING A SEMICONDUCTOR DEVICE**

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[21] Appl. No.: **08/996,000**

[22] Filed: **Dec. 22, 1997**

[51] Int. Cl.^{6} **H01L 21/00**

[52] U.S. Cl. **438/687**; 438/687; 438/627; 438/628; 438/643

[58] Field of Search 438/653, 627–28, 438/654, 656, 643, 644, 645, 648, 680, 681, 658, 687

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,206,187	4/1993	Doan et al.	437/192
5,231,053	7/1993	Bost et al.	437/190
5,289,035	2/1994	Bost et al.	257/750
5,323,047	6/1994	Nguyen	257/384
5,391,517	2/1995	Gelatos et al.	438/643
5,420,072	5/1995	Fiordalice et al.	438/607
5,468,339	11/1995	Gupta et al.	216/67
5,614,437	3/1997	Choudhury	437/140
5,677,238	10/1997	Gn et al.	438/653
5,747,360	5/1998	Nulman	1/1

FOREIGN PATENT DOCUMENTS

0 163 830 A2	12/1985	European Pat. Off.	H01L 23/52
0 673 063 A2	9/1995	European Pat. Off.	H01L 21/768

OTHER PUBLICATIONS

Wolf et al. Silicon Processing for the VLSI Era vol. 2, pp. 273–276, 1990, no month.

Han Sin Lee et al., An Optimized Densification of the Filled Oxide for Quarter Micro Shallow Trench Isolation (STI), 1996 Symposium on VLSI Technology, Digest of Technical Papers, International Electron Devices Meeting, pp. 158–159 (1966).

Torres, Advanced copper Interconnections for silicon CMOS technologies, Applied Surface Science 91 (1995) pp. 112–123.

Wang, Barriers Against Copper Diffusion into Silicon and Drift Through Silicon Dioxide, MRS Bulletin/Aug. 1994, pp. 30–39.

Reid et al., Evaluation of amorphous (Mo, Ta W)—Si–N diffusion barriers for <Si>/Cu metallizations, Elsevier Sequoia (1993), pp. 319–324.

Wang et al., Diffusion barrier study on TaSi^x and TaSi$_x$N$_y$, Elsevier Sequoia (1993) pp. 169–174.

Smolinsky et al., Material Properties of Spin–on Silicon Oxide (SOX) for Fully Recessed NMOS Field Isolation, J. Electrochem. Soc., vol. 137, No. 1, Jan. 1990, The Electrochemical Society, Inc., pp. 229–234.

Selective Oxidation of Titanium while forming Titanium Silicide at Polysilicon and Diffusions, IBM Technical Disclosure Bulletin vol. 27 No. 10A Mar. 1985.

Frisa et al.; U.S. appl. No. 8/804,589, filed Feb. 26, 1997.

Frisa et al.; U.S. appl. No. 08/887,654 filed Jul. 3, 1997.

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[57] **ABSTRACT**

A semiconductor device comprises a substrate (**100**), first conductive film (**22** and **32**) over the substrate (**100**), and a second conductive film (**54** and **64**) over the first conductive film (**22** and **32**). The first conductive film includes a refractory metal and nitrogen. The first conductive film has a first portion (**22**) that lies closer to the substrate and a second portion (**32**) that lies further from the substrate. The nitrogen percentage for the second portion (**32**) is lower than the nitrogen atomic percentage for the first portion (**22**). The second conductive film (**54** and **64**) includes mostly copper. The combination of portions (**22** and **32**) within the first conductive film provides a good diffusion barrier (first portion) and has good adhesion (second portion) with the second conductive film (**54** and **64**).
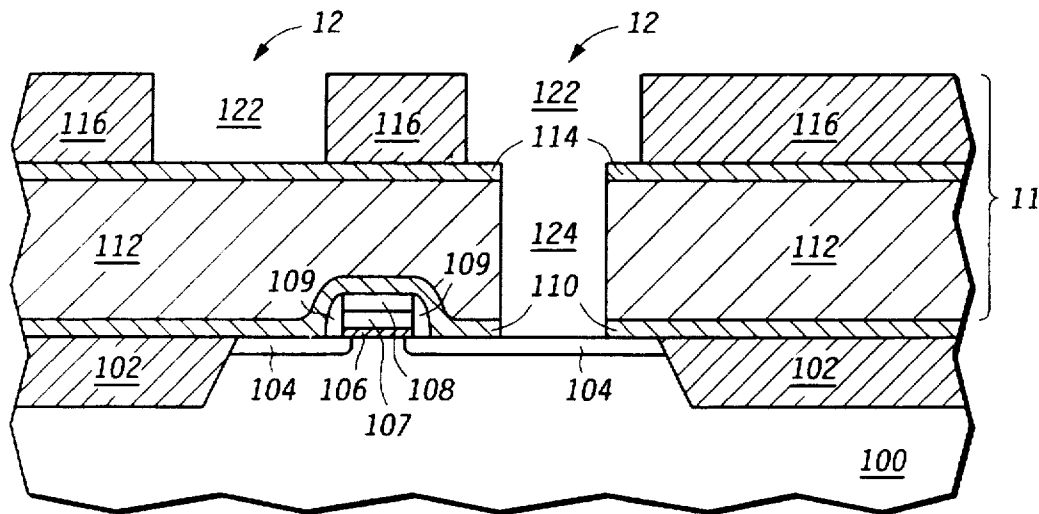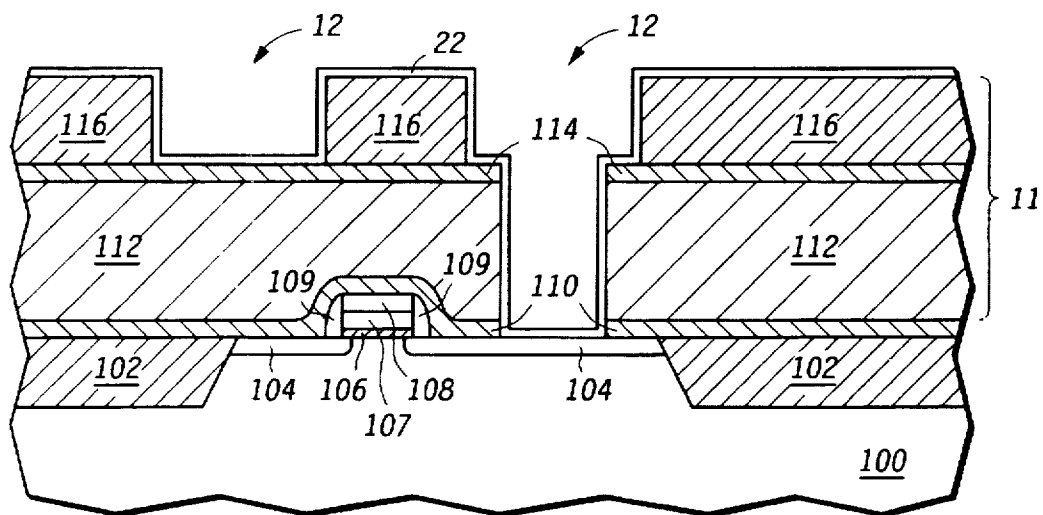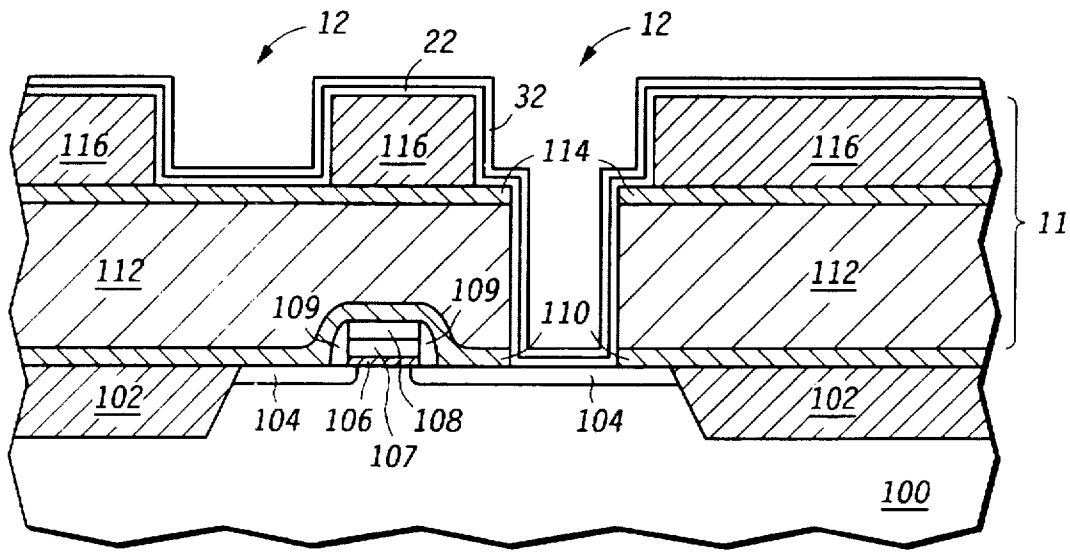
22 Claims, 5 Drawing Sheets
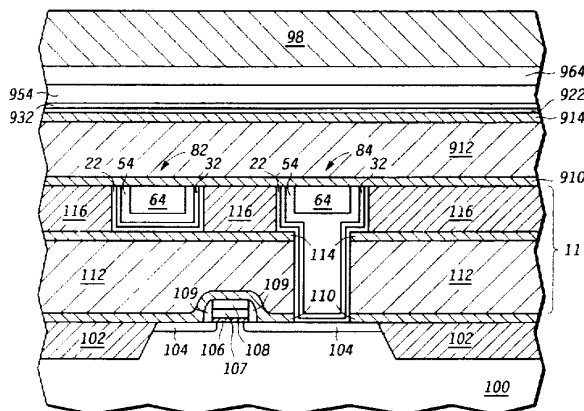
FIG.1

FIG.2

FIG.3
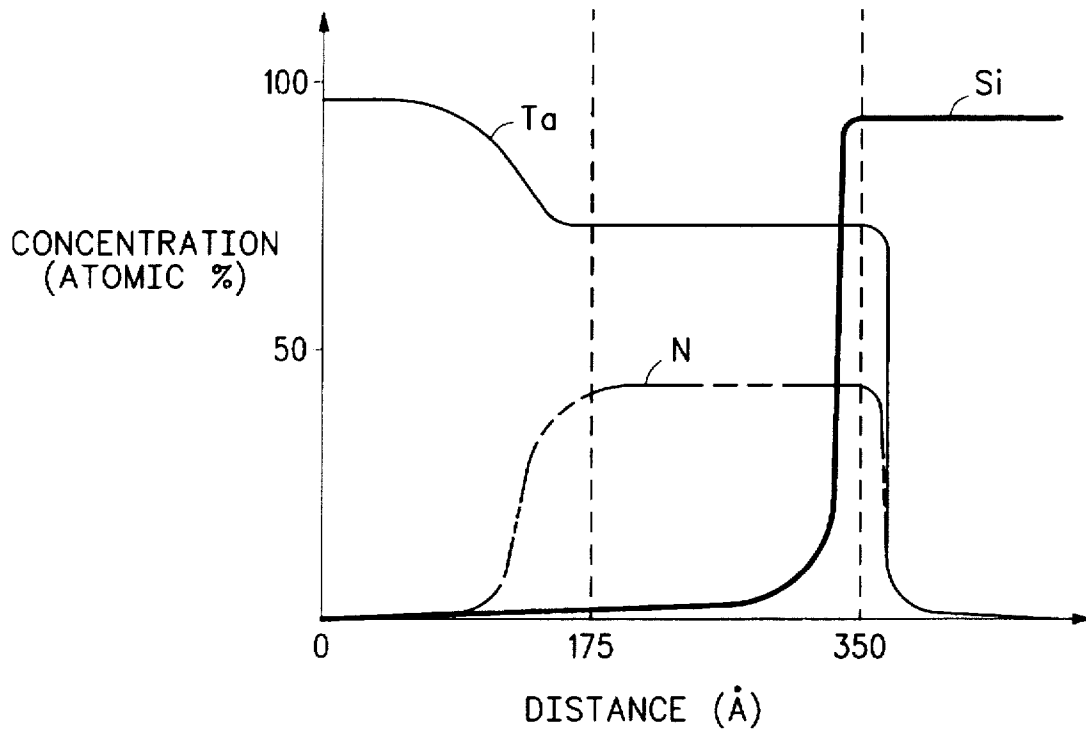
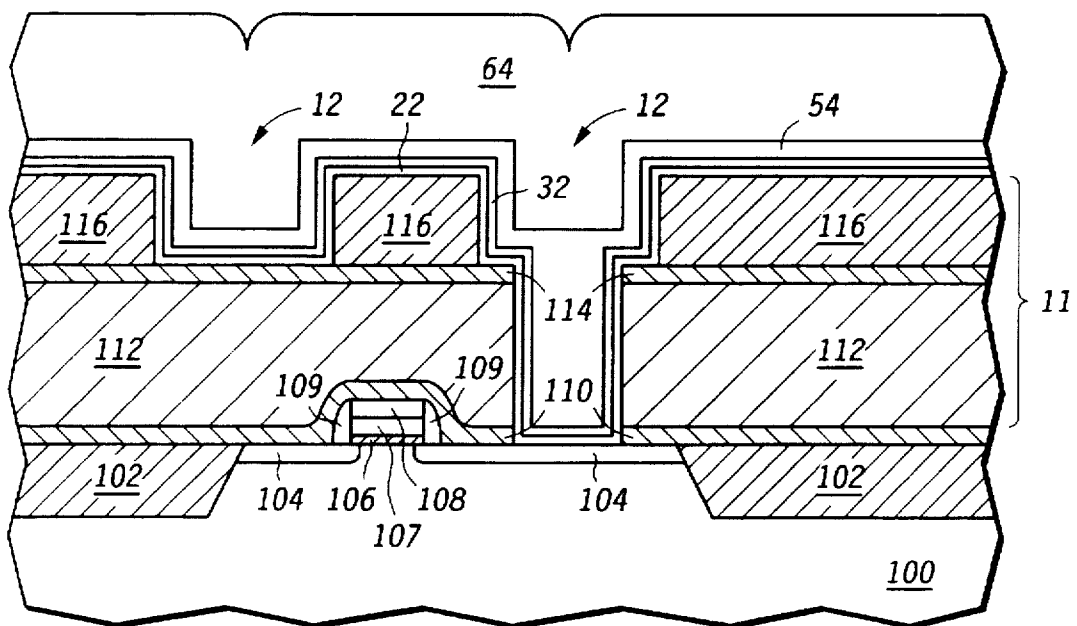*FIG.4*
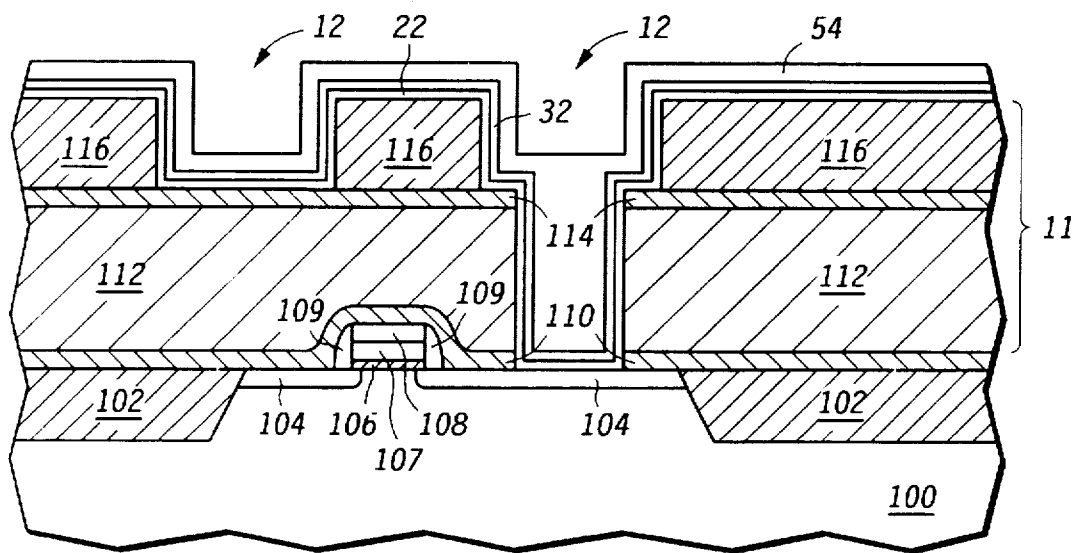
FIG.5

FIG.6

FIG.7

FIG.8

DOCKET ALARM
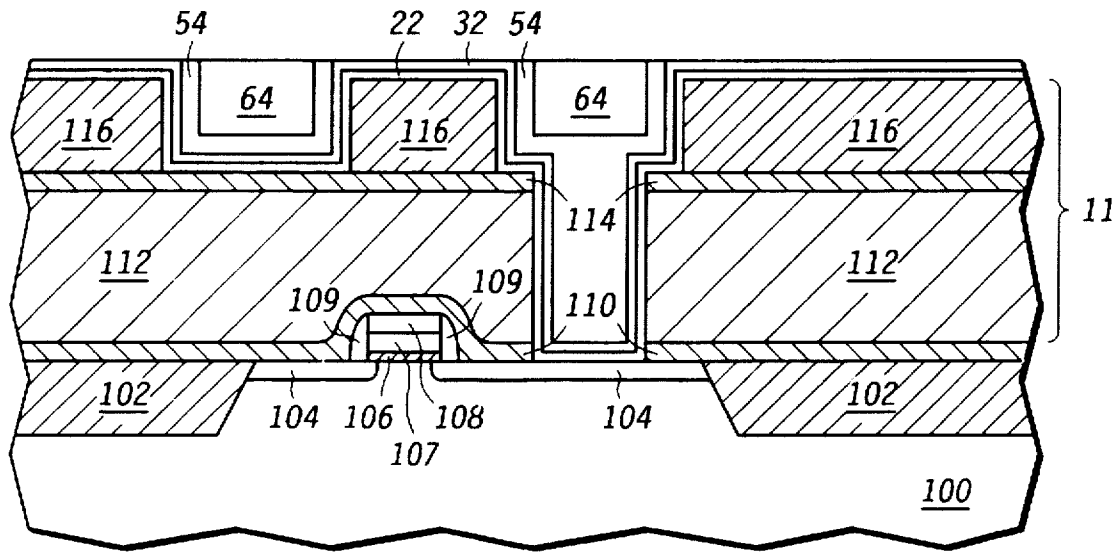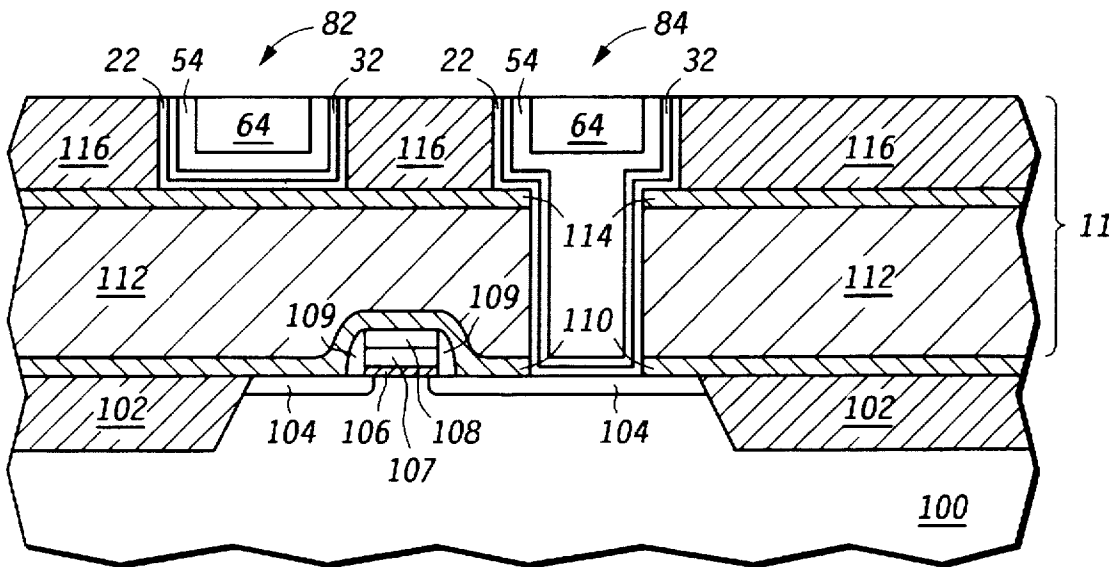
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