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(54) **HIGH/LOW WORK FUNCTION METAL ALLOYS FOR INTEGRATED CIRCUIT ELECTRODES**

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(58) **Field of Search** 257/407, 412, 257/768

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,591,838 A	*	7/1971	Fujiwara et al.	257/742
6,010,584 A		1/2000	Fonda et al.	148/563
6,166,417 A	*	12/2000	Bai et al.	257/407
6,376,888 B1	*	4/2002	Tsunashima et al.	257/407
6,458,695 B1	*	10/2002	Lin et al.	438/659
6,518,106 B2	*	2/2003	Ngai et al.	438/157
6,653,698 B2	*	11/2003	Lee et al.	257/407

OTHER PUBLICATIONS

IBM TDB vol.31 No.3 Aug. 1988 pp 46–47 "Method for producing . . . Electrodes".*

Ishii et al., *Work Function of Binary Alloys*, Appl. Suf. Sci., vol. 169–170, Jan. 2001, pp. 658–661.

Misra et al., *Use of Metal–Oxide–Semiconductor Capacitors to Detect Interactions of Hf and Zr Gate Electrodes with* SiO_2 and ZrO_2, Applied Physics Letters, Jun. 25, 2001, pp. 4166–4168.

Zhong et al., *Properties of Ru–Ta Alloys as Gate Electrodes for NMOS and PMOS Silicon Devices*, 2001 IEEE Electron Devices Meeting, IEDM Technical Digest International, Dec. 2001, pp. 20.5.1 –20.5.4.

Wuu et al, *Material characteristics and thermal stability of cosputtered Ta–Ru thin films*, J. Vac. Sci. Technol. A, vol. 17, No. 6, 1999, pp. 3327–3332.

* cited by examiner

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(57) **ABSTRACT**

Integrated circuit electrodes include an alloy of a first metal and a second metal having lower work function than the first metal. The second metal also may have higher oxygen affinity than the first metal. The first metal may be Ru, Ir, Os, Re and alloys thereof, and the second metal may be Ta, Nb, Al, Hf, Zr, La and alloys thereof. Both NMOS and the PMOS devices can include gate electrodes of an alloy of the first metal and the second metal having lower work function than the first metal. The PMOS gate electrode may have a higher percentage of the first metal relative to the second metal than the NMOS gate electrode. Thus, a common material system may be used for gate electrodes for both NMOS and PMOS devices.

12 Claims, 11 Drawing Sheets