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[54] **REFRACTORY METAL CAPPED LOW RESISTIVITY METAL CONDUCTOR LINES AND VIAS FORMED USING PVD AND CVD**

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Related U.S. Application Data

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[52] **U.S. Cl.** **437/190**; 437/192; 437/195; 437/228; 148/DIG. 15

[58] **Field of Search** 437/185, 190, 192, 195, 437/200, 228, 245, 246; 148/DIG. 15

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[57] **ABSTRACT**

Capping a low resistivity metal conductor line or via with a refractory metal allows for effectively using chemical-mechanical polishing techniques because the hard, reduced wear, properties of the refractory metal do not scratch, corrode, or smear during chemical-mechanical polishing. Superior conductive lines and vias are created using a combination of both physical vapor deposition (e.g., evaporation or collimated sputtering) of a low resistivity metal or alloy followed by chemical vapor deposition (CVD) of a refractory metal and subsequent planarization. Altering a ratio of SiH_4 to WF_6 during application of the refractory metal cap by CVD allows for controlled incorporation of silicon into the tungsten capping layer. Collimated sputtering allows for creating a refractory metal liner in an opening in a dielectric which is suitable as a diffusion barrier to copper based metalizations as well as CVD tungsten. Ideally, for faster diffusing metals like copper, liners are created by a two step collimated sputtering process wherein a first layer is deposited under relatively low vacuum pressure where directional deposition dominates (e.g., below 1 mTorr) and a second layer is deposited under relatively high vacuum pressure where scattering deposition dominates (e.g., above 1 mTorr). For refractory metals like CVD tungsten, the liner can be created in one step using collimated sputtering at higher vacuum pressures.

37 Claims, 7 Drawing Sheets