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A B S T R A C T

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 metallizations 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 1mTorr) and a second layer is deposited under relatively high vacuum pressure where scattering deposition dominates (e.g., above 1mTorr). For refractory metals like CVD tungsten, the liner can be created in one step using collimated sputtering at higher vacuum pressures.

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