Tungsten Thin Films Deposited by Plasma-enhanced atomic layer deposition with tungsten chloride precursor

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Tungsten (W) is a hard, refractory, and relatively inert metal, with widespread applications such as making filaments, filling contact holes and vias in microelectronic circuits, high-temperature technology,medicine, aviation, military uses, sport equipments. Atomic layer deposition (ALD) is a vapor phase thin film deposition technique based on sequential,self-limited surface reaction between chemical species. ALD enables deposition of thin films with high material quality, good uniformity, high conformality,and sub-nanometer thickness controllability. Furthermore, plasma-enhanced ALD (PE-ALD) which uses radicals as a reactant has been investigated as an attractive deposition method in terms of processing temperature and film quality. The most commonly used precursor for vapor deposition of W is WF_6, a highly reactive gas that often produces toxic hydrofluoric acid (HF) as a byproduct. WF_6 is also reactive toward common semiconductor device materials such as Si, Al, or Ti, and thus can lead to spontaneous etching during device fabrication. Therefore, fluorine-free tungsten precursors have recently received attention. In this work, we fundamentally investigated PE-ALD process of W on SiO_2 substrate, using tungsten chloride (WCl_x) precursor and hydrogen plasma. Various analytic techniques such as X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), rutherford backscattering spectrometry (RBS), 4-point probe, and field emission scanning electron microscopy (FE-SEM) were utilized, as well as density functional theory (DFT) calculations. Our PE-ALD W process showed typical ALD growth characteristics with a growth rate of 0.24 Å/cycle. W thin film deposited by our process showed low Cl impurity(< 1%) and low resistivity (~ 5.22 x 10-4 Ωcm).

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