WORK FUNCTION MEASUREMENTS OF METAL GATE - TiAlC by ULTRAVIOLET PHOTOELECTRON SPECTROSCOPY

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In order to obtain high performance and low power in integrated circuits (IC), feature sizes continue to shrink and new materials are being developed. One major challenge is finding a metal gate electrode with the appropriate work function when paired with a gate oxide. Titanium-Aluminum-Carbide (TiAlC) films deposited by Atomic Layer Deposition (ALD) were introduced in the semiconductor industry in the 22nm and beyond FINFET technology node. TiAlC can provide the necessary work function and ALD offers better thickness control, uniformity and conformity compared to Plasma Vapor Deposition (PVD). Electrical measurements are typically used to measure a film's work function. However, in an IC manufacturing environment this type of measurements can be performed only after several processing steps following the TiAlC deposition. It is often difficult and not cost effective to "rework" the affected wafers resulting in the loss of both product and time. Thus, it is important to monitor the work function during manufacturing. X-ray Photoelectron Spectroscopy (XPS) is used for in-line monitoring of the film composition and thickness, but it cannot directly measure the work function of TiAlC. In this work we demonstrate that Ultraviolet Photoelectron Spectroscopy (UPS) can provide work function measurements directly after the film deposition, to more effectively control the TiAlC ALD process parameters and resulting film properties. In addition, X-ray reflectivity (XRR) and X-ray diffraction (XRD) were used to investigate TiAlC film's density and crystallinity.