In-situ Synchrotron Radiation Photoemission Spectroscopy Study of Atomic Layer Deposition of Ta$_2$O$_5$ film on Si Substrate with Ta(NtBu)(dmamp)$_2$Me and H$_2$O

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The interfacial state between Ta$_2$O$_5$ and a Si substrate during the growth of Ta$_2$O$_5$ films by atomic layer deposition (ALD) was investigated using in-situ synchrotron radiation photoemission spectroscopy (SRPES). A newly synthesized liquid precursor Ta(NtBu)(dmamp)$_2$Me was used as the metal precursor, with Ar as a purging gas and H$_2$O as the oxidant source. After each half reaction cycle, samples were analyzed using in-situ SRPES under ultrahigh vacuum at room temperature. SRPES analysis revealed that Ta suboxide and Si dioxide were formed at the initial stages of Ta$_2$O$_5$ growth. However, the Ta suboxide states almost disappeared as the ALD cycles progressed. Consequently, the Ta$^{5+}$ state, which corresponds with the stoichiometric Ta$_2$O$_5$, only appeared after 4.0 cycles. Additionally, tantalum silicate was not detected at the interfacial states between Ta$_2$O$_5$ and Si. The measured valence band offset between Ta$_2$O$_5$ and the Si substrate was 3.22 eV after 3.0 cycles.

Keywords: Tantalum pentoxide, In-situ atomic layer deposition, In-situ synchrotron radiation photoemission spectroscopy