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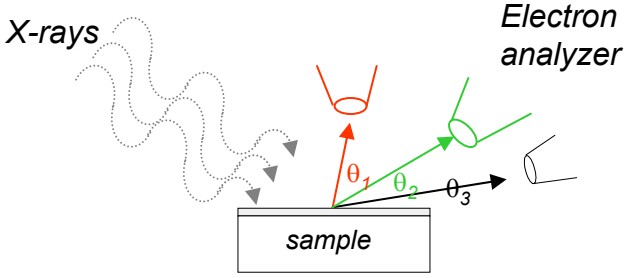
XPS and HR-TEM Analysis of High *k* Thin Films

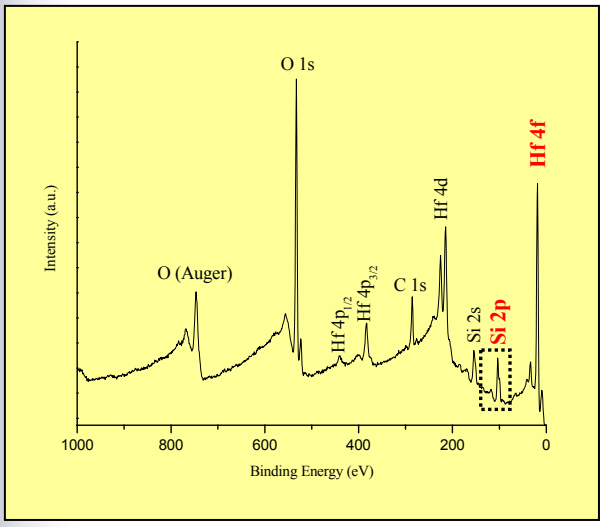
Background: $HfSiO_4$ is a candidate gate dielectric material for replacing SiO_2 in future generations of CMOS devices. Ultra thin films of $HfSiO_4$ were deposited from organometallic precursors on Si (100). Electrical measurements suggest there is an interfacial layer present between the Si and $HfSiO_4$.

Experimental approach: Angle resolved XPS (right) and high resolution cross-sectional TEM were utilized to investigate possible interfacial layer. XPS was chosen for its surface sensitivity and quantitative nature. TEM was chosen for its atomic-level spatial resolution.

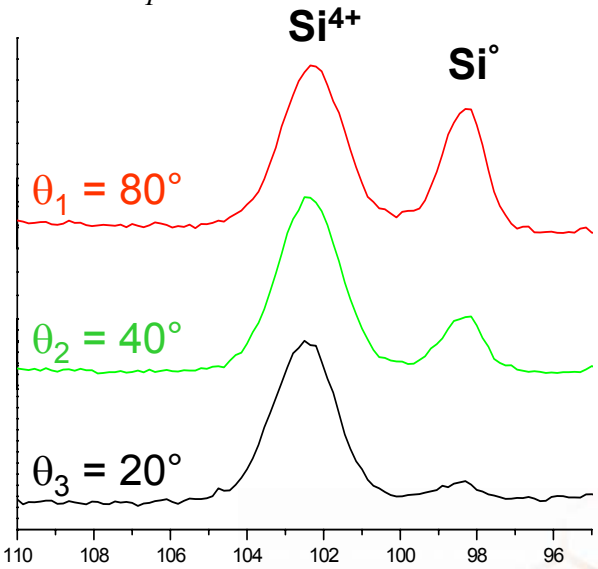


Angle resolved XPS experiment geometry

Results:
The XPS survey spectrum (lower left) reveals the presence of 17 atom% Hf. High resolution Si 2p spectra collected at different angles (lower right) confirms the presence of an extremely thin (<4 nm) oxidized silicon layer, but cannot determine if there is an intermediate SiO_x because of the similar Si 2p peak positions between SiO_2 and $HfSiO_4$.



Silicon 2p



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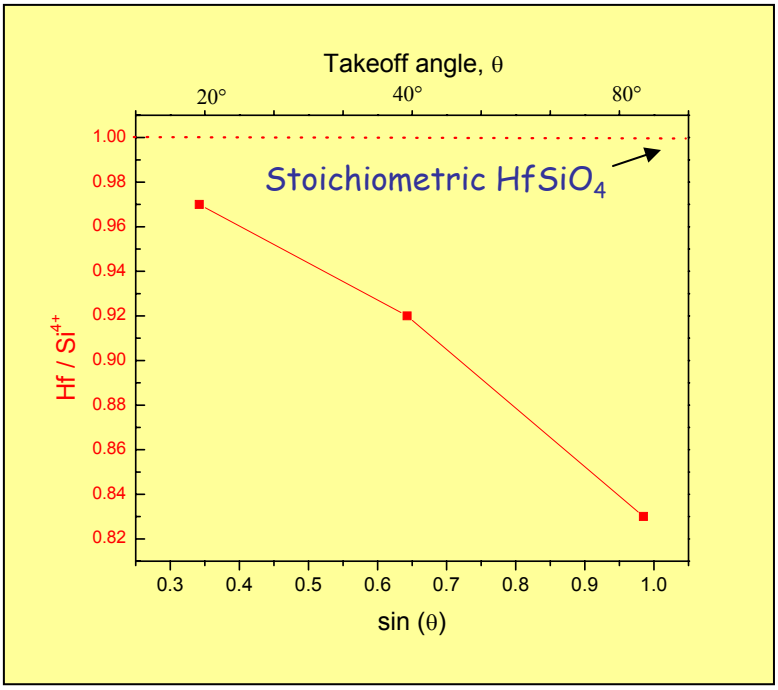
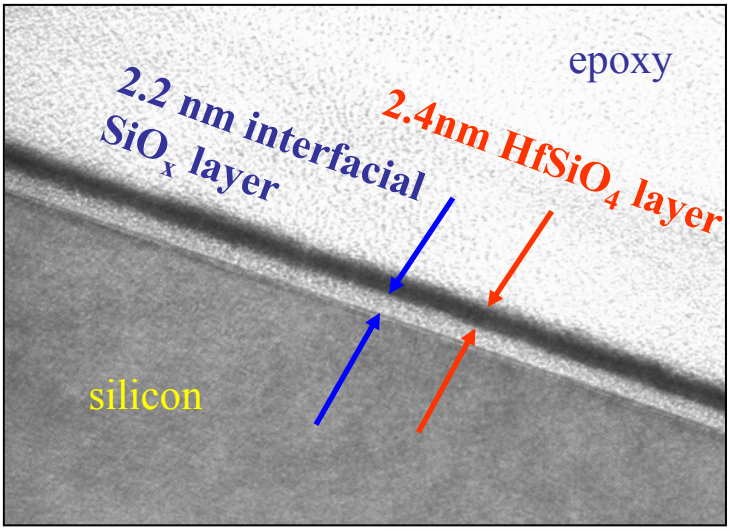
[Hf]/[Si^{4+}] ratio determined by XPS reveals a non-stoichiometric oxidized silicon layer at the $HfSiO_4$-Si interface.



Cross sectional TEM reveals a 2.2 nm interfacial layer underneath a 2.4 nm $HfSiO_4$ layer.



Acknowledgement: This work was performed by Dong Oh Lee under the direction of Prof. Jerzy Ruzyllo (Electrical Engineering).

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