Application Note: 31048

Parallel Angle Resolved X-ray Photoelectron Spectroscopy (ARXPS) Mapping of Ultra Thin SiO_2 on Si

Key Words

- Surface Analysis
- Elemental Information
- Measurement of Layer Composition
- Thickness Measurement to Below 1 nm

Wafer Mapping

Ellipsometry has traditionally been used by the semiconductor industry to monitor and measure the thickness of silicon dioxide grown on silicon. With the continuous trend towards reducing the thickness of the gate oxide to values below 2 nm it is not known if ellipsometer calibrations, made for thicker layers, can be extended down to the ultra-thin region.

Additionally ellipsometers are unable to distinguish between variations in oxide thickness across a wafer and variations in carbonaceous/water contamination. The replacement of silicon dioxide as the principal gate dielectric with more complex, multilayered materials also presents ellipsometry with a problem since buried layers cannot be directly characterized.

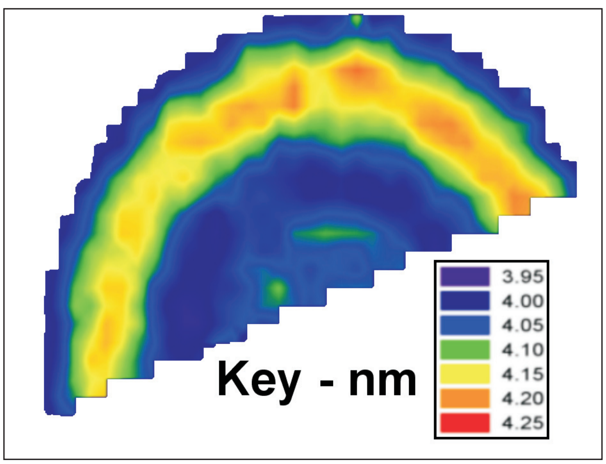

Figure 1: 2D representation of oxide thickness on 200 mm wafer from ARXPS data

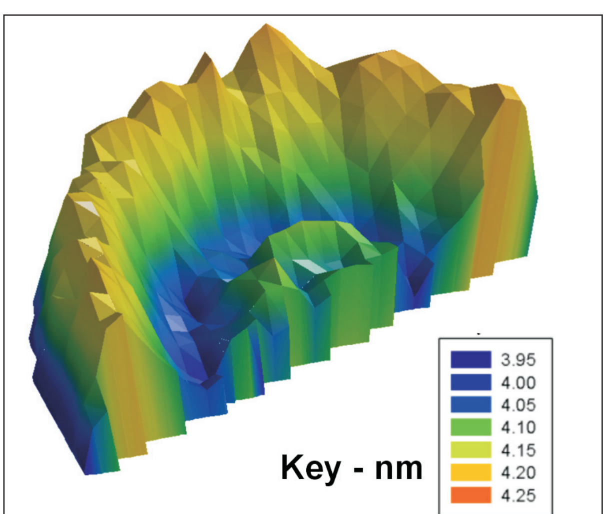

Figure 2: 3D representation of oxide thickness on 200 mm wafer from ARXPS data

X-ray Photoelectron Spectroscopy (XPS) and Angle Resolved XPS (ARXPS)

In contrast to ellipsometry, XPS can be used to measure silicon oxide thickness across a wafer with no interference from carbonaceous/water contamination. More complex gate dielectric materials can also be studied in detail, since the elemental specificity of XPS allows all elements and chemical states within the XPS sampling depth (~ 10 nm in silicon-based materials) to be explicitly characterized.

When combined with angle measurements, (ARXPS), it is possible to characterize the elemental and chemical state distributions within the gate material as a function of depth, providing non-destructive depth profiling.

Theta 300

Ellipsometric analysis of a segment of a 200 mm wafer with 4 nm of oxide showed a ring of oxide 0.2 nm thicker than the central region of the wafer. The true aspects of this oxide profile have been verified by mapping with the Thermo Scientific Theta 300 instrument. Theta 300 can provide similar maps to ellipsometry for 300 mm wafers with a thickness precision of 0.01 nm (0.2%).

Acknowledgement

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Reference

M.P. Seah and R. G. White Surf. Interface Anal. 2002; 33: 960-963

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In addition to these offices, Thermo Fisher Scientific maintains a network of representative organizations throughout the world.

Africa
+43 1 333 5034 127

Australia
+61 2 8844 9500

Austria
+43 1 333 50340

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+32 2 482 30 30

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+86 10 8419 3588

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Sweden/Norway/Finland
+46 8 556 468 00

Switzerland
+41 61 48784 00

UK
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