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Residual Stresses in Deposited Thin-Film Material Layers for IC Manufacturing
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MOTIVATION

- Residual stress widely exists in the thin-film material (metal, semiconductor and dielectric) layers used in IC manufacturing.
- The residual stress can significantly impact the device device behavior, performance, reliability and manufacturability.
- Fast and accurate characterization of residual stress is critical for the stress control and optimization of the fabrication process.

HYPOTHESIS

- Residual stress is contributed by a large number of factors, which can be either compressive or tensile.
- When deposited on one side, the residual stress in the thin film can cause bending or warpage of the supporting substrate.
- The overall residual stress and its spatial distribution can be characterized by the local curvature of the substrate.

RESULTS

- Substrate: 200-μm {100} single-crystal silicon wafer
- Deposited thin film: 200-nm SiO_2 with PECVD
- Wafer curvature measurement: Bruker Dektak® Surface Profiler
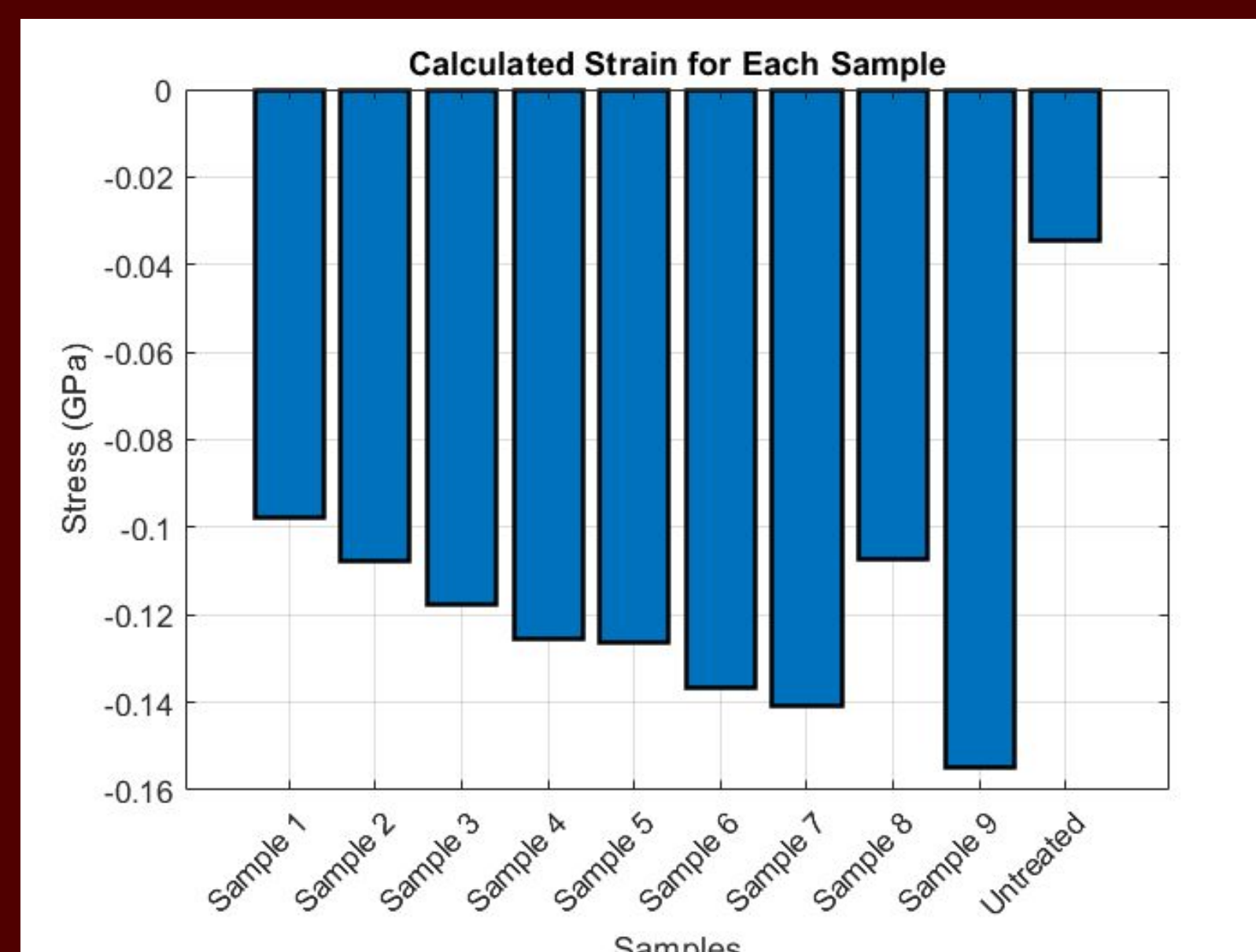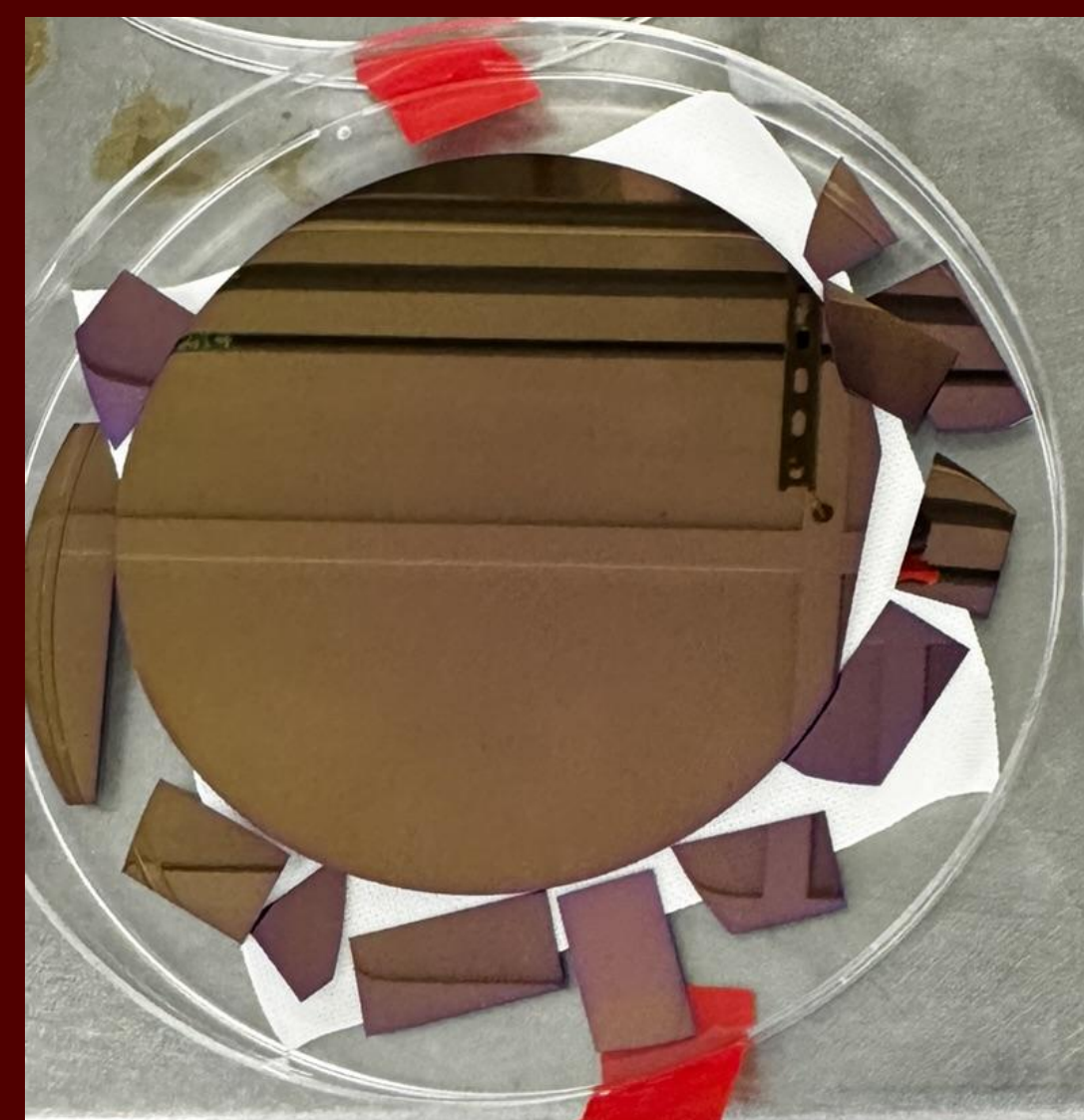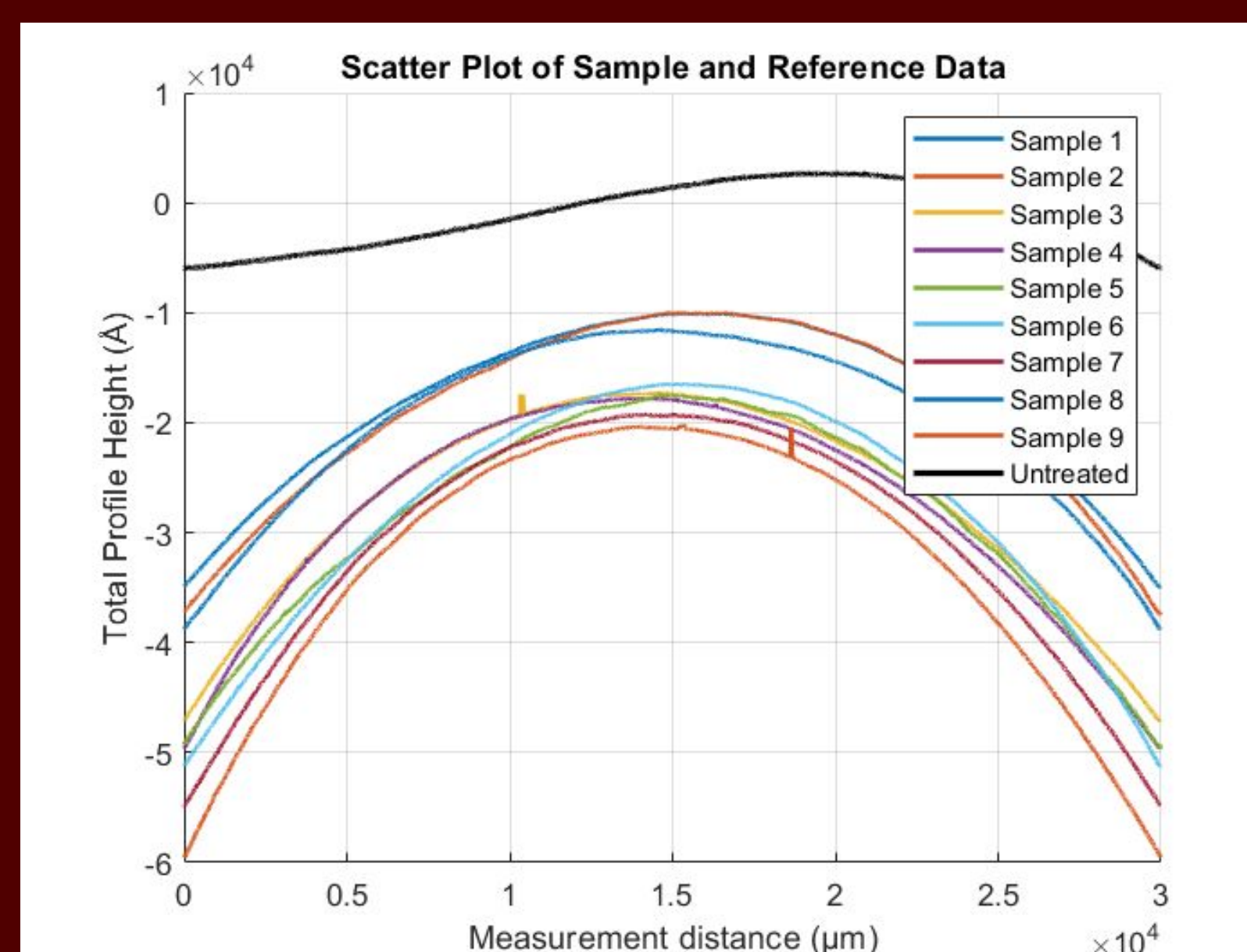
DISCUSSIONS

- Average stress level: -123.8 MPa
- Standard Deviation of 0.0183 MPa

- Negative stress means the deposited film is under compression, which makes the substrate buckle up.

- Some variation between the parts of the wafer, but still fairly closely grouped across the surface of the wafer sample.

$$T_f = \frac{E_s h_s^2}{6 h_f R (1 - v_s)}$$

T_f - Residual Stress E_s - Substrate Young's Modulus
h_f - Film thickness h_s - Substrate thickness
R - Radius of curve v_s - Poisson ratio of 100 Si crystal

CONCLUSIONS

- Wafer curvature measurements under a surface profiler can serve as an quick and effective way for non-destructive evaluation of residual stress in thin films.

- This method can be expanded for the investigation of different deposition conditions and different materials.

ACKNOWLEDGEMENT