

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

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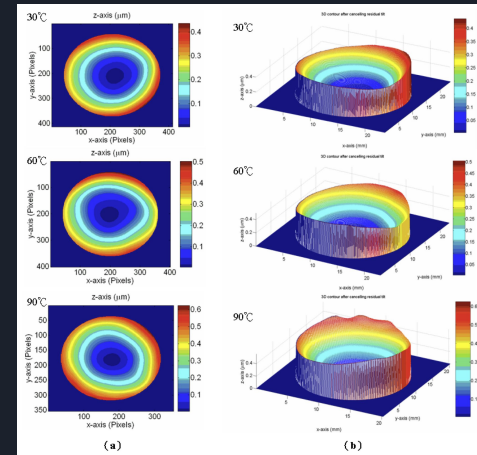
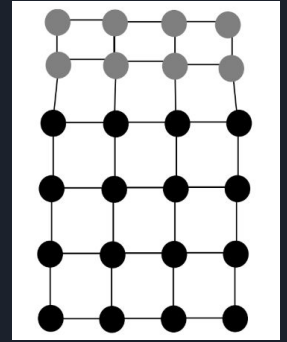
Introduction & Outline



- Importance of residual stress in IC manufacturing
- Residual stress measurement methods and results
- Methods to manage and mitigate residual stress
- Milestones achieved and future plans

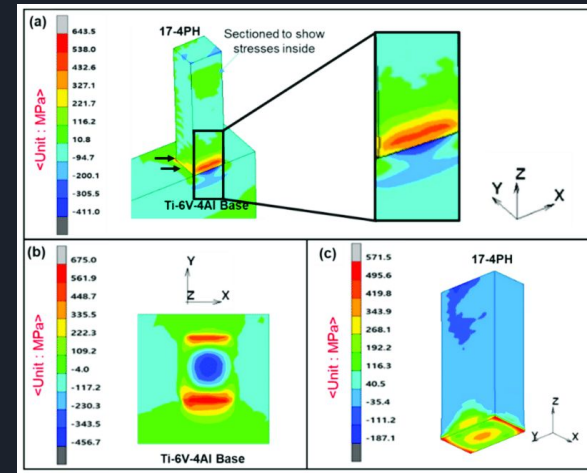
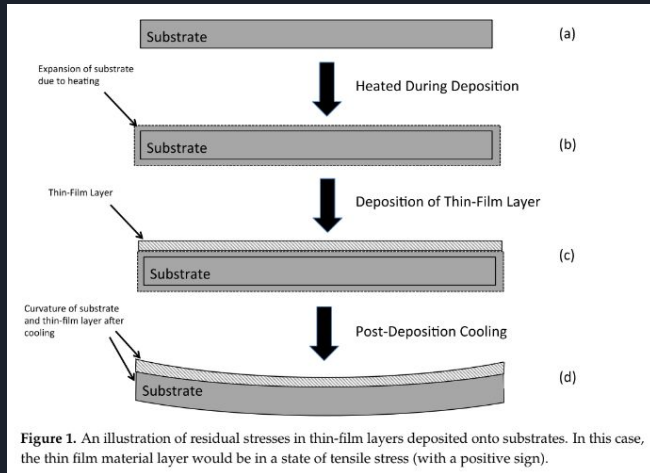
Importance of Residual Stress in IC Manufacturing

- Intrinsic Stresses
 - Caused by deposition process conditions (e.g., lattice mismatch, grain boundaries)
- Extrinsic Stresses:
 - Arise from environmental factors (e.g., thermal expansion mismatch)
- Impact on Device Performance
 - Altered mechanical stiffness
 - Device failures like cracking, buckling, or delamination
 - Strain engineering for device performance improvement



Residual Stress Measurement Methods

- Wafer Curvature Measurement
 - Stoney equation for calculating stress from curvature
- Test Structures
 - Buckling beams, Guckel rings, and strain-based tests



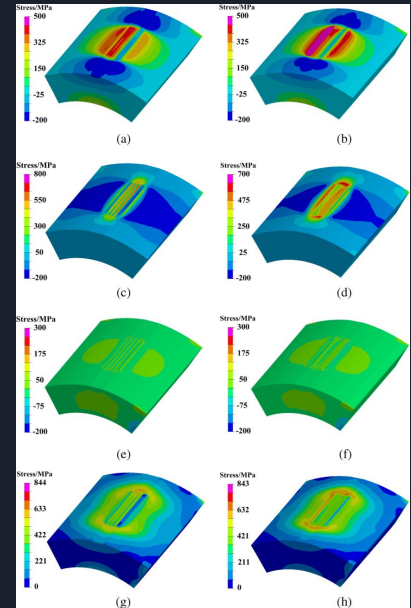


Residual Stress Level in Typical Thin-Films for Semiconductor Fabrication

Material	Chemical Vapor Deposition	Physical Vapor Deposition
Polysilicon	LPCVD: -340 to 1750 MPa	N/A
Amorphous Silicon	PECVD: -575 to -130 MPa	Evaporation: 300 MPa Sputter: -22 to 164 MPa
SiO	LPCVD: -10 to 200 MPa PECVD: -80 to -25 MPa	Sputter: -90 to 3000 MPa
SiN	LPCVD: 967 to 1020 MPa PECVD: -250 to 375 MPa	N/A
Metals	N/A	Evaporation: Varied
Takeaways	High residual stress variability	Lower temperature process with lower stress

Methods to Mitigate Residual Stresses

- Process Parameters for Optimization:
 - Temperature
 - Pressure
 - RF Power
 - Gas Mixture
 - Deposition Rate
- Material selection and layer design
 - Stacking material layers with different residuals stresses
 - Adjust the stoichiometry of the deposited material
- Annealing
 - Temperature Profile





Milestones and Future Plans

- Studied the different semiconductor fabrication processes
 - Deposition
 - Photolithography
 - Etching
- Conducted a literature study of the residual stress in thin-films
- Future plans
 - Obtain training in the AggieFab on facilities and processes
 - Conduct thin-film deposition experiments
 - Characterize the thin-film stress level
 - Study the optimization procedures and methods