A New Prognostic Tool for TSV Reliability Assessment Using RF Signals
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Objective
To assess the suitability of RF-based measurement technique as a metrology tool for studying the reliability performance of through-silicon via (TSV).

1. Why Use RF-Based Technique?
   - Reliability analysis over broad frequency ranges
   - Sensitivity to discontinuities in and around conductive paths; metals, dielectrics, semiconductors
   - Measurement of both reflected and transmitted signals
   - High sensitivity to the presence of defects

2. Experiment
   - RF Test Structure
     - Ground-Signal-Ground (GSG) configuration.
     - Daisy chain of 60 TSVs
     - 34 die samples analyzed
   - Temperature Cycling Profile
     - Two port S-parameter measurement: 500 thermal cycles intervals
   - Physical failure analysis: FIB and TEM techniques

3. RF-Based Results
   - Statistical analysis based on 34 dies show that at 20 GHz and below, that the maximum insertion losses occurs after initial 500 cycles and after 2000 thermal cycles.

4. FIB Based Results
   - No significant voiding in TSV central region
   - Void formation at TSV –TaN interface
   - Increases with # of thermal cycles
   - TSV-M1 voids linkup with TSV-TaN voids
   - M1 void propagation upon thermal cycling
   - Void propagation at the TSV- Bottom metal line interface upon thermal cycling

5. Conclusions
   - RF-Based technique is an effective method for the assessment of TSV reliability.
   - Thermal cycling leads to the degradation of RF signal characteristics of TSVs.
   - The degradation of TSV RF characteristics with thermal cycling is associated with the formation and growth of voids.