Finding a Nearest Neighbor Residual Threshold
A Linear Method

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Learning From Data
ECE457

Goal

• Find optimum NNR threshold

Background

• Defects are found using different methods.
  • Functional test
  • NNR method
  • Burn-in

Defects

• Same mechanisms for all defects
• Ease of detection
  – Location of Fault
  – Size of Fault

Finding Defects

• Wafer Sort
  – Functional Testing
  – NNR Method
  – Other Methods
• Burn-in
  – Catches Reliability Fails

Functional Test

• Sends inputs gets outputs
• Compare output to expected output
  • Catches Most faults.
  • Not 100% Coverage
What is NNR?

- Nearest Neighbor Residual
  - “Neighborhood” estimates IDDQ for a die location.
  - Difference between estimate and measured IDDQ
- NNR Looks at IDDQ Data
  - IDDQ is Quiescent Power supply current.
  - Defects increase Current
  - Process affects Current
- Picks out slight differences between “neighbors”
  - Differences have 2 possible causes
    - Process
    - Defect

Assumptions

- There is a Threshold where NNR method works.
- There is a linear relationship between the number of failures per die caught using the two methods.
- This relationship has a positive slope.
  - If there are x Functional fails I expect k*x NNR Fails
  - Basis is that the defect mechanism is the same for both.

Defect Mechanisms

- Particle
- Scratch
- Mask Flaw
- Crystal Structure Flaw

Procedure

- Find and count number of functional fails per wafer.
- Find and count number of NNR fails per wafer indexed by a range of NNR thresholds
  - Normalize both sets of data with 0 mean and unit variance
  - Estimate modeling coefficients
- Plot results over data
- Find results with slope >0
- Does it make sense

Linear Estimation for various thresholds

Least Squares solution of ASE generates coefficients

\[ w = (A^T A)^{-1} A^T y \]
What did I learn

• 16 wafers is not enough data to get conclusive results
• There is only a small range of NNR thresholds that resulted in a positive linear estimate of the data.

Significance

• There is a threshold where the data has a small positive slope.
  – NNR may be catching failures best at this threshold.
  – For intel data this slope has been shown to be about .01-.02
• More research is warranted with more data to decide more conclusively where to set this threshold