# Now Silicon is Cheap, but Testing is expensive

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# Impact on Dependability

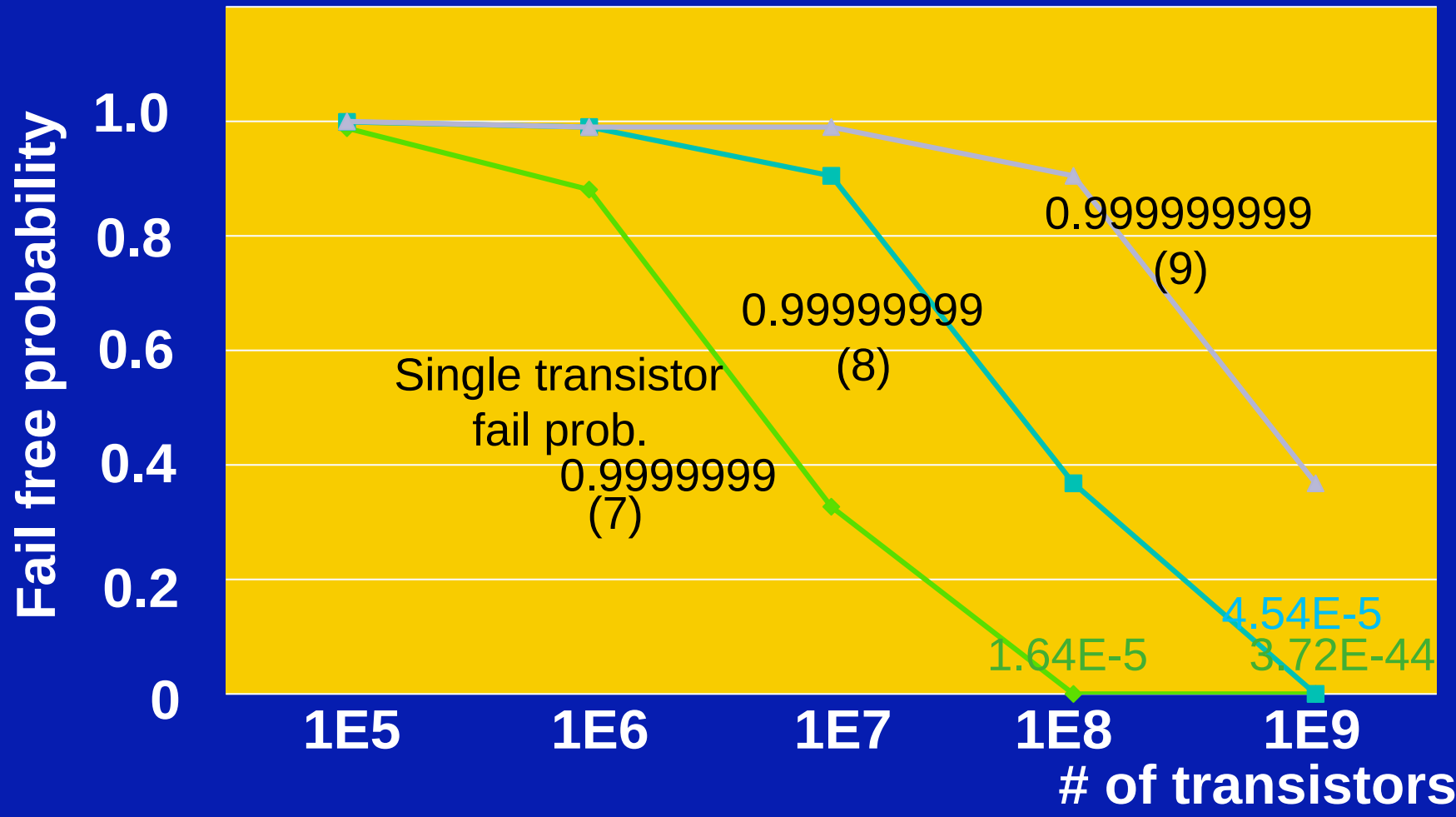
- What nanometer size devices mean to dependability?
  - Sorting out all defective chips is extremely difficult
    - Even high fault coverage means very large no. of uncovered faults
      - 99% stuck-at coverage for 10M gate design means 2b00,000 uncovered faults
    - More unmodeled defects that are not covered by traditional fault models (stuck-at, delay, etc)

# Impact on Dependability

- What nanometer size devices mean to dependability? (continued)
  - Premature failures due to latent defects may be even more serious problem
  - To maintain reliability, every single transistor on billion transistor chip should function correctly for a promised period

# Impact on Dependability

**Probability that no transistors fail in X years**



# Latent Defects

- Traditional latent defect screening methods are less effective in nanometer devices
  - Increase in leakage current -> IDDq testing
  - Low Vdd voltage -> accelerating burn-in time by applying higher voltage not work
  - Other reliability screening methods (outlier screening using minVdd, Fmax etc) are used or under development to improve screening
    - Significant cost increase is inevitable

# Latent Defects

- Applications that require very high reliability are increasing
  - Automotive (x-by-wire), remote patient monitoring, etc.
  - Less than perfect screenings will be serious problems in these applications

# Cheap Silicon

- Good news: while test is expensive, silicon is cheap
  - Relentless scaling drastically reduced manufacturing cost
    - Using some chip area to reduce other costs is very natural (economically)
    - E.g., DFT circuit is widely used to improve fault coverage and lower test cost
  - What about design-for-reliability?
    - Field-repair capability

# Cheap Silicon

- Many applications cannot use traditional nMR fault tolerance techniques
  - High cost, n-1 additional cores
  - High power
    - Larger heat dissipation can be a serious problem in automotive application
  - Common-mode-failure

# Built-in Self-repair

- Built-in self-repair is widely used in memory industry
  - But, it targets yield improvement rather than reliability
  - Repairs are done at manufacturing step and cannot be used for field repair
  - IBM eFuse targets field-repair of embedded memory
  - Why not field-repair of random logic?

# Built-in Self-repair

- Spare based field-repair
  - Achieves high reliability with low test cost
  - Has cost advantage over nMR
    - TMR needs 3 cores, but spare needs 2 cores
  - Consumes little additional power
  - There are many technical challenges to be solved before wide adoption
    - Quick and accurate diagnosis, self-repair mechanism (functional and timing correctness), spare cost, short repair time, etc.