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Burn-In Concepts and Recent Developments

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Content

- Early failures
- BI-concepts
  - Productive BI
  - Qualification BI
- Quality dilemma
  - Sample size vs. quality level
  - Incorporate additional information
- Summary

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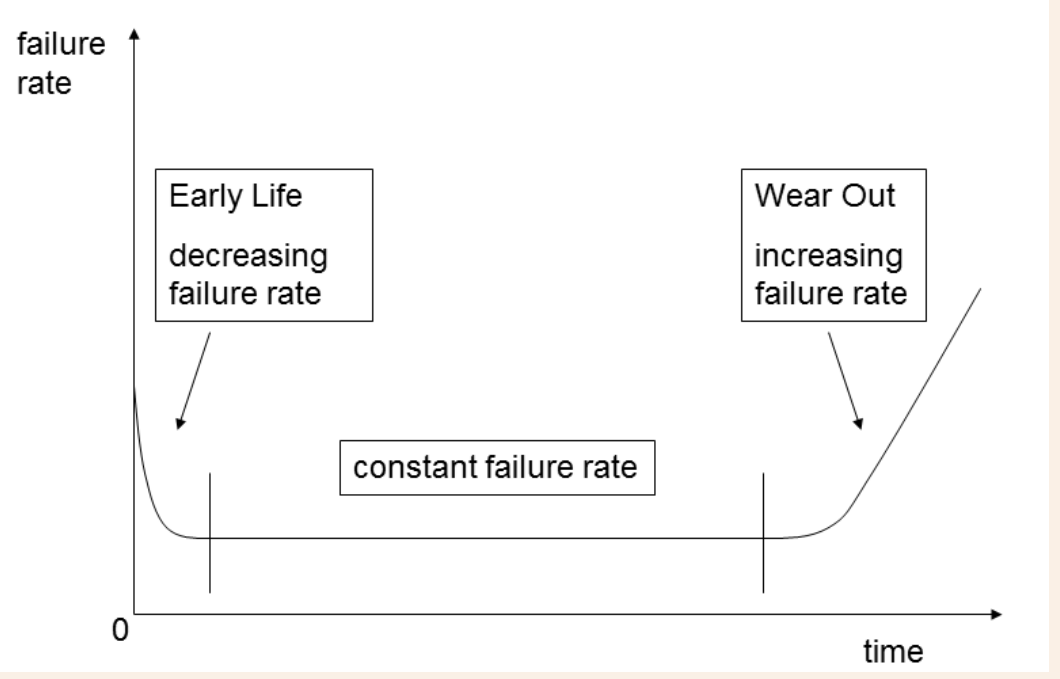
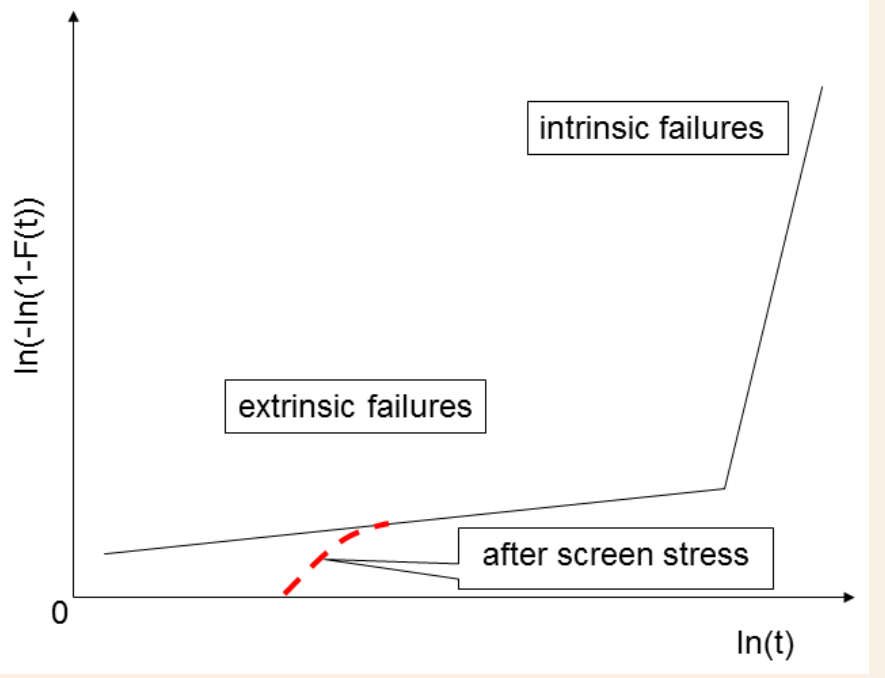
Early failures

- Bathtub curve



Early failures

- Overstress at oxides
  - Extrinsics follow Weibull-distribution with β < 1
  - Overstress screens out extrinsics
  - Modelled by a conditional Weibull distribution
    - → for small t: exponential distribution
    - → constant FIT-rate



Early failures

- Weed out early failures
  - Defect density reduction
  - Optical inspection
  - Stress test
  - Postprocessing
    - Part average testing (univariate, multivariate)
    - Statistical bin analysis
    - Nearest neighbor yield
    - …

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Productive Burn-In

100 % Burn-In

- Integrated part of the production flow
- Overstress during Burn-In
- BI-Time reduction, but no BI-release

Conditional Burn-In

- Burn-In is triggered by certain criteria
  - Yield loss at 100 % BI
  - Failure limits for certain tests
  - If BI is triggered: flow like 100 % BI

Qualification Burn-In

BI-Study

- Random sample from production
- BI is performed under very controlled conditions; every failure is investigated
- Inference from random sample to remaining production volume

BI-Monitoring

- Production monitoring
- Ramdon samples are taken continuously from production (e.g. from each lot) and put to BI
- BI-monitoring: flow like BI-study

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BI-sampling – sample size vs. quality

Quality dilemma

- Quality targets are continuously lowered
  - 0.1 %, 1 ppm, << 1 ppm
  - 0 defects
- Sampling resolution on attributive data:

Testplan	p @ 90 % CL
0 / 10,000	230 ppm
0 / 100,000	23 ppm
0 / 2,300,000	1 ppm

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Incorporate additional information

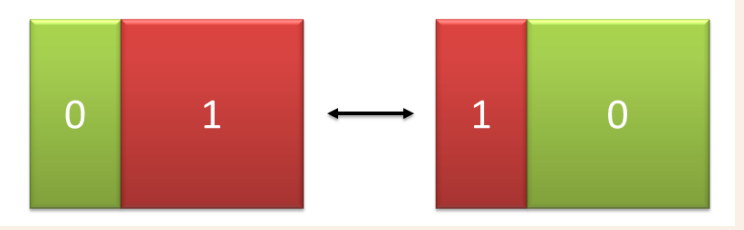
- Countermeasure Model
  - After a failure, a countermeasure is introduced.
  - The efficiency of the countermeasure is estimated with experts and quality department.
  - This information can be added to the random sample. It results in a lower *p*.
- Model equation:
  - α = efficiency of countermeasure
  - $1 - CL = \alpha \cdot B(0,n,p) + (1- \alpha) \cdot B(1,n,p)$

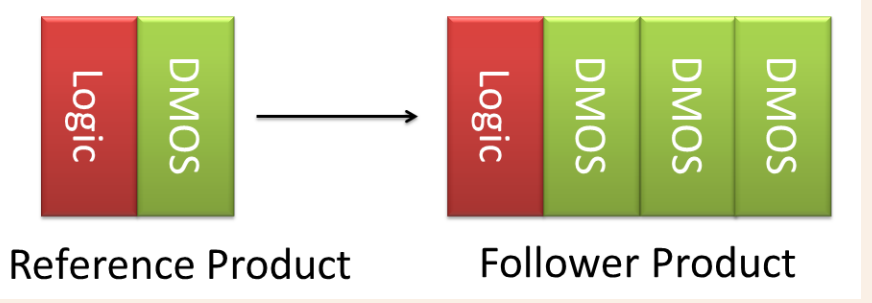
Incorporate additional information

- Countermeasure Model
  - Example:
    - α = 80 %,
    - p_{target} = 100 ppm @ 90 % CL → 0 / 23,000 pcs.
    - 1 / 23,000 pcs = 169 ppm @ 90 % CL
    - Model equation:
      - *1-0.9 = 0.1 = 0.8·B(0,n,p) + (0.2)·B(1,n,p)*
    - Numerical solution:
      - *p*: 119 ppm @ 90 % CL
      - *n*: 23,000 + 4,394 = 29,394 pcs.
    - Use for calculation: R-package *GenBinomApps*

Incorporate additional information

- Separate Area Scaling

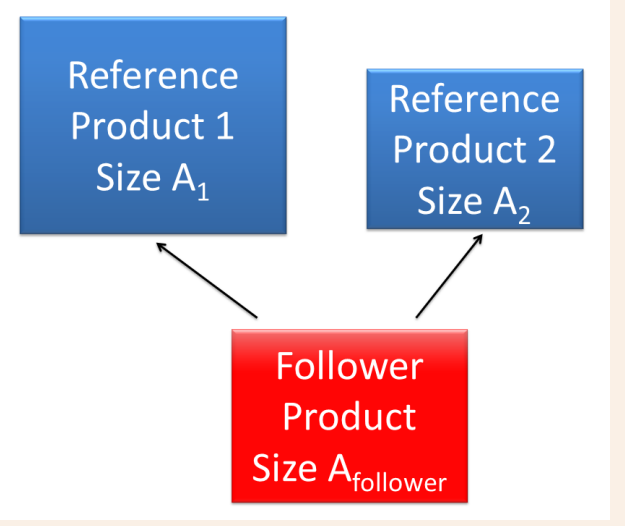




  - BI-Study: 1/100k → 39 ppm @ 90 % CL
  - Follower product:
    - Classical area scaling: 78 ppm @ 90 % CL
    - Separate area scaling: 65 ppm @ 90 % CL

Incorporate additional information

- Multiple Reference Products



  - Reference product 1: 10 mm^2, 1 / 75 k → 51,9 ppm @ 90 % CL
  - Reference product 1: 5 mm^2, 1 / 69 k → 56.4 ppm @ 90 % CL
    - → Follower product: 4 mm^2, 19.4 ppm @ 90 % CL

Incorporate additional information

- Synergy Model
  - Subsets were already burnt in other studies
  - Example:
    - Product with new metal block, 1 failure in Si.
    - 1 / 23,000 pcs = 169 ppm @ 90 % CL
    - Technologies with same Si: 0 / 69,000 pcs.
    - Synergy model:
      - → 130 ppm @ 90 % CL
      - Burn 23,000 + 8,177 = 31,177 to reach p_{target} = 100 ppm @ 90 % CL.
    - Use for calculation : R-package *AdvBinomApps*

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Summary

- 100% BI is a method to screen out (nearly) all early failures.
- BI sampling can be used to proof a certain early life failure level.
- In case of sampling plans with acceptance numbers > 0:
  - Additional information can be added to the random sample.
  - This can further reduce the estimated ppm-level.

References

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- Failure probability estimation with differently sized reference products for semiconductor burn-in studies, Applied Stochastic Models in Business and Industry, Volume 31, Issue 5, Sept./Oct. 2015
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