Tutorial: Probe Card Evaluation Process

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Agenda

- Acknowledgements
- Ground Rules
- Background
- Probe Card Selection Criteria
- Probe Card Specifications
- Evaluation Process
- Conclusions

Acknowledgements

- I wish to acknowledge the contributions of Intel's Next Generation Flash Probe Working Group to this tutorial:
  - Mike Dang, Santa Clara
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  - Susanne Lubash, Aloha
  - Kurt Guthzeit, Folsom
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- Suppliers: Cascade Microtech, Cerprobe, Custom One Design, Form Factor, Micro Probe, Probe Technology, SV Probe

Ground Rules

- Maintain an informal environment
  – Ask your questions as they arise
- Respect your colleagues
  – Keep side conversations under control
- Get out on time!

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Background

- Probe card industry
  - Dominated by epoxy ring cantilever needles
  - Many small suppliers, few large ones
  - Very competitive environment
  - Limited development capabilities
  - Stake in maintaining the status quo

Background (cont'd)

- Probing requirements are pushing beyond the envelope for cost effective use of needles
  - Fine pitch pads
  - Area array pads
  - Multi-die
- Building the cards is not the problem so much as using them is.

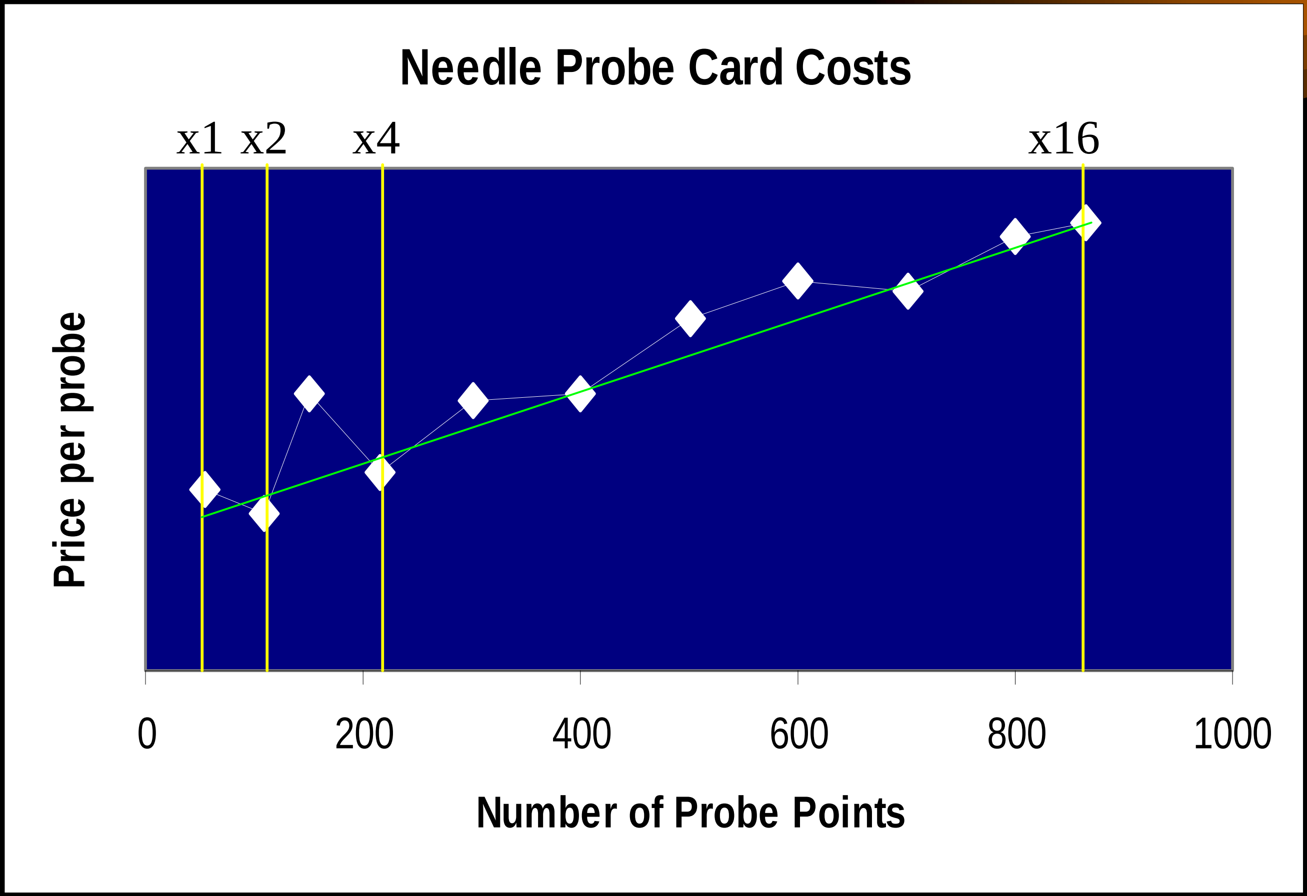
Background (cont'd)

- New technologies are appearing with key attributes:
  - Photolithographic
  - Machined
  - Manufactured
- Some new entries to the probe card market
  - Lack detailed knowledge of probing

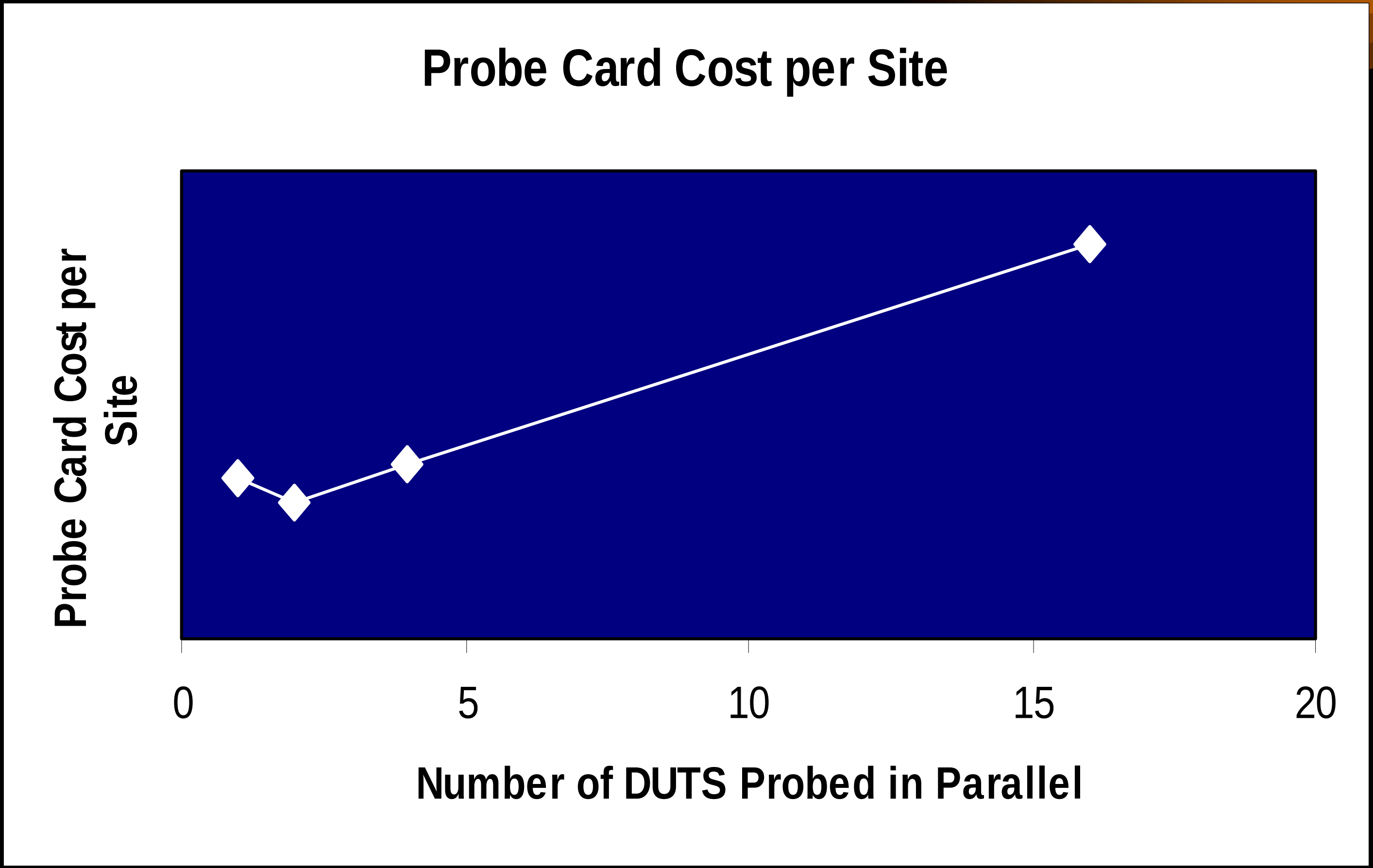
Background (cont'd)

- Our situation:
  - Highly competitive commodity flash memory
  - Manufacturing cost is key
  - Currently probing x16
    - Going wider
    - Considering full wafer ultimately
  - Need to enable next generation wafer testing with probe capability

Background (cont'd)



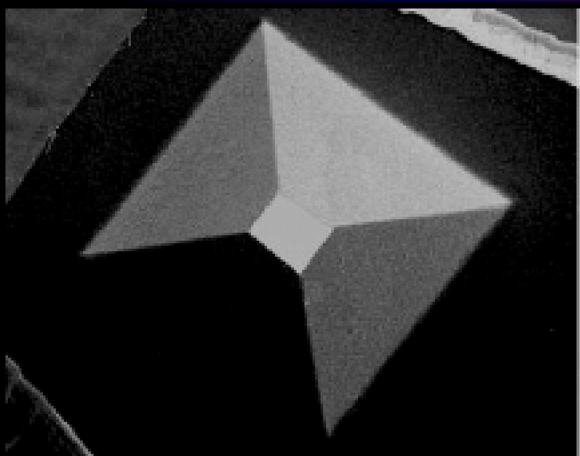
Background (cont'd)

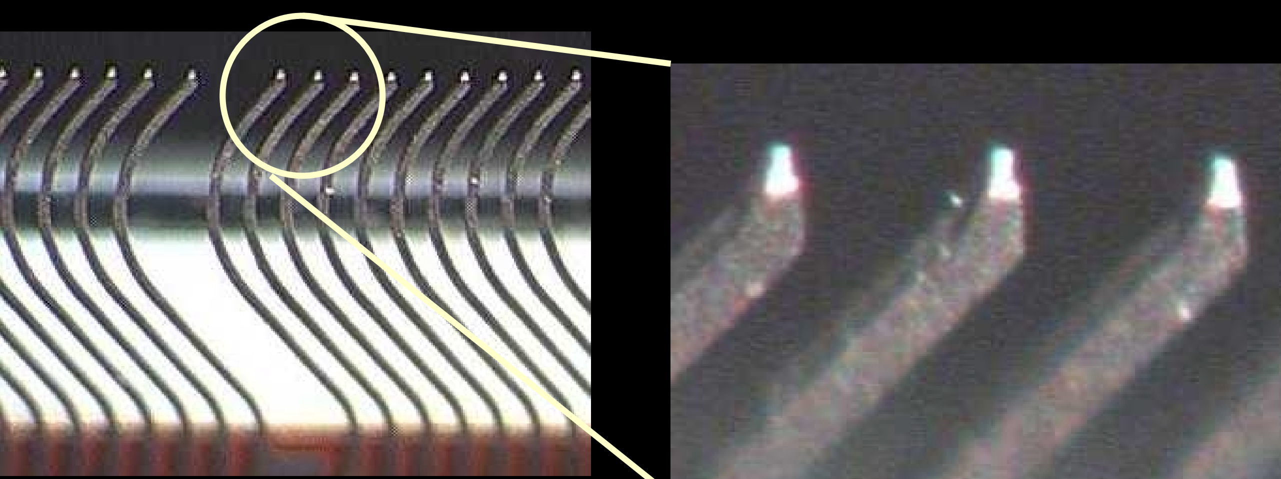


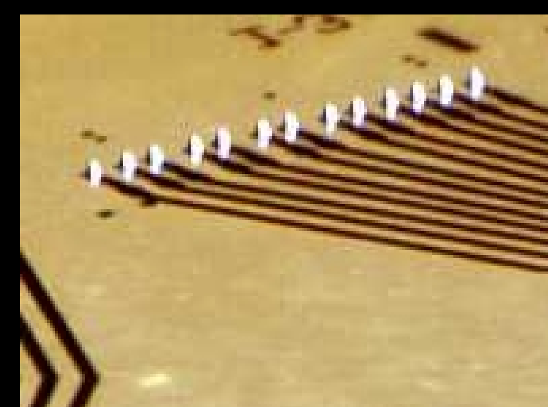
Background (cont'd) Candidate Technologies

- Vertical buckling beam
- Membrane
- Conglomerate bump
- Photolithograhpically defined beams
- others

Background (cont'd)
Candidate Technologies







Background (cont'd)

- So why are we doing this?
  - Probe technology is generally not viewed as providing a competitive advantage
  - New probe technology is expensive to develop
  - Higher volume drives lower costs
  - Suppliers cannot adequately evaluate their technologies independently
  - Sharing methods and results can accelerate learning and innovation in the market.

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Probe Card Selection Criteria

- Several areas of consideration in making a selection:
  - Technical
  - Performance
  - Commercial
  - Supplier capabilities
  - Financial
  - Environmental Health and Safety (EHS)

Probe Card Selection Criteria (cont'd): Technical

- Does the technology meet your specifications?
  - Layout flexibility
  - Planarity
  - Contact resistance
  - Current carrying capacity
  - Pad damage
  - AC characteristics
  - etc.

Probe Card Selection Criteria (cont'd): Performance

- Does the technology work in your manufacturing process?
  - Yield
  - Bin fallout
  - Repeatability
  - MTBF, MTTR
  - Run rate
  - etc.

Probe Card Selection Criteria (cont’d): Commercial

- Is the supplier prepared to meet your needs for manufacturing quantities?
  - Delivery
  - Capacity
  - Financial health
  - Warranty
  - Service
  - etc.

Probe Card Selection Criteria (cont'd): Supplier Capabilities

- Does the supplier have the technical capabilities to support the technology?
  - Engineering organization
  - Analysis capabilities
  - R&D organization
  - Technology roadmap
  - Design capabilities
  - etc.

Probe Card Selection Criteria (cont'd): Financial

- What is the total cost of ownership of the technology?
  - Purchase price
  - Lifetime
  - Maintenance and repairs
  - Retrofits
  - Headcount
  - etc.

Probe Card Selection Criteria (cont'd): EHS

- Does the technology include any EHS concerns?
  - Final product
  - Production integration
  - Manufacturing process
  - etc.

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Probe Card Specifications

- Define the technical requirements of the probe technology
  - DC electrical: contact resistance, leakage, signal path resistance, current capacity, etc.
  - AC electrical: bandwidth, capacitance, cross talk, etc.
  - Mechanical: alignment, planarity, force, pitch, layout, etc.
  - Other: pad damage, environment, lifetime, etc.

Probe Card Specifications (cont'd)

- Must be defined up front before discovery
  - Complete and specific
- Based on process/product requirements
  - avoid wish lists
  - clarify between "must have" and "nice to have"
- Avoid technology specific requirements
  - e.g scrub mark, beam length, contact force
  - Break out of the needle mindset

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Evaluation Process

- How do we determine compliance with specifications and fit into the manufacturing process?
  - Technical
  - Performance
- How do we do this repeatedly?
- How do we do it cost effectively?

Evaluation Process (cont'd)

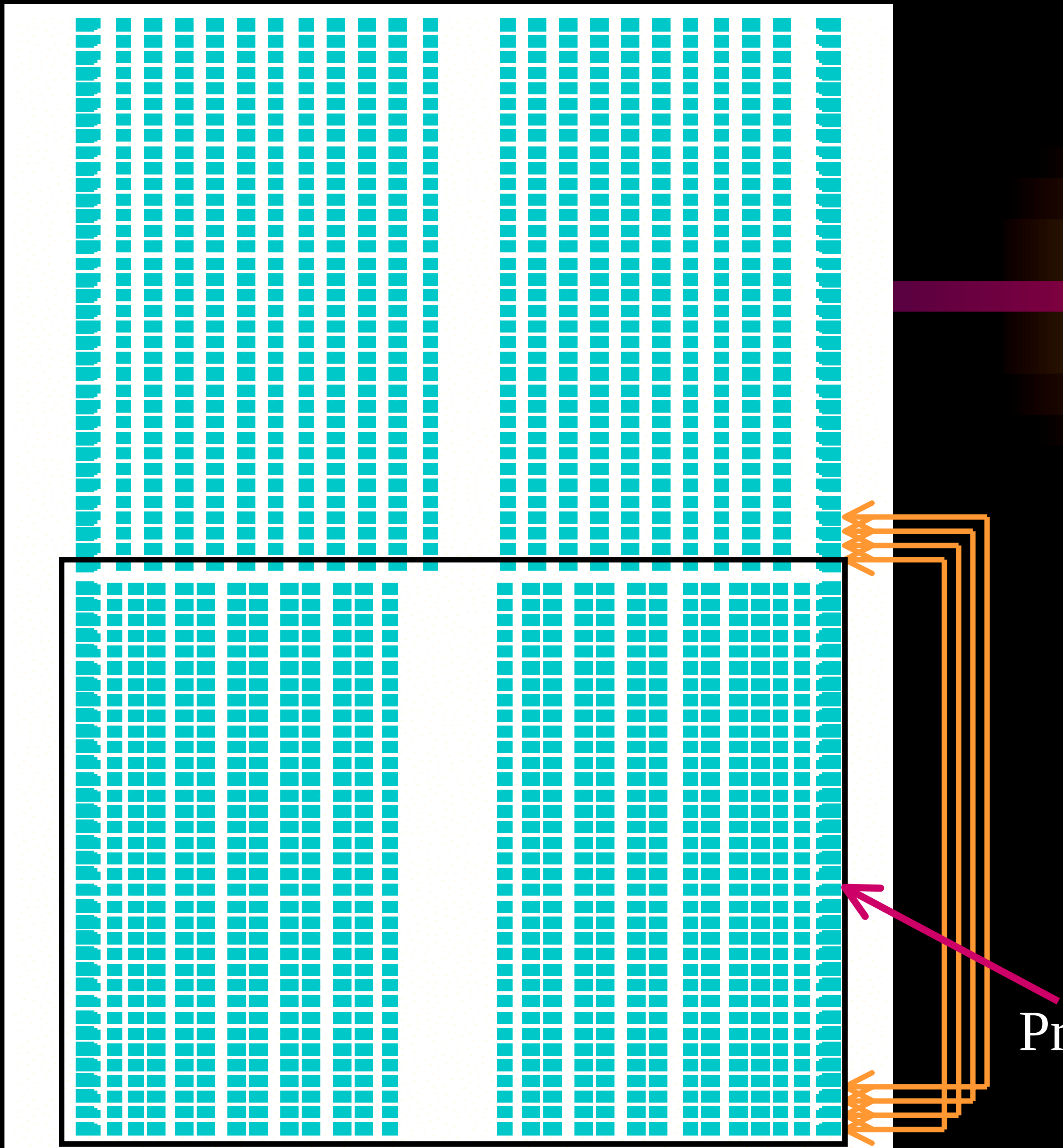
- What are the available resources?
  - People
  - Probers
  - Testers
  - Off-line tools
  - Wafers
  - etc.
- Where is the likely bottleneck?

Evaluation Process (cont'd)

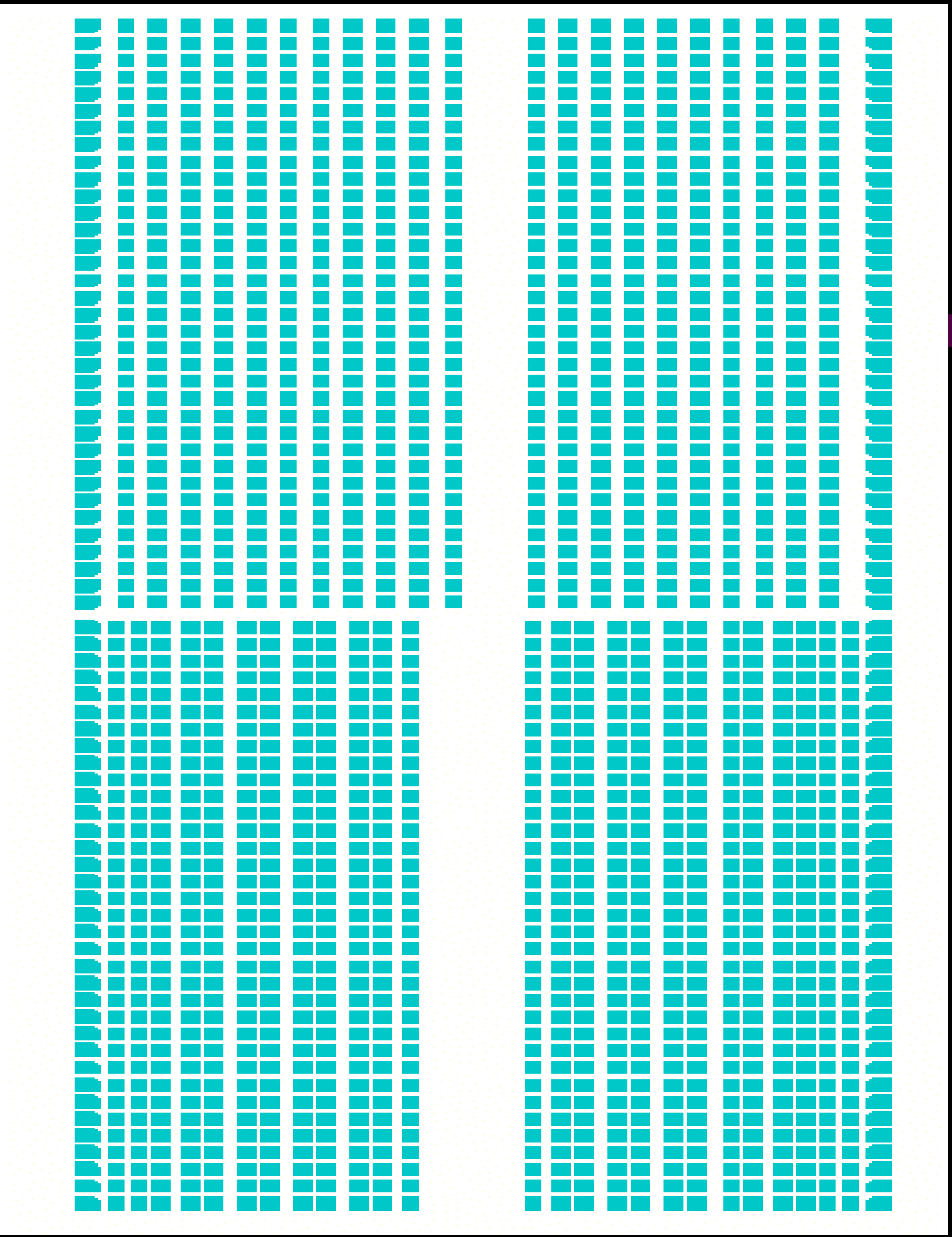
- Manage the bottleneck
  - Minimize demand
  - Maximize efficiency
- Warning--the bottleneck may change!

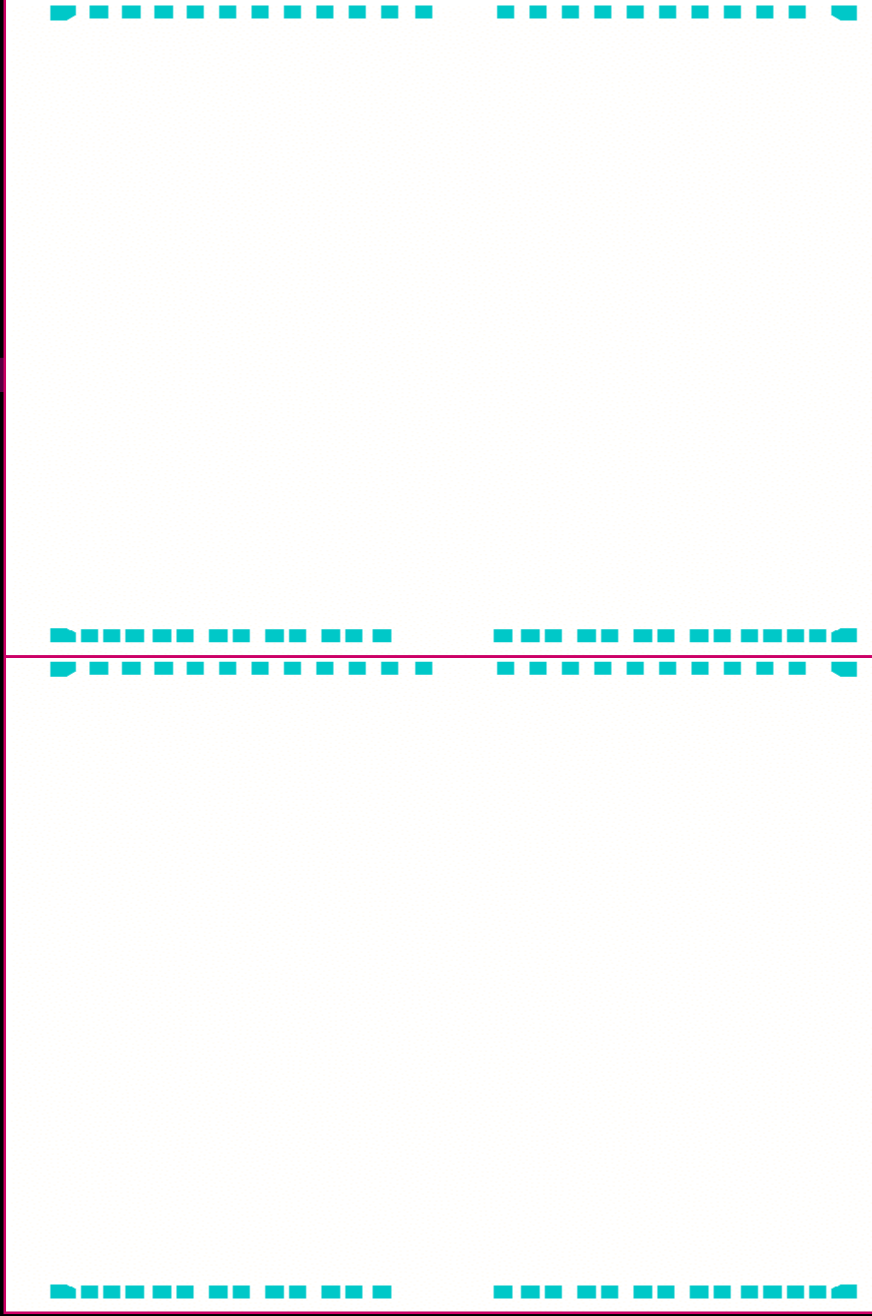
Evaluation Process (cont'd): Our Resources

- People
  - probe engineers shared with production
- Equipment
  - probers (shared)
  - IC testers (shared)
  - probe card analyzers (shared)
  - probe mark analyzer (shared)
  - microscopes (shared)
- Wafers: bare Al, probe test chip, and product



- Test chip provides for multiple touchdowns on a single die site. 30+ wafers worth of TDs per wafer.
- Allows for single probe card for both test chip and product.





Evaluation Process (cont'd) Our Bottlenecks

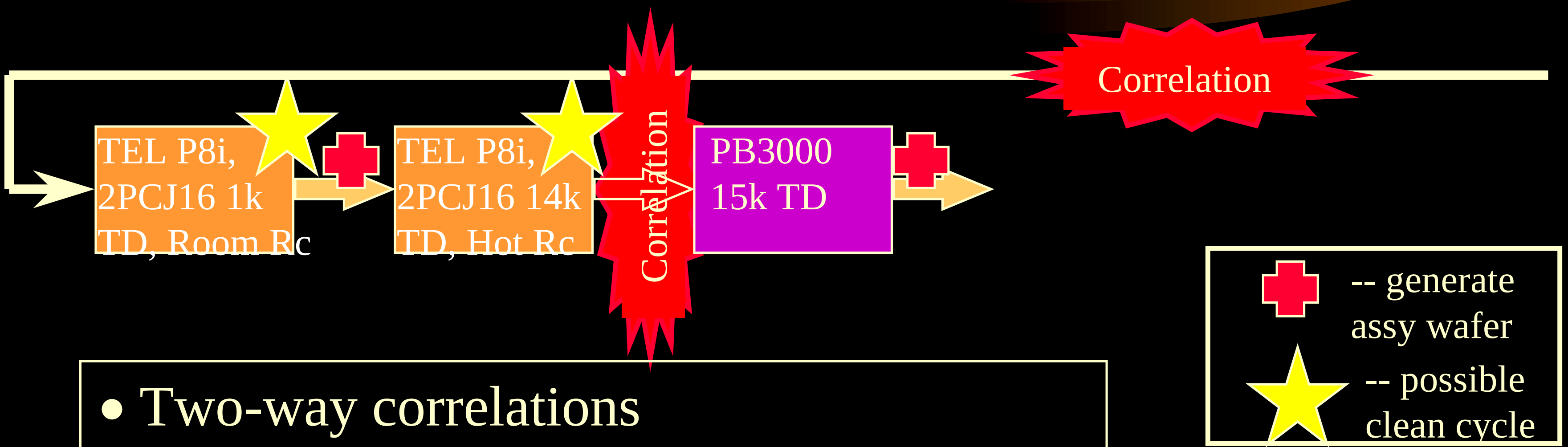
- Initial pass showed IC testers as bottleneck
- Evaluation protocol developed to minimize requirements for testers
- Learn all we can before putting card on the tester
  - Alignment, planarity, tip geometry, prober compatibility, probe mark characteristics, operating conditions
- Understand the starting state (t_0)of the card

Evaluation Process (cont'd) Protocol Phase 1

Evaluation Process (cont'd)
Performance Characterization

- How does the technology perform
  - right out of the box
  - throughout its useful lifetime
- Metrics
  - Yield, bin fallout
  - Contact resistance
  - Pad damage (bondability)
  - Planarity, alignment, leakage, etc.

Evaluation Process (cont'd) Protocol Phase 2

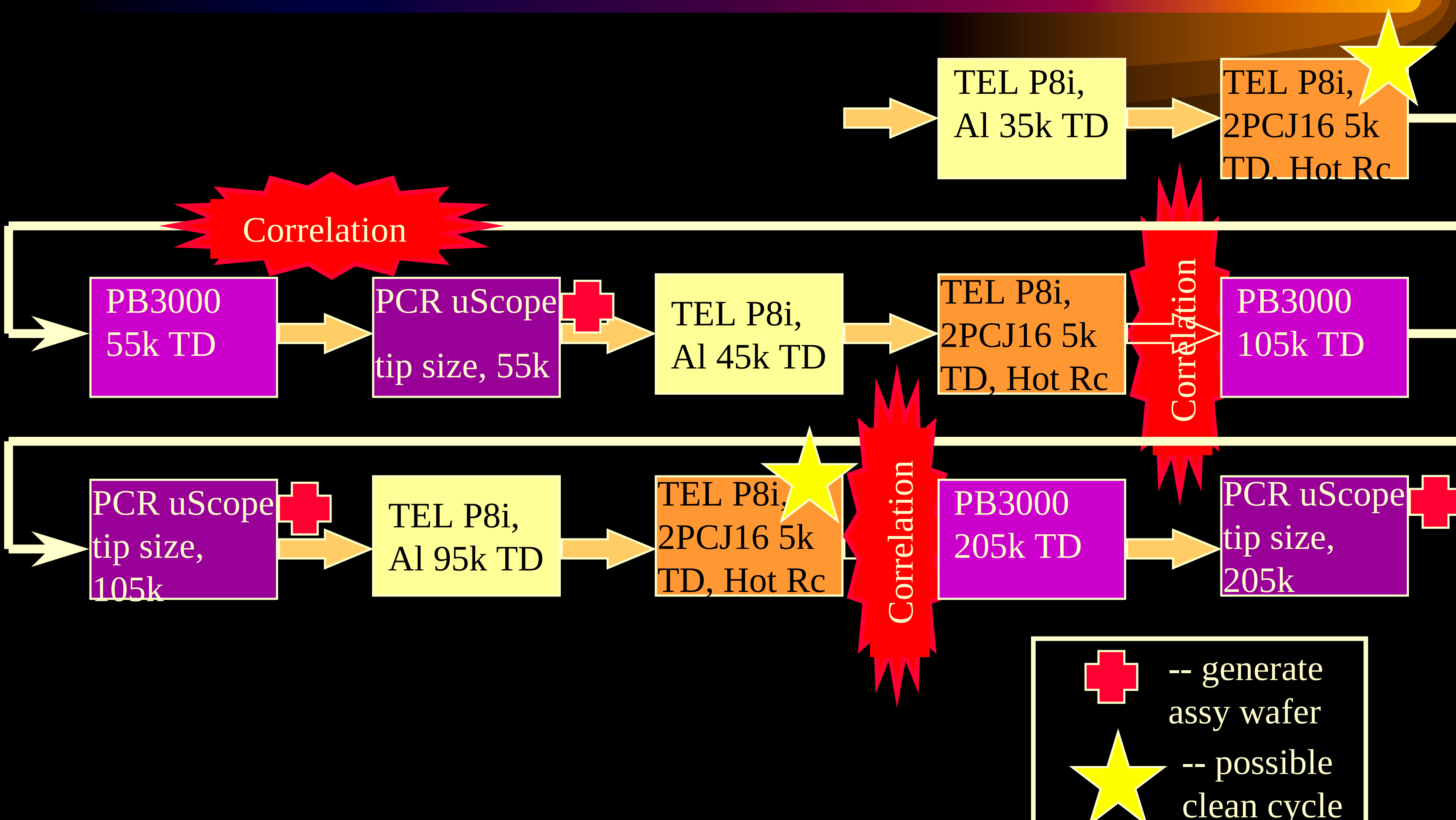


- Two-way correlations
- Multiple temperatures
- Acknowledge that cleaning frequency and requirements are unknown

Evaluation Process (cont'd)
Lifetime performance

- How does the technology perform and evolve with continued use?
  - Simulated useful lifetime with bare Al wafers
  - Electrical and mechanical characteristics
  - Test chip for contact resistance, PMA
- Is useful lifetime limited by the technology, the process, or the product life cycle?

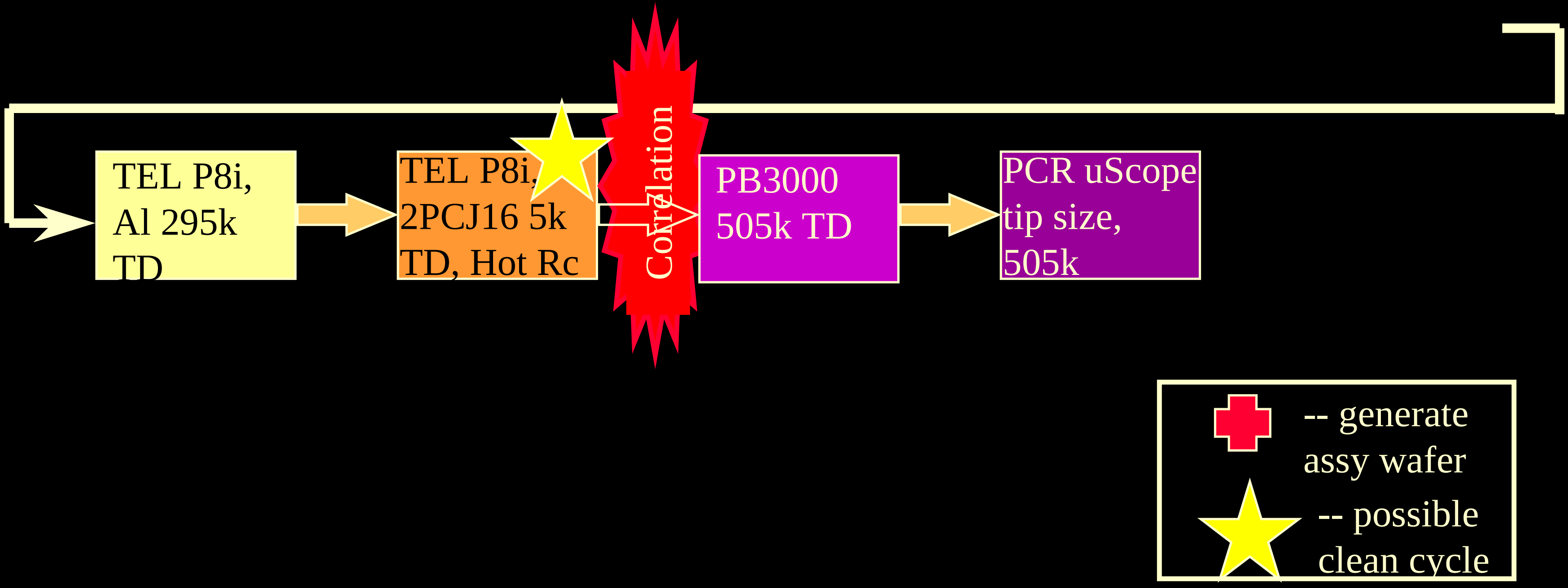
Evaluation Process (cont'd) Protocol Phase 3



Evaluation Process (cont'd)

- How much margin to the useful lifetime does this technology provide?
  - Assumes probe life exceeds useful lifetime

Evaluation Process (cont'd) Protocol Phase 4

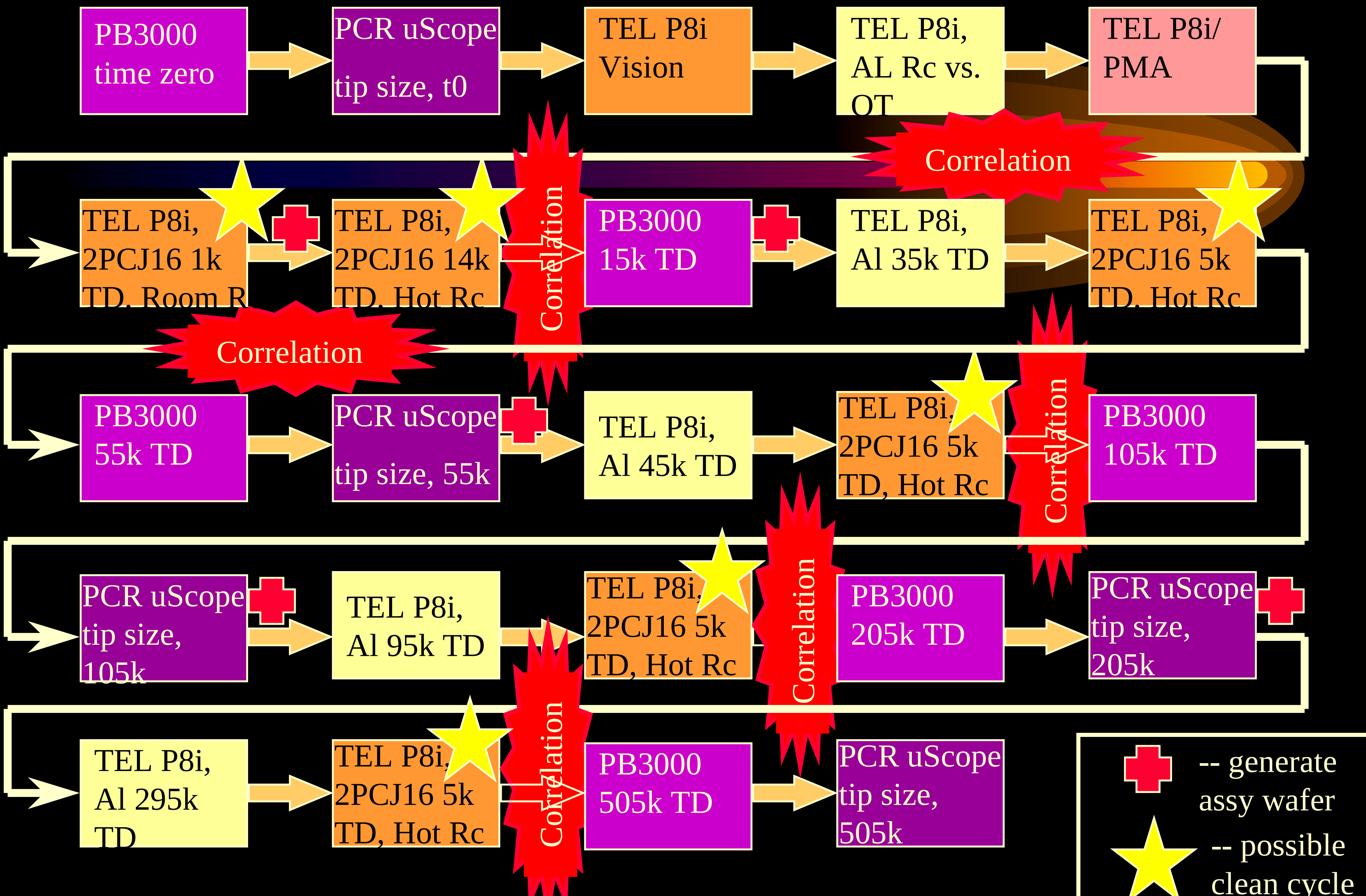


Evaluation Process (cont'd)
Technical Protocol

- Phase 1: t_0 characterization
- Phase 2: Early life characterization
- Phase 3: Lifetime characterization
- Phase 4: Lifetime margin

- Does this technology meet our technical requirements?

Technical Protocol



Evaluation Process (cont'd)

- Completing the evaluation protocol:
  - addresses technical concerns
  - touches on performance concerns
- Sufficient to weed out would-be contenders
- Probably not sufficient to identify a single "winner"
- Production pilot completes the performance evaluation

Evaluation Process (cont'd) Production Pilot

- Multiple cards
- In parallel with current technology
- Extended time
- On-going detailed analysis of results

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- New technology concepts to address the evolving probing requirements (pitch, arrays, multi-die) are out there.
- Converting concepts into hardware is a challenge for developers
- Validating the concepts is a challenge for potential users
  - Close cooperation with suppliers in needed

Conclusions (cont'd)

- Understanding your contacting requirements is a pre-requisite to technology evaluations
  – Clear, complete specifications
- Establishing a repeatable, cost effective process for evaluating contact technologies is critical for a successful selection
- Sharing of methods and results is key to quickly getting up the learning curve and down the cost curve.