National Aeronautics and Space Administration

Printed Circuit Board Quality Assurance

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Reliability and Risk Assessment Branch

Quality and Reliability Division

SAFETY and MISSION ASSURANCE DIRECTORATE Code 300

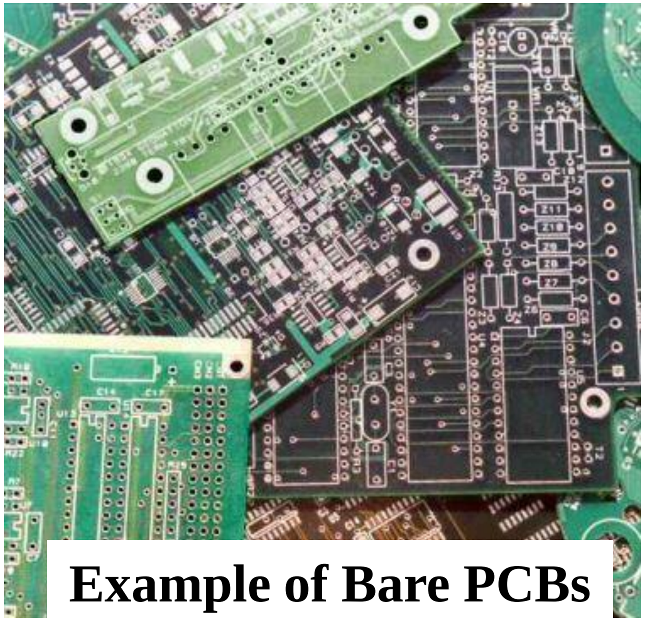
Safely Achieve Amazing Science Through Mission Success

Outline

- Introduction to PCBs
- PCB requirements and quality verification
- Risk assessment
- Example

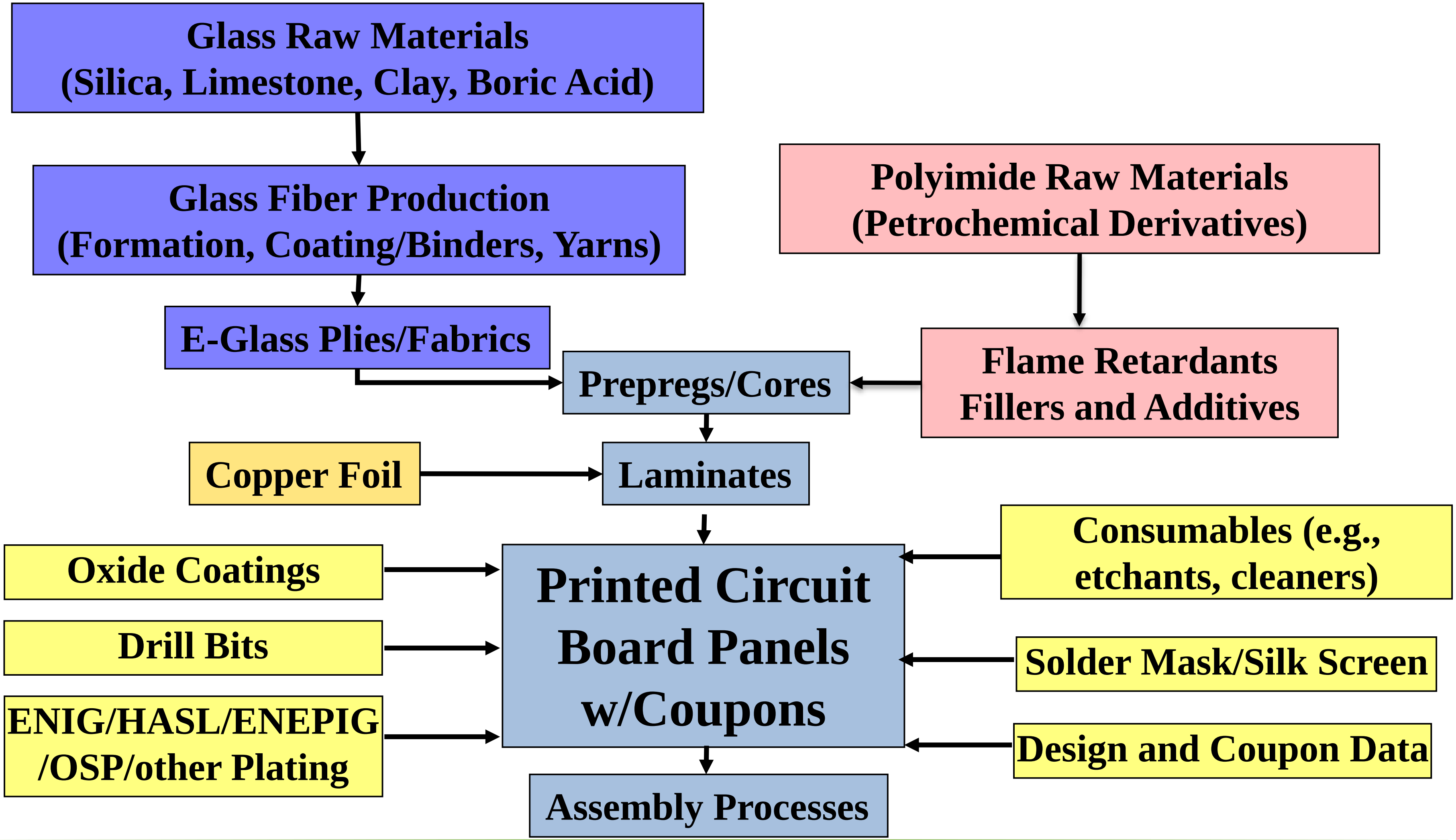
What is a PCB? Classification of PCBs

- Printed circuit boards are the baseline in electronic packaging – they are the interconnection medium upon which electronic components are formed into electronic systems.
  - PCB materials are glass reinforced PCBs, organic polyimide reinforced with woven glass.
- Classified on the basis of
  - Dielectrics used
  - Reinforcement
  - Circuit type
  - Component types
  - Board construction
  - Design complexity



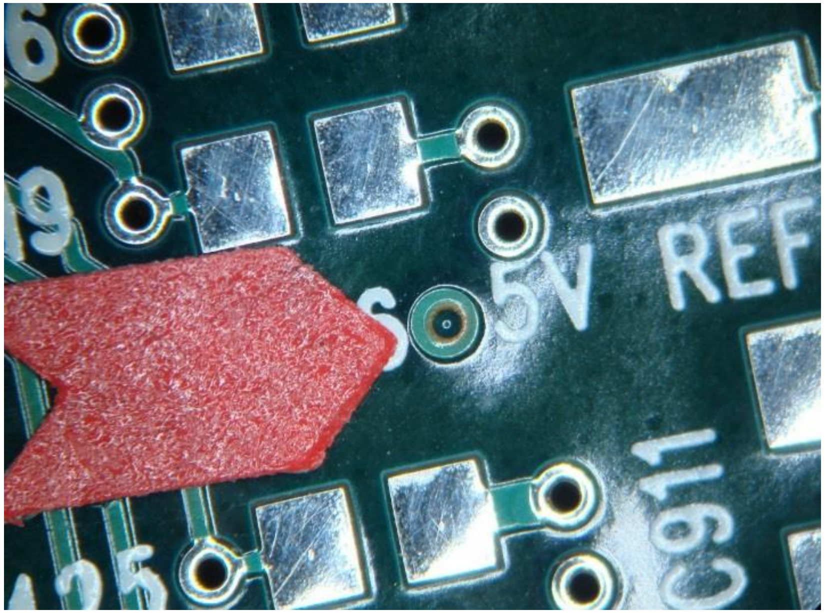
Example of Bare PCBs

Typical Polyimide Laminate Supply Chain



PCB Quality

- NASA uses IPC standards (e.g., IPC-6012, 6013)
- Inspection, testing and requirements include:
  - External visual examination
  - Microsection evaluation
  - Electrical continuity and isolation
  - Solderability
  - Surface finish evaluation
  - Cleanliness

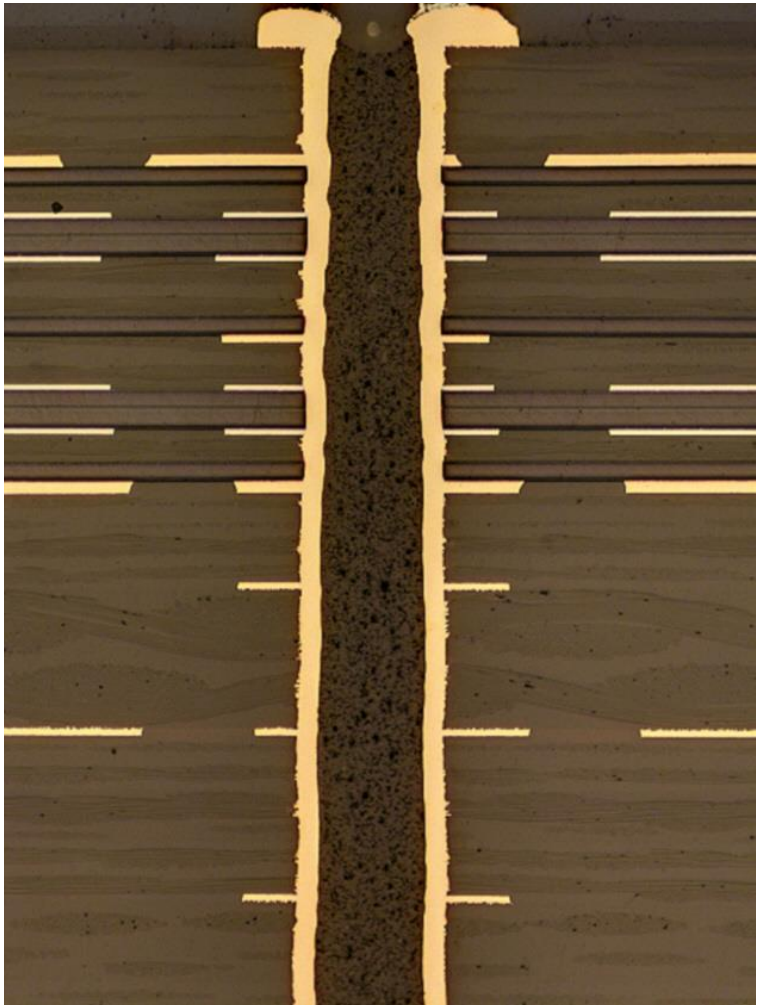


Significance of Board Requirements

- The requirements and coupons are a “front door”.
- Examples:
  - Internal Annular Ring:
    - Egregious violations indicate there may have been a serious problem in development of the board.
    - Minor violations don’t likely indicate any risk at all (IPC-6012DS)
  - Negative etchback:
    - With modern cleaning processes and flight experience can result in higher reliability with negative etchback.
  - Wicking of copper:
    - Requirements are conservative based on broad statistics.
    - A basic analysis of the board layout can indicate directly if there is risk or not, regardless of requirements violations.

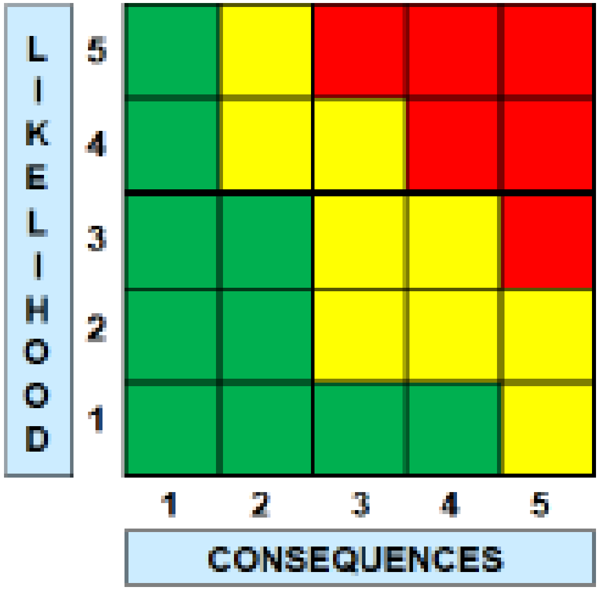
Microsectioning

- Suppliers perform microsectioning and inspect per specifications.
- Secondary GSFC independent microsection analysis yielded 20-30% inspection rejects, caused by:
  - Screening escapes:
    - Test sample quality not consistent
    - Supplier microsection process
  - Requirement interpretations
  - Requirements flow-down issues
    - Alternative specifications (MIL, ECSS)
    - Buying heritage and off-the-shelf designs



Impact of Non-conformances

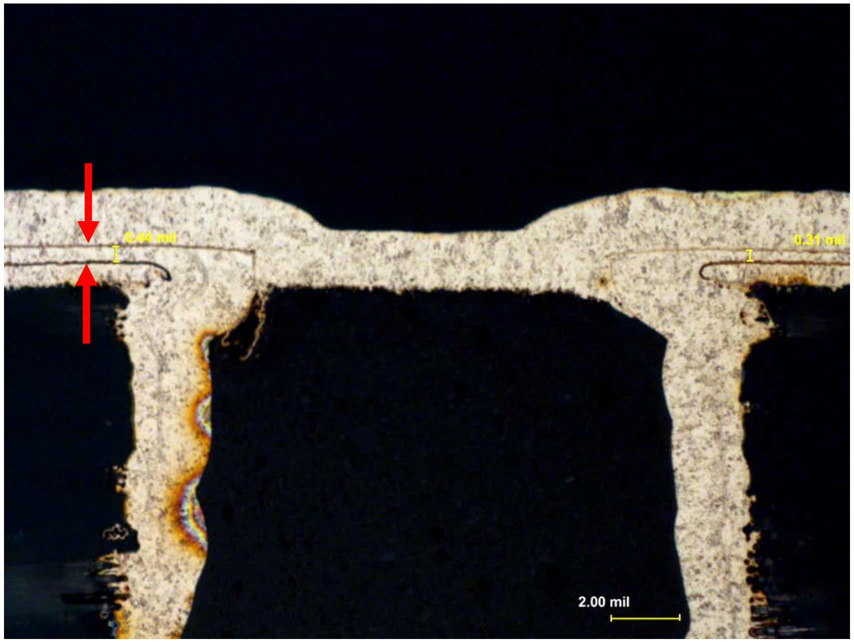
- Bare boards cost $$ and build schedules – expensive!!
- But failures are even more expensive!
- Test sample nonconformance is not the same as PCB failure.
- Risk-based decisions are used for disposition of non-conformances.
- Non-conformances may have little to no impact per application.
- Began to explore origins and merit of requirements (more later).



Risk Assessment

- Traceable PCB test coupons (designed per specs. such as IPC-2221B) are submitted to GSFC or to a GSFC-assessed laboratory.
- Reports that indicate nonconformance are dispositioned by risk assessment performed prior to refabricating or populating the PCB.
  - If risk assessment indicates elevated risk due to the nonconformance, then use is dispositioned by MRB.
- More than a 100 PCB lots assessed for risk since 2014, 95% dispositioned as UAI, significant cost and schedule savings.
- Risk assessment process eliminates waste and saves money and schedule, lowers overall risk for the project.
- The process reduces the need for repeated attempts to refabricate.

Example: PTH Copper Wrap Thickness Requirement



Per IPC-6012D for through-holes:

Class 1	AABUS
Class 2	5 µm [197 µin]
Class 3 & 3/A	12 µm [472 µin]

AABUS = As Agreed Between User and Supplier

- Thermal cycle stresses act on interfaces, outer layers experience the greatest stress.
- Reason: materials selection and geometry.

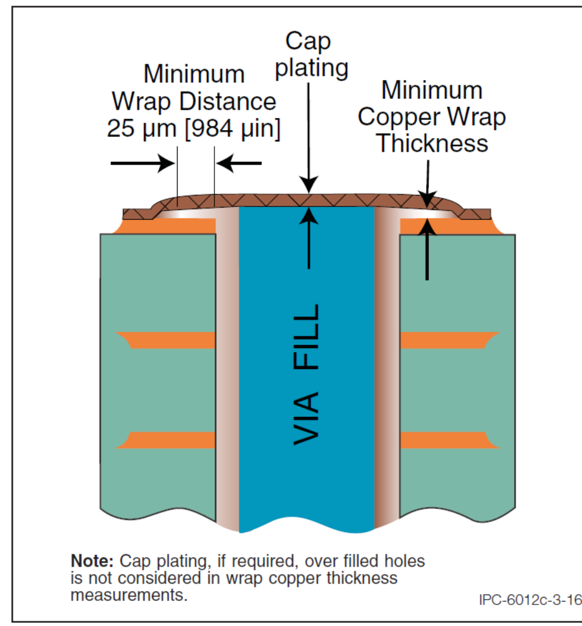


Figure 3-16 Surface Copper Wrap Measurement (Applicable to all filled PTHs)

PTH Copper Wrap Thickness: Disposition

- Mission had populated and integrated board with zero wrap, wrap planarization can cause 0.3mil or more variance in panel; manufacturers must target more wrap.
  – Wrap cannot be achieved at required thickness for designs with tight line-width spacing and/or with multiple lamination/plating steps
- Requirement was introduced to IPC with minimal data
  – Reliability reported to be better with wrap vs. butt joint
  – Half of barrel plating thought to be "good enough"
  – Higher quality limit used as safety margin against manufacturing variation during planarization
- **GSFC Studies:** Determined the impact of copper wrap plating thickness on PCB reliability, as characterized by thermal cycles to failure.
  – Able to determine acceptability of wrap defect based on reliability testing and analysis in context of mission environment and duration.
  – <u>IPC voted to change the requirement</u> (amendment in Rev. D and revisions in Rev. E).

PCB Assurance: Summary

- PCB assurance actives are informed by risk in context of the Project.
- Lessons are being applied across Projects for continuous improvements.
- Newer component technologies, smaller/high pitch devices: tighter and more demanding PCB designs:
  - Identifying new research areas.
  - New materials, designs, structures and test methods.

Thank you!

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