Printed Circuits Manufacturing Out of Standards

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CMS Tracker Hybrid Experience: a user and a manufacturer perspective

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  On behalf of the CMS collaboration

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The CMS Tracker Front End Hybrid

- Multiple functions
  - Electrical
  - Mechanical
  - Thermal
- Multiple constraints
  - Interface to pre-defined elements
    - Mechanical
    - Electrical
  - Low mass
  - High reliability
  - Cheap
- Perceived as low profile, soft glue element

The Hybrid Layout

- 120μm min feature size
- Up to 768 electrical channels
- 17500 pcs

The Finished Hybrid

History

- Several technologies investigated
  - Thick film ceramic
  - 94H
  - Rigid FR4
  - Flex
- Several teams with several opinions
- CMS-Tracker eventually converges on Flex solution
  - Project late start in 2002
  - Few companies involved
  - Chips and mechanics already frozen or well advanced
  - Constraints are hard
- Several design change requests from users
  - Resulting in several flavors and several modifications
- Several difficulties at production start
  - Technological
    - Circuit
    - Assembly
  - Organizational
**Technological difficulties, circuit**

- Metal on flex
- Lamination on ceramic
- Via metallization
- Hidden defect
- Fast production / Slow QA feedback
- Irreversible addition of value when mounting hybrid on sensor module
- Large effort to recover

**User recommendations**

- Hybrids must be part of system level design from the start
  - Define and advertise hybrid related constraints early
- Hybrids for large scale detectors must be designed for volume manufacturability, not for cutting edge performance
  - Avoid state of the art technology
  - Add margin whenever possible
- Limit variants
- Hybrids must be designed for testability, with direct feedback possibility to production process
  - Include panel-level test structures and chip-based test schemes
- Production ramp up must be slow and allow full qualification
  - Count on multiple steps from development to production
- QA and QC must be robust with rapid feedback possibility
  - Manufacturer and user QA schemes must be synchronized
- Organizational structure must be clear and well defined
  - Members of the structure must trust each other and communicate frequently

**Technological difficulties, assembly**

- Bonding:
  - Chip pad structure optimized for ball bonding
  - Unsuitable chip pad size
  - Irregular pad quality on circuit (and on chip?)
  - Special dicing requirement
- Large effort to optimize and maintain bonding quality, several production stops
- Mixed bonding at company and CERN
  - Chip loading accuracy +/- 22um
  - No globe top possibility
  - Long term bond adherence is a prime concern
- ASIC LPCC Package difficult to inspect
  - No boundary scan possibility
  - Detailed analysis of all functional test results required

**Organizational difficulties**

- 12 hybrid variants
  - Transform a high volume production into a multi-batch logistic nightmare
  - Complex delivery schedule
  - All variants needed simultaneously
  - Difficult stock build up and management
  - Management of ancillary hardware becomes problematic (boxes, adapter cards, etc...)
- Heterogeneous CMS community
  - Unclear internal definition of responsibilities
  - Multiple interfaces to company
  - Incompatibility between academic and industrial ways

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