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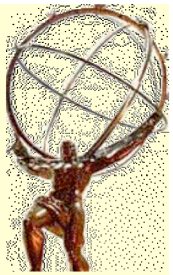
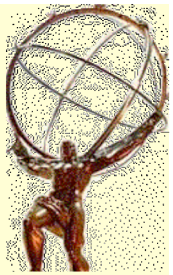


The PCB surface finish saga…

Tony Gillman

The story so far…

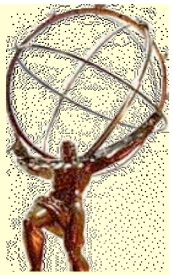


- Very mixed history of successes and failures of PCB manufacture/assembly over the last two years or so, using two different surface material finishes

- First CPM (February 2002)
  - PCB company A + Assembly company P
  - Au on Ni finish
  - Successful

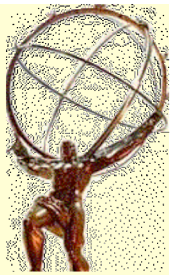
- Second CPM (February 2003)
  - PCB company A + Assembly company Q
  - Au on Ni finish – using PCBs from original 2002 batch
  - Unsuccessful – many failed BGA connections

The story so far…



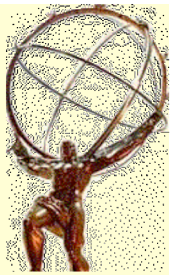
- Third CPM (April 2003)
  - PCB company A + Assembly company Q
  - Au on Ni finish – using new PCBs
  - Unsuccessful – many failed BGA connections
- Fourth + fifth CPM (July 2003)
  - PCB company A + Assembly company Q
  - Sn finish – believed to be simpler and to avoid the complications of Au-Ni interaction
  - Successful
- Conclusion from CPMs – Sn good (100% yield), Au-Ni bad (33% yield)

Conclusions



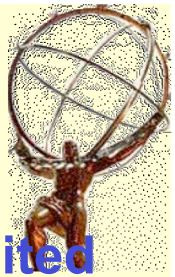
- **Statistics of small numbers! Experience of CMS *(FEDs)* and CALICE in 2003 shows very mixed success with Au-Ni and Sn *(PCB companies A, B)***
  - ***e.g.* six Au-Ni-finish FEDs were successful in January 2003, but several Sn-finish FEDs failed in September 2003**
- **Overall conclusions – empirical solution is much too expensive (>£10K per CPM) and time-consuming**
  - **Either Au-Ni or Sn can be successful, but there are many other factors involved which can reduce the yield**
  - **Vital that the assembly company owns and uses comprehensive diagnostic equipment, and exercises good QA practices**
  - **"One-stop shop" approach strongly favoured – we stay outside the blame-shifting loop, and the company guarantees working boards**

Strategy



- **Some questions:**
  - Are the CPMs *(and FEDs)* especially difficult to manufacture (combination of large area, many large BGAs, small line widths, high track density, many controlled-z traces, 10-year lifetime, …?
  - Had we used appropriate assembly companies for these types of boards?
  - How significant is the "Black pad" effect, where the Au attacks the underlying Ni to produce weak joints, in terms of long-tern reliability?
    - *"The 'Black Pad' phenomenon manifests itself as a gray to black appearance of the solder pad coupled with either poor solderability or solder connection weakness. In spite of, and also quite possibly due to ENIG's very good solderability, this 'Black Pad' problem can be exacerbated during soldering operations. Even when 'Black Pad' is not evident upon initial soldering, failures can be experienced during subsequent encounters where stresses are induced by thermal and mechanical excursions."* Bulwith et al, Global SMT & Packaging Journal
- **Other approaches:**
  - Short-list and visit a few promising "one-stop shop" companies
  - Obtain independent expert advice
    - talk to NPL, TWI, …
    - commission a report to recommend appropriate technique(s) for our requirements
    - employ a consultant to visit and assess companies for us
    - continue to share experiences with CMS

The companies



- Three “one-stop shop” companies *(L, M, N)* were short-listed, and visited between November 2003 and January 2004
- Geoff Hall (IC) and John Coughlan representing CMS, Viraj and I representing ATLAS, spent a day at each of the three companies
- Verdicts:
  - All three companies were impressive, with apparently good QA procedures
  - Good diagnostic facilities were available
    - Ersascope for 3-d optical inspection under BGAs, etc
    - Variable-intensity X-ray inspection images components on both sides of a board simultaneously
  - AOI (Automatic Optical Inspection) equipment was particularly interesting
    - performs image comparison between each board and “golden” board using a fine mesh grey-scale grid – flags up potential errors (wrong components, wrong orientation, bad placement, poor solder joints, …)

The companies

- Company M had hired their regular expert *(A N Other, Process Engineering consultant)* to answer our questions and advise on the best approach
  - Au-Ni recommended – ~60% of industry's PCBs use it, c.f. ~5% using Sn
  - "black-pad" very rare, but almost undetectable, even by X-ray
  - would offer guarantee if they carried out JTAG testing before delivery of *(production)* boards to us
- Company N has similar facilities to Company M but is much larger *(200 staff, 7,000m^2)*
  - QA particularly impressive – extremely thorough, with monitoring at numerous stages in the production process
  - in 2003, 45,000 BGAs were assembled – half of them <0.8 mm pitch
  - "FAST-TRACK low-volume prototyping facility in separate section of main plant – all prototype boards are X-rayed and AOI-inspected, with data → customer on CD
  - additional facilities – solder-paste thickness measurements, Burn-In Rigs *(can accept 9U boards, powered or unpowered)*
  - customer-driven technology – will produce any surface finish demanded
  - Au-Ni very strongly recommended – used in applications where very high reliability is essential (*e.g.* aerospace, inacessible bore-holes, …) – *"why use Sn – problems of whiskers, …"*
  - *"CPM2 design does not show any particular problems"*
  - would offer guarantee if they also procured components *(to ensure a "clean" history)*

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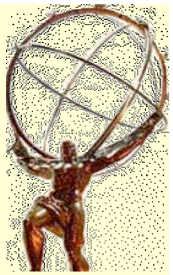
Next steps



- The unanimous advice from these two companies is to use Au-Ni finish
  - The first two CPM2 modules will be manufactured this way by Company N
- However, for the longer-term production, we still need more information about the *pros* and *cons* of Au-Ni *vs* Sn
  - A leading materials chemist from one of the companies will give a seminar at RAL
  - ID are considering commissioning independent expertise and advice
- Regular meetings of ATLAS + CMS people, chaired by Mike Johnson *(Director ID)*, will take place to share information and report progress
  - *n.b.* CMS need 500 FEDs – total cost ~MSF5 – they are *very* interested in yield!
- ***For CPM2, we concluded that either company would do a good job, but that Company N offered more facilities and more thorough QA procedures – and also gave the cheaper quotation***