An Overview of Recent SMT R&D Activities and a Look Into Future Technologies

Presenter: Jussi Hokka – TEC-QTM

21/05/2014

Electronic Materials, Processes and Packaging (EMPPS) Workshop

European Space Agency

Outline

1. Introduction
    - Background
    - ESA's Technology Programmes
    - Key Challenges
2. Recent SMT R&D Activities
3. Future Trends & New Technologies
4. Summary

Background

- Our knowledge needs to be continually expanded in order to improve the design, reliability and safety of launchers, spacecrafts and space instruments
- The key drivers for technology development are future mission requirements that are currently experiencing rapid advances in the performance requirements needed for scientific instruments
- The selection of materials, processes and packages for future space missions must also anticipate the causes of environmental regulations (e.g. REACH, RoHS) and to utilise cleaner technologies in order to mitigate the environmental impacts of space programmes
- ESA conducts numerous studies each year to investigate specific “problem” areas and to develop technologies for future ESA missions and emerging space applications

ESA’s Technology Programmes

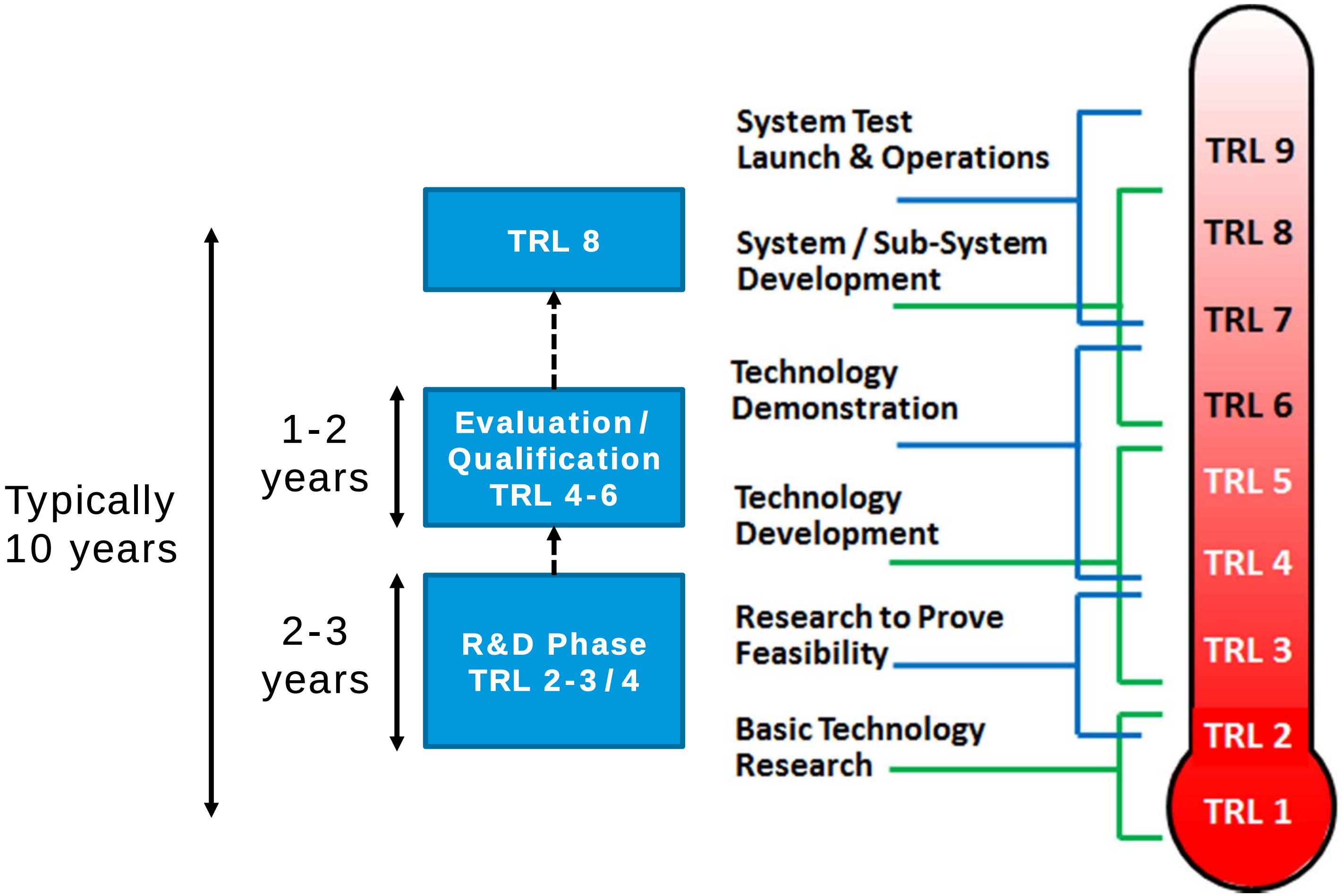
	Programme Name	TRL	Funding
GSP	General Studies Programme	0-1	50 – 100 kEuro
TRP	Basic Technology Research Programme	1-3	Up to 500 kEuro
GSTP	General Support Technology Programme	4-8	> 500 kEuro
ECI	European Component Initiative		

ARTES	Advanced Research in Telecommunications Systems
FLPP	Future Launchers Preparatory Programme

NPI	Networking Partnership Initiative	PhD (1 year at ESA)
YGT	Young Graduate Trainee	BSc (1 year at ESA)

- More details on EMITS and ESA’s Technology webpages

Timeline from R&D to Operation



Key Challenges

- Surface Mount Technology (SMT) is considered as a critical process for the soldering of materials within the European space community
  - Proper tools and equipment, correct materials and design, high-level workmanship, and verification testing are necessary in order to ensure that electronic assemblies will survive space flight conditions
- Larger and more powerful area array devices
  - Higher number of I/Os (>1600), smaller pitches (<1mm)
- PCBs are becoming more complex and components have more functionality
- Environmental concerns raised through initiatives such as Clean Space, will focus attention on environmentally friendly processes such as lead-free soldering

Key Challenges

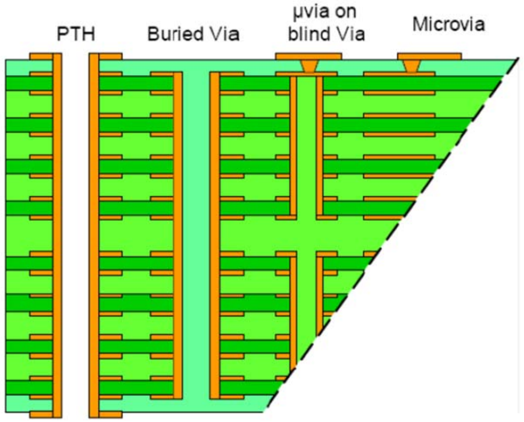
- Most advances in electronic component technology and manufacturing technology are being driven by commercial applications
- More interaction with other industry areas is needed since there are many solutions that could be beneficial for space industry
  - The underlying challenge is to apply technology designed for commercial applications to the requirements of the high-reliability equipment
  - Spin-in opportunities from other high-rel industries (e.g. military)
- New assembly technologies (e.g. 3d printing, solderless assemblies, embedded components) may provide significant improvements in the near future
  - New ways of evaluating and verifying assemblies are needed

Recent R&D activities

- Lead-free Finish (ENEPIG) PCB Evaluation
  - See session 3 presentation
- Impact of Meshed Ground Planes on the Electromagnetic Behaviour of PCBs
  - See session 7 presentation
- Assessment of Reliability of High Density Interconnected (HDI) Boards For Future Space Use
  - Follow-up activity to start
- Replacement of Thermount 85NT
  - Follow-up activity to start
- Evaluation of the High Fatigue Resistance of Lead-free Solder Alloys
- Preparatory Activities in New Member States to Support ESA Programmes

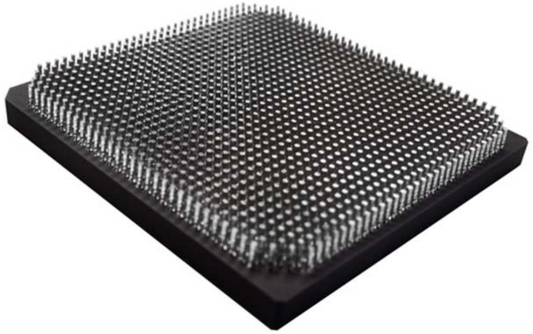
HDI PCB Compatible with Novel Flip-chip and High Pin Count Technologies

Budget: 500 kEur
Funding Scheme: ECI-4
Duration: 24 months
Kick-off: June 2014



Objectives:

- To evaluate and demonstrate a fully compliant High Density Interconnect (HDI) technology for PCB compatible with high speed digital signals (> 6.25Gbps) and to develop the required process and design guidelines
- The delivered solution shall have demonstrable performance benefits when compared to existing PCB solutions, and ultimately be suitable for qualification for flight high speed digital applications



HDI Technology and Thermount Replacement with Assembled Devices

Budget: 250 kEur
Funding Scheme: TRP
Duration: 24 months
Kick-off: Q3 2014

Objectives:

- To research and understand the end-user needs for low-CTE HDI PCBs - including PCB configuration(s) and manufacturing processes - driving PCB technology requirements
- To define different component packages and manufacturing constraints covering end-users needs
- To design and manufacture appropriate tests vehicles
- To define an evaluation plan for these test vehicles
- To assemble and to evaluate the test vehicles
- To give recommendations for PCB material and component assembly verification and guidelines for use in future space applications

Evaluation of ALD Conformal Coating to Mitigate Tin Whiskering

Budget: 150 kEur
Funding Scheme: StrIn/ECI
Duration: 14 months
Kick-off: Q3 2014

Objectives:

- To study the effectiveness of ALD (Atomic Layer Deposition) conformal coating to mitigate tin whisker growth on surface mount assembled parts
- To achieve more efficient protection against whiskers compared to other conformal coatings (e.g. epoxy, polyurethane, silicon) resulting in material and cost savings
- To give recommendations for further development and implementation of ALD conformal coating for electronic assemblies used in high-reliability applications

Future Trends: Opportunities and Main Drivers

1. Novel manufacturing methods (e.g. printed electronics) for better system integration and weight/cost saving
2. Novel materials (e.g. CNT doped solders) for improved reliability
3. New assembly possibilities (e.g. solderless/embedded assemblies) in order to reduce interfaces and simplify verification procedures
4. High temperature resistant materials to facilitate the use of next generation high performance components
5. Test methodology development for reduced test duration and cost
6. Anticipation of legislation and its impact on electronic assemblies (e.g. lead-free plan)
7. Need for clear, precise and user-friendly standards

1. Printed Electronics

- Emerging additive manufacturing method
    - Changing the way electronic devices are made and verified
    - Possible to combine electronics and mechanical manufacturing into a single additive manufacturing process
- Single process to add material to the substrate
    - e.g. inkjet, screen, gravure or flexographic printing
- Not a drop-in replacement for conventional electronics manufacturing
    - Different target applications (e.g. flexible substrates)
    - More complex structures/shapes and tailored products possible

    → Adding value to conventional manufacturing
- Transition from inexpensive consumer parts to the high reliability demands
    - Electrical performance and reliability not yet at the same level as conventional electronics
    - Developments required for applications to work in high reliability environments

1. Printed Electronics

- Potential applications for ESA and the European space industry
    1. Printed sensors, antennas, batteries, solar cells
    2. Embedded component structures (PCBs) and flexible substrates/cables
    3. Inkjet printed (e.g. graphene ink) interconnections/conductors
    4. Possibility for astronauts to print electronics on demand
- Benefits
    - Shorter development times →Testing can be done in parallel on multiple copies, rather than serially on verification and flight units
    - Mass reduction of electronic assemblies
    - Manufacturing flexibility: prototype/low volume production and on demand engineering
    - Complex structures (e.g. flexible PCBs inside complex structures)
    - Large area applications
- Challenges
    - Technical feasibility issues (e.g. manufacturing techniques and optimization, functionality, systems integration)
    - Cost/Benefit ratio
    - Long-term reliability

2. Solderless/Embedded Assemblies

1. Potential for reducing the total number of manufacturing steps and thus reducing manufacturing cost
2. Low material use and near zero waste as nearly all materials used can stay with product
3. Elimination of solders, which are increasingly use expensive (especially lead-free solders containing semi-precious metals such as silver)
4. Reduction of component height as the solder ball often represents up to one half of component height
5. Lower cost materials can be used in some assemblies
6. The elimination of solder land designs allows for improved routing and reduction in circuit layer count with associated cost reductions
7. Improved thermal management with integral heat spreader or even heat pipes, possibilities not easily implemented with soldered assemblies

Way Forward

1. To identify and investigate potential space applications, technical feasibility and current capabilities
2. To identify manufacturability and reliability challenges
3. To perform a technology gap assessment and to identify areas of necessary improvement (key technology advancements)
4. To propose a roadmap for future activities

Summary and Conclusions

- Need to start looking further ahead, anticipate the future needs/requirements and the problems arising from obsolescence issues
- Clear and coherent roadmap for SMT needed
  - Continuation and a clear way forward
  - Priorities based on needs (short/medium/long-term) and urgency
- More interaction needed with other high-rel industries
  - Spin-in opportunities from military, aerospace and automotive
- Identified critical areas and hot topics
  a. Lead-free assemblies
  b. High-pin count assemblies
  c. High-temperature electronics
  d. Printed electronics
  e. Embedded/Solderless assemblies
- New proposals and ideas are welcome!

Thank you for your attention!

Questions?

Jussi.Hokka@esa.int