Remanufacturing in Electronics

An Overview from the Perspective of Electronics Packaging

by Norman Stockham and Andy Whitaker
Content

- TWI and interest
- Overview of remanufacturing issues
- Applications
- Special issues for electronics
- Some technical solutions
- Conclusions
TWI

- Independent R&T organisation
- Membership based
- Limited by guarantee
- Specialising in materials, joining, assembly, training & technology transfer
- 3500 industrial members in 75 countries
- £40M turnover
- 550 staff
- 40 years experience in electronic packaging

Global Presence
Facilities: Malaysia & Vietnam
Offices: 14 countries

4 UK Technology Centres

Cambridge  Middlesbrough  Sheffield  Port Talbot

World Centre for Materials Joining Technology
Key Industry Sectors we Serve

- Aerospace
- Automotive
- Construction
- Equipment, Consumables & Materials
- Electronics
- Medical
- Oil & Gas
- Power

TWI
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Drivers for Remanufactured Electronics

- Monetary value
- Ethics – resources footprint
- Legislation - environmental impact
- Necessity – otherwise not available
- Fashion
  - +ve “Retro”
  - –ve “Out of style”
Rемануфактурирование процессов

- Сборка
- Обнаружение и идентификация дефектов
- Разборка продукта
- Очистка и хранение деталей
- Перепрессовка деталей (замена)
- Перестройка продукта (специальный инструмент?)
- Тестирование для обеспечения функционирования как нового продукта
- Идентификация

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Re-Added Value – the facts of life

Remanufactured Sales Price

DEDUCT:
- User return costs (information, logistics)
- Sorting, storage, waste stream
- New Components
- Remanufacture Process
- Requalification
- Future supply chain (components, software and service….)
- Insurance liabilities
- Distribution, Sales and Marketing

= Bottom Line  if +ve then 😊
General criteria for viable Remanufactured Electronics

- Products of high value – probably capital items
- Products with known service lifetime
- Reliability engineering support
- Intentionally Designed for Remanufacture for lower cost
- Component supply/recovery chain and obsolescence management in place
- Economies of scale - quantity, logistics, geography -> USA
- Export for higher relative value in developing markets
Opportunities for Remanufacturing Electronics

- Products with known shorter life components - electrolytics
- Some expensive components - processors
- Part of larger valuable products - building controls
- Can be damaged but salvageable - vehicles
- Upgrades of hardware and or software required – IT Servers
- Consumer items if easily cleaned, high volume, low build complexity
- Re-styling of consumer items
- Exploit WEEE legislation - provides incentives and routes
Current Examples of Remanufactured Electronics -1

- Volume Office Equipment
  - photocopiers
  - printers

- Civilian Motor vehicle upgrades
  - ignition and emission sensor control systems
  - drive train automation

- Military vehicles
  - eg Abrams MA1A2 MBT tank line
  - “common module” sensor systems
Current Examples of Remanufactured Electronics -2

- Military and Services portable communications
- Building and plant control systems
- IT Server upgrades
- Consumer products
  - Single use cameras
  - Mobile telephones (for secondary markets)
  - Laptops and PDAs (for secondary markets)
  - Set top boxes
Remanufactured Products on the Market – Amazon.com

- Remanufactured Olympus W-10 Digital Voice Recorder with Built-in Digital Camera
  - Buy new: $28.45

- Remanufactured Sennheiser RS100 Wireless Headphones
  - Used & new from $65.54

- Remanufactured Rio Forge 256 MB MP3 Player
  - Used & new from $55.62

- Remanufactured Nikon Coolpix 4800 4MP Digital Camera
  - Used & new from $279.00

- Remanufactured Dell Latitude C640 Notebook
  - Used & new from $449.00

- Remanufactured InFocus SP5000 ScreenPlay Home Theater Projector
  - Used & new from $799.85

- Refurbished Photosmart HP PSC1610 Printer
  - Used & new from $114.73

- Remanufactured Teac CD-X6 Wall-Mountable Stereo
  - Used & new from $59.95
Japan - Inverse Manufacture

Fuji Xerox copy machines:

- Leased
- Modular design for flexible upgrade
- Zero landfill
# World EMS* Rework/Repair Market**

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>$1.9 Bn</td>
</tr>
<tr>
<td>2003</td>
<td>$4.0 Bn</td>
</tr>
<tr>
<td>2009</td>
<td>$14.0 Bn</td>
</tr>
</tbody>
</table>

“OEMs expected to continue their drive to reduce costs and requirement for outsourced remanufacturing & repair services”

*Electronic Manufacturing Service (EMS) Providers
**Source: Frost & Sullivan
Special issues for Electronics Complexity

- Multiple electrical connections
- Increasingly thermal connections
- Possibly optical connections
- Highly resilient coatings/hermetic packages
- Multiple assembly technologies in one product
- Trend is even higher density – less accessibility
  - Flip chip and CSP with adhesive underfills
  - Embedded passives (eg ADEPT programme)
Special issues for Electronics
Lead-free Solders

• RoHS type legislation has produced a transition
• Legacy of products with leaded solders
• New lead-free solders may require higher temperatures
• Possible mixed-solder regimes with un-quantified performance
• New plated finishes on components
Special issues for Electronics
Original Design

- Most products are not designed for remanufacture
- Many products have a short “design” life
- Very fast technology development – massive obsolescence
- Insufficient precise knowledge of electronic device life
Solutions Required for Electronics

- Design for Disassembly (D4D)
- Non Destructive Testing
- Component recovery
- Re-Assembly methods
- Module partitioning
- Design for Test
- Lower cost Reliability prediction and test
What is “Design for Disassembly “?

• Designing joints in products to withstand all rigours of operation, but at end of life can be taken apart quickly and cheaply

Also called:
• Inverse manufacture (Japan)
Design for Disassembly

Shape Memory Polymers

- Standard polymers including ABS, PC, ABS/PC blend and PET may be processed to give highly effective shape memory properties.
- Standard manufacturing methods may therefore be used to produce self disassembling products.
- Hot liquid or hot air used to trigger shape recovery.
First commercially available shape memory polymers fasteners developed by Mitsubishi Heavy Industries.
Design for Disassembly
Active Disassembly using Active Fasteners

- Self Disassembling Products:
- Smart actuators or releasable fasteners in products produce disassembly when triggered at the end of product life
- Allows production of high purity, pre-defined fractions, ready for recycling.

18 active fasteners allowed all the components of this Sony Playstation to automatically disassemble.
Portable comms device packaged with thermally releasable clips
Non Destructive Testing
Automated multi-method MICROSCAN

In-line rapid assessment for diagnostics including:

• Real time micro focus X-ray tomography
• Surface Acoustic Microscopy
• Optical Image Analysis
• Thermal imaging
• High frequency ultrasonics
• Laser Thermal Pulse analysis
Component Recovery
Using Ionic Liquids - HIPERPOL

Metal removal
Recycling
Re-use
Drying + shaking
Collection
Polymer recovery & re-use
Ionic liquid re-use
Use
Component Recovery

Chemical Breakdown – PCB and Solder

Advantages: Often no additional energy required, full immersion, can be material selective
Disadvantages: H&S, volatile and toxic solvents, disposal, treatment of solvent to recover material
**Component Recovery**

**Biodegradation - BIOSORT**

- Electronic components → Fishfood → Shell Fish
- Fishfood → Shell
- Shell → Chitin (carbohydrate)
- Printed Circuit Board → Grain
- Grain → Electronic product

Collection → Biodegradation (enzymatic or bacteriological) → Use

**Twidiagram Group**

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Re-Assembly Method
Surfisculpt™ Metallic “Velcro”
Re-Assembly Method
Micro Friction Stir Welding - µFSW ©

Precision heat input allows fluxless soldering and welding from one side of metals and polymers for re-sealing packages and forming electrical and thermal connections.
Re-Assembly Method
Laser Soldering

PANASONIC
SOFTBEAM LD
Laser Diode
Micro soldering system

Wire Soldering

FPC and CCD Soldering

Precision heat input allows soldering without affecting the reliability of surrounding components
Module Partitioning for Residual Value

- Important to maximise residual value reclaimed
- Modular construction assists remanufacturing
- Modules increase original cost – packaging and connectors
- Present methods partition electronics mainly by function
- Remanufacturing also requires partitioning by lifetime
- Requires component level lifetime prediction tools
Virtual Qualification (VQ) Process

1. Hardware configuration
2. Conduct stress analysis
3. Apply PoF damage model
4. Life-cycle operational loads
   - Accelerated conditions
5. Ranking of potential failures
   - Load vs. Time to Failure
6. Prediction Experimental
   - Field
   - Modified
   - Mean Time To Failure

Lifetime Reliability Prediction - CALCE PWA™
Lifetime Reliability Prediction -CALCE PWA™
Stress Models

Thermal analysis

Mechanical analysis
**Reliability Assessment**

**Precision Reliability**

- Rapid detection of early onset failure during accelerated tests
- Advance warning without full “1000hr functional failure” type test
- Precise temperature control, ±0.01°C
- Precise in-situ measurement, e.g. ± 0.1µΩ resistance
- Example: Joint degradation during thermal cycling

![Graph showing resistance (R) over cycles for different temperatures (125°C and -55°C)]
**Remanufacturing of Electronics**

**Conclusions**

- Important technology to achieve world resource utilisation
- State of definition and development is variable worldwide
- Electronics has special issues due to complexity
- There are new diagnostic, process and reliability test methods becoming available
- Requires component level lifetime prediction tools and data
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