An Analysis of Solderability and Manufacturability of Moisture Sensitive Electronic Components After Long Term Environmentally Controlled Storage

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Subject Device Description

The subject device is comprised of five (5) very large scale integrated circuits mounted on a high density multi-chip hybrid module. The part number of the hybrid module is 216T9NGBGA13FHG with a device description of ATI (now an AMD company) Mobility Radeon ™ 9000 M9-CSP64 Graphics Processor Unit, RoHS compliant. The module is an FR4 material Printed Circuit Board (PCB) mounted with an ATI designed GPU circuit in a plastic encapsulated Fine Ball Grid Array (FBGA) package. This is then mounted on the bottom (ball) side of the PCB and conformal coated. Additionally, there are four (4) 128Mbit GDDR SDRAM devices from Samsung Semiconductor, part number K4D26323G-VC33 in 144 ball FBGA packages, mounted to the top (non-ball) side of the module. The multi-chip hybrid module is a 31mm x31mm (648 ball) Ball Grid Array (BGA) package with 1.0mm nominal ball pitch and includes a thermal heat spreader device integrated onto the top side. Various passive surface mounted components are also present on the top side of the hybrid module PCB. The module is rated as a Moisture Sensitive Device (MSD) level 3. The module functions as an integrated graphics display driver for high resolution LCD displays.

Long Term Storage Environment

The ATI Radeon ™ 9000 End Of Life Product Change Notification (PCN) was issued in 2007 and, since that date, significant quantities of the product have been held in a controlled environment storage facility for use by customers with long-term production and support requirements. The subject devices were originally received on automated tape and reels sealed in Moisture Barrier Bags (MBBs) containing passive desiccant packs, directly from the original manufacturing facility. On receipt, the product was inspected for physical conformance, removed from the tape and reel package and transferred into tray carriers. The product was then placed into long-term environmentally controlled storage.

The storage environment consisted of a secure and environmentally controlled vault containing monitored active desiccation cabinets. The desiccation cabinets monitor and control temperature to 25˚C +/-5˚C and humidity to less than 5% RH, with RH of typically less than 1%. The specially designed cabinets are data logged and alarmed with remote monitoring to alert in the case of an out of specification event. The humidity control is dual redundant and the subject devices remained within the controlled environment at all times prior to the analysis.

The test units were put into long-term environmental storage on 11/10/2007. The storage conditions were maintained from that date until two (2) devices were removed from long-term storage on 11/30/2011 and shipped to an independent firm for analysis. The independent engineering firm is a military and avionics system manufacturer with extensive experience in component quality analysis. The time of uninterrupted long-term storage prior to analysis of the subject devices was greater than 4 years. The analysis assessed physical condition and included a study of solderability and manufacturing suitability. The tests conducted, and the results found, are presented below.

Experimental Procedure and Results

Physical examination of the subject devices did not reveal any anomalies (see figures 1 and 2). To confirm that the solder balls were RoHS compliant and to detect the presence of corrosion, one of the two subject devices was placed into an SEM for elemental analysis. Elemental analysis showed that the solder balls were consistent with SAC 305 lead free solder (see figure 12). Further elemental analysis showed that there was no evidence of oxides or other contaminants on the solder balls (see figure 13).

To pre-condition for solderability testing, one of the two subject devices was subject to steam age for 8 hours (see figure 3). At the conclusion of the steam age, both the aged and the non-steam aged devices were soldered onto a test circuit card (see figure 4). SAC 305 solder balls have a melting temperature of 219˚C. To solder the units to the test circuit card, a maximum reflow temperature of 245˚C was used with a time above liquidus of 70 seconds. After cooling, the solder connections at all four corners of the steam-aged part were documented (see figures 5-8). In addition, an examination of the distance between the subject device hybrid bottom edge and the test circuit card was measured. This examination indicated that the parts were relatively coplanar with respect to the test circuit card with no evidence of potato chipping.

To determine solder joint strength, a pull test procedure to stress the solder joints to failure was undertaken on the steam aged subject device. First, a dye was applied underneath the circuit-mounted part followed by application of a vacuum to ensure even die distribution. An aluminum chuck was bonded to the top of the subject device with adhesive. The test circuit card was then placed upside down in a fixture that allowed application of increasing force to the aluminum chuck and therefor to the subject hybrid device. Force was progressively applied until the hybrid subject device to test circuit card solder bonds fractured. Initially, 50 pounds force was applied to the device for 24 hours with no sign of fracture. Subsequently, 70 pounds force was applied with the addition of heat to 50˚C. After an additional 24 hours in this condition, the subject device became separated from the test circuit card. An examination of both the device and the test circuit card showed all solder connections were present and that the solder connections appeared as expected (see figures 9 and 10). Close examination showed that some of the fractures occurred at the tin/nickel intermetallic interface and some occurred in the bulk solder pillar. These results and observations are considered typical for this test methodology.

To further examine and document the condition of the solder joints, the second subject device (non-steam aged) was cut from the circuit card and dissected diagonally, mounted in epoxy and cross sectioned. Close examination showed proper wetting of the subject device to the circuit card (see figure 11). This completed the analysis.

Conclusions

The subject devices did not exhibit any manufacturing assembly irregularities after four (4) years of controlled environmental storage. Solderability was found to be good and typical for the type of device and there were no signs of wetting problems or structural defects within the solder joints. It was found that a dry air active desiccant environment maintained to 25˚C +/- 5˚C and less than 5% RH (less than 1% typical RH) is an effective storage method over the study period. When deployed for long-term storage of moisture sensitive electronic components, the storage environment was found to prevent moisture intrusion, corrosion and other contamination.

References

IPC/JEDEC J-STD- 033A, “Handling, Packaging, Shipping, and Use of Moisture/Reflow
Sensitive Surface Mount Devices”, July 2002

IPC/JEDEC J-STD-020D.1, “Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices”, March 2008

GEIA-STD-0003, “Long Term Storage of Electronic Devices”, January 2006

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APEX Conference 2003
BAE SYSTEMS Information and Electronic Systems Integration Inc.
Information and Electronic Warfare Systems, 65 Spit Brook Rd, Nashua, NH 03061
J. Cambrils, M. Hickey, and D. Tibbets

“Moisture Effects on the Soldering of Plastic Encapsulated Devices”
Application Note S2080
Macom Tyco Electronics

“24 months Shelf Life for Moisture Sensitive SC Devices”
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Texas Instruments, 12500 TI Boulevard, MS 8640, Dallas, Texas 75243, April 2004

“Understanding Moisture/Reflow Sensitivity for IC Packages: Achieving Pb-Free Assembly Classification and Handling”
Intel Corp., Jack McCullen, December 2004

Figures

Figure 1
External top view of subject device

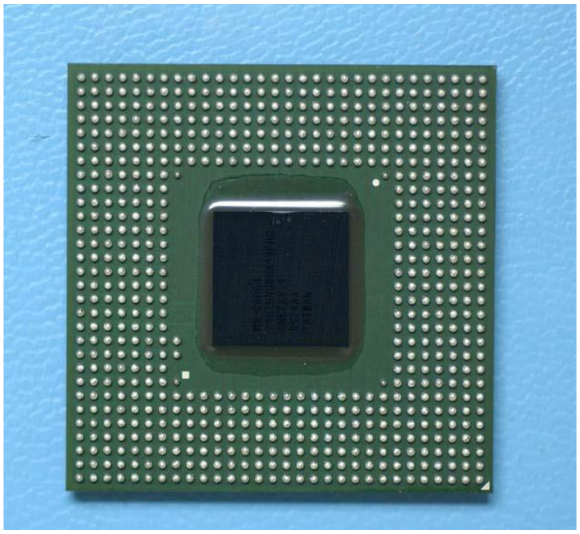


Figure 2
External bottom view of subject device

Figure 3
External bottom view of subject device after 8 hour steam age

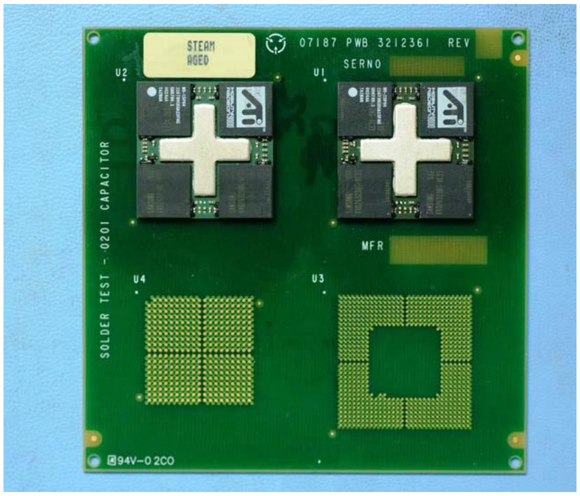


Figure 4
View of devices soldered to test circuit board

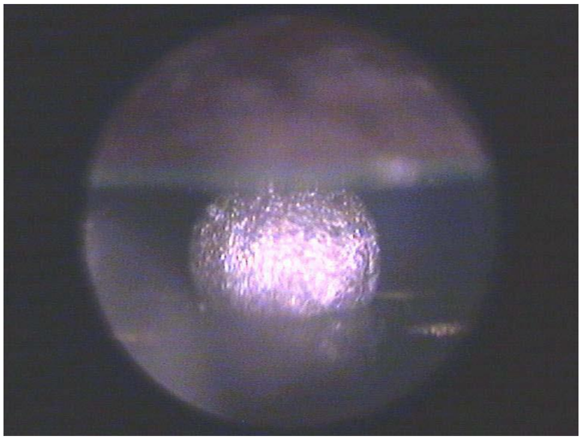


Figure 5
View of solder connection after reflow, upper left corner of steam treated subject device

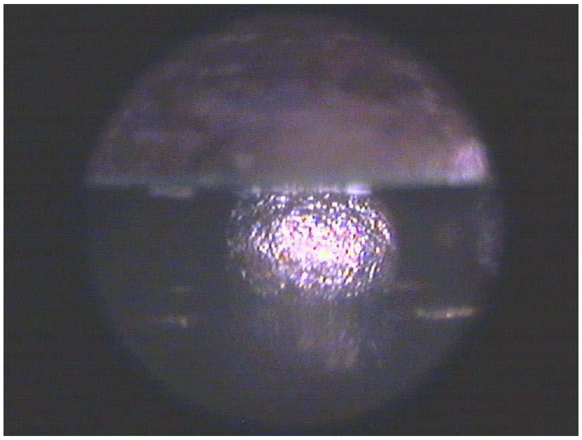


Figure 7
View of solder connection after reflow, upper right corner of steam treated subject device

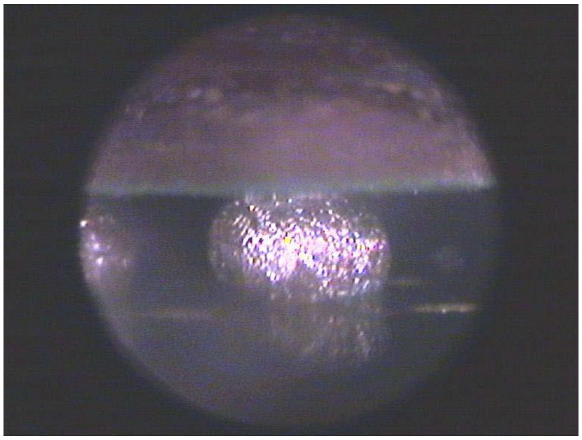


Figure 6
View of solder connection after reflow, lower left corner of steam treated subject device

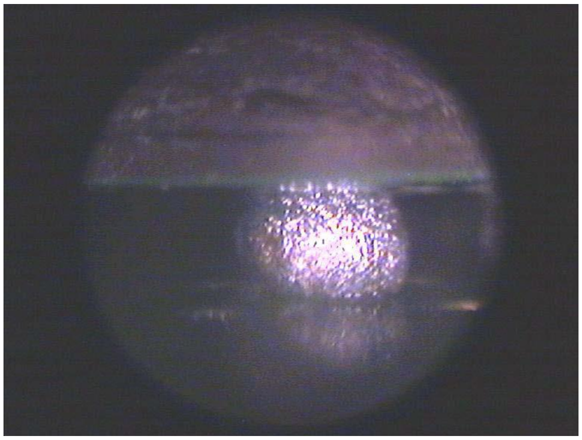


Figure 8
View of solder connection after reflow, lower right corner of steam treated subject device

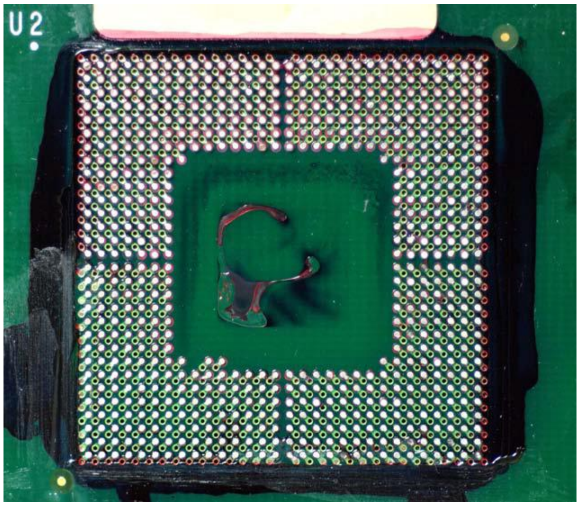


Figure 9
View of solder connections at test circuit card after pull test fracture

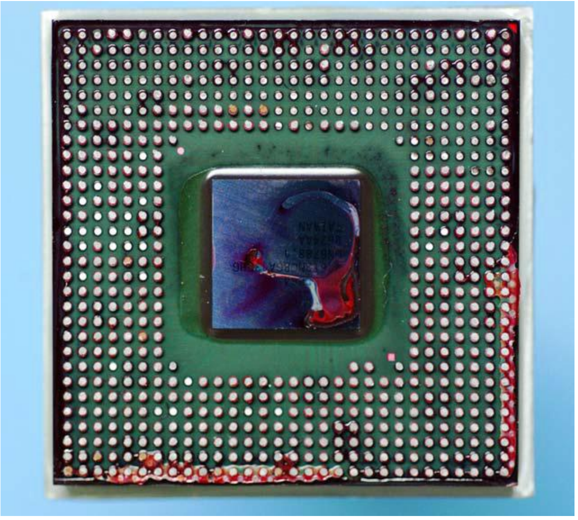


Figure 10
View of solder connections on subject device after pull test fracture

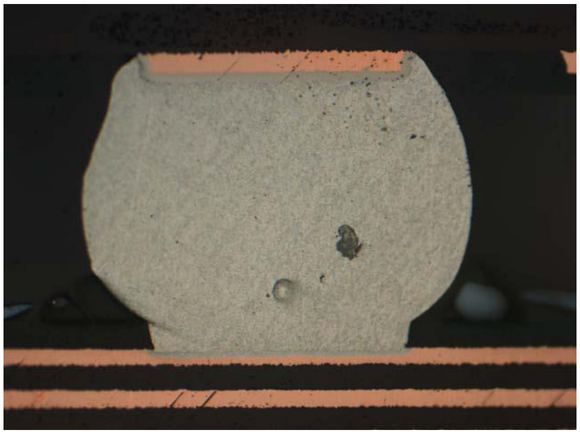
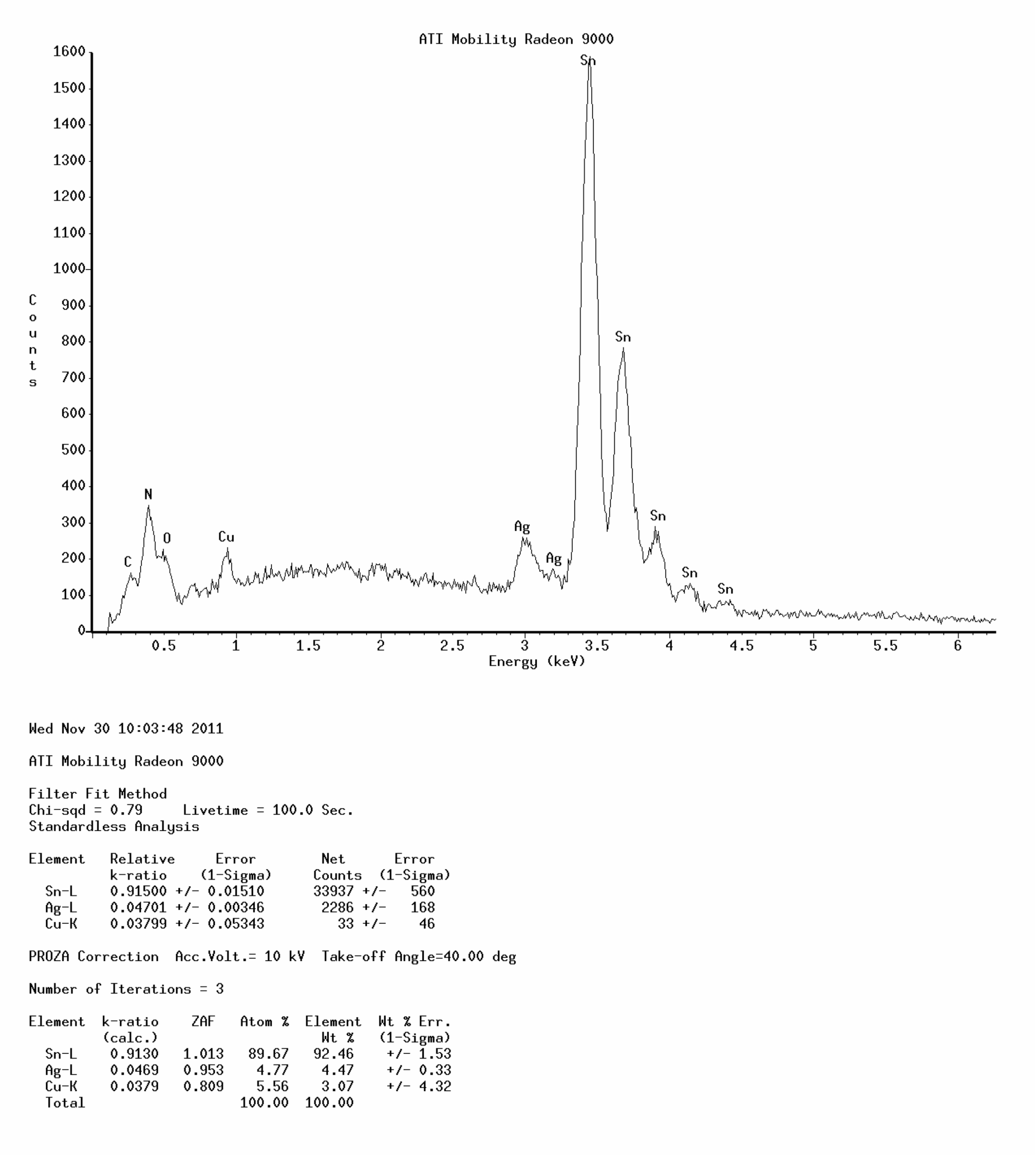


Figure 11
Cross section view of solder ball



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Wed Nov 30 10:03:48 2011

ATI Mobility Radeon 9000

Filter Fit Method
Chi-sqd = 0.79     Livetime = 100.0 Sec.
Standardless Analysis

Element   Relative     Error        Net      Error
          k-ratio    (1-Sigma)     Counts  (1-Sigma)
  Sn-L    0.91500 +/- 0.01510      33937 +/-   560
  Ag-L    0.04701 +/- 0.00346       2286 +/-   168
  Cu-K    0.03799 +/- 0.05343         33 +/-    46

PROZA Correction  Acc.Volt.= 10 kV  Take-off Angle=40.00 deg

Number of Iterations = 3

Element  k-ratio    ZAF   Atom %  Element  Wt % Err.
         (calc.)                   Wt %   (1-Sigma)
  Sn-L    0.9130   1.013   89.67   92.46    +/- 1.53
  Ag-L    0.0469   0.953    4.77    4.47    +/- 0.33
  Cu-K    0.0379   0.809    5.56    3.07    +/- 4.32
  Total                   100.00  100.00
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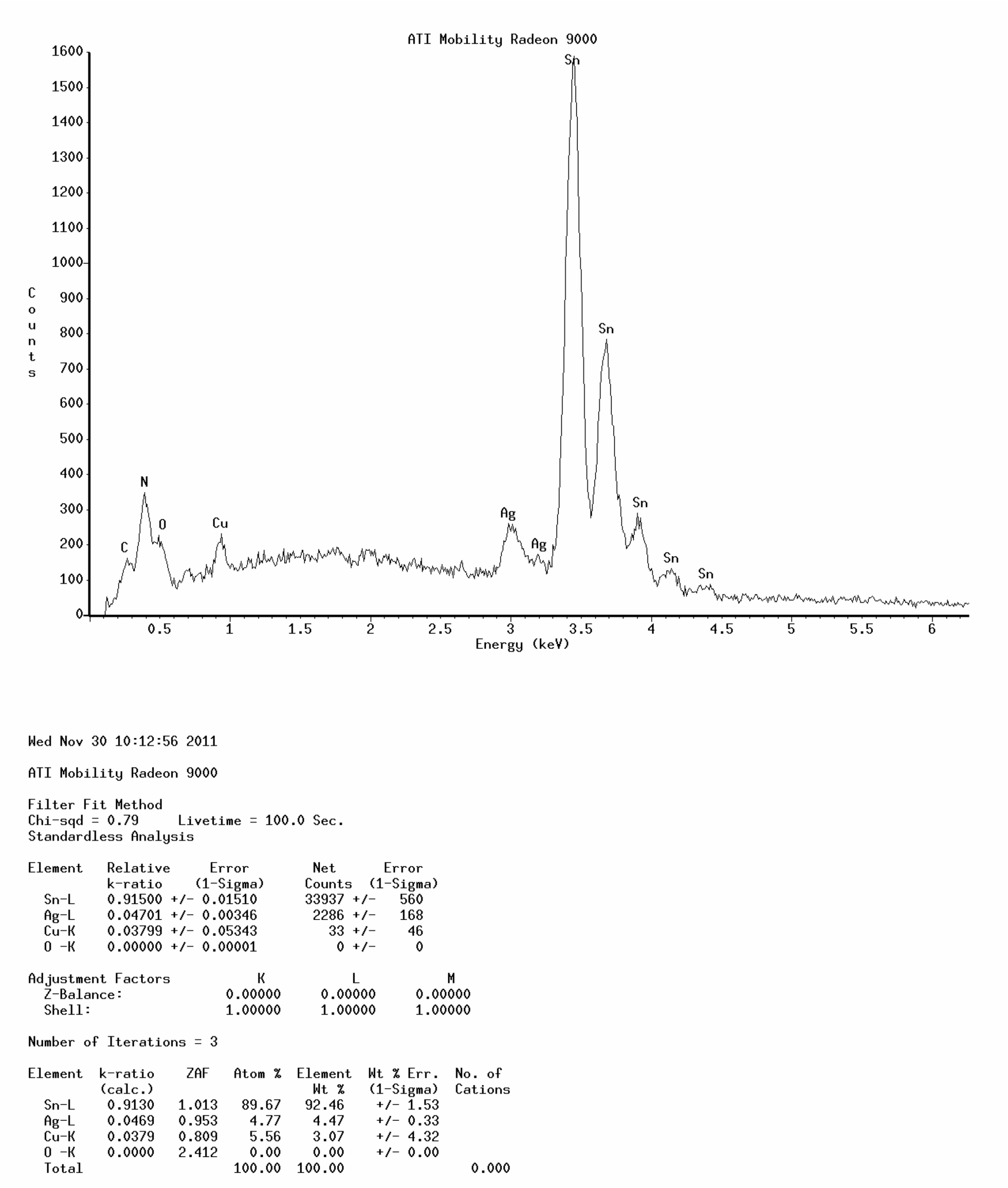
Figure 12
Element analysis of ball on subject device as received, prior to steam age and bond pull testing



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ATI Mobility Radeon 9000

Filter Fit Method
Chi-sqd = 0.79     Livetime = 100.0 Sec.
Standardless Analysis

Element   Relative     Error        Net      Error
          k-ratio    (1-Sigma)     Counts  (1-Sigma)
  Sn-L    0.91500 +/- 0.01510      33937 +/-   560
  Ag-L    0.04701 +/- 0.00346       2286 +/-   168
  Cu-K    0.03799 +/- 0.05343         33 +/-    46
  O -K    0.00000 +/- 0.00001          0 +/-     0

Adjustment Factors           K           L           M
  Z-Balance:              0.00000     0.00000     0.00000
  Shell:                  1.00000     1.00000     1.00000

Number of Iterations = 3

Element  k-ratio   ZAF   Atom %  Element  Wt % Err.  No. of
         (calc.)                  Wt %   (1-Sigma)  Cations
  Sn-L    0.9130  1.013   89.67   92.46    +/- 1.53
  Ag-L    0.0469  0.953    4.77    4.47    +/- 0.33
  Cu-K    0.0379  0.809    5.56    3.07    +/- 4.32
  O -K    0.0000  2.412    0.00    0.00    +/- 0.00
  Total                  100.00  100.00                0.000
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Figure 13

Oxygen element analysis of ball on subject device as received, prior to steam age and bond pull testing