CHARACTERIZING ELECTRICAL CONTACTS USING THE CHEMREVEAL™ LIBS DESKTOP ELEMENTAL ANALYZER

APPLICATION NOTE LIBS-025

Background

Connectors and tracks on printed circuit boards supply power and pass signals between electronic components soldered to the board. While primarily made of copper, alloying agents and overcoating are frequently used to improve the manufacturability and durability of traces and contact points.

Beryllium Copper refers to a family of copper alloys with excellent mechanical properties and resistance to flex, fatigue, abrasion and corrosion. Its strength and easy manipulation facilitates miniaturization of components and connectors like those found in consumer and portable electronics. Commercially available alloys have beryllium concentrations ranging from about 0.2 ~ 3% with the low end of the range selected for electronics applications.

Intact fabricated parts made from Beryllium Copper are not hazardous; however, elemental beryllium is highly toxic[1,2]. As more of the alloy appears in consumer wastes, controlling exposure through the whole lifecycle including disposal and recycling activities becomes a challenge. Due to this concern, electronics manufacturers are interested in assessing beryllium in consumer products and seek out substitutes in new product development.

Laser-Induced Breakdown Spectroscopy (LIBS) is uniquely suited for supporting studies of beryllium in metals, as well as other matrices. In fact, LIBS is has been used to measure beryllium in matrices ranging from gemstones to contaminated soil. What makes LIBS particular attractive for analyzing electronics?

- *Light element sensitivity*. Unlike x-ray fluorescence, LIBS is quite sensitive to so-called light elements with low atomic number such as beryllium.
- *Accurate targeting and direct analysis*. Guided by the video image, the focused laser targets particular electrical contacts and component of a circuit board without disassembly or sample preparation.
- *Depth profiling capable*: The high-fluence laser pulses can be controlled to remove and analyze sequential layers to compare plating layers to underlying bulk material.
- *Small sample size*. While not completely nondestructive, only a minute amount of material is consumed during a LIBS measurement.

This note reports on analysis metals contacts on an intact circuit board using LIBS. In a single analysis, we obtain information on noble and transition metals as well as beryllium in copper.

Results

We analyzed printed circuit board contacts using a Chemlogix ChemReveal™ Desktop LIBS analyzer equipped with a 200 mJ, 1064 nm Nd:YAG laser and a proprietary, 7-channel spectrometer, covering the range from about 170 – 980 nm. Instrument settings were as follows:

- Laser energy: 125 mJ/pulse
- Spot size: 100 µm
- Sample shots: 20 laser shots per contact
- Acquisition delay: 1 µs

<move this to the end, and report just the bulk concentration – not a profile. It comes out at concentration consistent with conductive BeCu. Start the

We observe distinct changes in composition as the laser ablates subsequent layers from the surface as shown in Figure 1. Spectra of some elements, such as Ca, Na and K associated with surface residues and are only persist for a few laser shots. Elements associated with the structure of the contact vary strongly with depth. The plating is gold coating, but just below the gold we find a nickel layer. Nickel is known to serve as a diffusion barrier between gold and copper (or other base metals). Once the laser has penetrated through both plating layers, the strong beryllium signal appears in the copper layer confirming it is a beryllium copper conductor. Figure 2 is scale expansion that more clearly shows the transition through the plating/conductor profile.

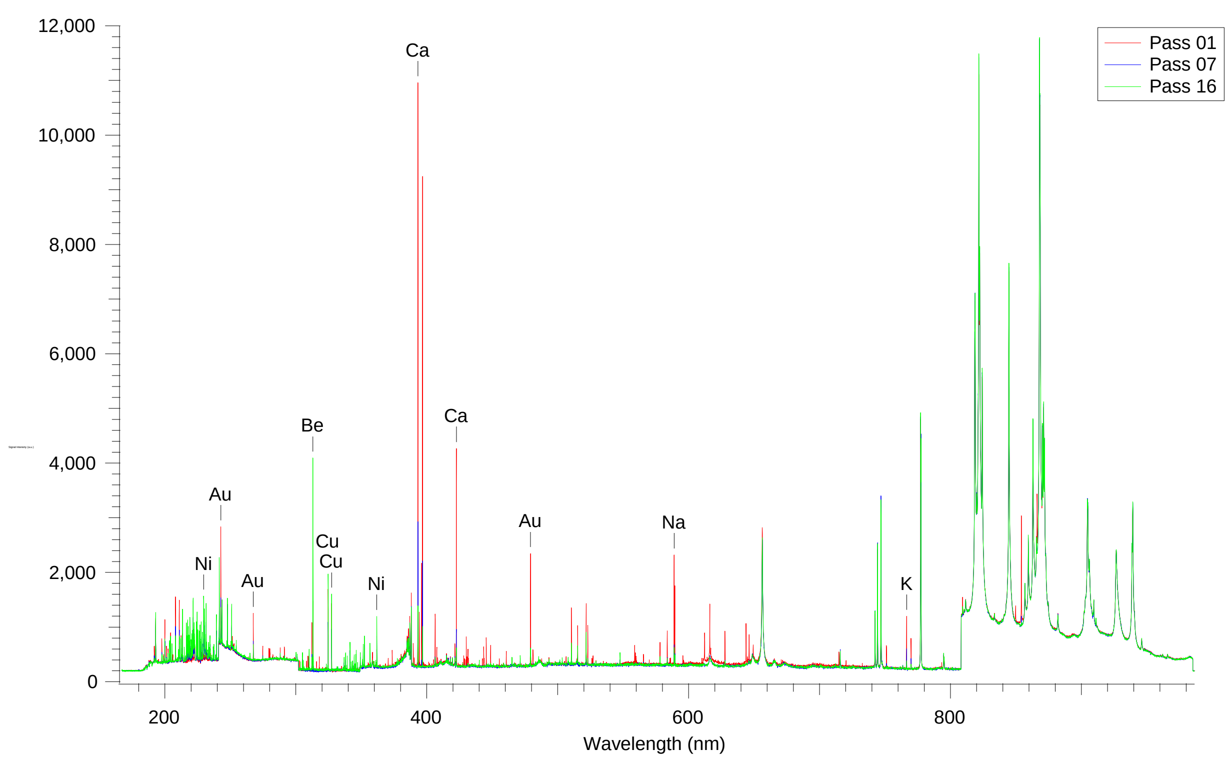

Figure 1: Overlay of 3 LIBS spectra of as-received surface, metal plating, and bulk conductor.

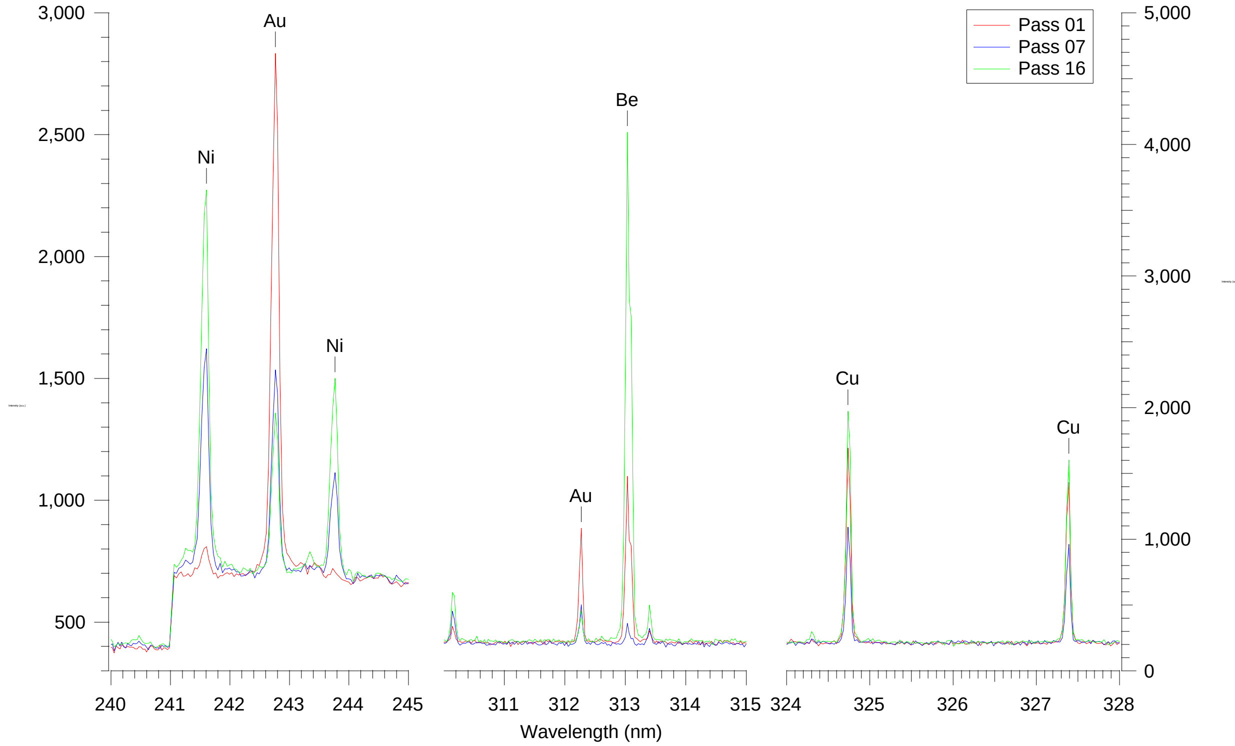

Figure 2: Scale expansion of spectra acquired through a contact plating showing a gold coated surface (red), nickel transition layer (blue) and beryllium copper alloy below (green)

LIBS can be used to predict the concentration of beryllium in the copper given an appropriate standard. Figure 3 shows spectra of two copper standard reference materials. Reference A contains 1.89% beryllium and Reference B has essentially 0%. The intensity of the beryllium emission relative to the copper lines from these references was used to create a matrix-matched, zero/span calibration for Be in Cu based on the integrated peak areas for the Be 313 nm peak. Using this calibration, we found the maximum concentration of beryllium in the circuit board conductor was 0.6%.

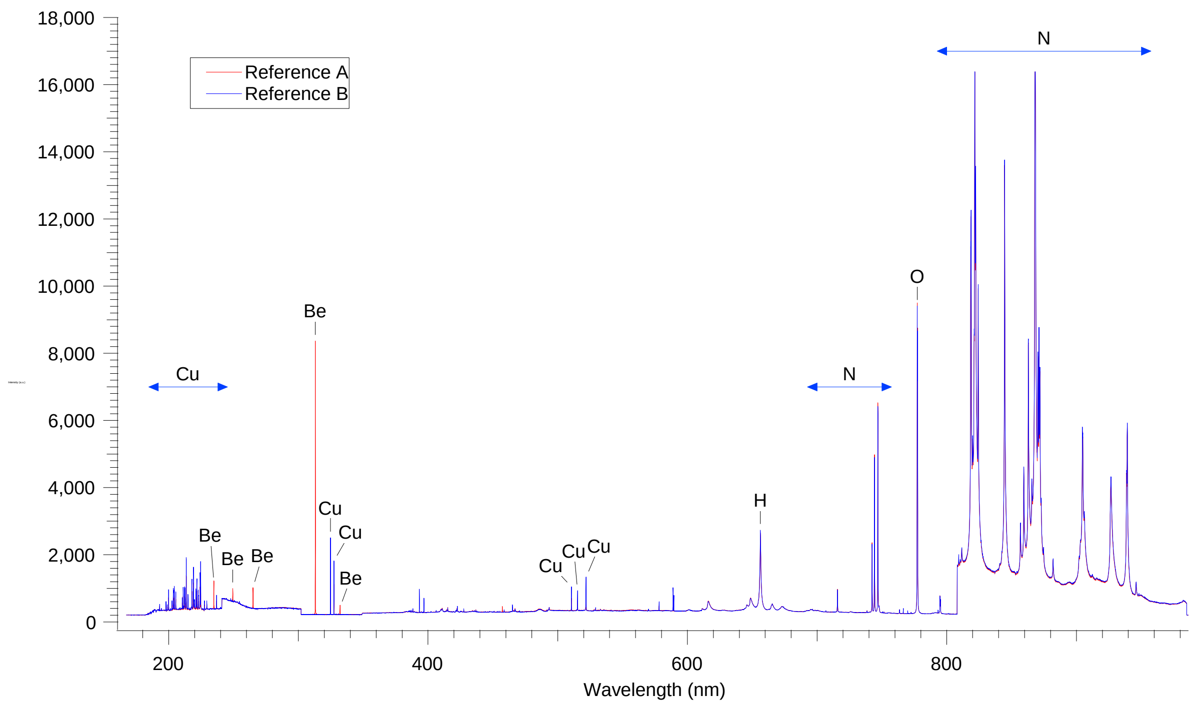

Figure 3. Overlay of LIBS spectra of the Cu standards. Average of 20 laser shots each (10 seconds).

Summary

LIBS works very well for determining relative compositions of small areas on printed circuit boards. In this work, the contact points were clearly shown to contain beryllium. Not only could the presence of Be be confirmed, but in addition we confirm the conductor is has a gold plating with a nickel sublayer.

References

1. BERYLLIUM AND BERYLLIUM COMPOUNDS. http://www.inchem.org/documents/iarc/vol58/mono58-1.html (accessed 2013/12/2).
2. Rosenman, K.; Hertzberg, V.; Rice, C.; Reilly, M. J.; Aronchick, J.; Parker, J. E.; Regovich, J.; Rossman, M., Chronic Beryllium Disease and Sensitization at a Beryllium Processing Facility. *Environ. Health Perspect.* 2005**, 113 (10)**, 1366-1372.

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