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# Polyurethane spray coating of aluminum wire bonds to prevent corrosion and suppress resonant oscillations

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Unencapsulated aluminum wedge wire bonds are common in particle-physics pixel and strip detectors. Industry-favored bulk encapsulation is eschewed due to the range of operating temperatures and radiation. Wire bond failures are a persistent, source of tracking detector failure Unencapsulated bonds are vulnerable to condensation-induced corrosion, particularly when halides are present. Oscillations from periodic Lorenz forces are documented as another source of wire bond failure. Spray application of polyurethane coatings, performance of polyurethane-coated wire bonds after climate chamber exposure, and resonant properties of PU-coated wire bonds and their resistance to periodic Lorenz forces will be described.

## Summary

The studies to be presented began at the behest of the Stave Task Force that was convened to understand and mitigate a corrosion attack affecting ATLAS Insertable B Layer (IBL) staves. The staves had been manufactured for a 14-stave, 5 cm radius, pixelated barrel detector to be used as the innermost tracking layer of the ATLAS detector at CERN's Large Hadron Collider. The corrosion is believed to have been induced from condensation during quality-assurance cycling in a climate chamber when humidity from outside air was not properly excluded, and exacerbated by residual halides which seem to be present on a variety of recent ENIG flex and solid printed circuit boards (PCBs). Wire bonds sprayed with polyurethane (PU) coatings were not fully-qualified at the time a decision was required for the IBL staves, but studies continued in the context of a future ATLAS Inner Tracker (ITK) upgrade.

Polyurethane coatings are applied with a commercial art-supply air brush. A variety of coating thickness from ˜10 microns to ˜100 microns are evaluated. All coatings prevent corrosion in deionized water tests, both before and after 350 cycles in a climate chamber from -30 C to + 50 C over 4 days.

Aluminum wire bonds (1% silicon) with 25 micron thickness, and 28 mm length are evaluated in a 1.7 T field with an "endcap/disk"geometry (B field parallel to the PCB normal and perpendicular to the wire bond) which is most vulnerable to Lorenz forces. Bond wire vibrations were excited with 50% duty-cycle square waves. Resonance characteristics are studied as a function of coating thickness. A sample where PU liquid is used to pot wire bond feet is included in the study. PU spray-coatings of with ˜100 microns are show to protect wires from currents as large as Ip-p of 200 mA that are applied at the resonant frequency of the wire bond.

A radiation-hardness study is ongoing. Results may be available at the time of the conference.

The workshop areas that are the best match for a study of wire bond encapsulation are:

- Radiation and Magnetic Tolerant Components and Systems
- Packaging and Interconnect Technologies

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