Bus-extender development for sPHENIX INTT detector

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sPHENIX is a major upgrade of the PHENIX experiment at RHIC, and it aims to study the properties of quark-gluon plasma by measuring jet and upsilon productions and their modifications. An intermediate tracker (INTT) is a silicon strip barrel detector for sPHENIX.[1)] A bus-extender is a special cable used for signal transfer between the INTT detector and read-out electronics placed at least 120 cm away from the INTT. The bus-extender has the following requirements: (1) flexibility, (2) length, (3) high-density signal line (128 lines/5 cm), and (4) high-speed signal transfer (by LVDS).

We developed a bus-extender in the past three years.[2)] We found that the prototype of our 120 cm-long bus-extender exhibits good electrical performance in terms of signal loss and reflection. Some issues were found in the prototype. The first issue is the formation of the through hole. The bus-extender comprises a four-layer flexible printed cuicuit, and the through hole is used to connect the signal lines between layers. We found that the through hole had a nodule structure, which can cause instability during long-term use. Figure 1 shows the layer structure of the bus-extender (left) and the cross section view of the through hole (middle); the nodule structure is formed in the through hole. We attempted the production procedure by changing the drilling methods and Cu-plating methods to remove the nodules; however, they still existed. We changed the glue used to laminate the multiple layers; this new glue works effectively. Figure 1 (right) shows the cross-section of the hole with the new glue.

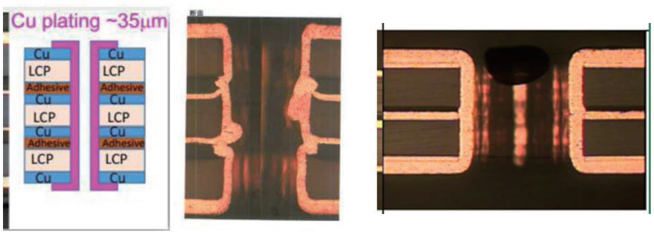

Fig. 1. (left) Layer structure of the bus-extender. (middle) Cross section of the through hole made by the original glue; nodules are formed. (right) Cross section of the hole with the new glue.

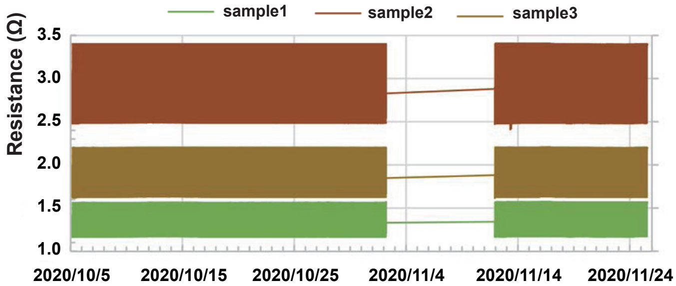

Fig. 2. Result of the thermal cycling test (1000 cycles in 50 days).

We performed a thermal cycling test to test its long-term stability. The test employs the application of high (75°C) and low (−15°C) temperatures for 30 min each; the temperature are changed at short time intervals (5 min). We repeated this test for 1000 cycles. We prepared three samples and measured the resistance of the through holes to evaluate the stability. These samples had 400, 600, and 1000 through holes that are daizy chained. During the test, the polymer of the sample expands and shrinks because of changes in temperature. This results in cracks in the through hole. If the through holes have cracks, the resistance becomes a large value. Figure 2 shows the result of the thermal cycling test. The resistances changes repeatedly within a valid range because of the changes in temperature for the entire periods. This indicates that the through hole has sufficent stability.

The second issue is that the peel strength of the prototype is about 4 N. This value is very small compared with the standard FPC (20 N). We found that the new glue improved the peel strength to 30–40 N. The results are summized in Ref. 3).

The radiation hardness and yield rate of the bus-extender are also studied. The current status of the studies are summarized in the Refs. 4, 5).

We successfully developed the bus-extender, and we plan to start mass production in 2021.

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