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EVALUATION OF BIPOLAR ELECTRODE ARCHITECTURE THROUGH DESTRUCTIVE ANALYSIS

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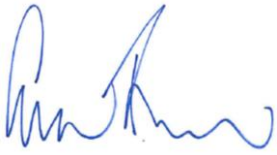

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DISTRIBUTION:

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EXECUTIVE SUMMARY

Donut Lab OU commissioned Intertek to perform a destructive examination of two delivered devices under test (DUTs) to assess their physical construction and internal layer arrangement. The objective of the investigation was to determine whether the DUTs were constructed according to a bipolar cell design. The scope of work included cell disassembly, visual inspection of internal components, and voltage measurements where feasible.

The examinations were conducted inside an argon-filled glovebox. The pouch cells were opened using a ceramic blade and scissors, and the internal components were systematically disassembled and documented. Voltage measurements were performed when electrical contact between layers could be established.

Both DUTs exhibited a similar overall construction. The electrode stack was enclosed within an outer plastic layer and supported by rigid sheets on both sides, which appeared to maintain compression of the electrode layers. The primary difference between the DUTs was the number of electrode sheets.

Visual inspection revealed that the electrode sheets were essentially identical in appearance throughout the stack. Each sheet had two distinct surfaces. Current-collector tabs were observed only on the two outermost electrode sheets, while no external tabs were present on the intermediate sheets.

Based on the observed electrode stack construction, the DUTs are consistent with a bipolar stack design. The arrangement of individual electrode sheets and the presence of current-collector tabs only on the outermost layers indicate that the intermediate layers are connected internally in series. This architecture enables the overall cell voltage to be generated through the cumulative voltage contribution of the individual layers within the stack.

CONTENTS

1 INTRODUCTION

Donut Lab OU (Donut Lab) commissioned Intertek to perform a destructive examination of two delivered DUTs to investigate their physical construction and internal layer arrangement. The objective of the investigation was to determine whether the construction of the DUTs is of a bipolar cell design. The scope of work included cell disassembly, visual inspection of the internal components, and voltage measurements where feasible. This report presents the observations, findings, measurements, and conclusions derived from the examination.

2 TEST SAMPLES

Table 1: DUTs delivered to Intertek

SAMPLE NAME	SAMPLE NAME (INTERTEK KAUFBEUREN)	DATE OF DELIVERY	COMMENT
ES26-42:1	KAU2607281108-001	2026-08-05	Fresh
ES26-42:2	KAU2607281108-002	2026-08-05	After nail penetration test

Two DUTs were delivered to Intertek by Donut Lab. These DUTs had previously been at Intertek's lab in Kaufbeuren. The results from the delivery control are found in Table 2. Intertek have not verified that the DUT is a functioning battery cell which can be electrically discharged/charged.

Table 2: Delivery control

SAMPLE NAME	WEIGHT (G) as received	OCV (V)	LENGTH (MM)	WIDTH (MM)	THICKNESS (MM)
ES26-42:1	26.02	4.98	87.1	71.5	3.3
ES26-42:2	42.98	2.96	88.7	71.3	5.3

Figure 1 to Figure 4 shows the DUT ES26-42:1 before the disassembly while Figure 5 to Figure 8 shows the DUT ES26-42:2 before the disassembly. According to information provided by Donut Lab, the holes observed in the pouch in Figure 4 and Figure 7 are introduced intentionally during the manufacturing process and not considered to be the result of mechanical damage or cell failure.

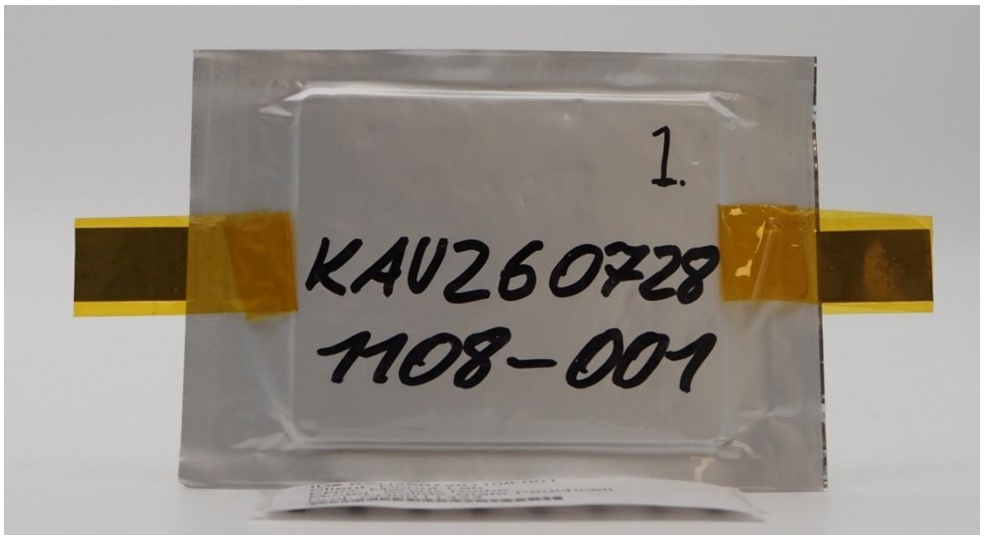

Figure 1: DUT ES26-42:1 before disassembly, top view

Figure 2: **DUT ES26-42:1 before disassembly, back view**

Figure 3: **DUT ES26-42:1 before disassembly, side view**

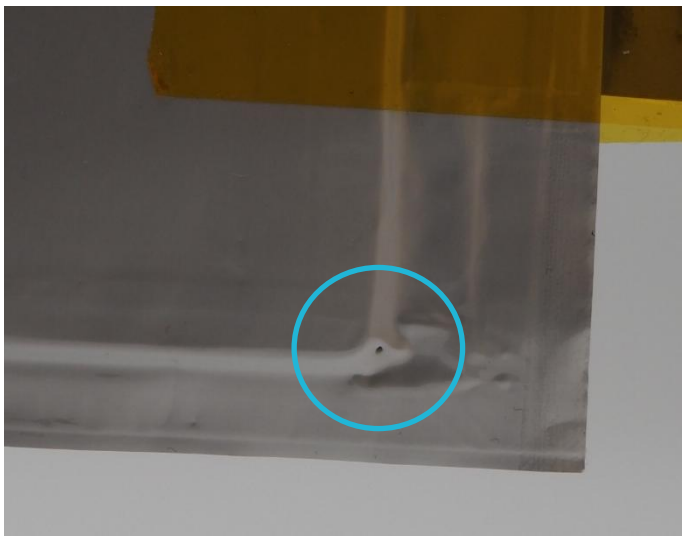

Figure 4: **DUT ES26-42:1 before disassembly, close-up showing intentional hole in pouch**

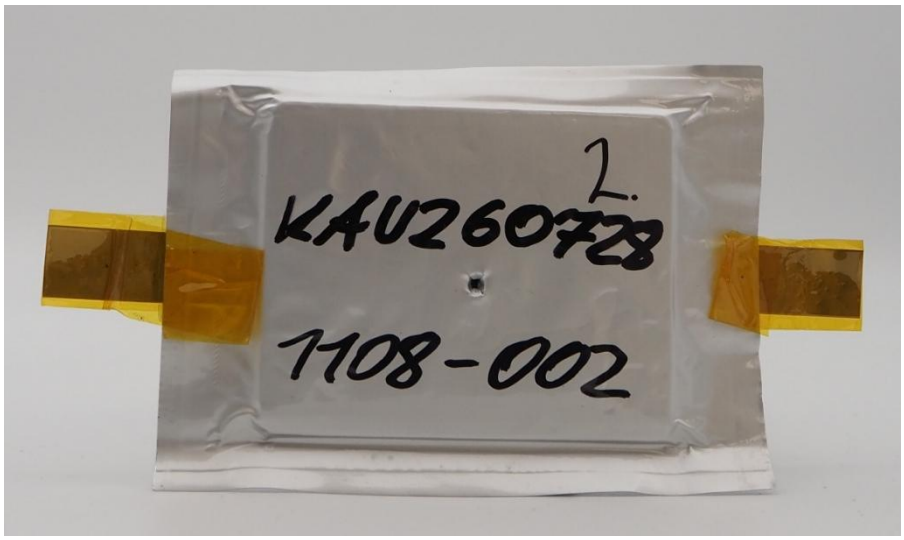

Figure 5: **DUT ES26-42:2 before disassembly, top view**

Figure 6: **DUT ES26-42:2 before disassembly, back view**

Figure 7: **DUT ES26-42:2 before disassembly, close-up showing intentional hole in pouch**

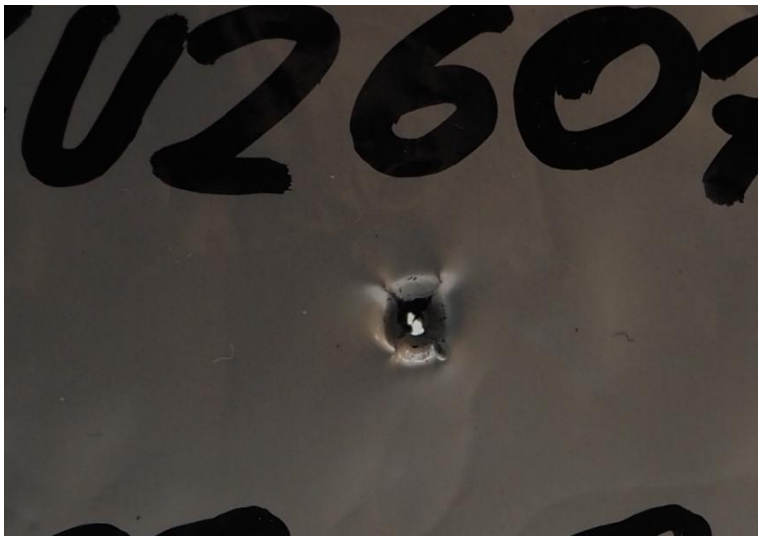

Figure 8: **DUT ES26-42:2 before disassembly, close-up showing hole from nail penetration.**

3 EXPERIMENTAL

The cells were disassembled inside an argon-filled glovebox. The pouch cell material was removed using a ceramic blade and scissor. The material inside the cell was systematically disassembled and documented with photos.

4 RESULTS

The DUTs were carefully disassembled by opening the pouch and removing the internal components using a ceramic blade and scissors.

Inside the pouch, the electrode stack was enclosed within an outer plastic layer (see Figures 9, 13 and 14). The stack was secured with tape and supported by rigid sheets on both sides, which appeared to maintain pressure across the electrode layers (see Figure 10 and 15). The number of electrode sheets differed significantly between the DUTs. Apart from this difference, the overall construction of the DUTs was similar, with only minor variations observed in the arrangement of the tape securing the electrode stack.

Visual inspection showed that all electrode layers were essentially identical in appearance, except for the top and bottom layers, each of which incorporated a current-collector tab (see Figures 16 and 18). Each electrode sheet exhibited two distinct surfaces (see Figures 12 and 18). One surface was covered by a grey layer, while the opposite surface was black. No visual differences were observed among the intermediate electrode sheets.

4.1 Photos from disassembly of DUT ES26-42:1

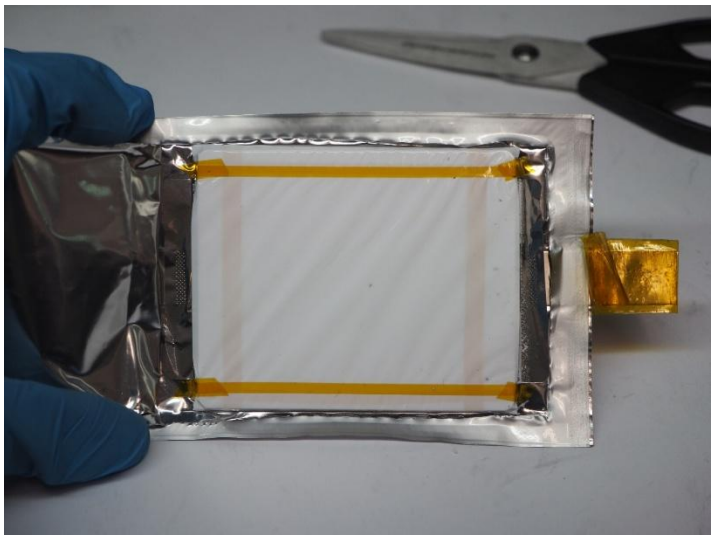

Figure 9: **DUT ES26-42:1 after disassembly. The pouch material has been removed on top. A plastic sheet is surrounding the electrode stack.**

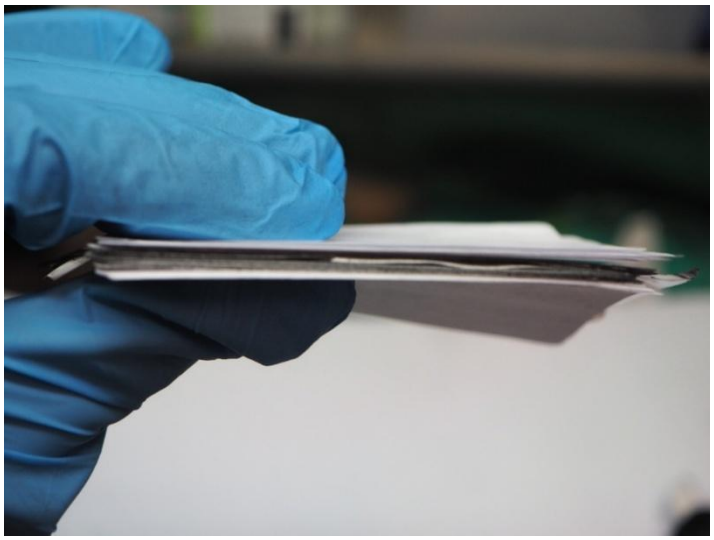

Figure 10: **DUT ES26-42:1 after disassembly, the electrode stack**

Figure 11: **DUT ES26-42:1 after disassembly, the two distinct different sides of the electrode sheets**

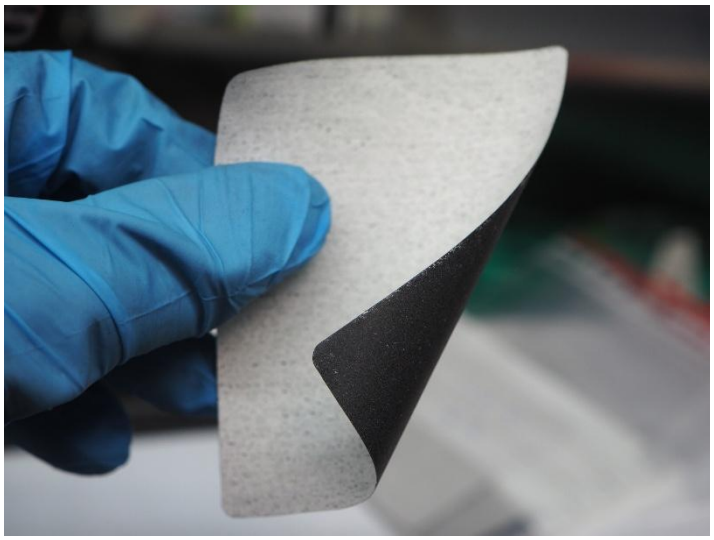

Figure 12: **DUT ES26-42:1 after disassembly. A single electrode sheet, showing two different surfaces on the opposite side of the sheet.**

4.2 Photos from disassembly of DUT ES26-42:2

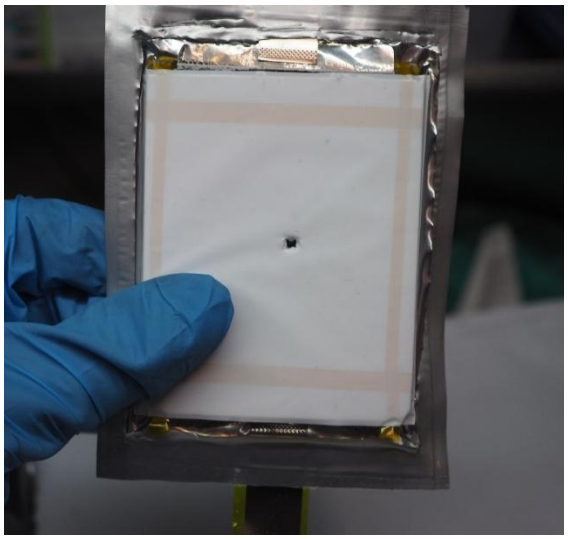

Figure 13: **DUT ES26-42:2 after disassembly, the pouch material has been removed on top.**

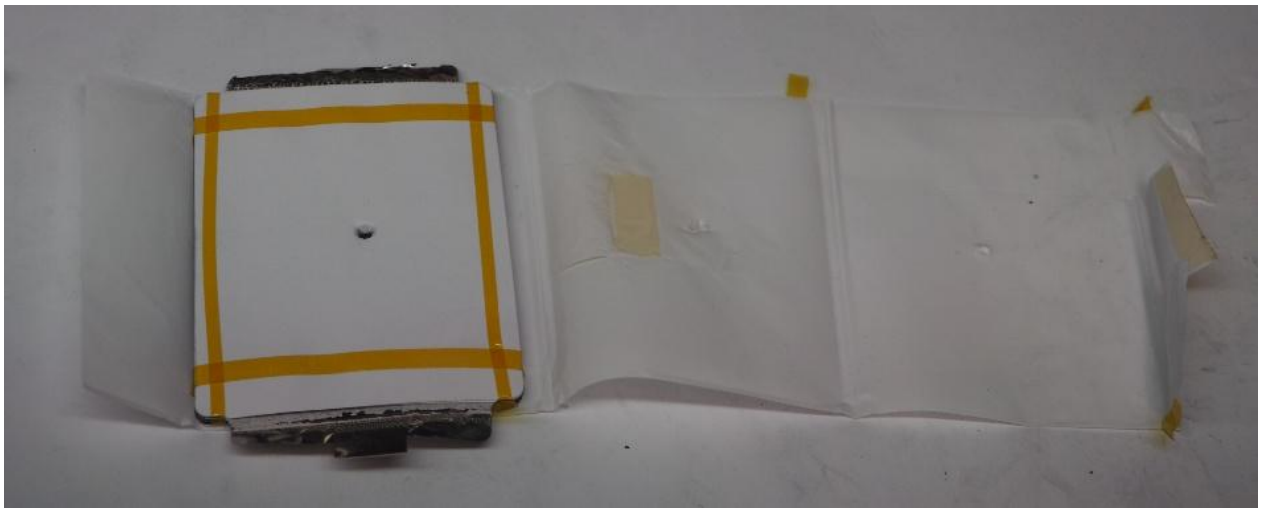

Figure 14: **DUT ES26-42:2 after disassembly. The removal of outer plastic layer surrounding the electrode stack.**

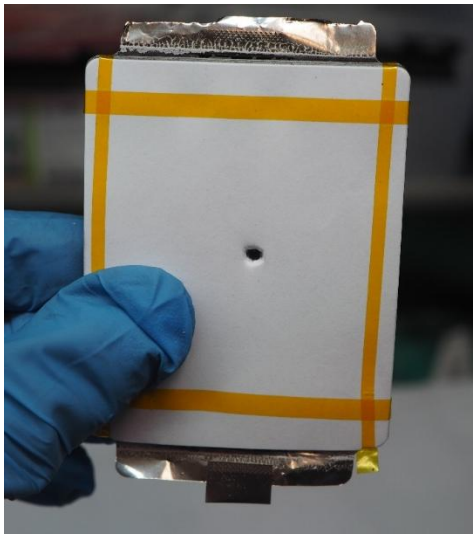

Figure 15: **DUT ES26-42:2 after disassembly. The plastic layer surrounding the electrode stack had been removed.**

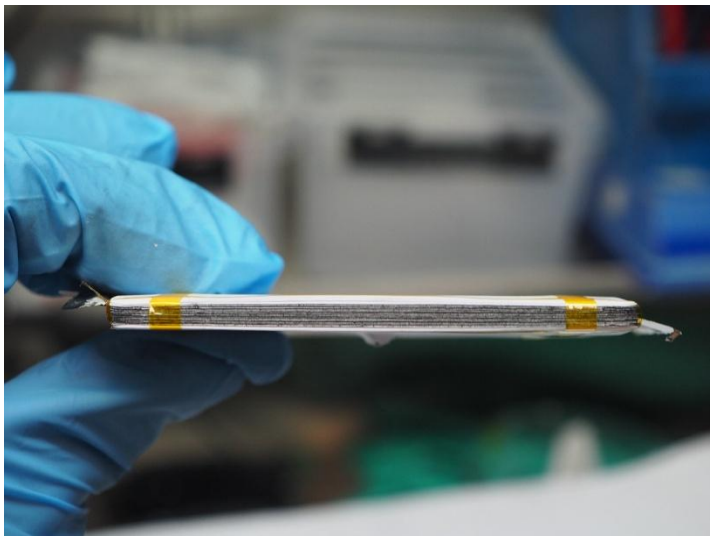

Figure 16: **DUT ES26-42:2 after disassembly. Side view showing the electrode stack with tabs on the top left and bottom right.**

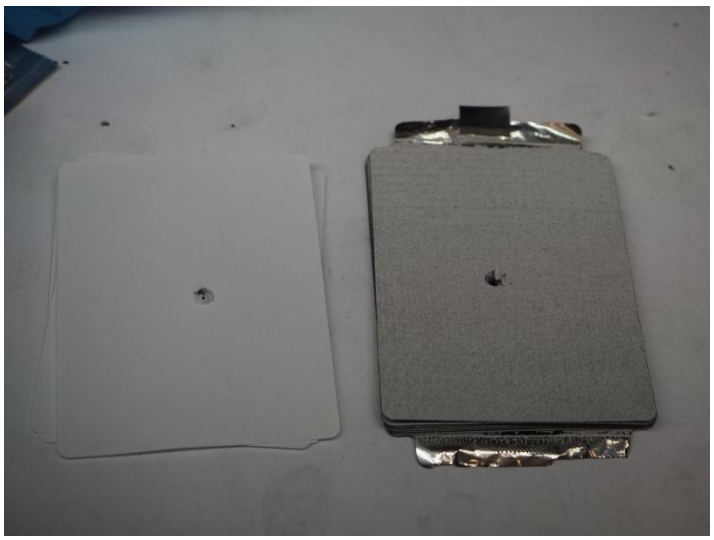

Figure 17: **DUT ES26-42:2 after disassembly. The electrode stack.**

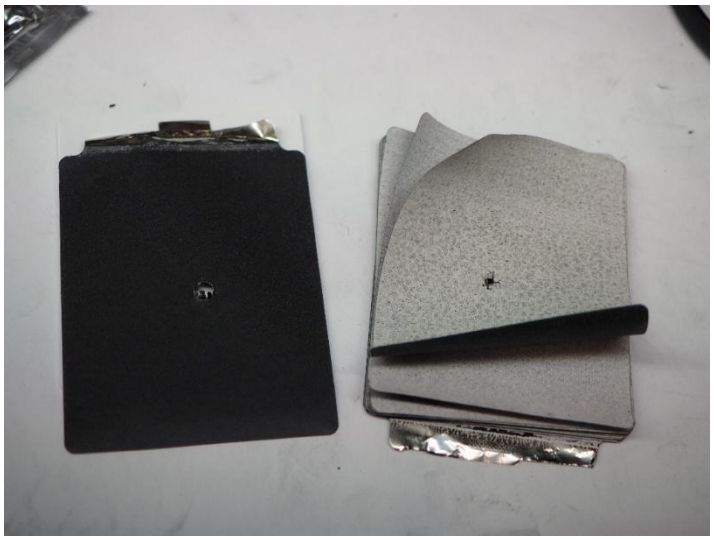

Figure 18: **DUT ES26-42:2 after disassembly. The electrode stack showing the two different surfaces of the electrodes.**

5 CONCLUDING REMARKS

A bipolar stack design is a cell architecture in which multiple electrochemical layers are connected internally in series. In such a design, only the outermost layers require external current-collector tabs, while the intermediate layers are connected through internal interfaces. Consequently, the overall cell voltage increases with the number of layers in the stack.

Disassembly of the DUTs showed that the electrode stack was composed of individual electrode sheets, with current-collector tabs present only on the two outermost layers. The intermediate electrode sheets did not have external tabs.

The observed construction of the electrode stack in the DUTs is consistent with a bipolar stack design, where the total cell voltage is generated by the series connection of the individual electrode layers within the stack.