Electrical contacting of current collector foils for lithium-ion batteries using conductive adhesives

Helene Jeske, Linsen Fu, Yuechen Wu, Maja Kandula, Klaus Dilger
Institute of Joining and Welding, TU Braunschweig, Langer Kamp 8, 38106 Braunschweig
STATE OF THE ART

Resistance spot, ultrasonic or laser beam welding are mainly used to join battery cells in the production of battery assemblies.

Each of these welding techniques has its own characteristics, depending on the material properties and contact geometry.

Access to the joint must be ensured, often on both sides, which can have a negative effect on the joint geometry or the required installation space.

Different types of materials must be joined, which poses major problems from a metallurgical and production engineering point of view.

Welding processes involve heat input, which should be locally limited in order not to damage the battery cells.

Resistance Spot Welding [https://huysindustries.com]

Laser beam and ultrasonic welding [https://www.tu-braunschweig.de/ifs]
Contacting the aluminum and copper foil by using electrically conductive adhesives:

- epoxy resins filled with silver particles or graphite and carbon black
- curing temperature and time, different amount of silver particle, graphite and carbon black are investigated
- samples are investigated in destructive lap shear tests regarding their mechanical strength compared to ultrasonic welded specimens
- contact resistance tests (four-point resistance method) were used to characterize the conductivity compared to ultrasonic welded specimens

This joining technique based on conductive adhesives allows other design principles and enable more form flexibility or layer quantity
JOINING BY SILVERFILLED CONDUCTIVE ADHESIVES

<table>
<thead>
<tr>
<th></th>
<th>Elecolit 3025 (2K) (Panacol)</th>
<th>Elecolit 3656 (1K) (Panacol)</th>
<th>Elecolit 1400 (1K) (Panacol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver content [w.-%]</td>
<td>84</td>
<td>87</td>
<td>86</td>
</tr>
<tr>
<td>Curing temperature at 180 °C</td>
<td>\</td>
<td>60 min</td>
<td>\</td>
</tr>
<tr>
<td>Curing temperature at 120 °C</td>
<td>15 min</td>
<td>\</td>
<td>15 min</td>
</tr>
<tr>
<td>Curing temperature at 80 °C</td>
<td>\</td>
<td>\</td>
<td>30 min</td>
</tr>
<tr>
<td>Curing temperature at 25 °C</td>
<td>16 h</td>
<td>\</td>
<td>\</td>
</tr>
</tbody>
</table>

Joining surface:
Ultrasonic welding: 7x11 mm
Bonding: 25x25 mm
5 mg per layer
5x aluminum + 5x copper
JOINING BY GAPHITE & CARBON BLACK FILLED CONDUCTIVE ADHESIVES

<table>
<thead>
<tr>
<th>Polyvertec 3452 and H1 (Schill+Seilacher)</th>
<th>Characteristic values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength</td>
<td>70 MPa</td>
</tr>
<tr>
<td>Mixing viscosity at room temperature</td>
<td>330 mPas</td>
</tr>
<tr>
<td>Pot life at room temperature</td>
<td>150 – 180 minutes</td>
</tr>
</tbody>
</table>

Curing conditions at 60 °C for 3h in heat press at 10 bar and post-cure at 60°C for 24h in batch oven

Graphite ACROS Organics: 30, 40 and 50 w.-%  
Graphite & carbon black mixture: 30, 40 and 50 w.-%

Bonding: 25 x 25 mm  
3 mg per layer  
5x aluminum foil + 5x copper foil
MECHANICAL PROPERTIES

Ultrasonic joining at 50 and 100 Joule and vibration amplitude at 20, 30 and 40 µm (blue)

Elecolit 1400 and 3656 silver filled epoxy resins (green) – best performance

Polyvertec 3452 & H1 epoxy resin (red)
ELECTRICAL PROPERTIES

Ultrasonic joining at 50 and 100 Joule and vibration amplitude at 20, 30 and 40 µm (blue)

Elecolit 1400 and 3656 silver filled epoxy resins (green)

Polyvertec 3452 & H1 epoxy resin (red), high contact resistance
SUMMERY & OUTLOOK

The focus of this work was to identify adhesives systems and parameters to evaluate whether conductive adhesives have the potential as an alternative joining system for cell contacts.

The tensile shear strength of the bonded specimens is higher compared to specimens which are joined by ultrasonic welding.

The conductivity of the ultrasonically welded specimens is higher than that of the bonded specimens with silver filled epoxy resin.

The conductivity of bonded specimens with graphite and carbon black filled epoxy resin is lower comparable to ultrasonically joined and bonded specimens with silver filled epoxy binder.

Reduction of adhesives amount per layer and a better incorporation of graphite and carbon black in the epoxy resin could improve the electrochemical performance.

Dr. Helene Jeske
Department of fiber composites and electromobility
Institute of Joining and Welding
phone +49 531 391-95591
h.jeske@tu-braunschweig.de