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ROLL PLATED COPPER ALUMINUM CONNECTOR

THE TASK

New developments in the area of electromobility increasingly demand new types of joints that are adapted to specific tasks and combine the properties of various materials. Such material combinations can be clamped or screwed. However, such connections are inferior in terms of productivity, material utilization and the long-term stability of the contract resistance. Classically welded joints often form intermetallic phase seams at the material transitions. These also increase the contact resistance in the connections.

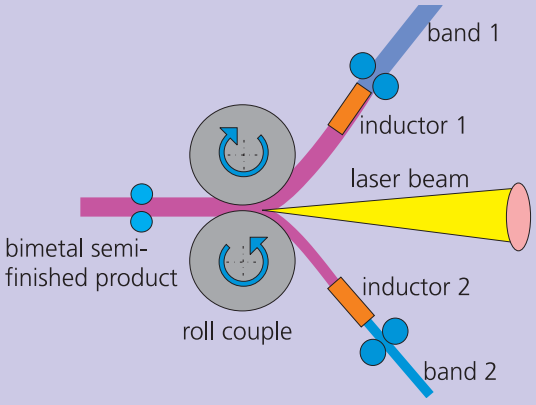
Semi-finished connector products made, for example, from copper and aluminum, would offer new possibilities to implement compact and lightweight powertrain components. Thus it is the objective of a BMBF project "DeLIZ" to develop effective manufacturing processes for long-term stable joints between copper and aluminum parts.

OUR SOLUTION

The idea is to use roll plated bimetal transition joints from aluminum and copper with the goal to generate metallurgically bonded current carrying connections with low contact resistance. Fraunhofer IWS engineers developed a special roll plating process, which is the so-called laser induction roll plating (LIRP, Fig. 3). The specialty of the process is a very limited overall deformation (< 11 %) of the components. The process also consists of only a single forming step with only a very brief peak temperature exposure in the welding zone. This process uses inductive preheating of the semi-finished components in combination with a line shaped laser beam that introduces energy only in the area of the roll plating gap. The welding zone is formed based on metallurgical reactions, caused by the deformation and the simultaneous temperature regime.

Since there is only one processing step and the energy input is very localized, the overall process is flexible in terms of welding various semi-finished parts. For example, the two components to be welded do not have to be geometrically identical. It is possible to join two metals in overlapping configurations to save materials. Thus the joints can be made from materials of almost any thickness and their widths can be adapted to the application as well.

Principle representation of the laser induction roll plating process



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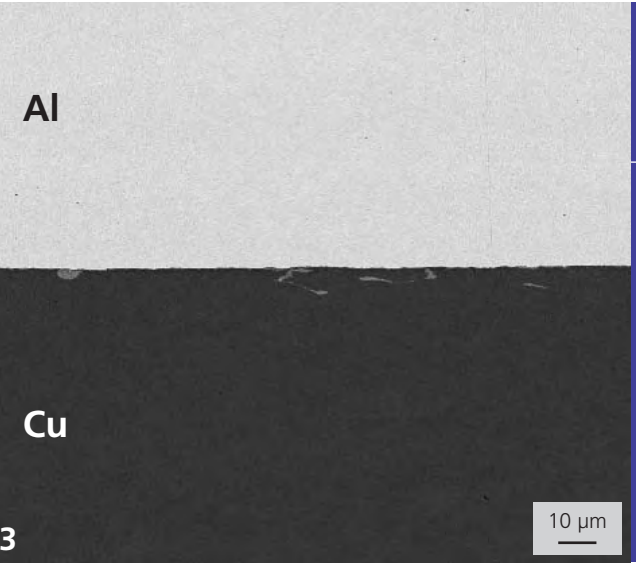

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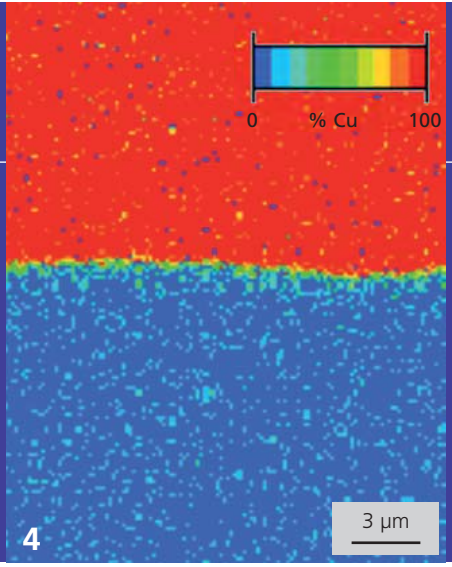

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RESULTS

The laser induction roll plating (Fig. 2) is well suited to fabricated material joints from combinations such as different steels, steel and aluminum / aluminum alloys and steel and copper / copper alloys. It is also possible to make connections between copper / copper alloys and aluminum / aluminum alloys (Fig. 1). Typical metal band geometries are 12 or 22 mm wide and the thickness is between 1 and 2 mm. The resulting plating speeds are up to 8 m / min with lasers of up to 10 kW and 45 kW induction power. Generally the roll plating process runs more stable at higher speeds. However, the achievable throughput depends greatly on the type of semi-finished feedstock (dimensions, materials) and the available power of laser and induction units.

Research focused on achieving excellent electrical parameters for the bimetal transition joints of copper and aluminum. There are also requirements in terms of their mechanical strength and formability. In particular the welding zone is of interest when evaluating the mechanical performance. For most of the fabricated parts it was not possible to determine adhesion values in the welding zone. The separation typically occurs outside of the welding zone in aluminum. Tensile shearing experiments showed the same failure mode. But for a few exceptions, the material separates with the heat influenced zone inside the aluminum band. The measure shearing strengths were on the order of 32 to 52 MPa depending on the applied parameter field.

During the process the laser beam heats the inner surfaces of the metal bands to significant temperatures even exceeding the melting point. However, the formation of an extended intermetallic phase seam can be suppressed (Fig. 3 and 4). Therefore the welding zone has little defects, which is a condition for achieving good electrical performance. Current activities aim at determining the electrical performance as well as the cyclic mechanical loading stability of the formed transition joints.

1 Plated band made from copper and aluminum

3 SEM micrograph: welding zone of a roll plated copper aluminum band, copper light, scattered copper is found within the aluminum

4 EDX analysis of the welding zone, quantitative distribution of the copper content

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