Laser welding tool

Laser bonding is suited for much larger connector cross-sections, where it offers the advantages of wire bonding, including high flexibility and ease of automation

Electric vehicles require much higher currents than those typical of traditional semiconductor applications – in the battery pack and in the drivetrain control system. This is where conventional ultrasonic wire bonding has its limitations, both on the technological and on the economic side. For a typical wire bond connection that uses aluminum wire of 500µm diameter, operating currents must stay well below the fuse current of about 35A. Using several wires in parallel, or even aluminum ribbons of 2,000 x 200µm size, is not a suitable solution either: the large amount of wires reduces productivity, and ribbons can be expensive. Not to mention the technical challenge of having to clamp the parts rigidly to sustain the high-energy mechanical friction needed for bonding.

Enter laser technology. Laser welding has long been a method of choice to connect much larger cross-sections, but for battery pack connections, automation is cumbersome because a connector bar or plate has to be placed across the cells with, ideally, zero gap between the spots that are to be welded. This is not easy to ensure and makes it all the more tricky to control the laser power precisely enough not to penetrate the thin metal can of a battery cell.

F&K Delvotec, which is based in Germany, has been manufacturing wire bonders for many years and took on the challenge to marry the two technologies. The company's new Laserbonder combines the flexibility and easy automation of a wire bonder with the high-quality welding performance of the laser. There are two major advantages of the laser: low clamping forces on the parts are sufficient, and the surfaces to be welded do not need to be very clean or even very smooth. True to its heritage from the wire bonder, the laser bonder simply reels off connections from cell to cell, or from cell to busbar, at the desired length and in the desired positioning, and cuts off the connecting ribbon after the second bond. Then it repeats the process for the next pair of contacts. If the heights of the battery cells are not precisely identical, the laser bonder will compensate for this by searching for the right height for each contact position. The same is true for shifting cell positions: an image processing unit locates the correct positioning and the machine automatically adjusts the connector length and direction, just like a conventional wire bonder.

For the welding itself, an infrared fiber laser of 1kW can handle copper ribbon connections up to around 10mm in width and 1mm thickness. A particularly powerful feature of the machine is deep penetration or keyhole welding, which, in combination with an oscillating beam, enables control of the width and depth of the weld seam independently of each other. This is ideal for battery cell connections where a large interconnection area – hence a wide weld seam – is desirable while the welding penetration should be in the range of 30µm or less, to ensure that damage does not occur to the thin sheet metal forming the battery cell container. These advantages, coupled with the cost-effectiveness of equipment, are generating a lot of interest in the industry.

The Laserbonder contains a wirebonder base with large working area (right) and a standard fiber laser with a control unit (left). Parts handling can be automated in a variety of ways, from manual loading and unloading to full in-line capability

A 18650 battery cell with a laser-bonded ribbon connection. Photo: Fraunhofer ILT