Approaching the battery of tomorrow with help from a laser

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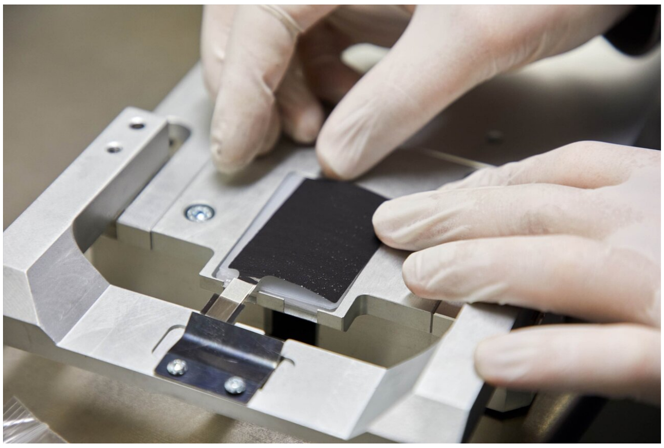

Cu foil with electroactive material. Image by . Credit: CIC energigGUNE

Eco-friendlier, cheaper, with a bigger storage capacity and increased lifetime: many demands are made on the battery of the future. A Spanish team of researchers uses laser technology to design the next generation of batteries.

The veteran lead-acid batteries, which have worked well for about one century at a low cost, seem unable to afford enough storage capacity for the needs of our time. Certainly, they were not designed for electric cars. Other attempts like Ni-Cd (nickel cadmium) or Ni-MH (nickel metal hydride) have proved too weak to push an electric vehicle.

Although quite expensive at its commercial pop-up in the early '90s, the lithium-ion (Li-ion) technology has become reasonable in time and it can now satisfy the driving range needs of many people. The average daily commute distance worldwide is below 50 km. However, important aspects like cost and stability have to be adjusted, researchers say.

Under the EU-funded project Laser4Surf, the scientists are addressing one of these parameters, namely the stability of the Li-ion battery. "We are using the laser to change the current collector surface, which is one of battery components, made of metal. These modifications will improve the battery's stability, thus extending its lifetime," explains the physicist Dr. Miguel Ángel Muñoz-Márquez, group leader of Advanced Interface Analysis at CIC energiGUNE in Álava, Spain.

Any lithium ion cell (battery) has a current collector on both ends. The electrode material is cast like paint on each current collector; it stores the lithium ions and releases them when necessary, during battery operation. Technically, the action of the laser on the metal surface allows for better adhesion of the electrode to the current collector. This prevents any undesired reaction that could trigger electrode delamination from the current collector.

"These modifications can also increase battery performance under high power loads. With the laser, we want to increase the active surface of the current collector, enabling it to handle more electrons in the charge and discharge process," adds Miguel Angel Muñoz.

The current Li-ion batteries which set in motion electric cars are strong enough. Depending on the manufacturing company, a car can run between 200 and 500 km without charging the battery. The main problem is affordability, as the cost of the battery is about 40% or 50 % of the cost of the car. "This figure can be brought down either by improving the technology, as we are doing in the Laser4Surf project, or by finding cheaper materials. If a solution for extending battery lifetime is found, this would be a success even if it comes at a higher price. The battery lasts longer and the investments will be paid off," says Muñoz.

Testing coin cells at battery tester. Credit: CIC energigGUNE

Another important issue of the project concerns battery sustainability. In Laser4Surf, the researchers skip one chemical step in the manufacturing process: the carbon coating of the current collector. Carbon coating on an ordinary Li-ion battery improves the current collector's performance, e.g. to ensure a better electric contact between the current collector and the electrode. "The laser modifies the surface of the current collector and removes the need for chemical coating. At the same time, the laser's engraving improves both the electrical and mechanical contact, hence the batteries perform better," explains Muñoz.

After the first lab test, Miguel Angel Muñoz is full of hope about the future of this research: "In this second half of the project, we are working on a prototype developed in the coating line, available in our center's dry room. This prototype will have the approximate size of a mobile phone battery and the cell obtained can be considered a pre-industrial trial." The next step is to convince the battery companies that these findings are competitive. "One of the goals in this project is to build machines able to modify the copper surface on a large scale, so there will be a pre-industrial prototype. If everything goes fine, in less than ten years, we will be able to produce it at industrial scale," he adds.

"Improving contact between the active material and the current collector is extremely important and it is a very good approach to increase the lifetime and the charge performance of the battery," says Prof. Stefano Passerini, director at Helmholtz Institute in Ulm, Germany and chief editor of the "Journal of Power Sources." He thinks that lasers could be a successful technology, as it costs less now. However, a benefits/costs balance should be calculated and only then can the effectiveness of the research be assessed.

"The fact that using laser technology can improve the contact should be demonstrated. I am aware of other laser applications, in which the teams are planning to make grooves in the electrodes to increase the electrode thickness, i.e., the energy density, while maintaining good power performance. This combination would be good for energy storage, but all these approaches need to be demonstrated on an industrial scale," Passerini says, adding that industry takes a very long time to change established processes unless a substantial improvement or huge cost saving is evident.

Nonetheless, this kind of research can bring about substantial cost savings for businesses, believes Muñoz. Any breakthrough has measurable impact on the battery industry and can help in getting more funding for a lab allowing to devote more efforts in this direction.

More and more scientific groups are devoting time to study batteries. "Various levels of research exist. Firstly, there is applied research, performed by companies. Results from this type of research give short-term impact and risk to the project's success is low. Secondly, there is research based on incremental improvements, with short to mid-term impact, with a higher degree of risk, typically developed by technology centers. Here, working groups attempt to improve battery capacity and reduce cost. Finally, there is fundamental research with medium to long-term impact and high risk, which is typically carried out by research centers or universities. Their results may bring about a revolution, a paradigm shift. Teams could discover for example a new material for high performance lithium ion batteries, a new production method, a new electrode material or a new electrolyte that could bring sodium ion or lithium sulfur batteries onto the market against Li-ion," Muñoz explains.

The overall demand for better performing batteries leads to various ways of approaching the topic and synergies among different levels of research seem to be needed more than ever.

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