Lithium-ion thin-film solid-state battery

Industrial project
Time to launch the plant: 9 months
Funds required for these months: 200,000 Euros

Today there are a huge number of systems for lithium-ion batteries. But the main features of the existing systems are the same, they consist of three elements: anode, cathode and liquid electrolyte (in the separator between the cathode and the electrode). The amount of materials used to create such systems is huge. Battery structures use from 1- or 2-component elements to complex 4- or 5-component elements.

Batteries are needed for mobile phones, computers, cars, small unmanned aircrafts, etc. including as energy storage devices for solar panels.

Automobile companies are actively starting the production of batteries with the aim of a quick transition to electric vehicles. For example, this year the Czech Skoda began construction of a plant for the production of lithium-ion batteries. The investment amounts to 200 million euros. They believe that their batteries are better than similar models of competitors.

It should be noted that all existing batteries are volumetric, and if their structure is layered, then the thickness of the layer is 300 microns, which brings the structure of the battery closer to volumetric. All such batteries have a number of negative factors related to the volume of the electrolyte. In particular, in bulky batteries over time:

- dendrites are formed, that is, crystalline tree-like non-conductive formations in which there is no ionic current, and therefore the power of electricity generation decreases;
- spontaneous local mechanical destruction of the crystalline 3D structure occurs during repeated recharging;
- due to permissible accumulations of lithium when it is blocked and interacts with oxygen, fires and explosions of the battery are possible;
- complex and expensive disposal and processing of spent batteries.

The typical lifespan that most manufacturers expect from lithium-ion batteries is around 5-6 years, and such a battery can withstand up to 3,000 charge cycles. Although some manufacturers of the latest crystalline lithium-ion batteries claim to achieve 5000 charging cycles. After this number of charging cycles, the battery must be disposed of.

In our approach, we propose a solid-state electrolyte (solid nanocomposite), which will be composed of two materials: the main material is graphite, which forms the basis of the layer, and the second material is a lithium composite, which actually plays the role of a solid-state electrolyte. Such an electrolyte has a huge number of empty spaces, which allows lithium ions to move freely under the influence of an applied electric field.

Our lithium solid-state electrolyte is a thin film, 2-4 microns thick. Such a thin crystalline electrolytic film can be obtained by sputtering using a magnetron.

In our thin-film electrolyte, the number of free lithium ions is about 30% more and the ratio of kW/kg (i.e., generated electric power to the weight of the electrolyte) is about twice as good as compared to bulk ones. In addition, in a thin-film electrolyte, the number of mobile lithium ions does not decrease over time. In a two-dimensional crystalline electrolyte, lithium ionic conductivity (2D conductivity) is much more stable than ionic conductivity in a bulk crystalline electrolyte (3D conductivity).

The 4 negative characteristics of bulk electrolytes listed above are completely absent in a thin-film crystalline electrolyte, namely:

- dendrites are not formed;
- spontaneous mechanical destruction of the film structure does not occur;
- ignition is not possible (because lithium ions freely move through numerous free places in the 2D crystal structure);
- it is easy to recycle and extract lithium from spent thin films.

Our thin-film lithium-ion solid-state batteries can handle over 10,000 charge cycles, which means a guaranteed 15-year battery life.

It should be noted that our first thin electrolytic crystal films were made 40 years ago. Their recent testing showed that the parameters of those films remained practically unchanged. The number of charging cycles in the test mode was 15,000.

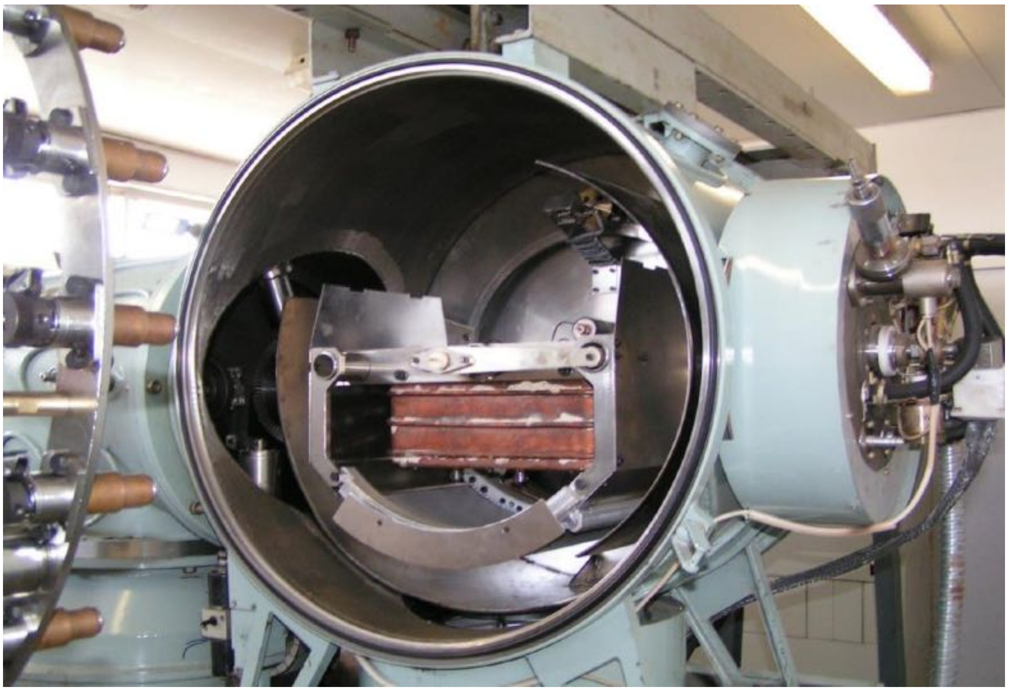
Over the course of 6 months, thin-film lithium-ion solid-state electrolyte prototypes will be made, several samples approximately 15 cm x 15 cm in size. The 3-micron films will have a porous crystalline nanostructure, which is necessary for the free movement of lithium ions.

A patent will be written.

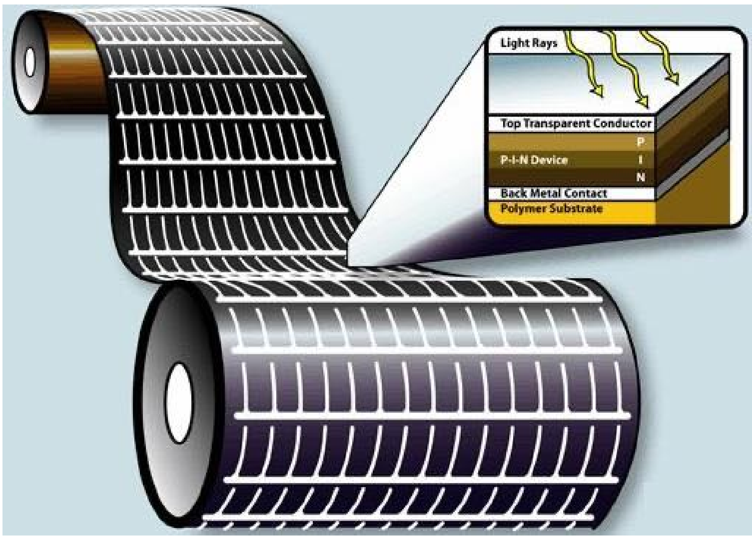
After that, we will be able to proceed to the installation of production lines for the production of batteries of various sizes with the number of thin film layers starting from 1,000 to 10,000 or more.

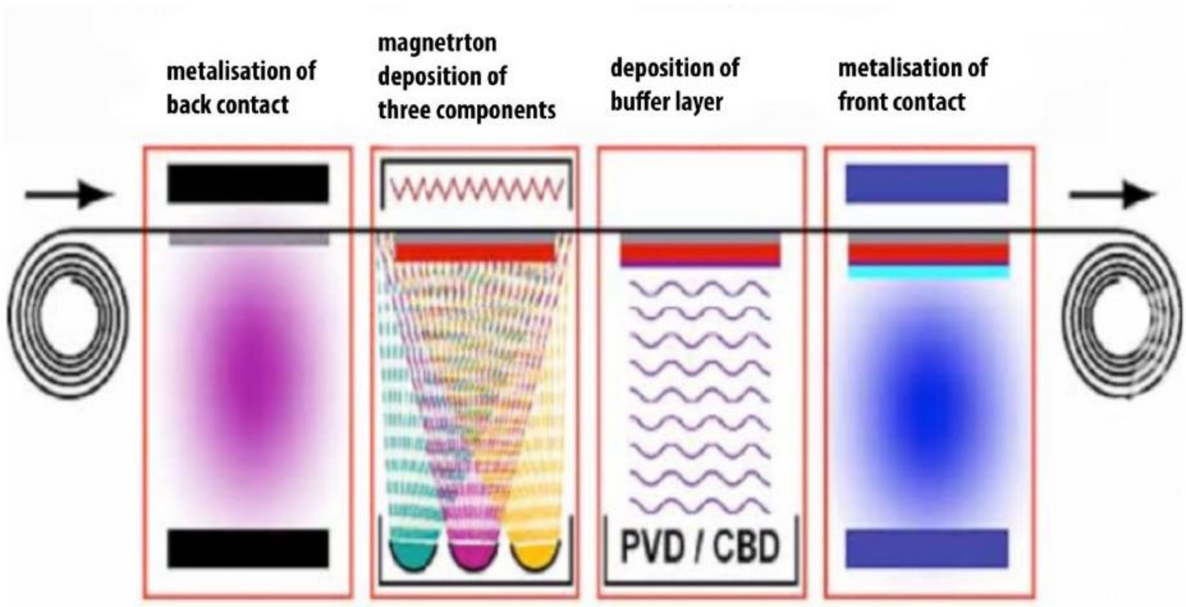
The principle of obtaining a film battery is shown in the photos and figures below. In English, this is called roll-to-roll technology.

This is what a typical machine looks like for vacuum magnetron sputtering of a thin film-electrolyte on a film base (polyethylene or aluminum foil), which is pulled through the machine from roll to roll at a speed of several meters per second:



In the magnetron vacuum machine, the roll is rewound with a length of several kilometers, with spraying on a flexible film-substrate of a thin film-electrolyte with a thickness of 3 microns directly on the roll in the machine:





Roll-to-roll technology for the production of thin solid-state nanocomposite film-electrolyte.

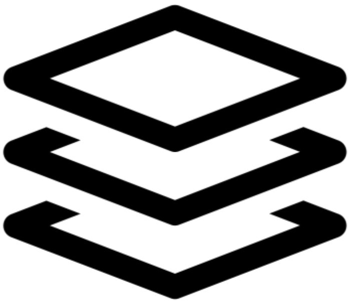
The level of electrical energy consumption during film production is low – approximately several kilowatt hours.

The cost of the produced electrolyte film will be low, which means the possibility of completely filling the world market with such a product.

The technology is fully developed and tested.

The production of such battery films requires certain capital investments, which will mostly go to the purchase and adaptation of expensive magnetrons for vacuum sputtering.

The battery will have the following layered structure:



The number of electrolyte layers can exceed 1000. Each layer will be a separate cell of the battery. The thickness of one layer (solid electrolyte on the substrate can vary from 20 to 50 microns. Then the height of the battery with 1000 layers will be about 5 cm. The weight of the battery will be small, but the power will be large. At least we can safely say that the dimensions and weight of our battery will be about twice smaller than competitors' batteries with similar energy performance.

Guaranteed: 15 years of life, more than 10,000 charging cycles.

There are no analogues in the world.