The modern world depends on lithium-ion (Li-ion) batteries, which are currently the best energy storage system in many respects. Their market counts in billions of Li-ion powered devices sold annually. Despite their great development potential, they have some flaws that have not been overcome so far. One of them is the large drop in the cell's capacity during its quick charging and discharging. Due to this limitation, mobile device creators has accustomed us to recharge our smartphones or laptops in time of about two hours. So far, we have been able to accept such a state of affairs, however, the rapidly growing electric car market cannot afford it, given that traditional cars are refueled in the time of one minute. Old habits do not change, that's why we need storage systems that can be charged in similar time and will give comparable or better ranges. In this area, it is equally important to increase the capacity of the battery, which also translates into better use of raw materials and the ability to store more energy in a smaller and lighter cell.

In order to achieve this goal, it is necessary to develop modern materials that store energy in a Li-ion cell. Our team developed a new material - nano-LKMNO, doped with precisely defined amounts of potassium and nickel lithium-manganese oxide of spinel structure. The introduction of these elements into the material structure unexpectedly raised the energy and power density of the cells based on it. These results far exceed the achievements that in today's literature allow to classify materials as systems for high power applications. Nano-LKMNO achieves similar capacities with five times faster charging and discharging. Moreover, in materials with an analogous structure, until now, such a high capacity for reversible energy storage has not been observed. The most important question to be asked at this moment is - why?

So far, it has not been possible to explain the source of the excess, exceptionally high capacity of LKMNO material. Its excellent work efficiency with very fast charging and discharging as well as unprecedented durability compels us to explore the unexplored paths of cathode materials research. Observations of the LKMNO performance in a Li-ion cell indicate imperfections in internal material electrical contacts with other elements.

In order to closely observe and understand the phenomena that are the source of such a high capacity of LKMNO material, it is required to create three-dimensional current collectors with an aluminum nanorod structure or nickel nanofoam. These metal skeletons capable of conducting electricity will serve as extended electrical contact, so that after coating with the LKMNO composite layer, they will transform into nanostructured 3D electrodes.

The result of the project will be the verification of research hypotheses about the origin of the excess capacity of the nano-LKMNO material and establishing the mechanism of energy storage in this material. An in-depth understanding of the phenomena occurring during its electrochemical work can open a new path of Li-ion cathode research in which yet unobserved energy storage mechanisms occur.