PHASE MOTION CONTROL

ELECTROCHEMICAL REACTOR FOR THE ASSESSMENT OF THE CONDUCTIVITY OF MATERIALS AND FUNCTIONALITY OF SOLID-STATE BATTERIES - 2023 -

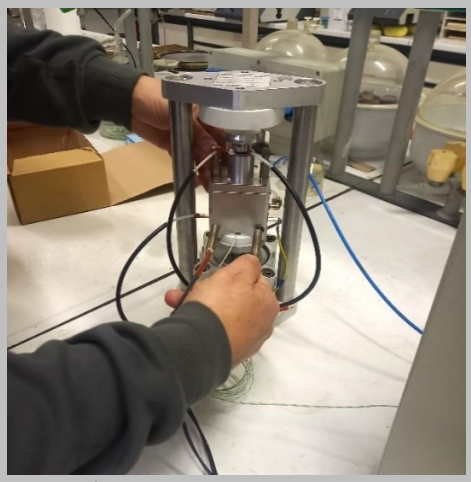
E R G O

The request for a reactor to test metal ion solid state batteries (e.g. lithium, sodium) in standard and special operating conditions is linked to the constant evolution of research in the field of energy accumulators with increasingly advanced characteristics. The study of Lithium or Sodium ion batteries is strategic for its fundamental contribution to the development of alternative energies and, for this reason, to study increasingly green solutions with low or zero impact on the environment (also regarding the raw materials used) becomes a crucial point of the work carried out by the scientific community.

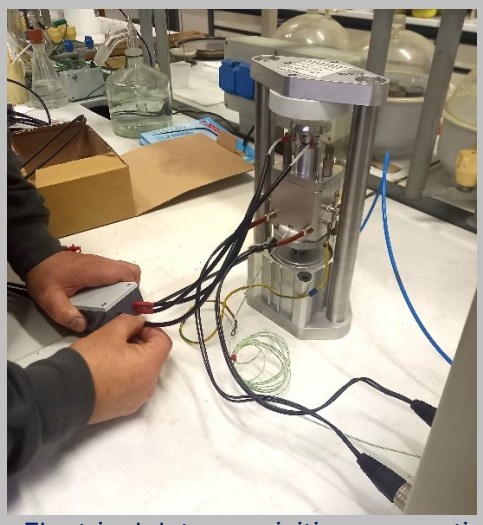
Solid-state metal-ion batteries are of strategic importance and, for this reason, the subject of numerous research that have high expectations. By their intrinsic nature they are made using static pressures that, during use, can be maintained or increased to ensure the operation with the best performance. Temperature also plays an essential role. As you know, low temperatures can be critical, but it is also true that there is an operating temperature that maximizes the performance so special systems are implemented to achieve them from the beginning of their functions. Nevertheless, there are temperature limits beyond which to operate as critical for some of the components of the battery that, being constituted by more active and passive parts, must consider all the materials present.

The reactor designed by ERGO DESIGN responds to the absence of an effective and reliable instrument that combines all the control characteristics of the parameters Temperature and Pressure, ensuring the management of the instrument in a controlled atmosphere and allowing four-pole measurements to: verify the correct operation of the battery, perform charging and discharging cycles repeated over time and related to the parameters of Pressure and Temperature, acquire information on the electrical resistance and the intrinsic ion resistance of the battery, verify the active life of the battery once it is in operation and subjected to charging and discharging cycles, estimate the performance as a function of the charging and discharging speeds (C-rate) during cycles.

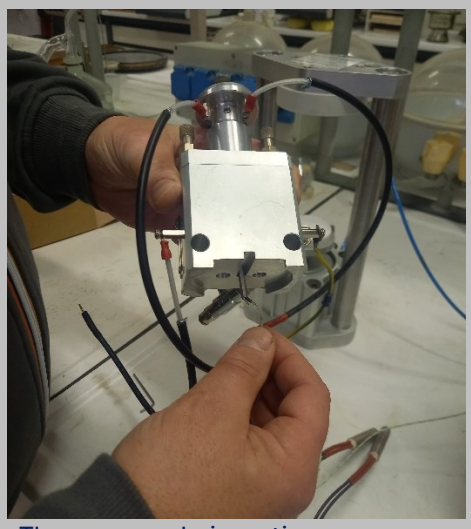
- Connections to control units



- Inserting heaters



- Electrical data acquisition connection



- Thermocouple insertion

Once the reactor was put into operation, it proved versatile in other sectors, allowing a series of measures of strategic importance in various fields of chemistry, electrochemistry and energy materials.

Its main features are:

1) It works on solid samples that can cover the maximum surface of about 113 mm2 with thicknesses ranging from about 0.05 mm up to about 10 mm.
2) The samples to be measured can be placed in the measuring chamber within a glove chamber with a controlled atmosphere (for example in the absence of oxygen and humidity). The chamber, once closed and locked with screws, remains isolated from the external atmosphere.

3) The reactor is equipped with an external connection that allows to make the vacuum ensuring an even more stable working condition and provides the opportunity to insert a specific reaction atmosphere even a posteriori.

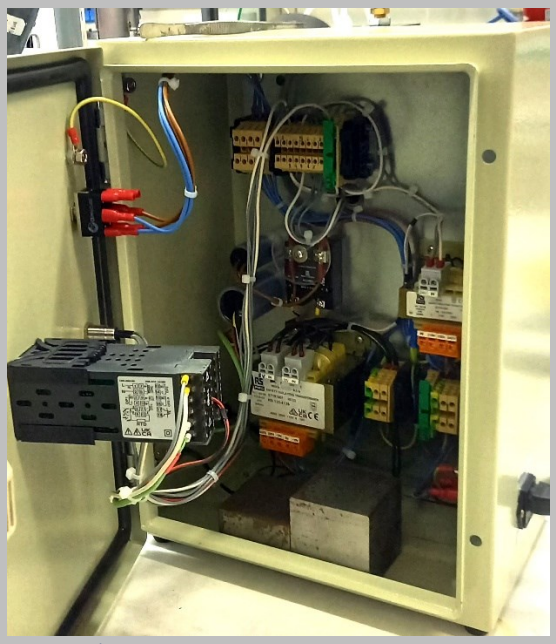
4) The system is born with its own pressure that allows the contact of the terminals with the two opposite surfaces of the sample

5)The reactor is equipped with a thermal system (thermocouple and heating system) which allows the reaction chamber with the sample to be brought inside the desired temperature in the range T environment - T 60 Volume C. This range can be modified according to the type of sample being tested.

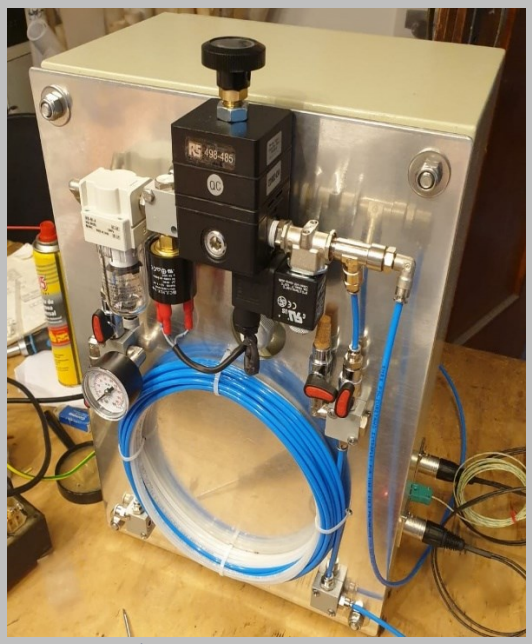
6) The reactor can work under pressure thanks to a system that allows the application and release of calibrated and measurable pressures on the piston head operating on the surface of a sample

7)The reactor is divided into two parts: the base with its contact surface with the sample (bottom side) and the head or piston in contact with the opposite side of the sample (top). These two parts are isolated from each other and only the sample allows the electrical connection.

8) Each part is connected to two wires that are dependent on each other and electrically coupled to two to two. These two wires can be connected to measuring systems, electrical load, specific electrochemical instrumentation both in two-pole configuration and in 4-pole configuration.



- Electrical panel

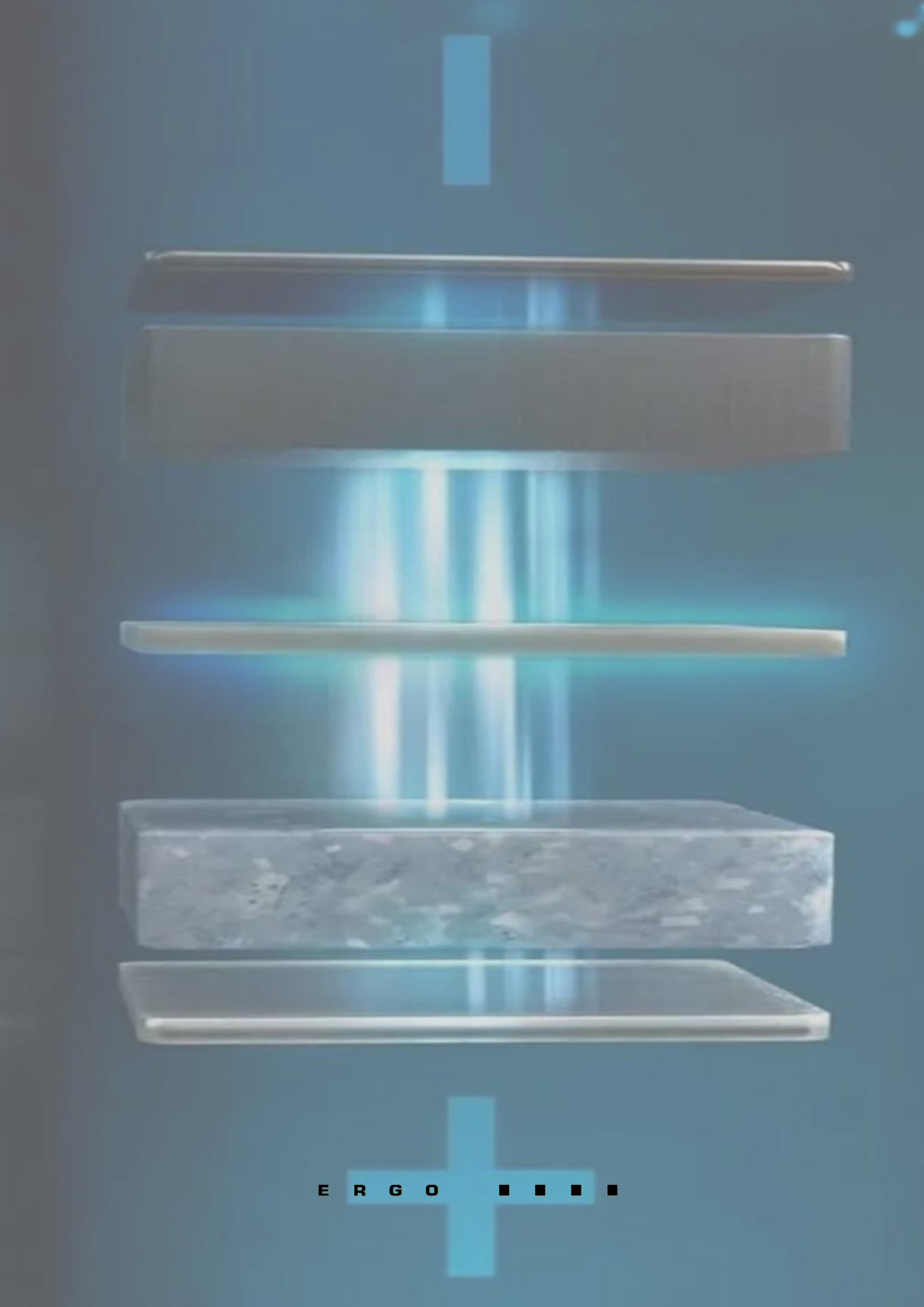


- Pneumatic panel

From the above information it can be inferred that the samples that can be tested inside the reactor are the most varied and that the measures that can be acquired are of wide interest. The peculiarities of the reactor are, in fact, linked to this versatility and to the possibility of measuring and analyzing the behavior of single or multi-component materials both in ambient conditions and at controlled temperature, pressure and atmosphere.
The application for which it was initially studied concerns metal ion batteries (e.g. Lithium and Sodium) built in the solid state. These batteries are currently at the center of numerous studies and require all the conditions of pressure, temperature and controlled atmosphere listed above. Thanks to this tool it is also possible to optimize the performance of the batteries thanks to the application of vacuum hot pressure that allows a better compaction of the single component or the entire battery. As indicated above, in fact, you can test the components individually to verify their properties and characteristics and then assemble and repeat the experiment on the complete battery.
The reactor has been tested connected to various instrumentation ranging from a single tester for electrical materials to scientific instrumentation for electrochemical and electrochemical impedance measurements. In all cases it has proved effective and functional without creating interference to the measure.
Other applications included the evaluation of the behavior of electrophiled membranes that required specific electrical properties and had to undergo pressure resistance tests. In this case too, it has been possible to gather complete and very useful results for the research activity.

Prof. Paolo Piccardo
Coordinator of the M.E.T.A.L.
Department of Chemistry and Industrial Chemistry
University of Genoa
Via Dodecaneso 31
16146 Genoa

- Reactor in operation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