# New Materials for Electrochemical Energy Conversion and Storage Devices

The research activity of the CheMaMSE (Chemistry of Materials for the Metamorphosis and the Storage of Energy) group is focused on the preparation and characterization of materials for application in the field of energy storage and conversion.

The research work consists in a broad range of activities, including: a) the design of new materials, starting from basic chemistry and physics concepts; b) novel chemical synthesis and processing; c) advanced materials characterization; d) measurement of physical and chemical properties; e) fabrication and evaluation of prototype devices; and f) the development of a fundamental understanding of the structure-property-performance relationships of the materials.

In particular, most of the research efforts are devoted to the synthesis and the study of: a) primary and secondary lithium and magnesium batteries; b) low and high temperature polymer electrolyte fuel cells (PEMFCs) including anion exchange membrane fuel cells (AEMFCs) and direct methanol FCs (DMFCs); c) aqueous and non-aqueous redox-flow batteries; d) field-effect transistors; e) sensors and actuators; and g) photo-electrochemical devices such as dye-sensitized solar cells.

In the field of rechargeable batteries several classes of materials are currently investigated comprising: a) solid state single ion-conducting polymer and ceramics; b) ionic-liquid-based electrolytes; and c) high voltage and high specific capacity cathodes. The interplay between structure, conductivity and electrochemical performance of these systems is studied in order to propose advanced materials for not only high energy density batteries but also for technologies beyond conventional lithium-ion systems.

Concerning fuel cell applications, core/shell carbonitride-based electrocatalysts for the oxygen reduction reaction as well as innovative cations or anion conductors for PEMFCs are synthesised and carefully investigated by means of several in-situ and ex-situ techniques. The most promising materials are then tested in prototype devices.

Most of these materials have been promptly patented, in collaboration with several companies, and are among the most innovative and better performing in the field of energy storage and conversion systems.

Energia
*Energy*

**CheMaMSE** (Chemistry of Materials for the Metamorphosis and the Storage of Energy).

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The research activity is carried out in collaboration with the following institutions and companies:

Main research topics:

- Electrolyte and electrode materials for fuel cells of the type PEMFCs (Polymer Electrolyte Membrane Fuel Cells), AEMFCs (Anion Exchange Membrane Fuel Cells), HT-PEMFCs (High-Temperature Proton Exchange Membrane Fuel Cells), DAFCs (Direct Alcohol Fuel Cells), and for PEM electrolyzers (since 1999)
- Electrolytes and innovative electrode materials for the reversible storage of electrical energy in secondary lithium and magnesium batteries
- Study of the electric response of ion-conducting, electric and dielectric materials by broadband electrical spectroscopy (BES)
- Redox Flow battery materials including ion-conducting membranes, innovative redox couples and electrode configurations