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## Foreword

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Future electrochemical energy storage materials: from nanoscience to device integration and real environment application –Symposium of the European Material Research Society 2022.

The transition towards the carbon neutral energy sector encompasses numerous types of energy storage solutions to satisfy the electricity demand in the coming future. In this scenario, electrochemical energy storage (EES) are already the better choice in a large number of applications for a long or short-term storage (i.e. renewable energy, household, electric vehicle, among others). Hence, the exigent EES market requires a balance between cost, lifespan, sustainability, safety and recyclability features. In spite of the advanced today market, the needs for improving the existing EES technology is crucial for achieving the total independency of non-renewable energy sources. Batteries and supercapacitor are the key technologies to meet the expectations of the future EES for their unique features, including scalability, affordability, among others. Particularly, the working principle of the batteries relies on storing electrical energy in the chemical form through electron transfer reactions or *vice versa* for delivering the energy. However, the supercapacitor works with capacitive process created in the electrochemical double layer. Both mechanism offer different features to improve the energy density (batteries) or power density (supercapacitors) of the EES. In addition, the so-called pseudocapacitor takes advantages of both processes (i.e. capacitive and charge transfer process in the electrode/electrolyte interface) with the simultaneous benefits on power and energy density values. Herein, materials engineering is crucial to develop the key components, leading a satisfactory performance and reasonable cost.

The aforementioned motivation has provided a broad of novel concepts for EES, developing new materials, modeling and tools, quite appealing for scientific and industrial community, which was the core of this symposium within spring meeting European Material Research Society (EMRS). Particularly, the spring meeting EMRS conference was hold in virtual mode from May 30 to June 3, 2022 (website: [Future electrochemical energy storage materials: from nanoscience to device integration and real environment application | EMRS \(european-mrs.com\)](https://www.emrs.com/conferences/2022/spring-meeting)). However, EMRS is celebrated periodically in two editions -spring and fall meeting- every year. The symposium was sponsored by the International Society of Electrochemistry (ISE) Division 3: *Electrochemical Energy Conversion and Storage*. As a ISE representative, Prof. Dr. Petr Krtil from *J. Heyrovsky Institute of Physical Chemistry of the Czech Academy of Sciences* (Prague, Czech Republic) has opened the symposium, presenting the Society. This symposium involved the pioneers and the most reputed scientists around the globe, developing supercapacitor, batteries (lithium and post lithium intercalation materials) as well as redox flow batteries. The symposium was divided in 8 half-day session (gathered ca. 100 participants), containing 44 oral contributions, 9 invited talks and 7 posters. Each session was opened with invited speakers, followed of oral contributions and, finally, the chairperson directed an open discussion between the speakers and the participants. In parallel, a chat was always available for any question or other matters. Finally, the “poster session” was conducted with a 3-min presentation by the authors and a discussion with the participants. Finally, the “close

session” was guided by a debate of the highlights learned in the symposium and the drawbacks to overcome in the future of the EES technology and the announcement of the “*Young Research Award*”.



Screen of the program presenting the symposium and ISE logo

Specifically, the scope of the symposium was based in the following topics: 1. *Supercapacitor*; 2. *Ionic liquid electrolytes*; 3. *Redox Flow batteries*; 4. *Lithium ion batteries*; 5. *Post lithium Ion batteries*.

1. *Supercapacitor* Session was opened with Prof. S. Simon (Université Paul Sabatier, France), Prof. T. Brousse (Université de Nantes, France) and Prof. M. F. Montemor (Universidade de Lisboa Instituto Superior Técnico, Portugal) presenting the latest results on materials for electrochemical capacitors and high-rate devices, microsupercapacitors, and also new characterization techniques based in impedance spectroscopy.
2. *Ionic liquid electrolytes* Session was opened by Dr. S. Fantini (Solvionic, France) where the key points of the Ionic liquids were presented from the production, commercialization and manufacture. Following, oral contributions were presented showing excellent results on electrolyte formulations based on ionic liquid for Lithium ion batteries.
3. *Redox Flow Batteries* Session with the following invited speakers: Prof. Ana Jorge Sobrido (Queen Mary university of London); Prof. Y. Li (Aalto University, Finland), and Prof. P. Leung (Chongqing University, China), where novel materials like sustainable electrodes, membranes for non-aqueous electrolytes and organic electroactive materials were discussed for the next generation of redox flow batteries. Finally, some examples of Zn-I flow batteries and solid booster concept for flow batteries were deeply analyzed.
4. *Lithium ion batteries* Session inaugurated by Prof. A. Franco (Université de Picardie Jules Verne, France), presenting the digitalization of the manufacturing parameters on electrodes and predict the impact on lithium ion batteries. After this, several electrode materials and solid electrolyte were presenting a new material for the technology.

5. *Post lithium ion batteries* was initiated by Prof. F. Soavi (Bologna University, Italy) presenting the high energy density Lithium/O<sub>2</sub> battery technology in semi solid formulation. Then, other intercalation materials- related technologies like Ca, Z, Al, K and Na were discussed in terms of novel materials for electrodes and solid state electrolytes.

This special issue contents the latest advances of the EES field, illustrating the most relevant results, high scientific and original level. Particularly, 13 contributions are compiled in the special issue, focused on several topics ranging from redox flow batteries (4 articles), supercapacitors (4 articles), lithium – ion and post lithium batteries (4 articles) to advanced tools for morphological analysis of the materials (1 article).

Regarding the contributions of Redox flow batteries, a cost evaluation of all existing technologies has been analyzed by techno economical approach. Additionally, the organic molecules for the anolyte and catholyte have been deeply reviewed and some directions for the new generation of soluble organic molecules have been pointed out. In parallel, solar redox flow batteries have been studied using VO<sup>2+</sup>/VO<sub>2</sub><sup>+</sup> and QDS/AQDS<sup>2-</sup>, demonstrating the positive benefits of the NH<sub>4</sub>Cl as additive in terms of thermal stability and improved capacity. Finally, an efficient strategy for suppressing the water migration on zinc Iodine flow batteries has been demonstrated.

In relation to lithium ion technology, several electrode materials have been explored like Al, silicon, LiNi<sub>0.8</sub>Co<sub>0.1</sub>Mn<sub>0.1</sub>O<sub>2</sub> leading to improved performance of the battery. Meanwhile, Zn<sub>x</sub>Mn<sub>3-x</sub>O<sub>4</sub> cathode has been demonstrated to yield a superior electrochemical performance on aqueous zinc ion batteries. Interestingly, Ar<sup>+</sup> milling cross-section is demonstrated to be a useful analysis to reveal the buried bulk information of materials without any physical or chemical variations.

Finally, innovative materials like 2-D hexagonal boron nitride nanosheets, SmMnO<sub>3</sub>/MWCNT, grafted carbon cloth electrodes and ZnO have been proved their feasibility to overcome the state of the art in supercapacitors like electrodes. As a result, we surely consider that the contributions presented could be quite interesting and inspiring for the future research of EES.

We are truly grateful to all organizing committee inside the EMRS and, specially, to Prof. Petr Krtil and Prof. A. Balducci as ISE representatives. We sincere thanks the Special Issue Editors of *Electrochimica Acta* and Prof. Sotiris Sotiropoulos (Aristotle University of Thessaloniki, Greece) for the coordination of this Special Issue. Finally, we would like to appreciate to the referees and authors for their vital participation in the publication of this special issue.

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