Abstract

The broader context to which the work presented in this thesis is to conceptualize and develop processes related to energy storage devices, in particular on supercapacitors, SCs. Applying a miniaturization and low-impact approach; with the aim to explore this technology, and its future use, as close possible compliant with the given definition of sustainability.

The aim is also to define the concept of a self powered device for sustainable electronics, and validate the fundamental role that a miniaturized supercapacitor, renamed micro-supercapacitors, will have for the development of this technology. Modern technologies value a lot those aspects, therefore the smart systems is linked to the smart use, that must embrace to concepts like low impact, green-like, eco-friendly. The final goal will be make, the entire life cycle of the product and its use starting from production to disposal, sustainable. The approach and methodology adapted throughout this thesis work are aimed for evaluating the hypothesis of scalability and transportability, this approach therefore contributes to and consolidates what we know today as self-powered devices. The study presented is based on two fundamental initial hypotheses. The first hypothesis aimed to explore the possibility of applying a miniaturization approach, similar to what has been observed in the field of electronics in past years, and which continues to progress towards increasingly stringent challenges. This has led to the development of portable/mobile microelectronics with consequences well known to all. The second hypothesis aimed to demonstrate, as much as possible, that some of the processes involved could adhere to a sustainable research trend.

The processes for loading the active material can be considered entirely green-like, as only low-impact materials were used during the process through the use of an aqueous-based solution. Additionally, the involved materials are easily available in nature, facilitating their sourcing. This is one of the fundamental strengths of this approach is that it will facilitate the transition to sustainable large scale production. The gold and manganese plating solution on dendritic gold for electrode fabrication was tested and characterized by a mass loading curve. After consolidating the technique, in-depth investigations were conducted, using different analysis techniques physical and electrochemical.

The hybrid capacitor presented, with a negative active car bon composite electrode and a positive manganese oxide-based composite electrode, operates in a neutral aqueous electrolyte. Furthermore, the hybrid capacitor with a negative iron oxide electrode and a positive manganese oxide electrode, operates in a 1 M $Na2SO4$ neutral aqueous electrolyte. Physical analyses were conducted to understand the morphology and quality of the electrode surface. Electrochemical analyses were successfully performed on the dendritic gold electrode, denoting its significant surface enhancement effect. By adding a dendritic gold layer between the current collector and the active material layer, we obtained a roughness factor of approximately 22. A predominant presence of the $\alpha Mn2O3$ phase (Bixbyite) was observed. This indicates an improvement in the surface factor by about 400%

However, result are promising but long cycling instability was observed, in these new challenge more caution is needed. Further research efforts are required in this area; not enough tests have been conducted to guarantee long-term use in also disadvantageous and non-ideal situations. Further development need to be conducted in this direction to be certain of future concrete applications. In closing, the aim of this work, namely simplifying the procedures inherently linked to microfabrication, can be considered a necessary step to bring this technology to the level of large-scale production. The original approach proposed in this work, involving eco-friendly processes and low-impact active materials, is considered very promising and impactful. Lastly, the environmental impact and possible material recovery are aspects that should never be underestimated and require constant development and research. The final considerations, although the devices presented here are a simplified ver sion, can have a significant impact on common usage, making the "human/device" paradigm, once again, the focus of the discussion. Their use involves humans as an integral part of the operation and is seen as both users and power sources, but all this applications can be extend not only for human being but also for other form of life such as plants or animals, to supervise and guarantee biodiversity.