Sustainable electrochemical energy harvesting and storage devices: development and integration

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Flexible electronics is developing even more rapidly and, presently, flexible power devices represent the missing element. In EARNEST@MPMNT (research group in Disat) we are exploring the applicability of 2D nanomaterials (Mono- and-Di-chalcogenides, MXenes, metal oxides, etc.) as stand-alone and in hybrid structures with other carbon-based nanomaterials (i.e., graphene and carbon nanotubes) for the realization of hierarchical (2D and 3D) electrodes for supercapacitors. The electrodes are realized by exploiting printing techniques onto both rigid and flexible substrates to fabricate EDLC supercapacitor, pseudocapacitors and/or hybrid supercapacitors. Such a development paves a way for the development of e-textiles and innovative implantable devices. Moreover fiber-shaped configurations using gel/polymer electrolytes were investigated in order to allow full device integration into smart textile.

We are selecting the materials and the technologies considering their mechanical properties, cost, safety and scalability, and reach the development of a pilot line exploiting roll-to-roll fabrication of large area flexible electrodes. Indeed, as for the batteries, supercapacitors are nowadays mass produced in roll-to-roll processes. Solutions, dispersions, of the active material in solvents, together with binders that guarantee adhesion and mechanical stability of the overall electrode are usually composed by harmful solvents because of the state-of-the-art binders. Our team is developing the design, the fabrication and the characterization of the green water processable supercapacitors exploiting also the green electrolytes based on bio-derived ionic liquids).

Finally, supercapacitor integration with energy harvesting devices in order to obtain self-charging portable powerpacks is of crucial interest to power both wearable and implantable electronics. For this reason, we aim to achieve full integration/hybridization with energy harvesting systems (photovoltaic and mechanical nanogenerators).